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Original Article

Application of BIM Methodology in Public and Private Electricity and Telecommunications Projects in Peru

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Abstract *- Peru currently faces inefficient performance, cost overruns, delays and stoppages in the construction of public investment projects; of the 2346 paralyzed building projects, 1042 appear as the application result of the traditional methodology for the planning and execution of projects. In the present work, an alternative to solve this problem is the application of the BIM methodology in electrical and communications installations associated with public and private investment projects through Revit 2023 software. As a result of the present study, it was possible to streamline the documentation, obtaining a multidisciplinary environment of three-dimensional modeling of both electrical and telecommunications installations with parametric and precise accuracy hand in hand with technological advances such as 3D printing, augmented reality, and industry 5.0, among others and leading a correct administration and supervision of all parties involved in the building throughout the life cycle of the project. These results demonstrate the multiple benefits of the BIM methodology applied in public or private projects related to electrical and telecommunications installations, serving as a basis for future actions.*

Keywords *- BIM methodology, Electrical plans, Public investment projects, Revit software, 3D modeling.*

1. Introduction

In view of the low level of management in the design, maintenance and planning of public and private building projects in relation to electrical and telecommunications installations, this research analyzes the current situation of building projects focused on electrical and communications installations that are currently generating additional costs and risk of work stoppage. These facilities represent 40% or 50% of the project's total cost, such as the supply of electricity, the data center, fire systems, access control, and the BMS system (Build Management System), such as the case of a hospital building. At present, it was investigated that there are 2346 public works paralyzed and in complete abandonment at the national level [1], a figure that represents an approximate economic expense of more than S/. 29 thousand 732 million soles ($ 7824'210,526.32), representing a lack of financial resources 27.2% (additional work and mutability in the budget), likewise, the breach of the contract 12.2% (delays in the time of design and execution of the work), as well as discrepancies and controversies during its execution that represents 4.3% (lack of cooperation and compatibility between the other specialists involved in the project). [2] It is worth mentioning that, of the 2346 works paralyzed, 1042 appear as the application result of the traditional methodology for the planning and execution of projects.

The report of the Ministry of Economy and Finance of Peru mentions that population growth generates a large gap in construction projects of public and private investment [3]. Where the traditional methodology used fails to meet the needs of the population, compromising building projects focused on electricity and communications facilities such as; the data center, voice, video, fire systems, access control, BMS, power supply, lighting electrical panels. The poor planning, management and maintenance of the traditional methodology is the result of delays and stoppages in most public and private works [4]. For example, hospital projects at the level of Lima and province [5], expansion of the Metropolitan (urban transport system), lines 2, 3, 4, 5 and 6 of the Lima metro, and solar and wind power plants, among others.

During 2018 and 2019, the entities of the National and Regional Government, as of July 31, 2018, had 867 works paralyzed for a contracted amount of S/. 16,930'455,876.00 ($ 4443'689,206.3) figure that currently amounted to S/. 29 thousand 732 million soles ($ 7824'149,606.3) [4][6]. Of the losses and stoppages of main buildings, 85% are linked to the lack of compatibility, organization and planning in the project's design.

Likewise, 91% of the problems that put the project at risk of paralysis during its execution are associated with poor documentation and conceptual design, generating additional work, variability in the budget, and terrible handling of technical information; therefore, among the causes of the stoppage, it is indicated that 39% correspond to technical deficiencies/breaches of the work schedule [7]. To this end, it is important that government entities adopt new and revolutionary techniques and/or methodologies for the creation, planning, development and monitoring of public investment projects in the building; in other words, take into account the formulation of a special strategic work plan specifically aimed at the points mentioned above, with special mention of the unique inclusion of electronic engineers trained and specialized in communications and weak current installations.

As mentioned in [8], every investment project, from a general point of view, responds to the participation of the project in solving a problem that exists within the required context, taking into account that it is intended to achieve a projected change. On the other hand, public investment in Peru increased considerably at the local and regional level during the periods from 2007 to 2013, taking into account the active participation of the corresponding municipalities, going from $2,214,000,000,000 to $7,179,000,000,000 in those years [23].

On the other hand, as detailed in [10], one of the main causes of the paralysis of public investment works in Peru lies in the lack of understanding of the reality of the project and, in turn, in the lack of experience of the state in this type of projects. This lack of experience means that the state does not adequately manage the deadlines or the proper supervision of the projects; likewise, as mentioned above, the people involved in these large projects do not represent the most qualified professionals with the proper knowledge.

In this sense, the impact and repercussions generated by this situation directly affect the public treasury and the state's own investments. For this reason, the inclusion of Decree No. 008-2019 was proposed at the time. However, neither the procedures nor the appropriate terms were specifically detailed to provide the options to conclude the paralyzed works and address this existing problem [11].

In view of the above, and facing this situation, a sophisticated alternative as part of the solution and reduction of these shortcomings lies in the application of revolutionary infrastructure planning techniques. One option lies in the BIM methodology, which contemplates a set of processes and methods supported by a series of innovative techniques. Globally, the adoption of the BIM methodology was demonstrated in projects such as the "Barts and the Royal London Hospital" located in London, United Kingdom, covering an area of 270,000 m2. Also, the project: "Sunshine Coast Public University Hospital" is located in Kawana, Sunshine Coast, Australia, covering an area of 200,000 m2. Likewise, the "Cantareira Norte Shopping" project is located in Sao Paulo, Brazil, surrounding an area of 50,000 m2. [12]. On the other hand, A McKinsey & Company report showed that 75% of companies that have adopted BIM achieved a positive return on investment [13] through shorter project lifecycles, generating material cost savings and reduced bureaucracy.

In Peru, by July 2030, the general objective is to adopt the BIM methodology in a regulated and standardized manner in all public sector building projects [14]. In order to correct, rebuild and build the new, abandoned and paralyzed public investment projects, since it is evident that the current methodology does not meet the expectations of planning, design, execution and maintenance of such building projects, generating unnecessary expenses and excessive costs of staking out and design.

Due to the above, this article aims to present an impact analysis of the advantages and benefits of planning public and private investment projects through the use of the BIM methodology in projects related to the fields of electricity and telecommunications. In this sense, this work exposes the set of processes and techniques to reduce the design and execution time of public and private building projects focused on electrical and communications installations, detecting possible construction compatibility errors, and reducing the additional work before and during the execution of the work.

2. Materials and Methods

The BIM methodology covers the entire life cycle of a work, whether it is a building, a new infrastructure existing, starting with the first ideas, sketches, sketches designs and is developed in the project phase, either previous study, basic project, execution of work, final certificate and then its management and maintenance of the said project. In hospital projects, the BIM methodology manages to adequately manage the information produced during the work [24], such is the case of the electrical installations that are pioneers at the beginning of any building, designing the substation, the ground wells, and protection systems against atmospheric discharges.

Quickly and optimally bringing electrical energy to the project. In another stage, the implementation of BIM modeling is reflected in a good technical file compatible with all specialties and specifically communications and electrical installations [16], since these aerial and underground installations face compatibility conflicts at the time of design by applying the BIM methodology, it is possible to reduce compatibility difficulties by eliminating additional work during the construction process.

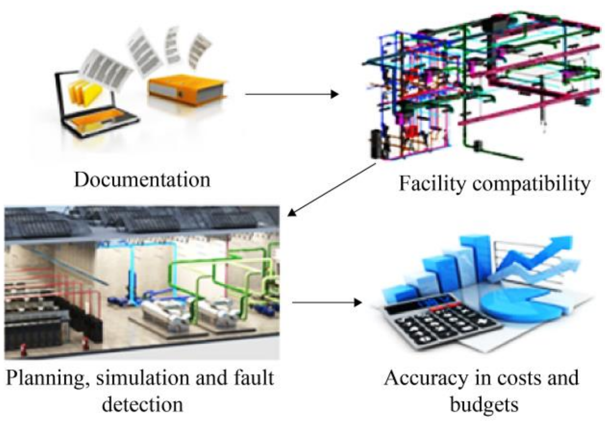

Fig. 1 Planning and design of the BIM methodology

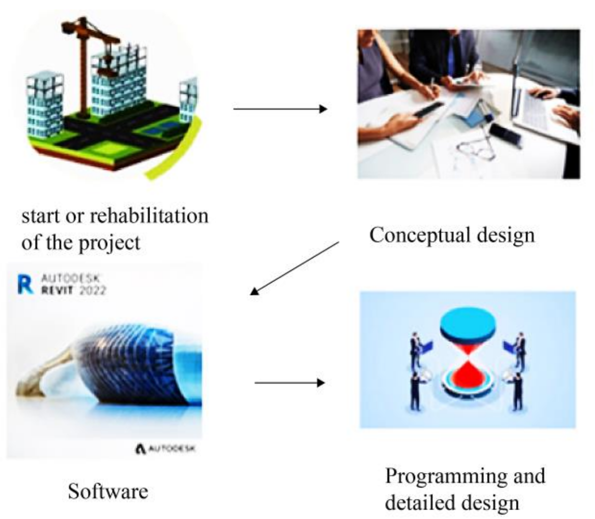

Fig. 2 Representative coordination process and detection of failures in the BIM methodology

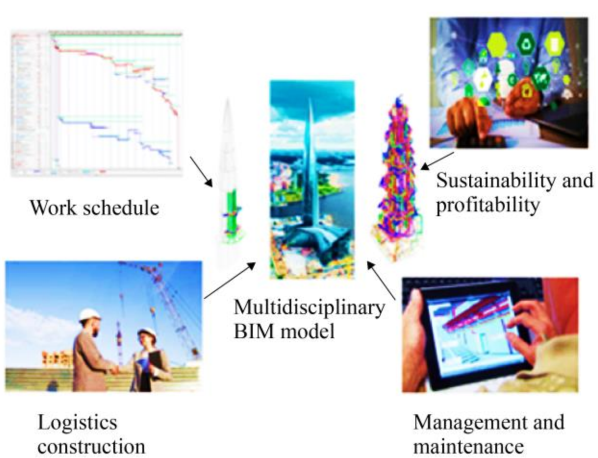

Fig. 3 Operation and maintenance cycle of the BIM methodology

The technology used by the BIM methodology is associated with a virtual model totally faithful to the reality of the work in all its phases, arriving as soon as possible with the electrical and communications installations, complying with and anticipating the schedules during the execution of the work and being able to be optimal and productive at the time of use and maintenance of said work.

The orientation of the application of the BIM methodology in this work consists specifically in designing the electrical and communications installations (electrical substation, generator set, general and emergency panels, data center, periphoneum, access control, BMS, [17]. Making use of the BIM methodology dividing the methodological stage into 3 phases of work; In the first phase, the planning and design of the project will be developed; in the second stage, the simulation will be followed by the coordination and detection of failures so that finally in the third stage the operation and maintenance of the project is executed.

2.1. Planning and Design

At this stage, the project begins developing a rehabilitation of the same for buildings that were paralyzed. You want to continue in the state that was left or simply part of the preliminary project for new buildings to be built through a design and conceptual sketch, there is a wide variety of software for the design of the BIM methodology, being this case, the use of Revit software oriented to electrical installations and communications, preparing the programming and detailed design in order to prevent and reduce future additional cost overruns of work.

2.2. Simulation, Coordination and Fault Detection

Continuing with the second stage, the detailed documentation of the electrical and communications installations is being worked on, making adequate compatibility with the other installations to detect errors in the field and simulate the different and appropriate trajectories of the facilities. Likewise, an approximation and possible accuracy is generated in the costs and budgets developed as the installations' design is being carried out.

2.3. Operation & Maintenance

For this last stage of the design, it is possible to model a multidisciplinary BIM system, which allows us to perform the optimal operation and permanent management of the building to give easy and correct maintenance in real-time to the electrical and communications installations of the building, starting from a correct constant execution with the schedule and programming of the work, complementing a logistics and productive construction towards a more competitive model in the search for innovation and collaborative technologies in construction and facilities, resulting in the sustainability of the project through energy efficiency, sustainability, profitability, complying with sustainability standards to obtain a future LEED certification (Leadership in Energy and Environmental Design) and achieving an operation and management of the facilities for easy and effective maintenance.

3. Traditional Design vs the BIM Methodology

3.1. Traditional Method

For traditional design, take a fire alarm system (ACI) as an example. In this image, you can see the cut of a data center plan with a fire alarm system seen from the top of the plane (2d).

Also, a cut of the data center is seen to show a voice and data cabinet making a new drawing and investing valuable time in making cuts of said installation.

The same happens with the fm-200 clean agent system; it is necessary to make cuts of the upper plane to determine the most appropriate location to make the facilities compatible with the other specialties.

It is evident that the traditional methodology for designing and planning projects in communications and electrical installations is more laborious [25], generating delays in the work, additional cost overruns and possible paralysis of the project. [19]

Table 1. Comparison between traditional methodology vs BIM methodology

Traditional Method vs BIM Methodology	
Traditional methodology	**BIM Methodology**
In Peru, there are 1042 paralyzed works to date due to the low level of management, design and planning of building projects.	85% use of BIM worldwide and 75% cost-benefit ratio worldwide.
2D representation and cuts for cable crossings.	Detailed 3D design without the need to cut
There is a lack of cooperation and compatibility between the different specialists involved in the project.	All the specialists can work on the same model without the need to waste time on the compatibility of the installations.
The main weight of the created files are planes independent of each other.	Everything generated can be managed through databases within the model itself.
The design is incompatible with new technologies such as 3D printing, virtual reality vision, etc.	The BIM methodology goes hand in hand with new technologies and design standards, facilitating the use of 3D printing and virtual and augmented reality views of the projects.

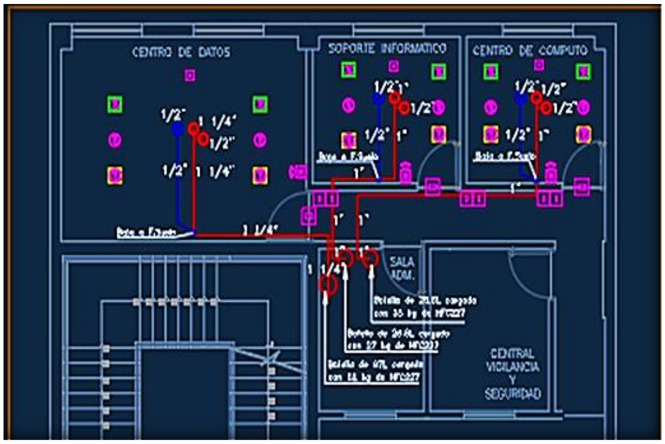

Fig. 4 2D plan of the data center fire system

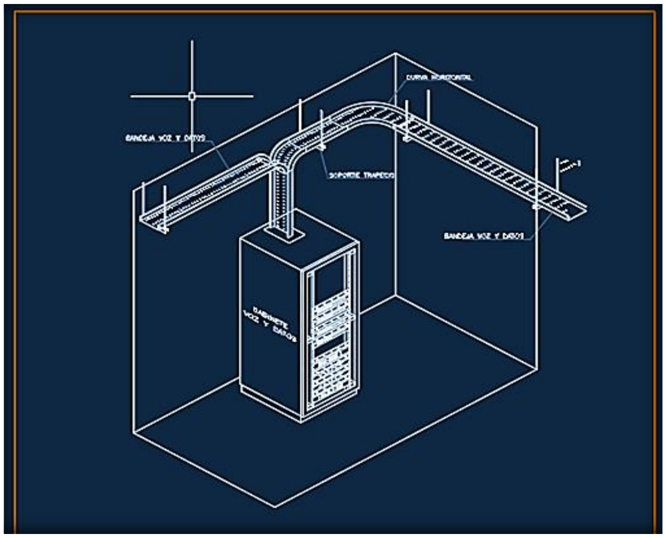

Fig. 5 Isometric plane of the communications room with voice and data cabinet

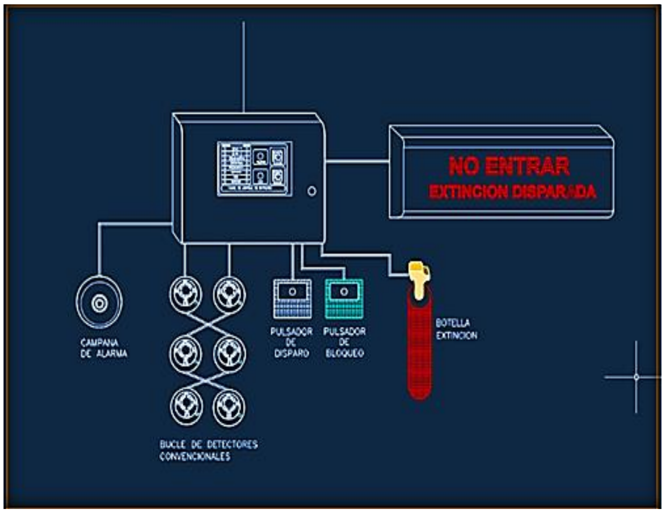

Fig. 6 Detail of the automatic fire system by the clean agent

The use of the BIM methodology avoids the conversion of data preventing additional and overruns of work, compatibility problems, independence of the projected system to future changes of regulations thanks to the application of open standards, integrity and ownership of the project data and transparency since the data are defined in a certain standard. It is easy to read them [12]. This has led to the implementation of work with digital models, more specialized software developments, more precision in modernization moving from 2D drawings to 3D plans with a higher level of detail, development of workflows for the compatibility of different specialties without overlapping together, ease of sharing information (ifc, gltf, pdf...), management platform and storage in the cloud, use of new technologies (apps, drones, 3D printing, virtual reality and augmented GIS for the models of the entire plane).

4. Results and Discussion

Several designs of electrical and communications installations were carried out, taking into account overdue and paralyzed building projects, making use of the BIM methodology through Autodesk Revit software in its 2023 version. Streamlining documentation, providing a multidisciplinary environment, and modeling precise three-dimensional installations with parametric accuracy to properly manage delivery materials during and at the end of the project.

Applying the BIM methodology, it can be seen that the same plane of the data center is shown in the third dimension without the need to have cuts in each stage of the plane, the cabinets, the structured wiring, the trays and the fire alarm system can be visualized using fm-200 clean agent (Fire extinguishing agent heptafluoropropane, non-conductive gas of electricity, colorless and practically odorless).

The same happens for electrical installations, in this case, a 500 kV electrical substation can be seen, which was designed with BIM methodology, and thanks to this design, you can size and observe in detail the appropriate loads, energy efficiency, better location and especially compatibility with other specialties saving time during the design and construction process of the work.

It is also possible to model any equipment considered within an electrical substation, such as this example of a capacitor bank with a BIM level of detail, stacked in its structure, with input and output switches, blade-type disconnectors, surge protection devices and their respective insulators.

As the three-dimensional modeling of the project is obtained detailed information about each designed stroke, generating a library of information that is reflected in the meters at the same time as the design as in the case of the design of the electrical substation, the list of electrical equipment necessary for the project such as 230kV current transformers, 245kV support insulators, 245Kv silicone surge discharger, 245Kv induced voltage transformer, among other equipment.

Worldwide, the BIM methodology generates good expectations, thanks to the thousands of success stories in the construction of public works, which are represented in Figure 12, intensifying the multiple benefits and expectations that it leaves during its application.

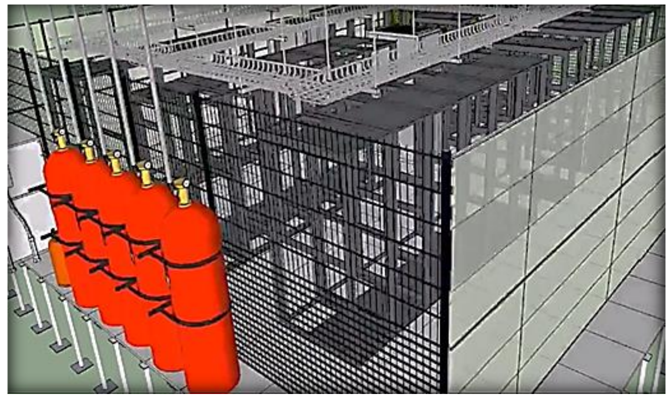

Fig. 7 Three-dimensional plan of the data center with cabinets, trays and automatic fire extinguishing system applying the BIM methodology

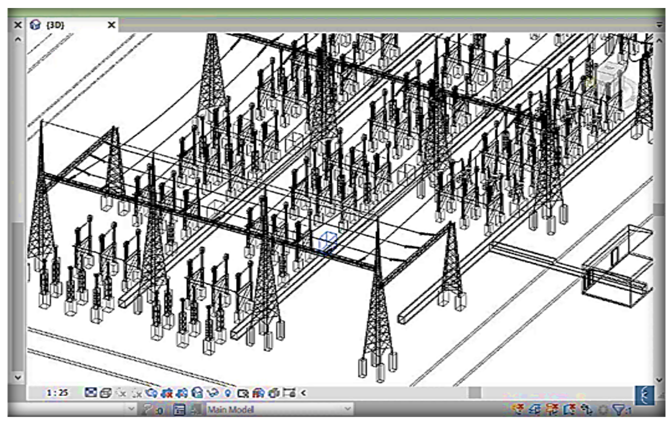

Fig. 8 Electrical substation designed with BIM methodology

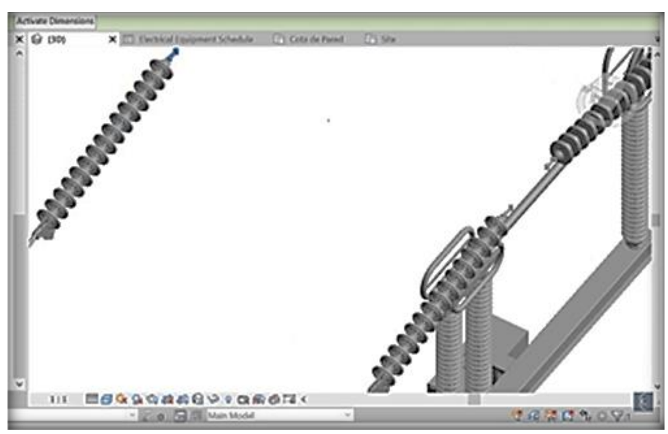

Fig. 9 BIM level of detail

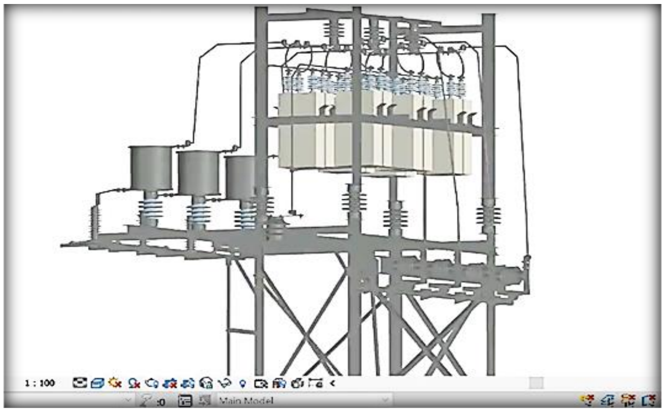

Fig. 10 BIM modeling of a capacitor bank for electrical substations

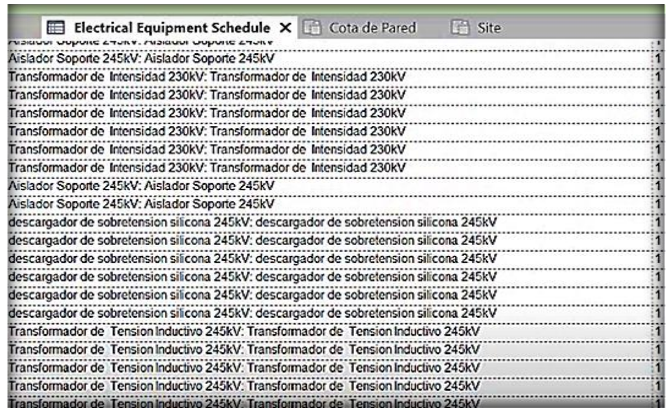

Fig. 11 Quantity of the list of electrical equipment for a substation in Revit software

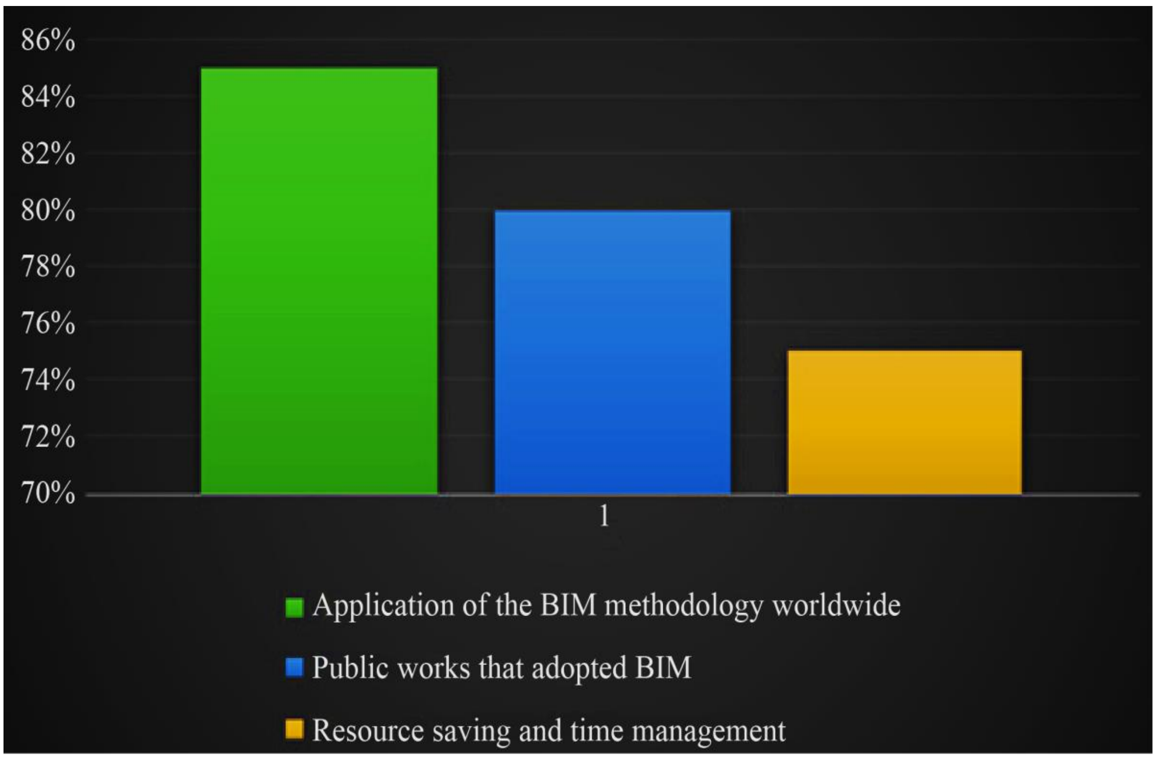

Fig. 12 Expectations of the BIM methodology worldwide

BIM collects all the details about each component of an asset in the same place. When another BIM actor needs to access information, regardless of its purpose, they can easily locate it and follow or update it as needed. In addition, when a team builds a BIM model with a high standard, project managers can perform several alternative scenarios to visualize the complete sequence of the planned project. The images can then be shared with stakeholders or customers and serve as a basis for future actions.

The BIM methodology contemplates the three-dimensional model where the electrical and communications installations are designed during the building project; ultimately, a digital file is obtained that contains crucial data of the project, which allows exhaustive and precise decision-making throughout each cycle of the same.

The limitation that arises in this research work is the high cost of BIM implementation. Likewise, the BIM methodology requires constant training and updating during the construction process of electrical installations and communications. Hence, resistance to change, fear of failure and leaving the comfort zone are barriers that harm the development and implementation of the BIM methodology. Also, for efficient multidisciplinary development, it is required that the specialists involved in the project go hand in hand in knowledge and updating with this methodology.

On the other hand, the BIM methodology stands out for its multiple benefits worldwide. Figure 12 shows the result of a reduction of 20% - 30% of the construction budget, 22% less in construction time, 50% less time in analyzing information ordered during the tender and 80% less time in locating the information; this facilitates and improves performance during predesign, schematic design, quantification, budget, administration and construction during the development of the project.

Unlike the research works compared [20], [22], and [26], an improvement in this result has been detected thanks to the advance in the BIM methodology; the design adds the quantity, costs and budgets as the project is traced and achieving a better capture of information. Since as soon as a stretch of wiring is drawn, a quantitative meter of it is generated, which is stored in the software library as the basis of the costs and budgets of the project. As shown in Figure 11, this metering model is dispersed in all the components and materials involved in the project during modeling, facilitating and providing multiple benefits.

5. Conclusion

It was demonstrated that the BIM methodology manages to reduce execution times, reduce the risks of work stoppage and integrate new technologies into the execution project. Although it must be applied in all phases of the life cycle of a project, economically speaking, it is more profitable since, on top of the growth to a large extent that the company will have, it will encompass a greater space in the market and if it is not applied it will have many limitations. You will continue to hear phrases like "cost overruns exceeded the initial budgets", leaving thus many unfinished works for not investing in the training and implementing cutting-edge methodologies.

The BIM methodology gives us complete graphic and non-graphic information with various data sets, showing control of quality standards, complying with standards and identifying interferences to intensify the performance of assets, incorporating information for the use of materials that analyze the constructive elements in all their parts.

With the BIM methodology, you can correct errors in the design phase but not in the execution phase, and this manages to increase productivity and reduce costs and project deadlines. Obtaining correct decisions and making more transparency throughout the investment cycle.

BIM models not only allow the detection of interferences but also allows to review of the design criteria and the functionality of the same for adequate supervision of work progress, simulating the progress and dimension of time in the model.

Better communication with citizens and highlighting the impact on the environment, making visible the design intention and potential risks hand in hand with the environment, achieving less construction waste, performance simulation and energy consumption. This BIM technology seeks the future to leave aside the usual construction to take it to a manufacturing process.

References

[1] [Online]. Available: https://cdn.www.gob.pe/uploads/document/file/3720744/Reporte%20obras%20paralizadas.pdf.pdf

[2] I. F. Taquire Zambrano, "*Execution of Technical Files with Deficiencies in the Construction of Public Infrastructure Works*," Peru Mg. Thesis, Graduate School, Cesar Vallejo University, Lima, 2019. [Google Scholar] [Publisher Link]

[3] Supreme Decree No. 289-2019-EF- Gobierno del Perú, [Online]. Available: https://www.gob.pe/institucion/mef/normas-legales/293869-289-2019-ef

[4] Reporte de obras paralizadas 2019 - Gerencia de Control de Servicios Públicos Básicos, La Contraloría General de la República del Perú. [Online]. Available: https://doc.contraloria.gob.pe/estudios-especiales/documento_trabajo/2019/Reporte_Obras_Paralizadas.pdf. 2019.

[5] Health in Abandonment: 2021 Ends with 16 Hospital Works Paralyzed [Report] RPP Noticias. [Online]. Available: https://rpp.pe/peru/actualidad/la-salud-en-abandono-el-2021-termina-con-16-obras-de-hospitales-paralizadas-informe-noticia-1374258?ref=rpp

[6] Retos para dinamizar la inversión pública, Banco Central de Reserva del Perú. [Online]. Available: https://www.bcrp.gob.pe/docs/Publicaciones/Reporte-Inflacion/2019/marzo/ri-marzo-2019-recuadro-4.pdf

[7] Apaza Mango et al, Failure to Comply with the Deadline and Cost due to the Deficient Preparation of Technical Files, by Not Using Bim Methodology Tools, In the Public Sector of the Arequipa Region. Case Study: Construction of the Professional Schools of Computer Science and Telecommunications Engineering, District, Province and Region of Arequipa, Peruvian University of Applied Sciences, 2021. [Online]. Available: https://renati.sunedu.gob.pe/handle/sunedu/3097775

[8] Walter Andía Valencia, La demanda insatisfecha en los proyectos de inversión pública, Producción y Gestión. vol. 14, no. 2, pp. 67-72, 2011. [Google Scholar] [Publisher Link]

[9] Husnul Khatimi, and Muhammad Rodlin Afif, "Implementation Building Information Modeling (BIM) 5D in Development Project of the Dakwah Building Campus 2 UIN Antasari Banjarbaru," *SSRG International Journal of Civil Engineering*, vol. 8, no. 12, pp. 29-34, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[10] Felipe Portocarrero M, "The Peruvian Public Investment Programme 1968–78," *Journal of Latin American Studies*, vol. 14, no. 2, pp. 433-454, 1982. [CrossRef] [Google Scholar] [Publisher Link]

[11] F. H. Mallqui Salazar, Propuesta de un método para formular presupuestos de reactivación en obras paralizadas de infraestructura sanitaria Junín. [Online]. Available: https://repositorio.uncp.edu.pe/handle/20.500.12894/8721

[12] A. Villamizar, Adoption of BIM in the world, 2021. [Online]. Available: https://idesie.com/blog/2021/04/15/adopcion-del-bim-en-el-mundo/

[13] A Way Forward for Spain, McKinsey & Company, 2021. [Online]. Available: https://www.mckinsey.com/~/media/mckinsey/featured%20insights/Europe/Women%20matter%202017%20A%20way%20forward%20for%20Spain/Women-matter-2017-A-way-forward-for-Spain.ashx

[14] Plan de implementación y hoja de ruta del plan bim perú, m.e.f 2021. [Online]. Available: https://www.mef.gob.pe/contenidos/inv_publica/anexos/anexo_RD0002_2021EF6301.pdf

[15] Arpit A. Bhusar, and Ashish R. Akhare, "Application of BIM in Structural Engineering," *SSRG International Journal of Civil Engineering*, vol. 1, no. 5, pp. 1-5, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[16] Díaz Valdivia, and José Carlos, Implementation of Bim-Vdc Technology for the Management of the Design and Construction of Electrical Mechanical Installations, case of Retail Restaurantes Ekeko, Arequipa, 2017-2018. [Google Scholar] [Publisher Link]

[17] O. A. Peña, New Perspectives Offered by Bim Technology for the Development of Telecommunications Infrastructure Projects, 2019. [Online]. Available: https://blog.bimserver.center/es/nuevas-perspectivas-que-ofrece-la-tecnologia-bim-para-el-desarrollo-de-proyectos-de-infraestructuras-de-telecomunicaciones/

[18] Khalid S. A. Al-Gahtani, "Review Current Value Engineering Studies Towards Improve Automation within Building Information Management (BIM)," *SSRG International Journal of Civil Engineering*, vol. 9, no. 2, pp. 1-9, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[19] The Paralyzed Hospitals Must be Audited to Find out if the Advanced is Useful or if we Have to Start From Scratch, 2022. [Online]. Available: https://www.cutivalu.pe/se-debe-hacer-auditoria-a-los-hospitales-paralizados-para-saber-si-lo-avanzado-sirve-o-hay-que-empezar-de-cero/

[20] Zhen-Zhong Hu et al., "BIM-Based Integrated Delivery Technologies for Intelligent MEP Management in the Operation and Maintenance Phase," *Advances in Engineering Software*, vol. 115, pp. 1-16, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[21] Soumyajit Koley, "Exploring Social Value Prospects of Australia's Construction Industry Towards the Aboriginal Communities, Under COVID-19 Recovery Efforts," *International Journal of Engineering Trends and Technology*, vol. 70, no. 12, pp. 227-251, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[22] Noa Mayta, Alberth, Vergara Ovalle, Omar, Design of special electrical installations applying Bim technology, automation and hybrid self-generation, of a 5-star hotel, Bachelor's thesis, National University of San Antonio Abad of Cusco, 2021. [Online]. Available: http://hdl.handle.net/20.500.12918/6414

[23] Stephanie L. McNulty, and Gustavo Guerra Garcia, "Politics and Promises: Exploring Fifteen Years of Peru's Participatory Decentralization Reform," *Public Organization Review*, vol. 19, no. 1, pp. 45-64, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[24] María Luisa Candia Maquera et al., "*Improvement of the Planning of Hospital Infrastructure Projects Applying BIM to Optimize Constructability*," Master's thesis, Technological University of Peru, 2018. [Google Scholar] [Publisher Link]

[25] Reactivación de obras públicas paralizadas, Banco central de reserva del Perú (B.C.R.), 2019. [Online]. Available: https://www.bcrp.gob.pe/docs/Publicaciones/Reporte-Inflacion/2019/diciembre/ri-diciembre-2019-recuadro-1.pdf

[26] E. Turpo, Aplicación de la metodología BIM para mejorar el desempeño de los procesos constructivos en la estación subterránea de la línea 2 del metro de Lima – 2020, Tesis de licenciatura, Universidad Privada del Norte, 2020. [Online]. Available: https://hdl.handle.net/11537/25178