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TOWARDS A LIFE CYCLE ASSESSMENT BASED SYSTEM FOR SAHARIAN BUILDING IN ALGERIA

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ABSTRACT

Facing the effects of the climate change and in the alignment of the commitments of Paris Agreement, many countries have laid down neutrality carbon and reheating to 2 C^{O} maximum as an objective up to 2050. In Algeria, the national energy balance shows that building environment consumes more than 51 % of total energy consumption. However, if measurements of attenuation of the emission of greenhouse gas GHG were not undertaken the reheating could reach 7 ^{O}C by the end of the century causing irrevocable environmental consequences. The adoption of the concept of neutrality carbon in the building sector can be included under a Zero Energy Building strategy. In order to reach this goal, architects often face problems that require suitable solutions. To carry out this task a multitude of software programs were developed. Nevertheless, it has been noticed that an important number of architects do not use any bioclimatic device tools during the design process, at least in the present case study. The inadequacy of these tools, to the professionals implied in the designing process, especially architects, is very probable. In this regard, the aim of this contribution is to develop an assistant tool for designers so that to produce high-performance buildings in terms of energy. It seeks to develop a bioclimatic sketching dashboard based on the Algerian guideline combined by case based reasoning and data visualization method. The research methodology embraces three steps: (1) analyzing the current designing practices; (2) integrating case based reasoning system by using artificial intelligence techniques; and (3) evaluating the performance of the proposed method. The validation section aims to check that the association Concept-Cases allows a correct interpretation and a performant appropriation of the neutrality Carbone concepts during the building life cycle (BLC), and to validate the practical, economic, environmental and creative benefit of the suggested method. The experimentation is carried out by two different means. The first set of experiments take the form of practical exercises; whereas, the second one is done by analyzing the energetic performance using Building Energy Performance Simulation (BEPS). This tool not only assists architects but also offers concrete illustrations to the various actors and feeds the design process from the early stages.

Keywords: Life Cycle Assessment, the Building Sector, Climate Change, Design Support, Data Visualization, Carbone Neutrality.

1.INTRODUCTION

The architectural design process is considered as a research field on its own. In 1992, Robert Prost notably points out that architecture should be considered as a process that produces

knowledge and not just objects, and elegantly frames it into problem formulation versus solution formulation processes. He perceived it as a problem solving activity, and the project is the result of a long complex multidisciplinary process of planning. It is not only a non-linear procedure but also a dynamic one (Sankar, 2004). The emergence of the conceptual solution is the result of various actions. It embraces different sorts of interactions between the actors and their subject-fields (Prost, 1992). Pierre Fernandez notices that the major character that renders the act of design process modeling awkward is the multiplicity of project elaboration methods. This feature can be interpreted by numerous ways of conciliating both the objective data (program, site, regulations…) and subjective parts (architectural style, composition, reference…) during the process of design (Fernandez, 1996). In this regard, the architect has to get as much as possible of information concerning the project, and call for his own experience in terms of knowledge and know-how (Benabdelfattah, 2018).

In view of that, the architectural design is an iterative solution formulation process between problem statement and design solutions. These iterations might be facilitated thanks to references to the building context or to the architectural corpus. Robert Prost (1992) points out that the transition from the problem statement to the solutions can be assimilated to a black box. It is largely considered as an obscure activity, as shown in Figure 1. Yet, it can be assumed that this alteration is not linear but rather spiral as it is bifurcated by references that feed the system with design solutions.

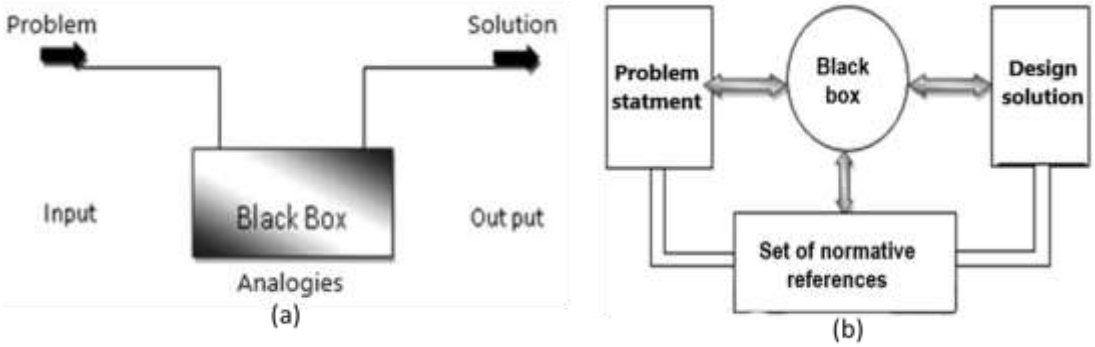

Fig 1: The iterative design process between problem statement, design solutions and references (a) according to Christopher (1980) and (b) according to Prost (1992)

Several approaches are suggested to integrate this fact into an intelligent device that can help architects to find solutions for the conceptual problems that they face. This can be achieved by providing the machine with the necessary knowledge that enables them to find the most suitable solution.

The Case Based Reasoning (CBR) is considered as being the closest technique to the human reasoning based satisfaction among all the various approaches related to artificial intelligence. Additionally, it is the most adopted in the activity of designing (Mazouz, 2001). Indeed, it can help architects overcome the problem of the lack of information concerning bioclimatic field issues and find optimal solutions. In his work on the reasoning base references, Roger Schank proposes that a problem resolution system based on the CBR must be guided by the experiment (Bendeddouch, 1998). The CBR is a form of reasoning by analogy. It consists in solving a new problem, called target problem, and by using a whole of already solved similar precedents (Riesbeck, 1989; Fadi, 2009).

As to the research methodology adopted, needs analysis approach is used in order to refer to the process of identifying the different aims and objectives of particular learners from tacking a specific support or training. Three different types of needs were identified (figure 2): present situation analysis (it means what the category of people concerned know about the subject field), target situation analysis (the desired outcome or what those people ought to achieve after using or taking the course), and learning needs analysis (the preferable and effective methods of achieving the objective, in other terms how to bridge the gap between the two stages (Hutchinson, 1987).

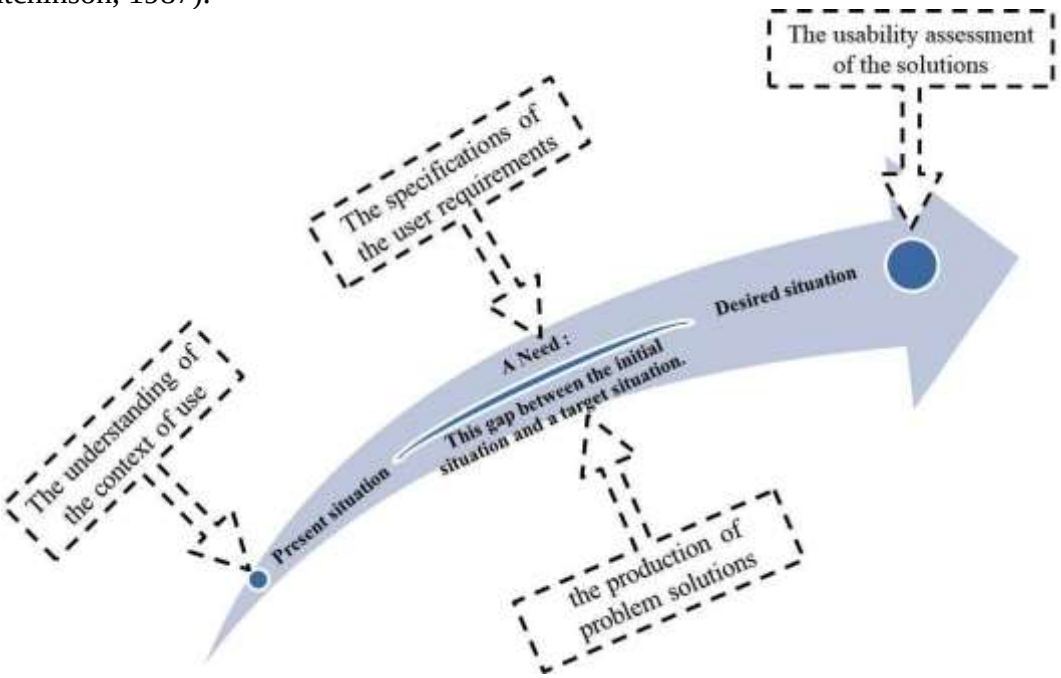

Fig 2: The definition of a need regarding the Needs Analysis method

According to this definition, Needs analysis approach encompasses (1) the understanding of the context of use, (2) the specifications of the user requirements, (3) the production of problem solutions and (4) the usability assessment of these solutions. Iterations between all these steps allow continuous improvement of the design. A great deal of experts see that human resource development and performance improvement should be based on needs assessment so that to develop and implement practical solutions for individuals, groups, organizations, communities, and nations (Berwick, 2017). Thus, in this context and under such conditions, being up-to-date depends on the degree of collaboration and cooperation among the members of the teamwork. Yet, if we consider this matter from architects' point of view, exchanging and interpreting the spirit of architectural bioclimatic design requirements might be the most important skill, especially when it comes to the issue of designing what we called "nearly zero energy building". The practice of the technical design depends on many factors where the principal element is the training of the different actors; among them the architect who orchestrates the design process in order to conceive building in conformity with the current standards, and take into account all the desires of the user. From this perspective, this paper concerns itself with:

- Meeting and conceiving a set of conceptual strategies related to the passive architectural bioclimatic design.
- Suggesting an innovative way that takes these last into account during the early stages.

- Finally, developing a sort of LCA-based tool founded by the case based reasoning and data visualization method in order to bring altogether the relevant actors of the construction industry to work collaboratively from the beginning of a project

2.THE UNDERSTANDING OF THE CONTEXT OF USE

According to the recommendations derived from ISO 9241-210, the context of use should include four main parts, such as: (1) the definition of the different users focusing on the relationship between them, their constraints and goals …etc. (2) their profiles, knowledge, skills, experiences, training, physical attributes, preferences and competences…etc. (3) the responsibilities and goals of each one (duration, interdependencies, frequency …etc.) Lastly, social environment including the technical and the physical sides such as: organizational structure, work practices, attitudes, hardware and software …etc.

Among the different methods used to analyze the context-of-use such as: identify stakeholders, context-of-use analysis, survey of existing users, field study or user observation, diary keeping and task analysis, the "survey of existing users" seemed particularly suitable to collect the data as it allows reaching out a diverse and difficult-to-access population (Maguire, 2001).

The method adopted is based on written questionnaires that encompass a mixture of open and closed questions. They include 29 items divided into 06 groups. Some questions used a Likert-scale so as to have short answers and facilitate the analysis of data; whereas Multiple-choice-item questions were used when this type was not appropriate. In order to make answers easy, the closed questions were formulated by means of a pull-down menu encompassing categorical data, interval data or by an ordinal data with Likert scales (e.g. not at all satisfied to very satisfied). Therefore, the survey prepared took about 15 minutes to fill out. All these questions aimed at a better description of the current bioclimatic design practice-context. Therefore, the determination of users' needs and requirements and the comprehension of their profiles are considered as a primary step towards an Algerian bioclimatic LCA-based System.

According to the rule of five of Hubbard (2010), the first version of the questionnaire was tested in order to check the length and the understanding of the survey. Thus, the feedback derived to enlighten some of the questions that were misrepresentative and approve the duration of the survey. Then, the questionnaire was targeted the Algerian architects, which was made up of 9215 members registered in the national table of the Architects (CNOA, 2020).

2.1 .The specifications of the user requirements

Since 2000, the Algerian authorities have put the issue of the elaboration of sustainable design codes as one of its priorities in order to take into account the natural and climatic variables in the designing process. This is clearly mentioned in the numerous promulgated regulations such as: laws (01-20; 02-02; 02-08; 04-05; 04-09; 09-99) and the executive decree number 14-27 (Hamrani, 2017). However, to interpret suitably the spirit of the code, the designer's experience has to be up to the level. Without this characteristic, a contrary result might occur especially in the case of bad interpretations (BRET, 1988). Moreover, the majority of the available building energy performance simulation (BEPS) tools are used as enhancers. They can be classified into five categories such as: (1) Energy Modelling software and (2) Environmental *LCA* Tools for Buildings. These two are active tools that deliver a quantitative assessment through requesting the user to calculate and evaluate different scenarios. They also check the feasibility of the

overall architectural forms and intervene at stages in which the architectural part is already done. (3) Environmental Assessment Frameworks and Rating Systems, (4) Environmental Guidelines or Checklists and (5) Environmental Certifications and Labels. These last are passive tools that serve to support the decisions taken with straightforward and qualitative recommendations.

On the other hand, the architectural bioclimatic design is - by nature - an iterative activity. It requires a consistent close collaboration between the technical parts and the architectural bioclimatic aspects. In an ideal scenario, it brings together all the relevant actors from the construction industry to work collaboratively from the early stages of a project. Indeed, it recognized that including knowledge into the designing from the beginning allowed for great deal of reconciliation between the architectural aspect and the technical design of the architectural project (MacLeamy, 2004). as illustrated by Jusselme (2020) (see figure 3).

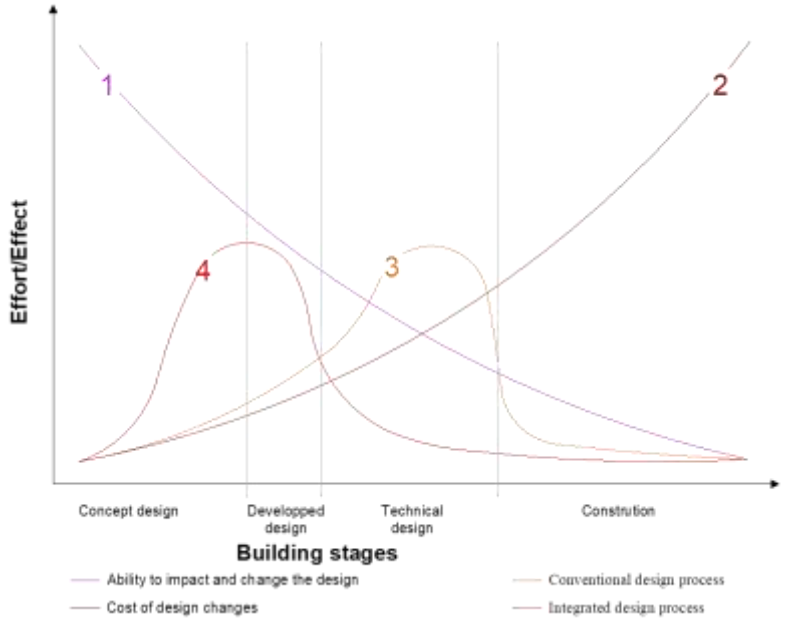

Fig 3: *Efforts and effects fluctuation for an integrated design process. Adapted from (Jusselme, 2020)*

Practically, the implementation of such methods is the result of the interaction of extremely complex factors such as: the current regulation, the economic situation, the technical know-how, the aptitudes, and even the different actors' behavior. Accordingly, the majority of Algerian designers do not use BEPS tools during the early stages of project. This is mainly due to the inadequacy of these tools to the professionals implied in the design process, especially architects (Benabdelfattah, 2018). This lack of use can be explained on various levels as:

- Like all BEP Simulation tools, the very low level of details available about the project at earlier stages is a common issue has to face. Accordingly, they are not used until the last phases of the design process.
- Designers are remarkably short of trainings in terms of using these tools.
- Their knowledge about bioclimatic designing concepts is quite poor.
- Architects consider that bioclimatic active strategies are in charge of treating the sustainable aspect of buildings.

- The fact of knowing about the existence of a state under control subsidy for the residences energy consumption is compulsory make designers lazy in considering bioclimatic aspects during the early stages.
- The current software devices are out of the mastery of architects as they are highly complicated and specialized.
- These tools require relatively long period of time for training sessions, which professionals can not actually afford.

The use of these support tools varies according to the mode of implication of the bioclimatic aspects in the architectural design process:

In case of post-implication, the support tools assume the control, validation, or sanction mission. And hence, the amendments have to be limited with regard to the schedule and project budget. Indeed, a great deal of rectifications during early advanced state of project design may imply revising a considerable work of design on various scales. On the other hand, in case of very early engagement, as of the draft stage, they are involved as assistants in the bioclimatic design (see figure 04).

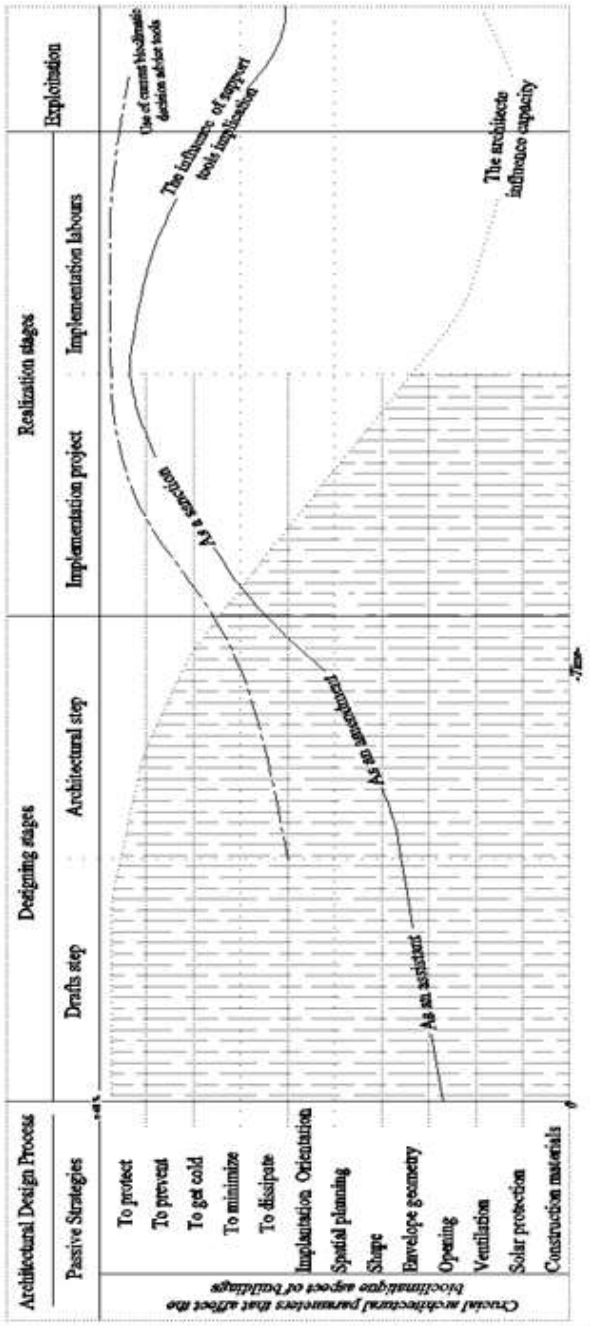

Fig 4: Implication of current BEPA tools in the design process (case of Algeria)

The current BEP Simulation tools available belong to the specialized codes which are not usually used in architectural practice. The early designing phases allow the highest ability to impact and change the design, while the cost remains very low. During these stages, architects do not need any validation but rather an enriching and an assistant tool ; as affirmed by the Ex-head of CLOA-Adrar (Local Council of the Architects Order), Mr. LAZRAG A. : «…when conceiving we always seek nutritive sources for the project that stimulates the architectural creativity…»

Actually, the designing act is rather a complex activity; it is a technical and sensitive labour at the same time. It often requires a search for ideas and information which can assist the designer in the development of his project. This idea was developed by many researchers, such as Conan (1990), Farel (1991), Prost (1992), Bignon (1998). According to Prost, references are at the core of the design process but start to be limited when it comes to an innovative statement. His work has been used recently as a reference in several research contributions to better define the role of architectural references within the design process, such as Leplat (2002), Kacher (2005), Halin (2007), Claeys (2013), Benabdelfattah (2019) and other…

They explain why during the architectural design process, recoursing to images (diagrams, sketches, pictures, photographs… etc.) is rather essential. They consider also that the information transmitted by the image is easy to understand or include in the project, than that transmitted by a written text. This probably results from the fact that the image requires less interpretations compared to written texts. Moreover, the image displays information that can be straitly integrated into the corpus of the project. Accordingly, the architectural design process is regarded as being a chain made up of several couples of problem/solution formulations which each one called upon specific representations (figure 05). In this regard, the representation is a means of anticipation, description, information and dialogue between the actors. It enables them to simulate the various assumptions, decision-making aid, control and validation lasting the development process of the project, and also a tool of communication towards a public not specialized.

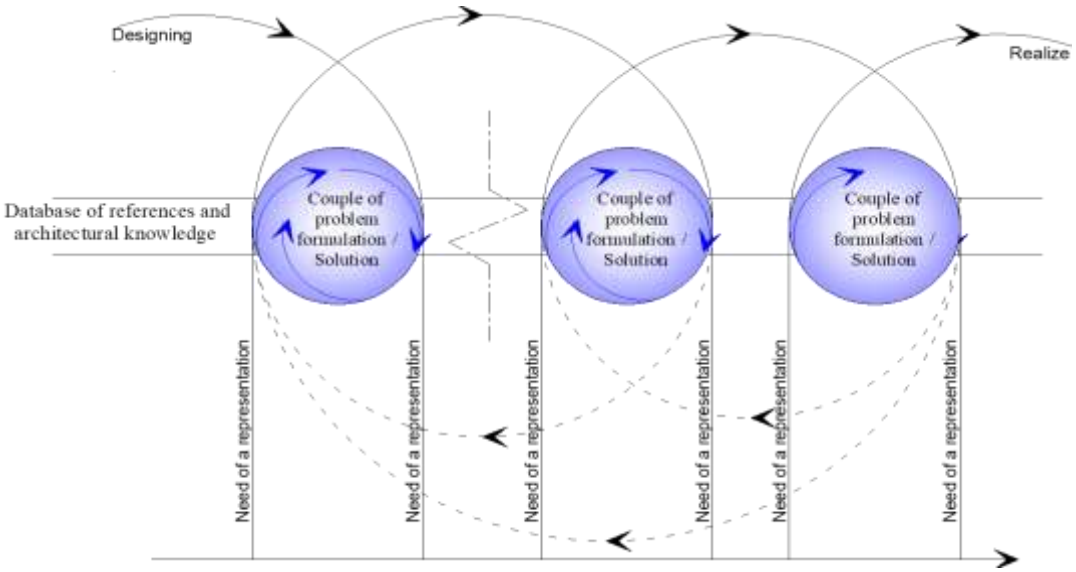

Fig 5: The role of the couple problem formulation/solution in the advance of the architectural design process according of Djafi (2005)

The need for schematizations is a necessity that appears on the various level of the dynamic articulation of this couple. It offers the possibility of expressing the idea of the project that one wants to carry out, and to communicate.

2.2 .The production of problem solutions

The designing act is a highly complex activity; it is both a technical and emotional action. It often requires a deep search for ideas and information that can assist the designer in the

development of architectural projects. During the conceptual process the need to resort to visual illustration (images, pictures, drawings, etc.) is paramount. Designers consider that the information transmitted by image is easy to understand compared to written texts. The image clarifies the various situations "analysis / development" of the designing process, and also simulates the comprehension of the bioclimatic architectural concepts. Moreover, it provides the actors with a clear illustration about how to include the formal relationships between the various attributes influencing the bioclimatic aspects of the building (Khelifi 2006).

In this piece of research, our aim is to suggest a tool that facilitates a sort of reconciliation between the objective and the subjective parts of the architectural design. More precisely, enhance the communication between the different actors, and hence ensure an effective collaboration between them as it is the fundamental principle of a professional teamwork. The proposed tool is composed of two types of structures: a linear structure and in loop one (Figure 06).

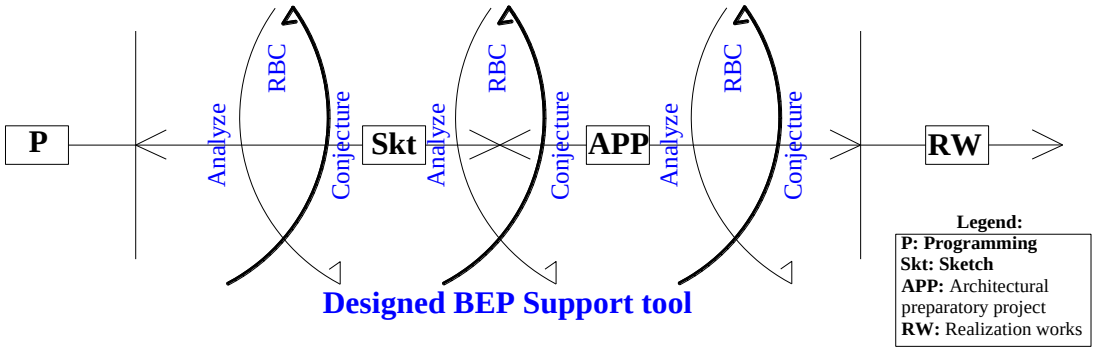

Fig 6: The proposed design procedure

The linear structure represents the vertical scheme of the process as well as the different developing phases of the project, from the beginning - where the problem is ambiguous - to the end - where the solution is clear and satisfactory. In addition, it defines the users' requirements and bioclimatic design principles. One the other hand, it allows the designers to assess the candidate solutions by comparing the score of the last situation with the previous one.

The early design process is usually take the form of an iterative path; it involves numerous pairwise comparisons between design alternatives. The second structure has a loop form. It represents the circular argument of the design act and concerns with generating alternative solutions and allowing the repetition of all the activities and phases of the linear structure in an iterative way. The loop structure divides the vertical linear one into loops of five successive stages. The first one examines the project candidates. The second stage selects bioclimatic concepts from the data given. At that moment, an analytic phase is carried out in order to suggest the various possible conceptual solutions. Then a synthetic step generates a potential solution through the exploration of various combinations of the primitive elements, as shown in figure 7.

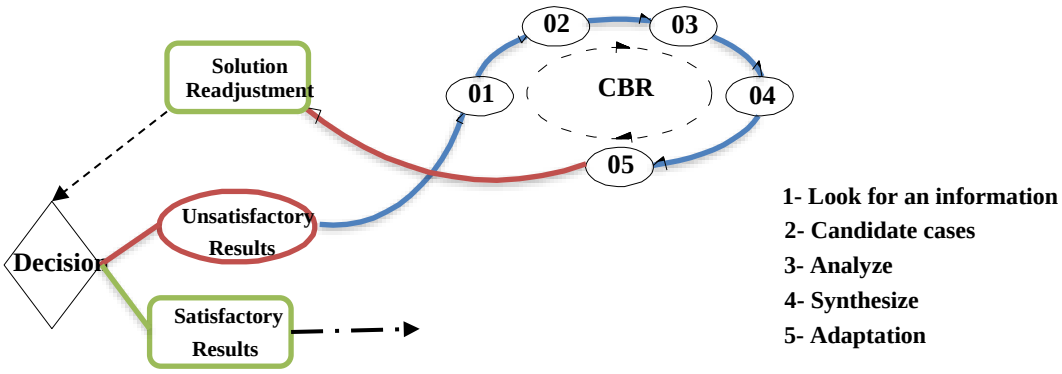

Fig 7: Steps of the loop structure of suggested approach

Finally, the results are evaluated, sometimes readjusted and reused. These phases are repeated until a satisfactory designing solution is obtained.

In order to perform a design project, architects usually use their previous knowledge conceptualized in terms of references and schematized cases so that to feed their new artistic products. They do not have predetermined ways of resolution, but instead they know a certain number of techniques and methods, among which relying on similar projects or existing prototypes. However, it is necessary for designers to reinvent and recombine some strategies to elaborate an adequate solution each time.

The need for usable BEP assessment tools during the early stages proves to be essential as they offer the architect the conceptual bases for his/her architectural project. They enable him/her also to ensure the integration and insertion of climatic variables from the outset of the project. The reasoning based case is by far the most suitable approach to problem solving adopted in the act of designing. Indeed, it implies the use of artificial intelligence “AI” that helps architects in the bioclimatic design and to find optimal solutions.

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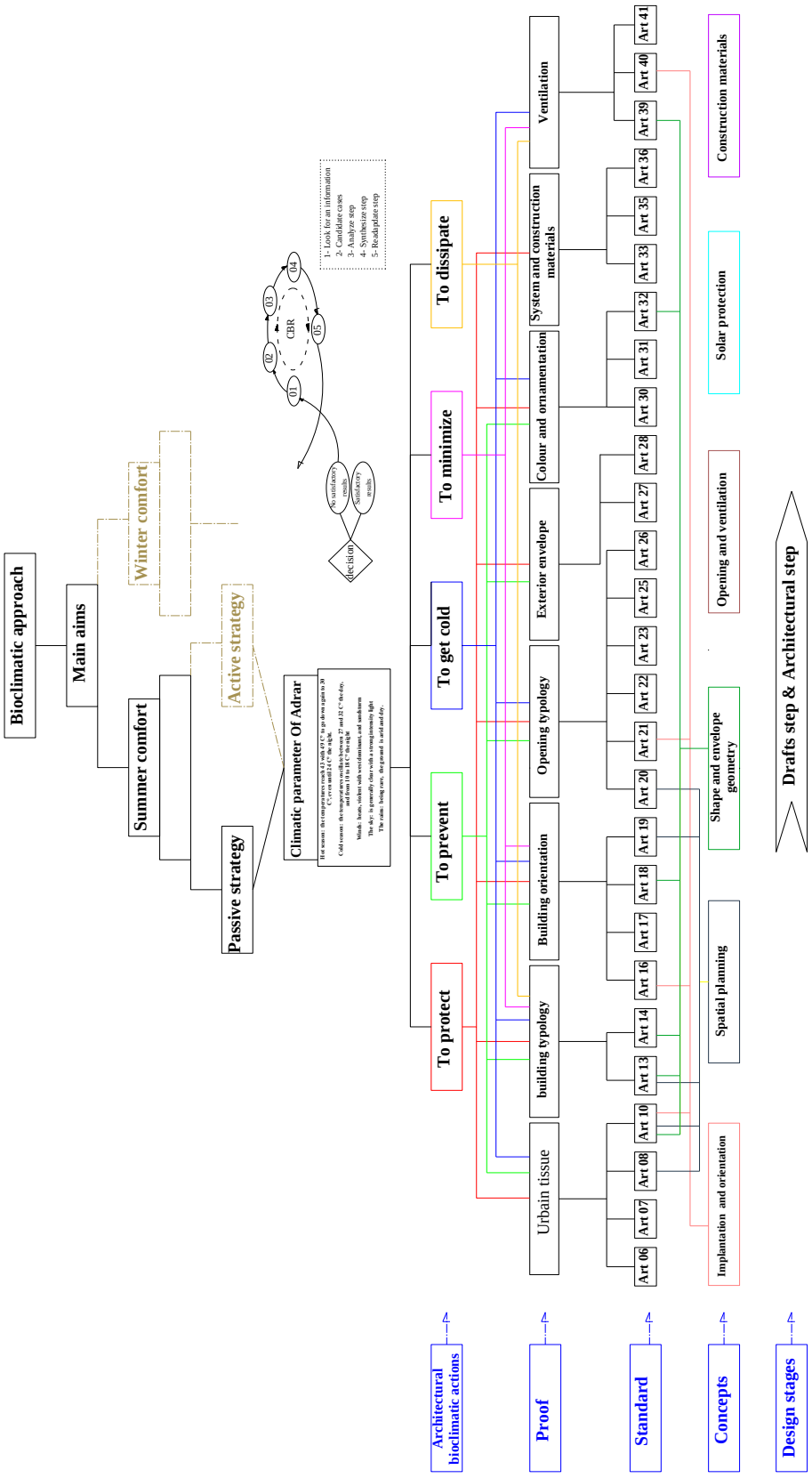

Fig 8: The architecture of the proposed BEPA-based Life Cycle tool

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The diagram shown in figure 8 recapitulates the bioclimatic sketching book. This last is the result of the superposition of the obtained bioclimatic, urban, architectural, and functional indicators. It is also the outcome of analyzing the executive decree n^0 14-27 and the synthesis of bibliographical study which fixes the various actions defining the bioclimatic cold passive strategy. The interface of first window of suggested prototype is given in figure 9.

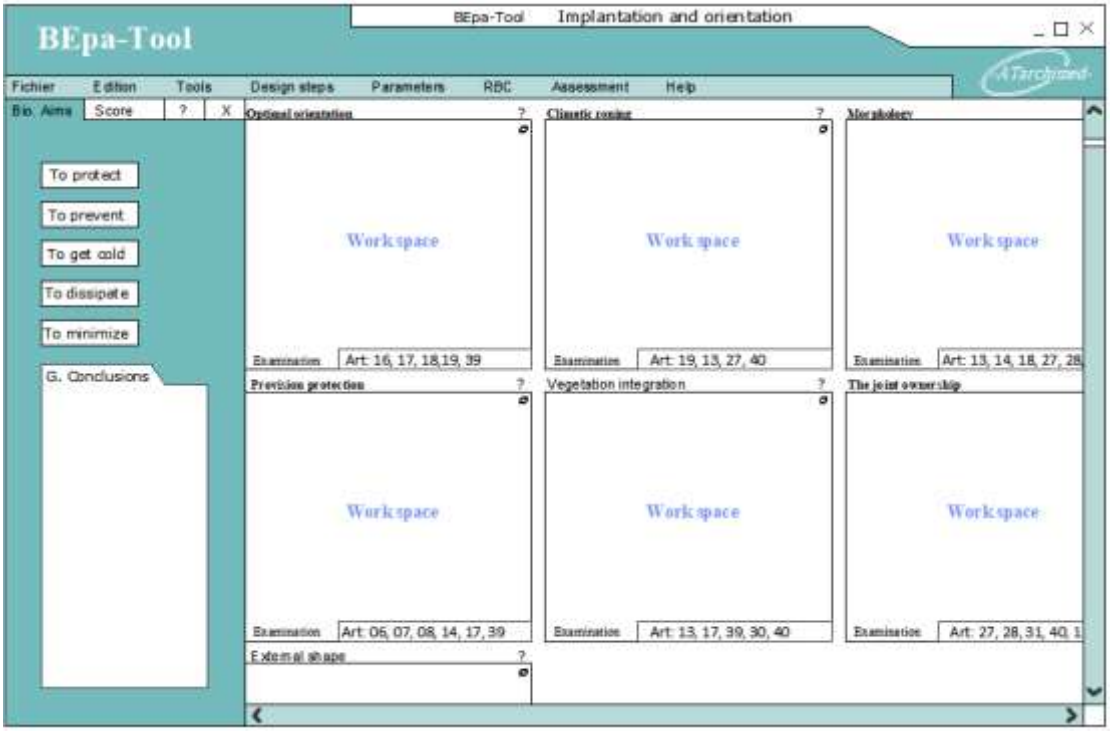

Fig9: The interface of first window of suggested prototype

The present model shows two sorts of information framing the representation and the progress of the architectural project; the first is meant to answer the question: « *what is to be done?* ». The answer could be considered as a source of bioclimatic conceptual ideas. And the second is an aesthetic answer to the question: « *how will it look like?* ». Its role is to seek conceivable solution forms. The tool suggested is conceived to be a tool of assistance for decision-makers during early stages of the design process. Additionally, it can be used as a tool of communication with the common people.

3. THE USABILITY ASSESSMENT OF THE SUGGESTED SOLUTION

To assess the usability of the approach suggested in the frame of a real design project, a prototype of a sketching book that imitates the designed BEPA-Tool was thereafter developed. This testing phase was carried out by asking the professionals involved to actually use the developed prototype to meet the 14-27 energetically performance objectives set for the Algerian Saharan Zero energy project.

The main aim of the experiments is to contribute to the reflection by focusing on two essential points. The first one is to check the association concept-schematization that allows a correct interpretation and performance appropriation of the nearly zero energy concepts. The second one is to validate the practical, economic and creative benefits of a schematized navigation in

standard referential of bioclimatic architecture of the Algerian southern departments. The work proceeds in the form of exercise in three universities: Blida University (module of project), Biskra University (module of RDM), and Adrar University (with some architects from CLOA-Adrar (Local Council of the Architects Order) who have received lessons in academic master at Adrar University in partnership with the University of Sciences and Technologies of Oran.). The assessment was done via design exercises before and after the use of the concepts of the developed prototype. All the drawings and written traces produced during the experimentation phase are also saved.

During the first examination, the Nearly Zero Energy design requirements is seen as an impoverishing constraint. In fact, in the professional context, designers look for any architectural element or shapes of buildings that suit the naturel variables as much as possible. At the aesthetic level, many successful projects prove, however, that a good quality of bioclimatic architecture is possible.

Through this experiment, we succeeded to improve the suggested BEPA-Tool, to determine architects' knowledge needs in terms of energetic performance, and also to define the main features of the context of use. It enabled us to check our assumption concerning:

- The presence of several loops of feedback makes it possible to return back in order to consider the new information generated during the designing process.
- The distinction between the various phases of the design process, especially the beginning and the end with loops between them, implies the existence of objective criteria. This illustrates the fact that the objective and its properties guide the mechanism of assistance to generate bioclimatic forms as from the early phases.
- The reliance on the concept of CBR and graphic demonstrations at each level of the design enables the possibility of expressing the idea of the project that one wants to carry out or communicate.

4. CONCLUSION

The Architectural design is a highly complex activity; it is both technical and emotional action. It requires gathering all the relevant information that seem important to the designer in the development of his/her project. Among these concepts, the architectural form is remarkably the most significant element in the passive strategies of nearly Zero Energy Building. Owing to the iterative aspect of the design process, the need to references supporting these iterations seems to be mandatory. Accordingly, the need for a sketch and / or representation that appear on the various level of the dynamic bifurcation of this couple is inevitable. This last enables the possibility of exchanging the idea of the project that one needs to carry out, and communicate. Therefore, in order to support the decision-making process, the main objective of the method suggested is to generate a system of references to be used as the database of knowledge. To do so, we opt to combine four methods in one single workflow as a Building Energy Performance Assessment tool: Reasoning Based Cases, Life Cycle Assessment Method, Data Visualization and Needs Analysis Method.

The tool suggested is meant to be used as a means of anticipation, description, information and communication between the shareholders. Additionally, it can be considered also as a decision-making aid, control and validation instrument during the development process of the project,

and a means of communication with the common people. Thus, beyond the energetic and thermomechanical behavior of the construction, it can support designers to better integrate the Neutrality Carbone concerns from the outset of the project.

REFERENCES

[1] Benabdelfattah M., Kehila Y., Makhloufi A. (2018) Meeting Paraseismic Knowledge Needs of Algerian Architects. In: Kallel A., Ksibi M., Ben Dhia H., Khélifi N. (eds) Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions. EMCEI 2017. Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development). Springer, Cham.
[2] Benabdelfattah, M. (2019). Développement d'un outil d'aide à la conception parasismique en architecture basée sur la notion de raisonnement à base de cas (RBC), Ph.D, EPAU D'Alger.
[3] Benabdelfattah, M. *et al.* (2018) 'L'intégration du " RBC" a la prise de décision pour assister l'architecture parasismique ; contribution méthodologique', *African Review of Science, Technology and Development*, 3(1), pp. 7–17.
[4] Bendeddouch, A. (1998) *Le processus d'élaboration d'un projet d'architecture*. 1st edn. Montréal, Paris: L'Harmattan.
[5] Berwick, R. (2017) 'ENDS / MEANS SPECIFICATION', in *Univ. of Sussex Library*. Sussex UK: cambridge, pp. 48–62. doi: file:///www.cambridge.org/core/terms.https://doi.org/10.1017/CBO9781139524520.006.
[6] Bret, M. (1988) Image de synthèse : méthodes et algorithmes pour la réalisation d'images numériques. Bo-Pré. Edited by St-Jean/Richelieu. France: Dunod.
[7] Christopher Jones, (1980). Design methods, seeds of human futures, john Wiley and sons, New York.
[8] Claeys, D., (2013). Architecture et complexité: Un modèle systémique du processus de (co)conception quivise l'architecture. Presses universitaires de Louvain.
[9] CNOA, , (2020). Conseil National de l'Ordre des Architectes, " Tableau national des architectes," CNOA., Algiers, Algeria.
[10] Conan, M. (1990) *Concevoir un projet d'architecture*. Paris : France: L'Harmattan.
[11] Djafi, F. (2005) L ' apport du réalisme visuel à la représentation de l ' image de synthèse dans un contexte de conception architecturale assistée par ordinateur (CAAO) Résumé. L'université Laval QUÉBEC : Faculté des études supérieures.
[12] Fadi B., (2009) "*Extraction de connaissances d'adaptation en raisonnement à partir de cas*," Thèse de doctorat : informatique, Ecole doctorale IAEM Lorraine UFR STMIA : Département de formation doctorale en informatique.
[13] Farel, A., (1991). Architecture et complexité. Les éditions de la passion.
[14] Fernandez, P. (1996b) Stratégie d'intégration de la composante énergétique dans la pédagogie du projet d'architecture. L'Ecole des mines.
[15] Halin, G., Chaabouni, S. and Bignon, J. (2007) 'Recherche de références par l'image dédiée à l'assistance à la conception architecturale', in *La conception Architecturale Numérique*. France: SCAN'07, pp. 1–13. Available at: https://hal.archives-ouvertes.fr/hal-00188793/document.
[16] Hubbard, D.W., (2010). How to Measure Anything: Finding the Value of Intangibles in Business, 2 edition. ed. Wiley, Hoboken, N.J.
[17] Hutchinson T. and Waters A., (1987) English for specific purposes, Cambridge University Press.
[18] ISO, (2010). ISO 9241-210:2010 - Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems.
[19] JORADP no 06, Décret exécutif n0 14-27 du 1er Rabie Ethani 1435 correspondant au 1er février 2014 fixant les prescriptions urbanistiques, architecturales et techniques applicables aux constructions dans les wilayas du Sud.

[20] Jusselme Th. B. (2020). Data-driven method for low-carbon building design at early stages, Ph.D, Ecole Polytéchnique fédérale de Lausane.
[21] Kacher, S. (2005) Proposition d'une méthode de référencement d'images pour assister la conception architecturale : Application à la recherche d'ouvrages. L'Institut National Polytechnique de Lorrain.
[22] Khelifi, L. (2006) Contribution méthodologique à la conception bioclimatique en architecture. Développement de modèles génériques. L'école polytechnique d'Architecture et d'Urbanisme EPAU d'Alger: Algérie.
[23] Leplat, J., (2002), De l'étude de cas à l'analyse de l'activité, In :PISTES, perspectives interdisciplinaires sur le travail et la santé, 4(2), DOI : 10.4000/pistes.3658.
[24] MacLeamy, P., (2004). MacLeamy curve. Collaboration, Integrated Information, and the Project Lifecycle in Building Design and Construction and Operation (WP-1202).
[25] Maguire, M.,(2001). Methods to support human-centred design. International Journal of Human-Computer Studies 55, 587–634. https://doi.org/10.1006/ijhc.2001.0503
[26] Prost, R. (1992) Conception architecturale une investigation méthodologique. Paris : France: L'Harmattan.
[27] Riesbeck, C. K. and Schank, R. C. (1989) *Inside Case-Based Reasoning.* New Jersey: Lawrence Erbaum Associates, Inc. : Hillsdale.
[28] S. Hamrani, (2017) " L'insertion passive des bâtiments dans un climat désertique ; État de lieu et recommandations ; Cas de la wilaya d'Adrar – Algérie," M.D. dissertation, University of Sciences and Technologies, USTO, Oran Algeria.
[29] S. Mazouz and M. S. Zeouala, (2001) "The integration of environmental variables in the process of architectural design; the contribution of expert systems," *Elsevier, J. Energy and Buildings,* vol. 33, pp. 699-710.
[30] Sankar, S. and Simon, C. (2004) Foundation of soft case-based-reasoning,vol 2, 150.