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Unite! Poster Competition Review Research on Architectural Energy for Low-Carbon to Sustainable Development



Bin Li, Yuqing Zhang, and Qipeng Mu

Abstract Unite! Poster Competition is a worldwide student competition to review the sparks on architectural energy for low-carbon to sustainable development. First, the competition was launched based on global environmental problems such as climate change and related policy guidance such as a series of guidance from the United Nations. Then, 12 posters from 10 universities worldwide were collected. The authors initially sorted out the related low-carbon strategies, and the related SWOT analysis were also summarized. The third section analyzed the evaluation contents of 15 judges. The jury characteristics, evaluation procedure and related comments are studied. Finally, the research got the ranking list of the posters. The fundamental analysis of the posters by authors compared with the scores and comments from professional judges to verify the rationality of the results. Then, more profound low-carbon revelations are sorted out. In this research, there are also some limitations, such as the wording problem of the "poster" use and overly broad requirements for the call for posters. However, the research is conducive to researching and promoting low-carbon development and also realizes closed-loop research on mitigating background problems.

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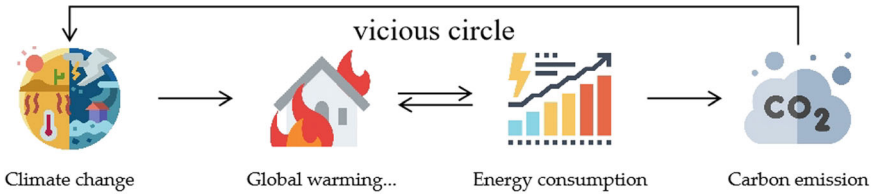


Fig. 1 Vicious circle of environmental problems. (Self-drawn)

Keywords Low-carbon · Sustainable development · Architectural energy · Unite! poster competition

1 Competition Background

1.1 Environmental Problems

Climate change has been a persistent global problem. The impacts of climate change come with increasing environmental problems, such as global warming, air pollution, bushfire and flooding [1]. Correspondingly, more energy consumption, especially for fossil energy use to deal with these problems, has contributed to more carbon emissions and the energy crisis. Therefore, a vicious circle was formed (Fig. 1).

1.2 Policy Guidance

To address these challenges, the United Nations has introduced various policy frameworks to foster sustainable development. The journey began in 1972 with the United Nations Conference on the Human Environment (UNCHE) in Stockholm, the first global gathering to highlight international concerns regarding global warming, air pollution, and so on [2]. In 1987, the World Commission on Environment and Development (WCED), a sub-organization of the United Nations, published "Our Common Future," a seminal work that sought to establish a consensus-based definition of sustainability for global development. The publication emphasized the need to reduce carbon dioxide emissions, a major driver of global warming [3]. In 1992, the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, occurred in Rio de Janeiro. This landmark event led to the adoption of the Rio Declaration on Environment and Development and Agenda 21 and introduced the Framework Convention on Climate Change (UNFCCC). These initiatives were designed to promote sustainable development through specific actions, including efforts to reduce carbon emissions [4]. In 1997, the Kyoto Protocol was adopted at the 3rd United Nations Climate Change Conference. As the first quantified legal

document under the UNFCCC, it aimed to advance global energy conservation and emissions reduction efforts in pursuing sustainable development [5]. In 2002, the World Summit on Sustainable Development was convened in South Africa. This summit sought to build on the momentum generated by the 1972 United Nations Stockholm Conference on the Environment, the 1992 Rio Earth Summit, and the 2000 Millennium Declaration to accelerate the development of sustainability initiatives [6]. In 2009, the 15th United Nations Climate Change Conference was held in Copenhagen, Denmark. The primary objective of this conference was to negotiate a global emissions reduction agreement from 2012 to 2020, following the expiration of the first commitment period under the Kyoto Protocol [7]. In 2015, the United Nations Summit on Sustainable Development was held in New York, where an ambitious new agenda for sustainable development was formally adopted. This agenda, titled "Transforming Our World: The 2030 Agenda for Sustainable Development," includes 17 Sustainable Development Goals (SDGs), such as Goal 7, "Affordable and Clean Energy," and Goal 11, "Sustainable Cities and Communities" [8]. Also, in 2015, the 21st United Nations Climate Change Conference occurred in Paris, France. The negotiations culminated in adopting the Paris Agreement, which has been the guiding framework for climate change mitigation efforts since 2020 [9]. In 2023, the Intergovernmental Panel on Climate Change (IPCC), the United Nations body responsible for assessing climate change science, released the Synthesis Report of the IPCC Sixth Assessment Report (AR6). This report revealed that the global surface temperature had risen by 1.1 °C above the 1850–1900 average during the period from 2011 to 2020. It also unequivocally attributed global warming to human activities [10]. Furthermore, in December 2023, the 28th United Nations Climate Change Conference was held in Dubai, UAE. One of the key objectives of this conference was to conduct the first evaluation of the Paris Agreement [11]. Alarmingly, the world is currently far from achieving its climate goals and is on a trajectory towards a temperature increase of 3 degrees by the end of this century [12]. UN Secretary-General António Guterres has called for a complete phase-out of fossil fuels to limit the temperature rise to 1.5 °C. He emphasized the need for countries to commit to tripling renewable energy capacity, doubling energy efficiency, and ensuring access to clean energy for all by 2030 [13]. These policy directives serve as the foundation for our research on sustainable development (Fig. 2). Clearly, to disrupt the aforementioned vicious cycle, research into low-carbon development is imperative.

1.3 Competition Origin

Therefore, the Unite! Poster Competition focuses on the Architectural Energy for Sustainable Development was launched. After almost half a year application from Unite! Seed Fund, the Poster Competition proposal was finally accepted on June 17, 2024. This project is related to SDGs 7 & 11, which aim to collect advanced ideas from bachelor, master and PhD students to contribute to sustainable development for architectural energy, especially in low-carbon fields. These practical and advanced

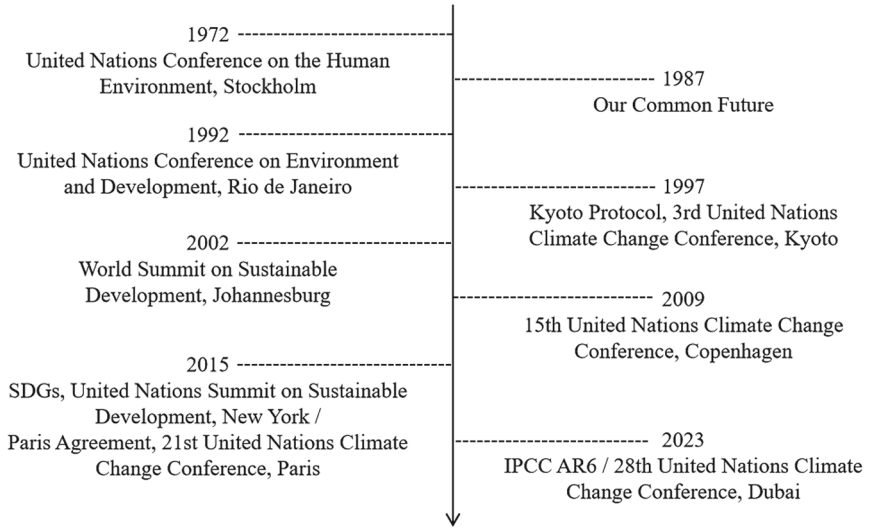


Fig. 2 UN policy guidance. (Self-drawn)

ideas will promote academic research and practical application, letting more people know that for a sustainable future. The competition principle is not to compete but to achieve an open, inclusive, and free exchange of cutting-edge knowledge under the same goals (SDGs), to deeply integrate our views on how building energy can achieve sustainable development in different ways. The main topics include architectural design with energy focus, green buildings and health, low-carbon demonstration projects, sustainable building design, advanced methods for architectural energy, but not limited to these [14]. The winning posters will be awarded with one 1st, three 2nd and five 3rd Prizes chosen by the jury members, plus a Special Prize selected by the public via an online voting poll. The award-winning posters will be part of the first Unite! online exhibit. Moreover, the poster must be anonymous and shown in a vertical one-page A1 (841 mm × 594 mm) size JPG, no less than 300dpi, no more than 50 Mb (CMYK Mode), and no layout requirements. The language used should be English.

2 Posters Analysis

2.1 Collected Posters

After one month of collecting, 12 qualified works have been received from 18 students in 10 universities worldwide. These posters are listed in Fig. 3, which clearly shows two styles. In one style, the content is compact and contains a large amount

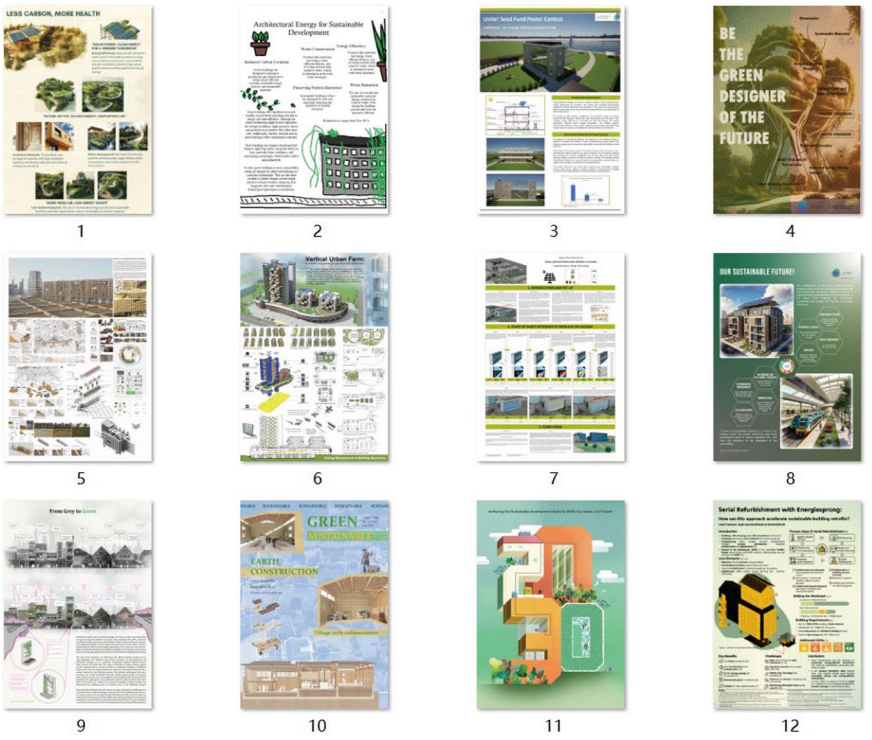


Fig. 3 Collected posters. (Self-drawn)

of information, while the others are indeed full of design sense to reflect poster connotation.

2.2 Low-Carbon Strategies

From these posters, the main low-carbon strategies have been sorted out in Table 1. Whether for content-intensive posters or posters that lean towards design styles, low-carbon design strategies that respond to the theme are reflected from different points of view. All low-carbon design strategies can be summarized as 1. solar panel application, 2. natural ventilation system, 3. ecological material use, 4. high insulation installation, 5. rainwater use, 6. grey water system, 7. energy-efficient system, 8. waste reduction, 9. air–water heat pump, 10. bamboo/wood structure, 11. triple-glazed window, 12. energy storage system, 13. smart grid, 14. AI adjustment, 15. heat recovery ventilation, 16. smart energy management, 17. modular construction, 18. greenery, 19. inter-modal transport. It can be seen that there are at least 19 low-carbon strategies related to architecture, even transportation, management, and so

on. These low-carbon strategies are helpful to the public to retrofit their buildings in the future or use some of the strategies immediately indoors, such as greenery, grey water usage, and so on. From the architecture discipline, these low-carbon strategies for sustainable development can be divided into passive design, active design, and renewable production in three main ways [15]. Passive design aims to reduce the building energy demand from the source, active design aims to save energy use with high energy efficiency during the building operation phase, and renewable production aims to produce green energy to cover the inevitable building energy use and even produce more for other use.

Table 1 Unite! Poster competition low-carbon strategies. (Self-drawn)

Number	Theme	Low-carbon strategies
1	No theme with AI generation	Solar panels on green roof, natural ventilation system, ecological materials with high insulation, rainwater harvesting system, grey water usage, use of renewable energy sources
2	No theme	Energy-efficient system, renewable energy sources, sustainable material, water conservation system, recycling system of water, waste reduction
3	Passive lakehouse	Photovoltaic system, air–water heat pump, cellulose fiber insulation, airtightness, renewable energy use, wood frame construction, foam glass gravel insulated floor, triple-glazed window, energy storage system
4	No theme with AI generation	Sustainable materials, natural light, natural ventilation, renewable energy, smart grid, AI technologies, advanced energy storage system, heat recovery ventilation
5	Johannesburg gold mining repair	Arundo donax material used for building panels and generating green energy, bamboo plywood, bamboo wooden poles, solar panels, recycled shed tiles
6	Vertical urban farm	Smart energy management, water recycling system, modular construction, roof water use, vertical planting
7	Shape-optimized photovoltaic modules on facades	Thin-film photovoltaic system, building integrated photovoltaics (BIPV)
8	Sustainable building with transportation	Rainwater system, renewable production, low impact storage, local utilization of waste/recovery, greenery, inter-modal transport
9	From grey to green	Water cycle regulation, biodiversity, ground-bound green facade, wall-bound green facade
10	No theme	Local materials
11	2030	Not applicable
12	Refurbishment with energiesprong	Prefabrication, digitalization (BIM), PV system on roof, basement insulation

2.3 SWOT Analysis

Based on these low-carbon strategies, SWOT analysis is used primarily for applying for that. For the Strengths, some posters focus on the specific issue, even only for the research of facade shapes for PV installation, such as poster 7. However, this poster wonderfully demonstrates the depth of research for one aspect of the competition topics. Some posters focus on multiple points simultaneously, which is more systematic. This provides people with an in-depth or comprehensive understanding of how to apply strategies for different situations. Regarding weaknesses, few posters present in-depth insights into specific issues or engage in extensive systematic summaries. There are also some cons in terms of aesthetic design for posters. This will give people a bad impression and even affect their understanding or use of relevant strategies. The opportunities show that only 19 low-carbon strategies are found. However, there should be more useful low-carbon strategies for future development. The threats show that if everyone uses the same low-carbon strategies, such as for building retrofit. All the buildings may look the same. This may destroy the diversity of the living environment. More comments can be seen from judges.

3 Evaluation Analysis

3.1 Jury Characteristics

For this competition, 11 professional judges in the architecture discipline and 4 professional judges in the energy discipline are invited from 11 universities worldwide. Their research focuses on architectural energy, especially for low-carbon strategies. Even though this competition started in Europe, 4 Chinese professors were invited to join as judges to enhance the internationalization of this competition (Fig. 4). This may lead to attracting 4 Chinese students who submitted their posters in a one-month short-term submission period out of 18 submitters to some extent.

Moreover, an online voting award from the global public gathered more than 2000 voters from October 22 to November 1, 2024. The voting website is https://take.supersurvey.com/poll5306566xB8744F5a-160.

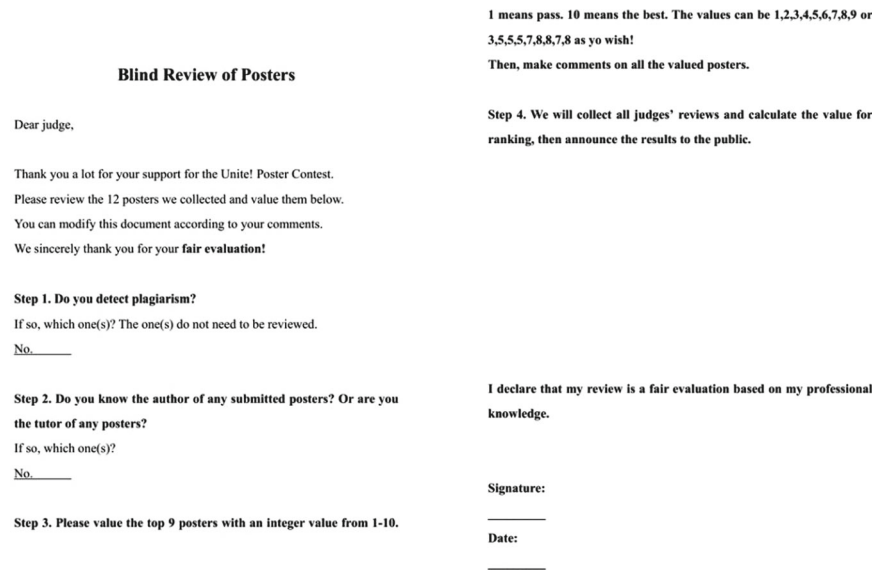
3.2 Evaluation Procedure

For jury review, the evaluation procedure included four steps, as shown in Fig. 5. To ensure a fair evaluation of this competition, all the judges were required to detect plagiarism on all the posters as the first step. In fact, the organizers detected ahead when receiving that in case of any academic misconduct. More importantly, all



Fig. 4 Judges by country. (Self-drawn)

contributors are responsible for ensuring that their works are original and not plagiarized [16]. The second step is to indicate the relationships between judges and posters in advance to avoid any unfair evaluation. In this competition, one professional judge encouraged his students to submit four posters. They are numbers 3, 7, 9 and 12. However, the data shows that even if all the scores of this judge are removed, the final results are the same, proving the fairness and rationality of his professional scoring. Step 3 is to indicate that the judges only need to score the best 9 posters because this competition only has 9 jury rating awards. Scoring all of them may lead to the same rating results, affecting the setting of the awards. Moreover, referring to similar competitions, if a large number of works are collected, it is hard to score all of them. However, some judges neglected this notice and scored all the posters. After the unified requests, the judges scored again only for the best 9 posters. However, some judges gave more than three posters a score of 0, which means that in their professional opinion, some works had no chance of winning the award. This does not affect the fairness and rationality of the results. As for the specific scores from each judge, no one valued the poster with 1, 2, 3, 4, 5, 6, 7, 8, 9. This ensures consistency of results to a certain extent. For step 4, all judge were informed that their decisions would be announced to the public. It is intended to suggest and remind that professionalism should be exercised fairly and impartially. Overall, all the steps aimed to obtain a fair and credible result on the sustainable development of building energy, especially for the low-carbon aspect.



Blind Review of Posters

Dear judge,

Thank you a lot for your support for the Unite! Poster Contest.
Please review the 12 posters we collected and value them below.
You can modify this document according to your comments.
We sincerely thank you for your **fair evaluation!**

Step 1. Do you detect plagiarism?
If so, which one(s)? The one(s) do not need to be reviewed.
No._____

Step 2. Do you know the author of any submitted posters? Or are you the tutor of any posters?
If so, which one(s)?
No._____

Step 3. Please value the top 9 posters with an integer value from 1-10.
1 means pass. 10 means the best. The values can be 1,2,3,4,5,6,7,8,9 or 3,5,5,5,7,8,8,7,8 as yo wish!
Then, make comments on all the valued posters.

Step 4. We will collect all judges' reviews and calculate the value for ranking, then announce the results to the public.

I declare that my review is a fair evaluation based on my professional knowledge.

Signature:
_____
Date:
_____

Fig. 5 Evaluation procedure. (Self-drawn)

3.3 Evaluation Comments

After more than a month of jury evaluation, the blind review scores from the judges were received (Fig. 6). It can be seen that almost all the scores are significant differences on the same poster. Each poster has a minimum score of 0. At the same time, there is at least one maximum value of no less than 7 points. On the one hand, this is due to the judges' different backgrounds and scoring thresholds. On the other hand, the two styles of the submitted posters analyzed in 2.1 also led to different scores among the judges. Most judges made text comments on posters to explain how they evaluated them. Such as for reviewers 1 & 4, they gave posters 5, 6, 7 lower scores. The main comment is that there are too many graphics, which makes it too hard to read. This can be seen as a perspective-oriented poster design evaluation. For most other posters, the research content on low-carbon sustainable design mainly affected the evaluation results. Although the evaluation results also showed two tendencies, they also reflected the inclusiveness of the call for posters and the comprehensiveness of the evaluation.

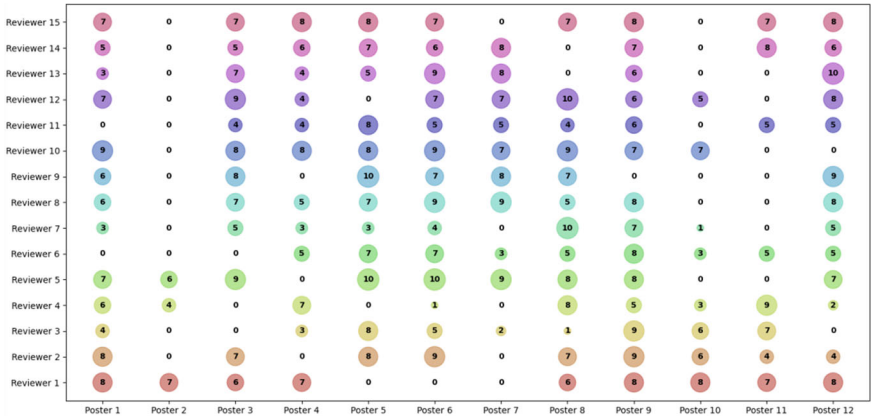


Fig. 6 Jury scores (Generated by Python 3.11). (Self-drawn)

4 Research Results

4.1 Ranking List

Finally, the ranking list by jury was calculated with each poster's average score after subtracting one highest and lowest scores separately from the total score (Fig. 7). To verify the accuracy of the results, the average of the total scores of each work was also used in the ranking calculation. The ranking results shown by the two calculation methods are the same, even though the average scores are different. At the same time, for judge 12 mentioned above, who encouraged his students to submit four posters, removed all the ratings of this judge and then calculated the average score, the ranking result is consistent with the above two results. This proves the rationality and effectiveness of the judge rating to some extent. Therefore, poster 9 got the first prize, posters 6, 5, and 8 got the second prize, and posters 12, 3, 1, 7, and 4 got the third prize.

For the public vote, voting closed at 23:59 on October 31, 2024. Finally, poster 8 won the Special Prize selected by the public (Fig. 8). It votes accounted for 30% of the total, while poster 7 was very close to first place with 29%.

4.2 Comparison Between Sects. 2 and 3

Based on the ranking list by jury, the analysis of the second and third sections can be compared and analyzed to reveal the rationality of the result. Poster 9, which got the first prize, shows the harmony between the aesthetics of poster design and the in-depth research questions. It balanced the two styles of posters and got the favor of

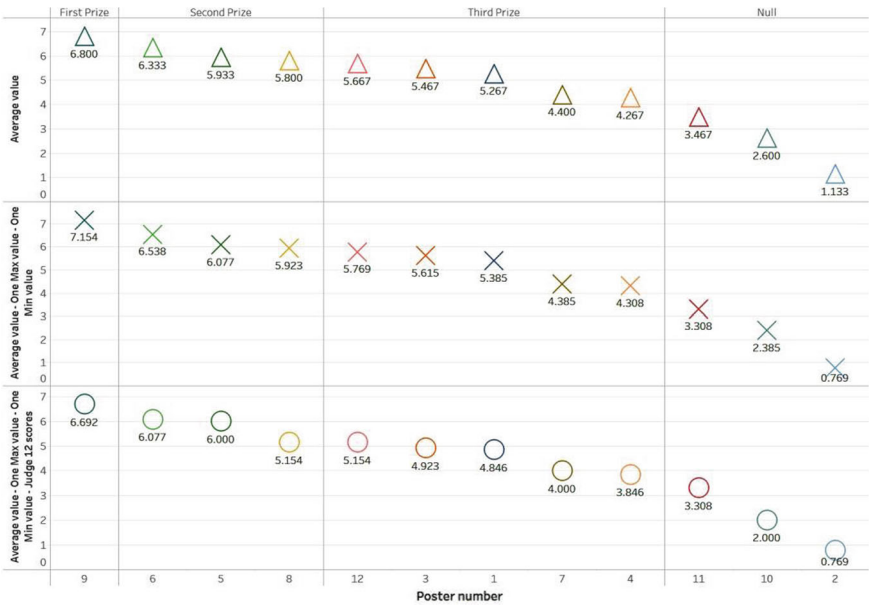


Fig. 7 Ranking list (Generated by Tableau Public 2022.4). (Self-drawn)

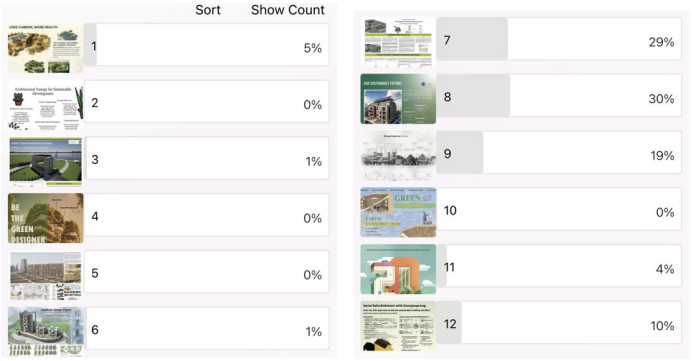


Fig. 8 Online voting results. (Self-drawn)

most two fields of judges. Judges 1, 2, 3, 6, and 15, one-third of reviewers gave poster 9 the highest score. They made comments showing: The contrast between gray and green colors highlights sustainable design's advantages in energy conservation and pollution reduction, offering depth and creativity; One of the best posters presented, with a clear message style and idea attractive; The conception is quite interesting; A good balance; and so on. Poster 8 seems to use a similar way to present the work. This may be one of the reasons why it won the first prize in the online voting. However, half of the panel focuses on green transportation, which weakens the response to

the theme. The other second prize, posters 6 & 5, are all compact research-oriented posters. For the third prize posters, posters 12, 3, and 7 are also research-oriented. Posters 1 & 4 are more perspective-oriented with AI generation. From the comparative analysis of Sects. 2 and 3, the ranking results reflect to a certain extent that the winning works are well-deserved.

4.3 Low-Carbon Revelations

Through a series of research and analysis of the Unite! Poster Competition, the low-carbon revelations can be sorted out. First, renewable energy production is essential nowadays for low-carbon development. It is the green energy that opens the source for building energy use. Second, green measures, including greening and natural material use, are also vital for low-carbon development. Vertical planting helps improve the building's performance over the seasons. Using green materials for building structures or enclosure materials can effectively achieve carbon sequestration. Third, the energy management system in buildings is also useful. It generally combines with AI technologies to achieve real-time energy regulation and improve building energy efficiency. More low-carbon strategies can be found in Table 1. In short, these revelations correspond to the three main aspects of renewable production, passive and active design. But it is difficult to determine which technology is better. There is no good or bad technology, only reasonable use [8].

5 Discussion

So far, the review research of Unite! Poster Competition on architectural energy for low-carbon to sustainable development is almost done. However, there exist some limitations. First, the wording used in the poster may not be quite appropriate. The word "poster" gives people the illusion of preconceived results, which leads some judges and students to focus on pure layout design from an aesthetic perspective. Although aesthetic literacy may be more important and harder, it weakens the focus of this research on low-carbon development. This problem will be solved in the future with more accurate language use. Second, the requirements of the call for posters were too broad, leading to receiving too many different content posters, including case studies, system summaries, and graphic designs. This brought challenges to the evaluation for judges. Correspondingly, it affected the priority judgment of this research on low-carbon design strategies. These limitations will be avoided in future competition with clearer competition targets, goals, principles, and more. The next competition will collect more low-carbon strategies, expand the number of submissions, and further improve the quality of selected works to promote the sustainable development of the competition effectively. The improvement of applying low-carbon strategies should be shown in the works, especially from practical engineering. Therefore, the

next competition may mainly call for practical engineering applications to show the improvement of low-carbon strategies to some extent. The designers' capacity should be considered compared to the first competition; only the better ones should be considered for awarding, attempting to further achieve sustainable development on the existing foundation.

6 Conclusions

Based on the background analysis of environmental problems and policy guidance, this research reviewed the Unite! Poster Competition as a case study introduced the competition framework. 12 collected posters worldwide are used to sort out the low-carbon strategies. The related SWOT of these posters are analyzed. Meanwhile, the jury evaluation on these posters is also analyzed based on the jury characteristics, evaluation procedure, and related comments in three aspects. Then, the ranking results are obtained according to the jury's scores. The basic posters analyzed in Sect. 2 were compared with the evaluation from judges in Sect. 3 to verify the reasonableness of ranking results. Moreover, the low-carbon revelations based on these valuable results are sorted out. Finally, this research came to conclusions after the necessary discussion. The research process is shown in Fig. 9. The conclusions are:

1. Based on the Unite! Poster Competition operation, 12 posters from 10 universities worldwide were collected. These posters demonstrate different low-carbon development thinking and current major low-carbon strategies.
2. At least 19 low-carbon development strategies have been summarized from these 12 posters.
3. The first-prize poster, poster 9, achieved a balance between low-carbon technologies and poster aesthetic design. The low-carbon technologies mainly include greening on buildings, which is also reflected in the second prize, poster 6, as the main low-carbon strategy.
4. For low-carbon development in architectural energy fields, passive, active design and renewable production are the three main ways to achieve that. Passive design focuses on the building itself, reducing energy consumption through

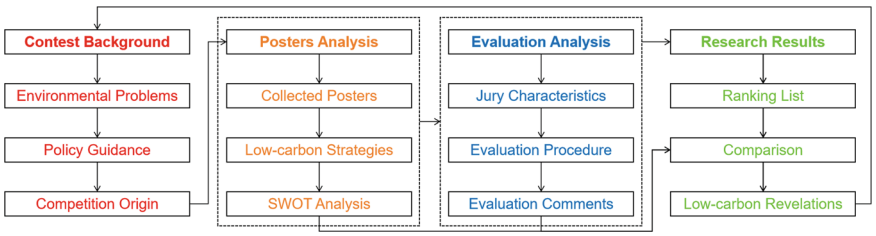


Fig. 9 Research process. (Self-drawn)

greening, recyclable materials, high-performance construction, etc. The active design combines AI management, efficient equipment, etc., to achieve energy conservation. Renewable production opens the source to generate green energy through solar panels and so on to achieve green energy use.

5. Tools are neither good nor bad, only for fair use. There are 19 low-carbon strategies in these posters. However, it is difficult to determine which strategy is more important than others. In particular, sustainable development in buildings needs to be adapted to local conditions and time. Appropriate use of the above strategies is encouraged.
6. After systematic research, based on the Unite! Poster Competition, this study achieved a closed-loop research from background problems to low-carbon development, aiming to contribute to sustainable development, especially in the architectural energy aspect.

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Declaration of Competing Interest The authors have declared no conflict of interest.

Data Availability The organizers have the right to exercise the right of multi-terminal information network dissemination of the entries, especially for academic research purposes only, not for commercial use, according to https://www.unite-university.eu/unitenews/draw-your-vision-of-our-sustainable-future. The scores data collected from 15 judges were only used for anonymous analysis.

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