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Dominant Designs for Wings of Airborne Wind Energy Systems

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Abstract: This paper focuses on the design of the wings used in airborne wind energy systems. At the moment, two different designs are being developed: soft wings and rigid wings. This paper aimed to establish which of the two alternative design choices has the highest chance of dominance and which factors affect that. We treated this problem as a battle for a dominant design, of which the outcome can be explained by factors for technology dominance. The objective was to find weights for the factors for technology dominance for this specific case. This was accomplished by applying the best worst method (BWM). The results are based on literature research and interviews with experts from different backgrounds. It was found that the factors of technological superiority, learning orientation and flexibility are the most important for this case. In addition, it appeared that both designs still have a chance to win the battle.

Keywords: standards battles; dominant design; best worst method; BWM; airborne wind energy systems; AWE

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1. Introduction

This paper is about high-altitude airborne wind energy systems. Since higher altitudes are characterized by increased wind speeds, this opens up the potential to harvest more energy [1]. At the beginning of the 20th century, German engineer Aloys van Gries filed patents for the use of kites to use wind turbines at high altitudes. Around the 1970s, Hermann Oberth acted upon this idea as an alternative to fossil fuels and nuclear power when there was an energy crisis [2]. It took another 20 to 25 years for airborne wind energy systems (AWES) to acquire real interest because of growing awareness of global warming.

Airborne wind energy systems operate at much higher altitudes than conventional wind turbines; therefore, they are designed in a completely different way. In order to harvest the potential energy from high-altitude winds, one needs to make use of aerodynamic or aerostatic lift devices that can collect this. Currently, two configurations are under development; (1) "Fly-Gen systems", which consist of a group of tethered rotorcrafts that generate the electricity in the sky, which is then transferred through electric cables to a ground station, and (2) "Ground-Gen systems" whereby kites, gliders or wings generate power in the sky and the conversion to electricity takes place on the ground [3]. As is shown in [4], no clear "dominant design" has appeared yet for these two different generator configurations in airborne wind energy systems, and both have an equal chance of success at future market dominance.

This paper targets on Ground-Gen systems and focuses on another aspect of these systems, namely the type of wings that these systems use. Currently, two configurations are under development; (1) "Soft wings", which are flexible kites, and (2) "Rigid wings", which are hard structures that have many similarities with airplanes or drones [3].

Regarding the type of wings, currently, no dominant design has appeared yet. This can be treated as a typical example of a battle for a dominant design. Scientists studying the strategic management of technological innovation have described various factors that can explain and even predict the outcome of such a battle [5,6]. Apart from technological characteristics, they point, for example, to factors pertaining to specific company strategies (e.g., the timing of entry [7] and penetration pricing [8]) and the role of other stakeholders (such as a regulator that can enforce a design on the market [9]).

The aim of this paper was to apply these factors to this battle in order to gain insight into the relevance and importance of the factors for this particular innovation. Thus, an answer would be given to the research question: "According to experts, which factors affect the chances that a dominant design will be established for the design of the wings for airborne wind energy systems?". A proven research design was used for this endeavor where the weights of factors for technology dominance were determined by applying the "best worst method" [4,10]. Technology dominance is defined as the outcome of a complex process by which several competing alternatives and versions are de-selected until a preferred technological hierarchy becomes evident [6]. The best worst method allows for identifying important factors at the current moment within the development of the technology for the battle of a dominant design. By pairwise comparing decision criteria, it identifies the weights of a finite set that is desired in this situation.

The literature has shown that in many examples of battles for dominant designs, the outcome is not purely a matter of technological superiority or a better price/performance ratio but can, in fact, be explained by using factors for technology dominance [11–13]. This study contributes to that research by providing additional support by studying the specific case of wings for airborne wind energy systems. Practical contributions include recommendations concerning which design configuration has the highest chance of achieving dominance and which are the determinants that affect that.

The paper starts by providing an overview of the two design configurations of the aircraft used for airborne wind energy systems and then describes the paper's theoretical background and methodology in detail. Subsequently, the results are presented, analyzed and discussed in light of the extant literature. The paper concludes with a more thorough discussion of contributions, limitations and suggestions for future research.

2. Airborne Wind Energy (AWE) Wing Types

First, we described the two wing types in airborne wind energy systems based on their technological characteristics. Table 1 provides an overview of the two technologies.

Table 1. Current characteristics of soft-wing and rigid-wing airborne wind energy systems with ground-generator [[14], anonymous, personal communication, 7 October 2021].

Properties	Soft Wing	Rigid Wing
Knowledge	Mainly new	From conventional airplane research
Rated power	60–200 kW	0.5–150 kW
Wing Span	12.5–22 m	2.6–14 m
Wing surface-area	90–180 m^2	0.6–12 m^2
Operating altitude	70–400 m	10–500 m

It can be seen that the rated power of airborne wind energy systems with soft wings is higher than the maximum rated power of airborne wind energy systems with rigid wings. The wing span of soft wings for most designs is larger than the wing span of rigid wings, as is the wing surface area. The operating altitude of rigid wings beats the operating altitude of soft wings on both ends. Sections 2.1 and 2.2 explain the differences in more detail.

2.1. Soft Wing Types

A soft wing is a wing type that is flexible and soft. Most of these models are kites, and they can have various forms. Currently, the most common types are Leading Edge Inflatable (LEI) kites and Foil kites. LEI kites that are mainly used in AWEs are Supported Leading Edge kites (SLE) and C-kites. SLEs gain support from at least one bridle close to its central part on the leading edge. In order to increase aerodynamic efficiency, the traction force is used to flatten the wing in the central region [3]. C-kites are directly attached to the extreme lateral points of the kite edges by four main bridles.

Foil kites are inspired by parafoils which are double-layer kites made of canopy cells. The cells are inflated during the flight, which gives the kite stiffness. Foil kites have better aerodynamic efficiency than LEI kites and can be one order of magnitude bigger in size. The bridles can be grouped in a control pod or directly to the ground.

One of the main problems of soft wings is the durability of the kites. The lifetime of most kites is around several hundred hours, and performance is compromised relatively soon [anonymous, personal communication, 4 October 2021].

2.2. Rigid Wing Types

A rigid wing is a wing type that maintains the wing's shape with the airframe structure. Their construction is solid, resulting in a wing surface that remains roughly fixed the entire flight. One of the factors determining the difference between a flexible wing and a rigid wing is the fact that rigid wings need aerodynamic systems to control the wings. These are, for example, spoilers, tip rubbers, or elevons [15].

Rigid wings are based on traditional airplane design knowledge. Planes with rigid wings can drive ground generators, but the planes can also be implemented with generators on board [16]. They also offer higher aerodynamic efficiency than soft wings and can therefore deliver more power. In addition, rigid wings are the sturdier of the two types [3]. Moreover, the aircrafts offer a shorter reel-in phase, and handling characteristics are different [17]. However, as the mass of rigid-wing airplanes is higher, they are likely to have a higher capex, and most of the landing and launching is challenging [17].

Through the years, both wing types have been in development simultaneously, and the AWE community has viewed both types differently. Early on, rigid wings were mentioned as "the most promising concept to extract AWE" [18]. Around the year 2015, an increasing amount of companies were switching from soft wing development to rigid wings [3]. However, in the last few years, soft wings have gained ground again [anonymous, personal communication, 4 October 2021].

3. Theoretical Background

A range of scholars studied how technologies achieve a dominant market position [5,6,12,19–22]. Scholars that study dominant designs from an evolutionary perspective argue that every industry may experience a technological shock once in a while that could change that industry [23]. At one point, a dominant design may emerge, but the characteristics of that design are not known beforehand [24]. The dominant design is innovated upon to improve its efficiency, and at a later point in time, another technology discontinuity may emerge in the industry, which starts over the process again. This characterizes the evolutionary character of technological change that these scholars stress.

Before the dominant design is established, multiple technological options may battle for market dominance. Technology management scholars argue that the outcome of such a battle may be explained by way of a list of relevant factors [22]. Van de Kaa et al. [25,26] pose that these factors can be categorized into five groups. The first group contains factors that pertain to the characteristics of the organization that attempts to establish dominance with the technological option. These include, amongst other things, financial resources and reputation. The second group consists of the strategies that can be applied by utilizing these resources, such as the timing of market entry and marketing strategies. The third group contains characteristics pertaining to the technological option itself that may affect the chances that it will achieve dominance. An example is technological superiority, which can be defined as a design with features that allow this design to outperform other designs. The fourth group contains all stakeholders that may affect the chances that a dominant design is reached. For example, a regulator may enforce a certain technological option. Finally, there are other factors that affect the speed and likelihood of design dominance, such as network externalities [27,28].

In 2004, Suarez [6] developed a 5-stage model of technology dominance that assigns these and other factors for design dominance to stages through which a technology travels during its path to maturity. The first stage of the model is from the first time that an actor is doing applied research to the moment that a first prototype is developed, whereas the second stage lasts from the first prototype until the first commercial product is available. As the first commercial wings are expected to be for sale soon [29], the case that is studied in this paper can thus be located in the second stage.

4. Methodology

In order to establish the importance of factors for technology dominance for this specific case, we followed a proven two-step research design. Step 1 consisted of determining the relevant factors for technology dominance out of a list of factors for technology dominance as described in Section 3 of this paper. Step 2 consisted of determining the relative importance of these factors by using the best worst method.

4.1. Step 1: Determining the Relevant Factors

Step 1, determining the relevant factors, was performed by interviewing two experts and evaluating the literature that has reported on this case, namely [3,30–32]. A factor was considered relevant when it was implicitly or explicitly mentioned by at least one of the interviewees and/or in at least one of the literature sources. Where necessary, the factors were translated to the case studied, potentially leading to, e.g., a broadening or specification of the factor. Moreover, new factors not mentioned in [26] were added to the list of relevant factors.

Interviewees and their characteristics are included in Table 2. Interviewees 1 and 2 participated in interview round 1 in Step 1 of the study, while interviewees 2–7 participated in interview round 2 in Step 2 of the study.

Table 2. List of respondent details.

Background	Position	Expertise and Years of Experience
Industry/Academia	Co-founder Airborne Wind Energy start-up and Associate Professor	Airborne wind energy, soft-wing systems. Over 30 years of experience.
Industry	Consultant	Policy and regulation expert on airborne wind energy. Over 20 years of experience.
Academia	Researcher	TU Delft AWE researcher. Three years of experience.
Academia	Researcher	TU Delft AWE researcher. Five years of experience.
Academia	Full Professor	Diffusion and adoption of innovations, among others airborne wind energy systems. Over 30 years of experience.
Industry/Academia	Head of Technology of airborne wind energy company	Airborne wind energy, rigid wing. Over 25 years of experience.
Industry/Academia	CTO of airborne wind energy company	Airborne wind energy, rigid wing. Over 15 years of experience.

4.2. Step 2: Determining the Relative Importance of the Factors

Step 2 was performed by six interviews in order to determine the relative importance of all the factors. The method used for the analysis of the interview results was the best worst method. BWM is a multi-criteria decision-making method using two pairwise comparison vectors (best-to-others and others-to-worst) as input for an optimization model to obtain the optimal weights of the criteria [33].

The BWM consists of five steps:

Step 1: Defining a list of criteria $\{c_1, c_2, \ldots, c_n\}$.

These criteria are relevant factors for design dominance that came out of step 1 of the analysis;

Step 2: Determining the best and worst criterion.

The interviewed experts determined the most and least important factors for design dominance for this case;

Step 3: Comparing the best criterion over other criteria.

The interviewed experts assigned a number between 1 and 9 (1 shows that the best criterion is equally important to the other criterion, and 9 means that the best criterion is absolutely more important than the other criterion), resulting in the best-to-others vector $(B - O)$:

$$B - O = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \quad (1)$$

Step 4: Comparing the preference for the other criteria to the worst criterion.

The interviewed experts assigned a number lying between 1 and 9 (1 shows that the other criterion is equally important to the worst, and 9 means that the other criterion is absolutely more important than the worst criterion), resulting in the others-to-worst vector $(O - W)$:

$$O - W = (a_{1W}, a_{2W}, \ldots, a_{nW})^T \quad (2)$$

Step 5: Optimal weights calculation.

The two sets of pairwise comparison rankings of Steps 3 and 4 were used as input for determining the optimal weights of the criteria. This is accomplished by solving the following problem:

$$\min \xi \quad (3)$$

s.t.

$$\mid w_B - a_{Bj} W_j \mid \leq \xi, \text{ for all } j \quad (4)$$

$$\mid w_j - a_{jw} W_w \mid \leq \xi, \text{ for all } j \quad (5)$$

$$\sum W_j = 1 \quad (6)$$

$$W_j \geq 0, \text{ for all } j \quad (7)$$

The solution to this problem results in a set of optimal weights $(w_1^*, w_2^*, \ldots, w_n^*)$ and a consistency ratio ξ^*.

5. Results

5.1. Step 1: The Relevant Factors

In Step 1 of the study, eighteen relevant factors were found based on the literature review and interview round 1, and these factors were subdivided into four categories. Table 3 provides a description of how each relevant category and factor is interpreted in light of the case under investigation. Most factors but one (social acceptance) were also mentioned in Van de Kaa et al. [26].

5.2. Step 2: The Relative Importance of the Factors

In this section, the results of the BWM analysis are presented. As can be seen from Table 4, the consistency ratio of each expert's answers is close to zero, which indicates that the consistency that was provided by the experts was high. Table 5 shows the relative importance (weights) of the relevant factors that were found by applying the BWM to the interviews with the experts. Local weights are the average of the weights given to the categories and factors, while global weights are obtained after multiplying category weights with the factor weights.

Table 3. Relevant factors (partly adapted from [26]).

Category/Factor		Explanation
Characteristic of the Format Supporter		**Resources of the Company that Develops the Technology**
1	Financial strength	All the financial resources that are needed to develop the technology. Sources include governmental funding, crowdfunding, capital funding, or the company's own capital. These financial resources can be utilized to apply various technology strategies.
2	Operational supremacy	Aspects related to the composition of the company that makes it outperform other companies. This also includes aspects related to the supply chain, company structure and operations.
3	Learning orientation	The capability of the company to learn from mistakes, the available knowledge and the firm's absorptive capacity.
Characteristics of the Format		**The Technological Characteristics of the Technology**
4	Technological superiority	The performance of the technology in terms of energy production, efficiency and durability.
5	Compatibility	The extent to which various systems can work together. Systems include, e.g., the launching and landing platform, the generator and other existing materials and components.
6	Flexibility	The extent to which small improvements are easy to apply in the technology. This also refers to scalability and modularity (the ease of replacing parts).
Format Support Strategy		**Strategies That the Company Uses to Promote the Technology**
7	Pricing strategy	Actions that are taken to establish a price for the technology. This relates to, on the one hand, how expensive the technology will be once it has entered the market and, on the other hand, how expensive the power that is generated per kWh will be.
8	Appropriability strategy	The actions that can be taken to open up technology so that it can be easier to imitate (this may increase the installed base). Activities include not filing IP (intellectual property) and opening up certain patents.
9	Timing of entry	The point at which the technology enters the market.
10	Marketing communications	Actions taken to promote the technology through marketing may, e.g., increase the reputation of the firm.
11	Pre-emption of scarce assets	Firms can pre-empt the market by obtaining limited resources such as knowledgeable people to develop the technology, money and materials.
12	Distribution strategy	How easily and efficiently can the technology be delivered to the customer once, e.g., demand becomes large.
13	Commitment	Commitment of the promotor of the technology can increase the chances that the technology will achieve dominance.
Other Stakeholders		**Parties outside the Developing Company That Also Have an Influence on the Development of the Technology**
14	Big Fish	A big fish is a big player that can exercise a lot of influence by financially supporting the design.
15	Regulator	A regulator can push the outcome in a certain direction by way of policy support instead of letting the outcome depend on the market.

Table 3. *Cont.*

Category/Factor		Explanation
16	Judiciary	The judiciary can prohibit technology from achieving dominance, for example, by not allowing monopoly formation.
17	Suppliers	Suppliers are companies that develop complementary goods, for example, generators. These companies can have an influence on the technology because their technology should be compatible.
18	Social acceptance	Is the technology accepted by the public? How are they going to react to the technology? Will there be any negative or positive reactions when the technology is flying "in their backyard"? This can influence technology dominance.

Table 4. Consistency ration results.

	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7
Categories	0.05	0.14	0.08	0.10	0.15	0.11
Characteristics of the format supporter	0.06	0.24	0.02	0.06	0.06	0.06
Characteristic of the format	0.06	0.11	0.11	0.17	0.09	0.08
Format support strategy	0.07	0.08	0.04	0.06	0.09	0.11
Other stakeholders	0.08	0.12	0.11	0.11	0.12	0.08
Market characteristics	0.05	0.14	0.08	0.10	0.15	0.11

Table 5. Local and global average weights.

Categories and Factors	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Local Average Weight	Global Average Weight
Characteristics of the format supporter	0.26	0.06	0.30	0.48	0.14	0.07	0.22	
Financial strength	0.63	0.20	0.07	0.13	0.66	0.08	0.29	0.06
Operational supremacy	0.23	0.06	0.32	0.31	0.10	0.25	0.21	0.05
Learning orientation	0.14	0.74	0.62	0.56	0.24	0.68	0.50	**0.11**
Characteristics of the format	0.47	0.23	0.53	0.04	0.24	0.62	0.35	
Technological superiority	0.63	0.54	0.68	0.71	0.59	0.58	0.62	**0.22**
Compatibility	0.23	0.14	0.06	0.08	0.06	0.10	0.11	0.04
Flexibility	0.14	0.32	0.26	0.22	0.34	0.33	0.27	**0.10**
Format support strategy	0.10	0.57	0.12	0.19	0.56	0.18	0.29	
Pricing strategy	0.39	0.15	0.12	0.14	0.21	0.13	0.19	0.06
Appropriability strategy	0.08	0.06	0.33	0.08	0.08	0.43	0.18	0.05
Timing of entry	0.09	0.37	0.03	0.36	0.33	0.18	0.23	0.07
Marketing communications	0.12	0.11	0.10	0.07	0.14	0.07	0.10	0.03
Pre-emption of scarce assets	0.05	0.03	0.19	0.10	0.03	0.08	0.08	0.02
Distribution strategy	0.12	0.22	0.12	0.03	0.07	0.04	0.10	0.03
Commitment	0.16	0.06	0.09	0.21	0.14	0.08	0.12	0.04
Other stakeholders	0.17	0.14	0.05	0.29	0.06	0.12	0.14	
Big Fish	0.18	0.11	0.04	0.52	0.14	0.08	0.18	0.02
Regulator	0.45	0.41	0.42	0.05	0.09	0.50	0.32	0.04
Judiciary	0.05	0.18	0.26	0.10	0.04	0.05	0.11	0.02
Suppliers	0.13	0.04	0.18	0.21	0.28	0.08	0.15	0.02
Social acceptance	0.18	0.27	0.11	0.13	0.44	0.29	0.23	0.03

The results show that the factor of technological superiority is the most important factor (0.22), followed by learning orientation (0.11) and flexibility (0.10).

6. Discussion and Conclusions

The paper studied the AWE wing type standards battle. Eighteen factors relevant to the battle were found after conducting interviews with experts and analyzing the literature that reports on the battle.

This study contributes to the standardization literature and the literature that studies the establishment of dominant designs [6,21,22,34]. It replicates earlier findings with respect to the importance of technological superiority [4,35–37] and flexibility [38] in cases of technology battles and specifically for sustainable energy technologies, and it provides some new insights. Four specific contributions can be distinguished.

Firstly, experts indicate that technological superiority is the most important factor in this battle. They indicate that important aspects related to this include the technologies' lifespan, durability and efficiency. One of the experts argued that: "In terms of technological superiority, soft kites are more advanced. Especially because the development is faster. It is easier to develop prototypes". Another expert mentioned that the scaling of soft wing systems is less critical in terms of the material used. Technological superiority is also found to be an important factor in other cases of standards battles and battles for dominant designs that were reported in the literature [39,40]. Furthermore, it was shown to be of importance for various sustainable energy systems [38] and, specifically, generator configurations of airborne wind energy systems [4]. This study replicated these earlier findings.

Secondly, the learning orientation is seen by the experts as an important factor. As one of the experts mentions: "If you start developing a new product, learning orientation is very important. Whereas if you already have a developed product and it is more about improving it by a few percentiles, then the increase of knowledge is less important." A company that is able to learn quickly and efficiently in terms of resource use can make relatively fast steps in the technology development process. Although this factor was shown to be of importance for reaching technology dominance in the IT industry [41] and in the telecommunications industry [42], this is the first time that experts have indicated that it is also important for reaching technology dominance in the case of a sustainable energy system.

Thirdly, experts indicate that flexibility is one of the most important factors. Flexibility refers to the extent to which the technology can be adapted, e.g., to changing user requirements; requirements related to, e.g., the location where the wing is deployed. A client that wants to use the wings in different locations might want to have a wing type that can be easily transported. A location where the wings are deployed that is less accessible asks for a wing type that does not ask for frequent maintenance. Flexibility also refers to the extent to which improvements can be made to the wings. The factor has been found to be important in earlier cases of standards battles in the IT and consumer electronics markets [43]. It has also been mentioned to be of importance in other cases of sustainable energy technologies (see, e.g., [38]), including for generator configurations of airborne wind energy generators [4].

Finally, as mentioned in Section 3, Suarez argued that technological superiority is especially important in the second stage of the technology dominance process. We provided empirical proof that this is indeed the case, thereby, in part, replicating earlier evidence that focused on the battle between ground-gen and fly-gen airborne wind energy systems; these authors found empirical proof of the importance of technological superiority and flexibility in the second stage of the dominance process [4]. This paper contributes to that research by replicating that finding and by providing evidence that experts find another factor important as well at this stage: Learning orientation.

According to the experts, both wing types can still win this battle for dominance, and a dominant wing type will not emerge soon as both types are still in quite an early phase of development. However, currently, quite some experts believe that the soft wing is considered more advanced and more promising, especially because development is faster and scalability has appeared to be possible for these systems too. That is interesting because, as also mentioned in Section 2 of this paper, around the year 2015, the rigid wing was considered to be more promising [3]. However, as one expert argued: "It is not always the best technology that wins. I think it is technologically possible if there are enough resources, but whether we will see any of the technologies on a Mega-watt scale I don't know, there are still challenges to be overcome".

Some limitations of this paper can be mentioned. The first limitation is that only two experts were interviewed to determine the relevant factors, and only six experts were interviewed for the BWM interview. Additionally, all interviewees are European. The BWM method has a certain degree of subjectivity that should be taken into account. Evaluation of the factors and thus assigning weights demands substantial knowledge of the experts, and this is always limited to some extent. As the focus of the paper was on a technology that is in the early stages of development, this inherently results in fewer experts being available and, therefore, a challenge with respect to finding a sufficient number of experts. However, the experts we interviewed are top experts in the field, so their opinions are important. Thus, the insights provided by the experts combined with those from the literature are valuable. In addition, we found that the results of the BWM analysis did not significantly change anymore after adding the interview findings of BWM interviews 5 and 6. This indicates that a sufficient number of interviews were conducted. Another limitation is that, although we discussed with the experts which wing type they thought would win the battle, due to time constraints, we did not ask the experts to rank both wing types based on the dominance factors we found in this research.

7. Suggestions for Future Research

The aim of this paper was to identify important factors in the battle for a dominant design. The limitations mentioned in Section 6 logically lead to some suggestions for future research. The first suggestion is to expand the number of interviewees and especially to diversify the group of interviewees. Secondly, as mentioned above, the research also did not dive into evaluating the two wing types according to the factors that were found. Future research could investigate how the two alternatives score for the identified factors and establish a status quo for the battle between the two wing types. Another recommendation for further research would be an in-depth case study into the development trajectories of both wing types. This research could investigate assumptions that were made years ago regarding the two alternatives and track if the development of AWE systems goes according to the assumptions made.

Further research related to technology dominance, in general, could focus on the different stages of technology development. As mentioned, airborne wind energy systems are now in the second stage of the Suarez model, but they are almost commercially available. Therefore, in a few years' time, similar research could be conducted to compare the results in stage 3 with the results in this paper. The fact that this technology is now close to commercialization also opens up a whole new field, both in terms of research and in terms of the practical situation. Research is needed into the best introduction strategies of airborne wind energy systems in different contexts, for different applications and perhaps also for different technological configurations. Additionally, what are the best strategies for scaling up the market? In addition, research is needed into the aspects that come into play when airborne wind energy systems are integrated into the electricity grid.

The outcome of this paper points to three factors that, according to the experts, affect the emergence of a dominant design in this market: technological superiority, flexibility and learning orientation. This finding contributes to the scientific field and provides entrepreneurs, managers and public policymakers with an insight into what is especially important to focus on in the case of airborne wind energy systems. We hope this will bring us one step further towards a dominant design and, ultimately, large-scale implementation of these systems.

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