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Chapter 27
Niche Strategies to Introduce Kite-Based Airborne Wind Energy

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Abstract Kite-based airborne wind energy systems are new high-tech systems that provide sustainable wind energy. Instead of using a wind turbine, these systems use a kite to generate energy. Commercializing such new high-tech systems is a risky strategy, the failure rate is high. This chapter identifies barriers that block large-scale diffusion of kite-based airborne wind energy systems and specific niche strategies to deal with these barriers. The results are based upon literature research and interviews with six academic and industry experts active in the field of airborne wind energy. We identified the most important barriers to large-scale implementation of airborne wind energy. We show how particular barriers, such as the lack of knowledge of the technology and the lack of support and investment opportunities, interact and together block large-scale production and diffusion. The second result is that several niche strategies can be identified to tackle the barriers in this field. The "geographic niche strategy", the "demo, experiment and develop niche strategy" and the "educate niche strategy" are identified as good strategies to introduce the kite-based systems. The chapter ends with a discussion of these niche strategies and how they relate to previous research into introduction of sustainable energy technologies.

27.1 Introduction

This chapter focuses on airborne wind energy systems and explores how specific niche strategies can be selected for introducing these systems by analysing barriers to their large-scale implementation.

Airborne wind energy (AWE) is a cluster of technologies with the ability to extract wind power by using airborne elements. How the wind energy is converted into

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(predominantly) electrical energy is what differentiates the technologies in the cluster, as different mechanisms are applied to lift the systems into the air and convert wind energy into electrical energy [3]. In this chapter we focus on one particular AWE configuration: kite-based traction power systems.

A serious problem with radically new high-tech systems in general is that it takes long before large-scale diffusion starts [27]. That is particularly true for sustainable energy provision systems such as biomass gasifiers [34, 40], wind turbines [21] or solar PV [19, 39]. An explanation for the time span between invention and large-scale diffusion can be found by looking at barriers. Many barriers have to be faced before large-scale diffusion is possible. A way to deal with these barriers is to introduce the product in a small part of the market first—a niche market. The term niche market refers to a relatively small group of customers with specific wants and demands regarding a product [11, 38].

This chapter has two goals. Firstly, it investigates the types of barriers that exist for the introduction of an innovative kite-based airborne wind energy system and the relative importance of these barriers. Secondly, it explores how these barriers can be dealt with by means of specific niche strategies that either break away or circumvent these barriers.

In recent years, a number of papers, such as [9, 15, 29] have been published that used a strategic niche management approach to investigate the introduction of sustainable energy systems. The current chapter is the first to apply such an approach to the case of airborne wind energy systems. It is also the first to investigate specific niche strategies that companies can use. Within the research field of airborne wind energy systems, most publications so far have focused on technical aspects. Some publications have taken another viewpoint and investigate issues such as economic aspects [12], and patent analyses [33]. However, in this field no research has been published yet on barriers to large-scale implementation of these technologies and on strategies to deal with these barriers.

The remainder of this chapter is organized as follows. Section 27.2 describes the kite-based airborne wind energy systems. Section 27.3 describes theoretical notions derived from earlier work on barriers and niche strategies. Section 27.4 covers the research methodology. In Sect. 27.5 are the research findings with regard to barriers and strategies. Section 27.6 presents the conclusion, discussion and recommendations. The preliminary content of the present chapter has been presented at the Airborne Wind Energy Conference 2015 [30].

27.2 Practice: Airborne Wind Energy Systems

The idea of using airborne devices, mainly kites, goes back many centuries. Yet, it was not until 1827 that the first book on the topic was published by George Pocock. In this book Pocock describes his successful experiments with carriages driven by kites. After that came the “Golden Age of Kites” (1860—1915) in which kites developed technically to a high level before being pushed out by the rising aviation

industry. But it took many decades, dominated by fossil fuels, before the idea of airborne wind energy was reinvigorated after the oil crises of the 1970s. In 1975, space pioneer Hermann Oberth published a book on airborne wind energy, "Das Drachenkraftwerk" [26] and Payne and McCutchen patented airborne wind power concepts. In 1979, Bryan Roberts conducted demonstration experiments of "flying electricity generators" in Australia. In 1980 Miles Loyd published his chapter "Crosswind Kite Power", in which the foundations for quantitative analysis of airborne wind power systems was laid [23].

In 1997, the late Dutch astronaut and university professor Wubbo Ockels patented the Laddermill and started a research group at Delft University of Technology [3, 10]. In 2001 in Germany SkySails developed the first commercial kite system for ship traction. The company Makani Power was founded in 2006 with substantial funds from Google. That same year, Windlift in the US and NTS in Germany were founded, while the KiteGen project realized a pumping kite system [10]. Following a High Altitude Wind Power Conference in Chico, California, in 2009, the first international Airborne Wind Energy Conference (AWEC) was held 2010 in Stanford, California, and from then on six annual international conferences have taken place, including the 2015 event. In 2013 Makani Power was fully acquired by Google and the first book on "Airborne Wind Energy" was published by Springer Verlag, in part cataloging the history and development of airborne wind energy. Currently, the technologies occupy a niche in a fossil-fuel driven landscape but the number of research institutes involved in the development of AWE systems has grown enormously [3].

Airborne wind energy systems require exceptionally strong yet lightweight system designs. Currently, different airborne systems are proposed. Some systems use conventional turbines to generate electricity, either suspended in the air by a helium-filled structure or on a crosswind flying wing. There are also system configurations and technologies that use drag sails to harness wind power or systems that use the auto-gyro effect for both lift and power generation.

27.3 Theory: Barriers and Niche Strategies

Rogers [35] describes a model in which the diffusion of a product follows a smooth S-shaped pattern. This model is based upon two assumptions: (1) that a new product is directly introduced into the large market and (2) that the product remains essentially invariant over the life cycle. However, evidence shows that often products are not introduced into the large market directly because in this market there are barriers for market introduction. A way to deal with these barriers is to first introduce the new product in a small market—a niche market—using a niche strategy. This may also involve developing the product further through incremental and radical innovations, as also found in [1]. Several types of niches exist. We define a "strategic niche" as a niche that emerges prior to industrial production and large-scale diffusion of a new high-tech product in a mainstream application.

There are many examples of new innovations that were introduced in a strategic niche before large-scale market introduction [28, 32]. A typical example is the use of solar PV in satellites. This strategic niche appeared prior to the use of solar PV for generating electricity for households. Strategic niches appear when one or more factors that are needed for large-scale diffusion of a new high-tech product are missing. Here we define a high-tech product using three elements: a high-tech product is an artifact with a certain functionality, based on technological principles and consisting of a number of main components. Using this definition, we define an AWE system as a high-tech product. An overview of the factors needed for large-scale diffusion is presented in Table 27.1. This overview, taken from [31], is based on literature research in [6, 13, 16, 22, 24]. These sources investigate factors that have to be present in the market and in the wider social context in order to make development and large-scale diffusion of innovations possible. All of the resulting factors were ordered and combined into twelve categories, presented in Table 27.1.

After analyzing these factors, specific niche strategies can be derived. In practice that is not as straightforward as it seems. If, for example, the factor 'availability of customers' (factor 5 in Table 27.1) is not present in the system, then this is a barrier which seriously hampers large-scale diffusion. However, the mere existence of this barrier does not reveal what type of niche strategy can be adopted. More knowledge of the market and the context is required to derive possible niche strategies. The twelve categories of factors have different roles. The absence of some factors can directly block large-scale diffusion (such as the lack of customers) whereas the absence of other factors serve as a cause of that barrier. Customers can be lacking, for example, because they miss the knowledge required to understand and use a product (factors 7 and 8 in Table 27.1) or they can be lacking because these customers cannot afford the product (factor 11 in Table 27.1). In these cases, completely different niche strategies should be considered. In the first situation, a niche strategy should be aimed at educating customers. In the second situation, a niche strategy can aim at a simple and cheaper version of the product or a niche strategy can supply the product to a wealthy top customer segment. In this way, the twelve factors in Table 27.1 can be divided in six core factors and six causes, as shown in Fig. 27.1.

Factors 1-6 in Table 27.1 and Fig. 27.1 have a direct effect on the large-scale diffusion of the high-tech product whereas factors 7-12 have a more indirect effect, because they influence one or more of the factors 1-6.

Figure 27.1 is built up in two layers. Factors 1-6 (middle part of Fig. 27.1), referred to as core factors, represent the core technological and market system required for large-scale diffusion. Some of these core factors refer to technical components and subsystems such as the product itself, the production system and complementary products and services. Some other factors refer to availability of actors such as customers or the availability of support and investors. The institutional aspects refer to the laws, rules, norms and values used to guide processes such as production, supply, adoption and use. Each of these core factors need to be in place in order to enable large-scale diffusion to occur. The second layer of factors (left part of Fig. 27.1), referred to as influencing factors, contains contextual factors that explain why problems in the core system emerge. Two of these influencing factors relate

Factors	Description
1. Availability of a new high-tech product	The product needs to have a good price/performance ratio compared to competitive products in the perception of customers before large-scale diffusion is possible. If (one or more components of) the product is/are not available, large-scale diffusion is not (yet) possible.
2. Availability of a production system	Availability of a system to produce the technology is required for large-scale diffusion. In some cases a product can be created in small numbers but if industrial production technologies are not yet available, then large-scale diffusion is not possible.
3. Availability of complementary products and services	Complementary products and services refer to products and services required for the production, distribution, adoption and use. The unavailability of such products and services means that large-scale diffusion is not (yet) possible.
4. Availability of support & investments	The availability of local support and partners that facilitate the investment of suppliers, customers and others in the technology
5. Availability of customers	The availability of customers means that a market application for the product is identified, that customer segments for these applications exist and that the customers are knowledgeable about the product and its use and are willing and able to pay for adoption. If applications are unknown or if customer groups do not exist, are not able to obtain the product or are unaware of the benefits of the product, large-scale diffusion is blocked.
6. Availability of supporting institutional aspects (laws, rules and standards)	The regulatory and institutional environment refers to the laws and regulations that indicate how actors (on the supply and demand side of the market) deal with new product. These laws and regulations can either stimulate the diffusion of radically new high-tech products (such as subsidy that stimulates the use of sustainable energy) or completely block it (such as laws prohibiting something).
7. Availability of knowledge of technology	The knowledge of the technology refers to the knowledge required to develop, produce, replicate and control the technological principles in a product. In many cases a lack of knowledge blocks large-scale diffusion.
8. Availability of knowledge of application	Knowledge of the application can refer to knowing potential applications. If a technological principle is demonstrated but there is no clue about its practical application, large-scale diffusion is impossible. A lack of knowledge of the application can also refer to customers that do not know how to use a new product in a particular application. In that case large-scale diffusion is not possible either.
9. Availability of relevant natural resources and labour	Natural resources and labour are required to produce and use a new high-tech product. These resources and labor can be required for the production system, for complementary products and services or for the product itself. In many cases a lack of resources and labor block large-scale diffusion.
10. Availability of supporting socio-cultural aspects	Socio-cultural aspects refer to the norms and values in a particular culture. These aspects might be less formalized than the laws and rules in the institutional aspects but their effect can completely block large-scale diffusion.
11. Availability of supporting macro-economic aspects	Macro-economic aspects refer to the national or global economic situation. For example, a recession can stifle the diffusion of a new high-tech product.
12. Availability of a positive vision and image	If the main actors and the broader public hold a negative perception regarding the technology and its potential, this can block large-scale diffusion.

Table 27.1 Actors and factors necessary for large-scale diffusion [31]

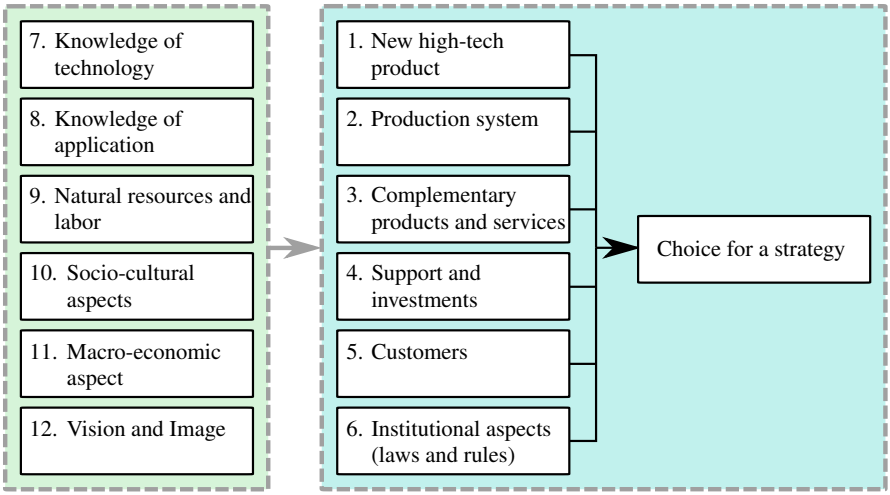

Fig. 27.1 Factors important for the development and large-scale diffusion of new high-tech products and hence for the choice of niche strategies [31]

to knowledge, i.e., knowledge of the technology and knowledge of the application. One factor represents the natural resources and labor. Two other factors refer to the socio-cultural aspects and the macro-economic aspects that drive or hamper the core system. Finally, the vision and image aspects were added to the model because they were found to be important in particular for AWE systems.

After distinguishing the barriers, we formulated specific niche strategies in three steps (see also [31]). First, we identified 21 logical combinations of a core factor and an influencing factor that together can form a barrier for large-scale market introduction. For example, lack of customers because of lack of knowledge of the application (example 1), or lack of investments because of macro-economic aspects (example 2). Second, we argued what would be needed to overcome or circumvent each of these 21 barriers. For example, educating customers can overcome a lack of knowledge (example 1 above) and subsidizing can overcome a lack of spending power among potential customers (example 2 above). This systematic search for strategies in each of these situations resulted in a list of ten strategies that can be applied to remove or circumvent at least one of the 21 identified barriers. Third, we found 50 historical cases of high-tech products in which these strategies were applied in practice to deal with specific barriers. More information on these cases can be found in [31]. Table 27.2 shows the ten niche strategies, as also published in [31].

Description	Description of the specific niche strategy
1. Demo, experiment and develop niche strategy	A niche strategy can be adopted to demonstrate the product in public in a controlled way so the limited quality of performance is not a problem. As part of the strategy experimenting with the product is important to develop the product further.
2. Top niche strategy	A niche strategy can be adopted where specially made products can be made to order, in small numbers, for a specific top-end niche of the market. A skimming strategy can be adopted in which the top niche of customers is supplied first with a special product.
3. Subsidized niche strategy	A niche strategy can be adopted where the product is subsidized if its use by a particular segment of users is considered as societally relevant or important.
4. Redesign niche strategy	A niche strategy can be adopted where the product is introduced in a simpler version that can be produced with the existing knowledge, less use of resources and therefore for a lower price
5. Dedicated system or stand-alone niche strategy	A niche strategy can be adopted where the product is used in stand-alone mode or a dedicated system of complementary products and services is designed (e.g., a local network when an infrastructure is not available on a wider scale).
6. Hybridization or adaptor niche strategy	A niche strategy can be adopted by which the new product is used in combination with the old product and thereby all existing complementary products and services can be re-used. Or an adaptor/convertor is provided to make the product compatible with existing complementary products and services.
7. Educate niche strategy	A niche strategy can be adopted aimed at transferring the knowledge to suppliers and customers.
8. Geographic niche strategy	A niche strategy that can be adopted to introduce the new product into the market in another geographic area where the conditions are more favorable.
9. Lead user niche strategy	A niche strategy can be adopted finding innovators or lead users. These users can co-develop the product because they are willing to experiment with the product.
10. Explore multiple markets niche strategy	A niche strategy can be adopted in which multiple customer applications can be explored. Visibility of the first applications can stimulate explorative use in new applications.

Table 27.2 Specific niche strategies and the conditions in which they can be considered [31]

27.4 Research Methodology for the AWE Analysis

Our research methodology to find out the main barriers for large-scale diffusion of kite-based high-altitude wind energy and the strategies to deal with these barriers can be divided into two parts. The first part consisted of literature research into barriers and suggested strategies for market introduction of AWE systems. The sources used in the literature research are [3, 8, 17, 20, 25]. The second part consisted of six interviews with AWE experts from different countries, two of which from academia and four from business (founders or managing directors from AWE companies).

The interview method is described in more detail below. For a still more detailed description of the interview method see [29].

Assessing the market for radically new high-tech systems is very difficult. Even experts can experience difficulties [37, 41]. In general they tend to be prone to bias and inconsistency, both of which can damage their accuracy [18, 37], they tend to place too much trust in their own predictions [4, 7], they only consider a very limited set of alternative strategies [14] and they tend to choose strategies intuitively rather than systematically [2]. Several expert methods have been developed (see e.g. [5, 36]). The Delphi technique, for example, can lead to a consensus between a range of experts on a specific topic.

The goal of the method used in this chapter is to assess the market situation, to indicate the most important barriers for large-scale diffusion of AWE systems, and to select niche strategies to deal with these barriers. Rather than consensus, we aim to seek consistency in each individual expert's evaluations. Therefore, we did not use the Delphi approach but, instead, decided to interview experts separately. In order to make the outcomes of each interview as consistent as possible and therefore as reliable as possible, we designed four steps in each interview, as described below. As input for the interviews we used the pre-specified list of theoretical barriers (describing the factors required for large-scale diffusion and their causes) as presented in Fig. 27.1 and the pre-specified list of theoretical niche strategies as presented in Table 27.2.

In the first step we asked the experts to indicate their experience and expertise regarding technological and market aspects of AWE systems. The information was used to describe the general market situation and to indicate the case specific knowledge of the experts. This knowledge serves as a proxy or indicator of the validity of subsequent expert evaluations in the interview. In the second step we addressed the market situation for AWE systems further and in particular discussed the barriers for large-scale diffusion and their causes. In this step we started asking for barriers (open question) to find out what the experts thought. The answers also served as a check whether our pre-specified list of barriers was complete. We then proceeded by showing the experts the pre-specified list of barriers and requested them to select the most important ones (closed question). Also, we asked them to reflect upon a list of barriers for diffusion of high-altitude wind energy that we had extracted from written sources [3, 8, 17, 20, 25] (closed question).

Finally we discussed possible discrepancies between the answers to the open and closed questions. In the third step we addressed possible niche strategies in a similar process: an open question about possible niche strategies, a closed question to rate our pre-specified list of theoretical niche strategies and suggested strategies for high-altitude wind energy, and a discussion to address possible discrepancies between the answers to the open and closed questions. In the fourth step we asked the experts about the linkages between the most important barriers on the one hand and the selected niche strategies on the other hand. After the interviews, we checked the interview outcomes with our findings from the literature on barriers and strategies for market introduction of AWE systems. Using all these steps and checks we ensured that the outcomes were as consistent and as reliable as possible.

27.5 Findings from the AWE Analysis

This section presents the barriers (combinations of core and influencing factors) blocking large-scale diffusion of AWE systems and the main strategies to deal with these barriers.

27.5.1 Findings regarding the barriers and their relative importance

Table 27.3 provides an overview of the barriers blocking large-scale diffusion of AWE systems. We list eight of these barriers, starting with the most important one. Each barrier is formulated in terms of a core factor and an influencing factor. For example, the first line in Table 27.3 indicates that a lack of knowledge regarding the AWE technology has a negative effect on support and investment, which represents a serious barrier to large-scale diffusion.

The results in Table 27.3 clearly indicate that a lack of knowledge of technology is one of the most important influencing factors. This factor is present five times in the eight most important influencing factors. Some of the remaining influencing factors have a clear link with the knowledge of technology. The vision & image has a negative effect because of the uncertainty regarding reliability, operation and safety and that is also related to a lack of knowledge of the technology. The same applies to the uncertainty about economic performance.

27.5.2 Findings regarding the strategies and their relative importance

The strategy ranking provides an overview of the niche strategies to introduce kite-based AWE systems, which can be used to tackle certain barriers. In Table 27.4 we list the three main niche strategies, starting with the most important one.

The table indicates that the most important strategy is the geographic niche strategy. It is interesting to find out that this most important niche strategy has no obvious link to the predominant barrier of a lack of technological knowledge. However, the geographic niche strategy is an obvious choice for high-altitude wind energy. Firstly, rules and regulations as well as investment climate for AWE systems vary widely across geographic regions. As indicated by our interviewees, this is the most important reason to opt for the geographic niche strategy. Other reasons can be that the average wind speed varies per region and that AWE systems require a large area to lift and use them safely, which limits the regions where they can be used.

The other two niche strategies are more logically linked to the predominant barrier of a lack of technological knowledge of the AWE systems. This current lack of

knowledge of the technology makes a "demo, experiment and develop" niche strategy a logical choice. If this knowledge is mastered but has not yet diffused among stakeholders then an "educate niche" strategy is a logical strategy.

27.6 Conclusion and Discussion

Based on literature research and a structured interview method we have detected the most important barriers that block large-scale diffusion for kite-based airborne wind energy systems (AWE systems) and we selected three niche strategies for introducing these systems.

A central problem for the AWE systems is a lack of knowledge of the technology. This indicates that the principle is still experimental. For this problem a so-called "demo, experiment and develop" niche strategy is suggested by our results. Also during the early stages of the innovation process of quite a number of other sustainable energy technologies such as wind turbines or PV the "demo, experiment and

No.	Barriers in terms of influencing factors and core factors	Description
1.	Knowledge of Technology—Support & Investment	Lack of proof of concept and performance of the technology inhibit investment and support for further development of kite-based AWE systems.
2.	Vision & Image—Support & Investment	Uncertainty regarding reliability, operation and safety of kite-based AWE systems amongst the general public and investors has a negative effect on the support for and investment in kite-based AWE systems.
3.	Macro-economic aspects—Customers	Competition of other (renewable) energy systems inhibits market access for kite-based AWE system customers.
4.	Knowledge of Technology—Institutional aspects	Lack of knowledge and experience inhibits access and regulation of airspace for kite-based AWE systems.
5.	Knowledge of Technology—Customers	Lack of experience and data regarding safety and reliability inhibits customers of kite-based AWE systems.
6.	Knowledge of Technology—Technological development	Technical challenges regarding control systems and materials inhibit a marketable AWE system.
7.	Macro-economic aspects—Support	Investment Uncertainty about the economic performance of kite-based AWE systems undermines investment and support.
8.	Knowledge of Technology—Product processes	Experience and knowledge of the manufacturing and the supply chain of kite-based AWE systems is minimal.

Table 27.3 Ranking of barriers (in terms of core factors and influencing factors) for AWE systems

develop" niche strategy has been used [21, 39]. Especially in the Netherlands this strategy was the predominant one. However, it should be noted that sources such as [21] and [39] show that too much focus on this strategy alone can slow down the innovation process because of the risk of too much focus on R&D aspects and not involving the demand side of the market enough.

Another central problem for the AWE systems is the lack of knowledge of these systems that relevant stakeholders have. The lack of knowledge explains the poor image of these systems. This image, in turn, has an impact on available investment funds. For this problem a so-called "educate niche strategy" is suggested by our results.

The previous two problems are related to the early and experimental stage of AWE systems. In due course, we expect these problems to be solved. The third and most important strategy that we found, the geographic niche strategy, at first sight seems unrelated to the selected barriers. This strategy is required because of the large differences in rules and regulations between different countries. Another reason for this strategy is that AWE systems require a significant amount of space both on land and in the air to be used safely. This requirement calls for a selection of regions that fulfill this requirement, and that implies a geographic niche strategy. In the early stages of wind turbine development in the early 1980s, this strategy was also pursued by, among others, Dutch and Danish wind turbine manufacturers that entered the market in California because more space was available there and regulations and subsidies were more favorable [21]. As [21] shows, when pursuing this strategy it is important to build up strong relationships with other local stakeholders such as the demand side of the market and local policy makers since this improves the knowledge flows between stakeholders and therefore the innovation process. Pursuing the suggested strategies will remove the barriers and therefore turn them into opportunities for accessing new (niche) markets.

No.	Strategy	Description
1.	Geographic niche strategy	A niche strategy can be adopted to introduce AWE systems in the market in another geographic area where the conditions are more favorable and there are less barriers.
2/3.	Demo, experiment and develop niche strategy	A niche strategy can be adopted to demonstrate AWE systems in public in a controlled way. As part of the strategy experimenting with the product it is important to develop the product further, for example in a research environment.
2/3.	Educate niche strategy	A niche strategy can be adopted aimed at transferring the knowledge of AWE to consumers, suppliers, policy makers and other relevant actors.

Table 27.4 Strategy ranking for AWE systems

References

1. Abernathy, W. J., Utterback, J. M.: Patterns of innovation in technology. Technology Review **80**(7), 40–47 (1978)
2. Agor, W. H.: The logic of intuition: How top executives make important decisions. Organizational Dynamics **14**(3), 5–18 (1986). doi: 10.1016/0090-2616(86)90028-8
3. Ahrens, U., Diehl, M., Schmehl, R. (eds.): Airborne Wind Energy. Green Energy and Technology. Springer, Berlin Heidelberg (2013). doi: 10.1007/978-3-642-39965-7
4. Arkes, H. R.: Overconfidence in judgmental forecasting. In: Armstrong, J. S. (ed.) Principles of Forecasting: A Handbook for Researchers and Practitioners, pp. 495–515. Kluwer Academic Publishers, Dordrecht (2001). doi: 10.1007/978-0-306-47630-3_22
5. Armstrong, J. S. (ed.): Principles of Forecasting: A Handbook for Researchers and Practitioners. Springer Science+Business Media, New York (2001). doi: 10.1007/978-0-306-47630-3
6. Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A.: Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy **37**(3), 407–429 (2008). doi: 10.1016/j.respol.2007.12.003
7. Brenner, L. A., Koehler, D. J., Liberman, V., Tversky, A.: Overconfidence in Probability and Frequency Judgments: A Critical Examination. Organizational Behavior and Human Decision Processes **65**(3), 212–219 (1996). doi: 10.1006/obhd.1996.0021
8. Bronstein, M. G.: Harnessing rivers of wind: A technology and policy assessment of high altitude wind power in the U.S. Technological Forecasting and Social Change **78**(4), 736–746 (2011). doi: 10.1016/j.techfore.2010.10.005
9. Caniëls, M. C. J., Romijn, H. A.: Actor networks in Strategic Niche Management: Insights from social network theory. Futures **40**(7), 613–629 (2008). doi: 10.1016/j.futures.2007.12.005
10. Cherubini, A., Papini, A., Vertechy, R., Fontana, M.: Airborne Wind Energy Systems: A review of the technologies. Renewable and Sustainable Energy Reviews **51**, 1461–1476 (2015). doi: 10.1016/j.rser.2015.07.053
11. Dalgic, T., Leeuw, M.: Niche Marketing Revisited: Concept, Applications and Some European Cases. European Journal of Marketing **28**(4), 39–55 (1994). doi: 10.1108/03090569410061178
12. De Lellis, M., Mendonça, A. K., Saraiva, R., Trofino, A., Lezana, Á.: Electric power generation in wind farms with pumping kites: An economical analysis. Renewable Energy **86**, 163–172 (2016). doi: 10.1016/j.renene.2015.08.002
13. Edquist, C.: Design of innovation policy through diagnostic analysis: identification of systemic problems (or failures). Industrial and Corporate Change **20**(6), 1725–1753 (2011). doi: 10.1093/icc/dtr060
14. Ehrlinger, J., Eibach, R. P.: Focalism and the Failure to Foresee Unintended Consequences. Basic and Applied Social Psychology **33**(1), 59–68 (2011). doi: 10.1080/01973533.2010.539955
15. Eijck, J. van, Romijn, H.: Prospects for Jatropha biofuels in Tanzania: An analysis with Strategic Niche Management. Energy Policy **36**(1), 311–325 (2008). doi: 10.1016/j.enpol.2007.09.016
16. Geels, F. W.: From sectoral systems of innovation to socio-technical systems. Research Policy **33**(6–7), 897–920 (2004). doi: 10.1016/j.respol.2004.01.015
17. GL Garrad Hassan: Market Status Report High Altitude Wind Energy, now merged with DNV GL, Aug 2011
18. Hogarth, R. M.: Judgment and Choice: The Psychology of Decision. 2nd ed. John Wiley, New York (1987)
19. Huijben, J. C. C. M., Verbong, G. P. J.: Breakthrough without subsidies? PV business model experiments in the Netherlands. Energy Policy **56**, 362–370 (2013). doi: 10.1016/j.enpol.2012.12.073
20. Inman, M. (ed.): Energy High in the Sky: Expert Perspectives on Airborne Wind Energy Systems, Near Zero, 9 Sept 2012. http://www.nearzero.org/reports/airbornewind/pdf

21. Kamp, L. M., Smits, R. E. H. M., Andriesse, C. D.: Notions on learning applied to wind turbine development in the Netherlands and Denmark. Energy Policy **32**(14), 1625–1637 (2004). doi: 10.1016/S0301-4215(03)00134-4
22. Kemp, R., Schot, J., Hoogma, R.: Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technology Analysis & Strategic Management **10**(2), 175–198 (1998). doi: 10.1080/09537329808524310
23. Loyd, M. L.: Crosswind kite power. Journal of Energy **4**(3), 106–111 (1980). doi: 10.2514/3.48021
24. Malerba, F.: Sectoral systems of innovation and production. Research Policy **31**(2), 247–264 (2002). doi: 10.1016/S0048-7333(01)00139-1
25. Megahed, N. A.: Landscape and Visual Impact Assessment: Perspectives and Issues with Flying Wind Technologies. International Journal of Innovative Research in Science, Engineering and Technology **3**, 11525–11534 (2014). http://www.ijirset.com/upload/2014/april/88_Landscape.pdf
26. Oberth, H.: Das Drachenkraftwerk. Uni Verlag, Dr. Roth-Oberth, Feucht, Germany (1977)
27. Ortt, J. R.: Understanding the Pre-diffusion Phases. In: Tidd, J. (ed.) Gaining Momentum Managing the Diffusion of Innovations, pp. 47–80. Imperial College Press, London (2010)
28. Ortt, J. R., Delgoshaie, N.: Why does it take so long before the diffusion of new high-tech products takes off? In: Proceedings of 17th International Conference on Management of Technology, International Association for Management of Technology (IAMOT), Dubai, United Arab Emirates, 6–10 Apr 2008
29. Ortt, J. R., Kamp, L. M., Doe, M. F.: Niche strategy selection to introduce radically new systems – The case of kite-based airborne wind energy. In: Proceedings of the 21st IEEE International Conference on Engineering, Technology and Innovation/ International Technology Management Conference (ICE/ITMC), Belfast, Northern Ireland, 22–24 June 2015. doi: 10.1109/ICE.2015.7438672
30. Ortt, J. R., Kamp, L. M., Doe, M. F. A.: How to Introduce Kite-Based Airborne Wind Energy Systems – The Selection of Niche Strategies to Overcome Barriers to Adoption. In: Schmehl, R. (ed.). Book of Abstracts of the International Airborne Wind Energy Conference 2015, pp. 64–65, Delft, The Netherlands, 15–16 June 2015. doi: 10.4233/uuid:7df59b79-2c6b-4e30-bd58-8454f493bb09. Presentation video recording available from: https://collegerama.tudelft.nl/Mediasite/Play/d923a66b221b4117872189e7a73d29e71d
31. Ortt, J. R., Langley, D. J., Pals, N.: Ten Niche Strategies To Commercialize New High-Tech Products. In: Proceedings of the International Conference on Engineering, Technology and Innovation (ICE) & IEEE International Technology Management Conference, The Hague, The Netherlands, 24–26 June 2013. doi: 10.1109/ITMC.2013.7352687
32. Ortt, J. R., Suprapto, M.: The role of strategic niches in creating large-scale applications for high-tech products. In: Proceedings of 20th International Conference of the International Association for Management of Technology, Miami Beach, Florida, USA, 10–14 Apr 2011
33. Phan, K., Daim, T.: Forecasting the Maturity of Alternate Wind Turbine Technologies Through Patent Analysis. In: Daim, T., Oliver, T., Kim, J. (eds.) Research and Technology Management in the Electricity Industry: Methods, Tools and Case Studies, Chap. 8, pp. 189–211. Springer, London (2013). doi: 10.1007/978-1-4471-5097-8_8
34. Raven, R. P. J. M.: Strategic Niche Management for Biomass – A comparative study on the experimental introduction of bioenergy technologies in the Netherlands and Denmark. Ph.D. Thesis, TU Eindhoven, 2005. http://alexandria.tue.nl/extra2/200511821.pdf
35. Rogers, E. M.: Diffusion of Innovation. 1st ed. Free Press of Glencoe, New York (1962)
36. Rowe, G., Wright, G.: Expert opinions in forecasting: the role of the Delphi technique. In: Armstrong, J. S. (ed.) Principles of Forecasting: A Handbook for Researchers and Practitioners, pp. 125–146. Springer Science+Business Media, New York (2001). doi: 10.1007/978-0-306-47630-3_7
37. Schnaars, S. P.: Megamistakes; Forecasting and the Myth of Rapid Technological Change. 29th ed. Free Press, New York, London (1989)

38. Shani, D., Chalasani, S.: Exploiting Niches Using Relationship Marketing. Journal of Consumer Marketing **9**(3), 33–42 (1992). doi: 10.1108/07363769210035215
39. Vasseur, V., Kamp, L. M., Negro, S. O.: A comparative analysis of Photovoltaic Technological Innovation Systems including international dimensions: the cases of Japan and The Netherlands. Journal of Cleaner Production **48**, 200–210 (2013). doi: 10.1016/j.jclepro.2013.01.017
40. Verbong, G. P. J., Christiaens, W., Raven, R. P. J. M., Balkema, A.: Strategic Niche Management in an unstable regime: Biomass gasification in India. Environmental Science & Policy **13**, 272–281 (2010). doi: 10.1016/j.envsci.2010.01.004
41. Wheeler, D. R., Shelley, C. J.: Toward More Realistic Forecasts for High-Technology Products. Journal of Business & Industrial Marketing **2**(3), 55–63 (1987). doi: 10.1108/eb006036