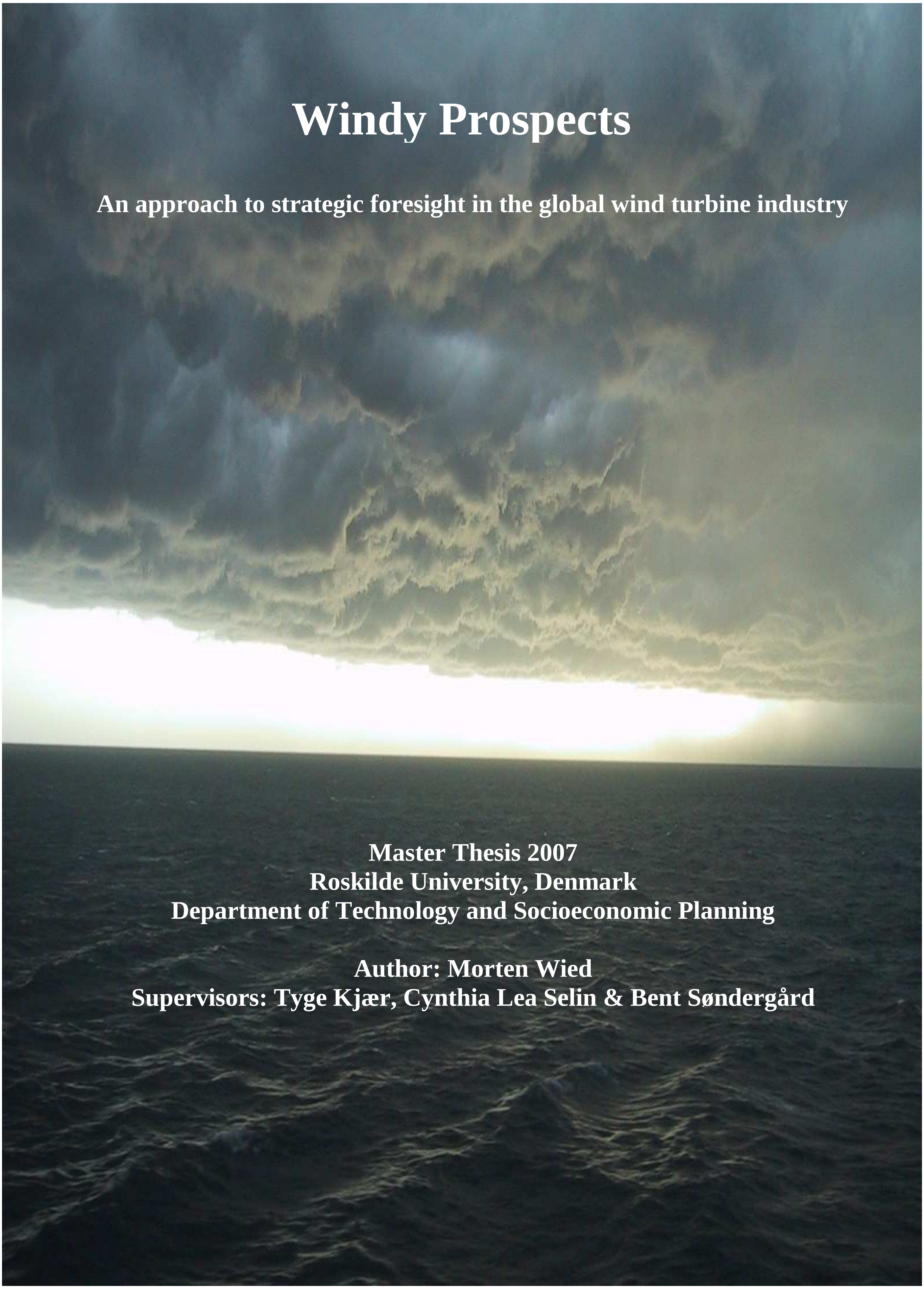

Windy Prospects

An approach to strategic foresight in the global wind turbine industry

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Abstract

This report explores the forces of change which will influence the competitive environment of the wind turbine industry over the coming decade. It further explores the strategic consequences of such change for wind turbine manufacturers and investigates possibilities for adaptation, pre-emption and early warning. In the somewhat experimental approach to strategic foresight adopted in this thesis involves the following steps:

Firstly, a number of variables and interrelationships considered relevant to strategic decision-making in the context of the competitive environment of the wind turbine industry are made explicit through the construction of an integrated conceptual model (ICM). The ICM is constructed on the basis of strategic theory and a survey of industry literature, covering analysis, empirical measurements, observations and assessments about the current structure of the competitive environment.
Secondly, expectations and principal questions about the development of the competitive environment over the coming decade are identified through in-depth interviews and assessed on the basis of current empirical evidence and historical precedence. The ICM subsequently forms the basis against which the impact of these changes upon the competitive environment is systematically explored.
Thirdly, a number of strategic groups are identified among the business models of current wind turbine manufacturers. The consequences of the known forces of change are explored for each strategic group along with possibilities for adaptation, pre-emption and early warning.

On this basis, the report concludes that wind turbine manufacturers face a number of very diverse strategic challenges over the coming decade. The report concludes that several options are available to all types of manufacturers, both in terms of adaptation in defence of status quo, pre-emption to influence developments, and exit, should all else fail. The central determinant of the range of possibilities open to wind turbine manufacturers over the coming decade is the early recognition of the forces of change and their strategic consequences.

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Morten Wied

Chapter 1: Introduction, scope & objectives

At a glance it becomes evident that the history of the wind turbine industry has indeed been a bumpy ride down the learning curve. From the meagre beginnings spurred by growing environmental concerns and the first oil crisis in the mid 70s, to the internationalising, maturing and consolidating industry we see today. The history of the industry has claimed its casualties. Only few of the pioneering manufacturers made it this far, and those that did have undergone drastic change along the way in response to an even more drastically changing competitive environment.

The early competitive environment of the late 70s and early 80s was characterised by radical innovations and frequent technological failures as a wealth of turbine designs competed for small national niche markets in Europe and North America. Technological dead ends put an end to many early pioneers. The development of a technological standard in the form of the so-called 'Danish concept' caused a major upheaval in the competitive environment. It resulted in a technological shakeout in the young industry and only few of the original pioneers persisted. The competitive environment again changed dramatically in 1982, with the introduction of the Californian Production Tax Credit (PTC), causing an unprecedented increase in demand, which forced the wind turbine industry to expand and internationalise overnight. In this turbulent period, rapid up scaling was the key source of cost reductions and turbine concepts became obsolete at an unprofitable rate, eating into margins in spite of the booming turnover[1]. The expiration of the PTC in 1987 and the subsequent collapse of the Californian market caused a third major change in the competitive environment. Rapid decline in demand instantly resulted in overcapacity, intense competition and low profitability. Bankruptcy and major structural changes followed, as the industry adjusted to the demands of a much smaller market. The fourth major change occurred during the mid 90s with the emergence of Germany and Spain as large European markets for wind turbines along with rapid increases in industry concentration as new and old competitors merged into fewer and larger manufacturers[2]. The competitive environment of the wind turbine industry of today is global, highly concentrated and characterised by intense rivalry among the remaining manufacturers[3].

The history of the competitive environment of the wind turbine industry has been a history of surprise and constant change. Every major shift has lead to disaster for those who were unprepared. Looking ahead, it is evident that the future of the competitive environment of this industry will be no less interesting than its turbulent past. New and powerful competitors have recently made entry into

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[1] Kjær 1988:20
[2] Skytte *et al* 2004:120-131
[3] Lewis & Wiser 2005:9

the maturing industry and others are likely to follow. New global markets are opening in Europe, Asia, Australia and the Americas, and technological breakthroughs set new standards for size, capacity and location of turbines, on- as well as offshore[4]. As ever, the future of the wind turbine industry remains uncertain and seems to confirm the conclusions of Keith Suter, stating that the future comes about through either disaster, drift or design[5]. Disaster in the form of major surprises and shakeouts, drift in the form of constant adaptation and catching up to seemingly unpredictable developments, and design in the form of conscious pre-emption and planned change. The key question faced by wind turbine manufacturers today is in many ways the same as it has been throughout the history of the industry: what future to design for and what are the opportunities for design?

1.1 Scope and objectives

The idea of controlling and adapting to future industry developments through foresight is not new. The new wave of planning and business theory emerging after the Second World War spurred the adoption of 'Corporate Planning' in many industries in the 50s and 60s. This approach was mainly based on time-series extrapolation of current trends into the medium- and long-term future. The relative economic stability of the 1960s, combined with the deceptively accurate mathematical outputs made Corporate Planning seem reliable. The limits of this approach became apparent in the more turbulent 70s, where 'Scenario Planning', aimed at exploring and anticipating a range of diverging eventualities, replaced the predict-and-control paradigm of Corporate Planning. Led by successes in the oil industry, this approach was adopted in a wide range of industries throughout the decade. The use of Scenario Planning receded in the 80s after the death of Herman Kahn, the founder and forceful proponent of the method. Simultaneous failures in the field of simulation modelling, most famously exemplified by the Club of Rome's World3 Model, meant that planning horizons of many industries shrank from as much as a decade in the 70s to less than a year. In spite of several methodological advances in the field of foresight, this trend has largely persisted up until today[6].

The problems of obtaining knowledge about the future have been enduring and the future of many industries remains woefully uncertain. In this respect the wind turbine industry is no exception. From the viewpoint of strategic foresight, the wind turbine industry exemplifies all the major problems and dilemmas contained within this field. Given the current situation of the industry, it is clear that long-term decisions and strategic commitments must be made in spite of increasingly uncertain future competitive conditions. In this sense, the problem of obtaining reliable intelligence about future

[4] DWIA 2006
[5] Quoted in Bell 2003:109-110
[6] See Mercer 1998:41-42, RAND 2003:11-36, Bell 2003:6-58, Sherdan 1998 and Wack 1985

developments is as relevant today as it has been throughout the history if the industry. This report aims to explore the possibility of extending the panning horizons of the wind turbine industry - asking what lies ahead in a structured and explicit manner. Rephrasing this question, this report explores the strategic challenge of avoiding disaster by moving from drift to design through answering the following research question:

What forces will shape the competitive environment of the global wind turbine industry over the coming 10 years and what will be the strategic consequences for wind turbine manufacturers?

In this thesis I aim to construct an experimental conceptual model of the variables and interconnections considered relevant to long-term strategic decision-making in the competitive environment of the wind turbine industry. This model will form the basis, against which the strategic consequences of both anticipated and unexpected eventualities can be explicitly and consistently explored, making possible pre-emption, adaptation and early warning over the time horizon of a decade. The 10-year time horizon investigated in this report was chosen somewhat arbitrarily. On the one hand, it is a future time period in which historical precedence suggests that the competitive environment is likely to change significantly. On the other hand, it is short enough to be meaningfully investigated while remaining strategically relevant to decisions made in the present – or so I will argue. The *competitive environment* is understood here in the broadest sense of the word, as the business environment with which wind turbine manufacturers interact competitively in order to earn a profit in excess of the cost of capital. *Strategic consequences* thus include both the consequences of changes in the competitive environment upon the success of strategic choices, but also the consequences of changes in the competitive environment imposed by strategy itself.

Chapter 2: Approach & methodology

The research question guiding the efforts made in this report is clearly a difficult one to answer. As it is evident from the turbulent history of the wind turbine industry, a decade is a long time. A key issue in this report is whether such a question can even be answered in any meaningful way. Although the question of the strategic consequences of long-term change may be difficult to answer, it is in many ways an unavoidable question. Competitors in the wind turbine industry are faced with this question in one form or another, and are forced to answer it as best they can, and have been, throughout the history of the industry. This chapter will be concerned with the theoretical basis of strategic foresight and its role in strategic decision making.

2.1 Strategic decision-making

Decision-making is by its very nature a forward-looking activity. Any conclusion reached, and any action taken, based on such conclusions, naturally relies on assumptions about the future of the system in which the decision will play out as well as the change induced by the decision itself. When these assumptions are correct, action leads to desired results. When they are not, the unexpected occurs. The validity of assumptions made about the future therefore lies at the core of the success of any decision. This is particularly true about strategic decisions. Strategic decisions are set apart from other kinds of decisions in ways that make the formulation of accurate assumptions about the future particularly vital – and particularly problematic.

Strategic decisions are important; they involve a significant commitment of resources and they are not easily reversible[7]. Strategic decisions are concerned with the long-term direction of an organisation and the scope of its activities[8]. Here, *long-term* is understood as the horizon at which many things are likely to have changed[9]. Assumptions upon which strategic decisions are based must therefore be valid over long periods of time. Because of the irreversibility of strategic commitments, invalid assumptions lead to irrecoverable losses. Perhaps because of the principal nature of strategy, there are numerous definitions of the term. In the broadest sense of the word, Johnson & Scholes (2002) defines strategy as follows:

"Strategy is the *direction* and *scope* of an organization over the *long-term*, which achieves *advantage* for the organisation through its configuration of *resources* within a changing *environment* and to fulfil *stakeholder* expectations.[10]" (Emphasis in original)

[7] Grant 1998:14
[8] Johnson & Scholes 2002:4
[9] Godet 1994:6
[10] Johnson & Scholes 2002:19

In other words, strategic decisions are the major decisions in the lifetime of an organisation. Strategic decisions define the organisation for what it is, and orchestrate all subordinate decisions towards common strategic objectives. Avoiding disaster by moving from drift to design is about strategic choice. In this sense, the role of strategic decisions moves beyond mere adaptation to current and future conditions, towards conscious pre-emption to promote desired future states and to avoid undesirable ones. But what future should the organisation design for itself, and what are the disasters to be avoided?

Wind turbine manufacturers are firms. This basic fact makes answering the above questions very simple. In the end, any business *must* design a future for itself in which it earns a rate of profit in excess of its cost of capital. Any future in which this basic premise is not fulfilled *will* eventually lead to disaster[11]. There are two principal types strategic decisions that must be made to meet this fundamental criterion: *corporate strategic decisions,* concerned with selecting an attractive industry in which to compete, and *business strategic decisions,* concerned with how to compete in the selected industry[12]. As the focus of this report is the competitive environment of the wind turbine industry, I will emphasise the role of business strategy rather then corporate strategy. As a consequence, I will not be concerned with the question of *whether or not to compete* in the wind turbine industry as opposed to other industries, but with the question of *how to compete* in the wind turbine industry once the first decision has been made.

From the point of view adopted in this report, strategic decision-making *is* the process of moving from drift to design, whereby disaster can be avoided. Any wind turbine manufacturer is forced to make strategic decisions about how to achieve competitive advantage – consciously or not. As we have seen, all such decisions rely on assumptions about the future competitive environment of the industry. Strategic success is determined by the validity of these assumptions and the way these are translated into strategic choice. In this sense, the answer to the research question is the formulation of a set of *valid strategic assumptions* about the future competitive environment of the wind turbine industry. This raises the question of how such assumptions are formed.

2.2 The role of learning and experience

Assumptions about the future competitive environment are ultimately the product of experiences gained and lessons learned in the past. New experiences lead to revised assumptions on which decisions are based. Following Sterman (2000), this process can best be described through the concept of *feedback*.

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[11] Grant 1998:19
[12] Grant 1998:52

Through the process of *single loop learning*, information about the state of the real world system[13] is compared to various strategic goals. Discrepancies are perceived between desired and actual states, and actions are taken that (are believed to) cause the real world system to move towards the desired state (see figure 2.2). If these initial decisions do not close the gap between the desired state and the real world, the process iterates around the loop again and decisions are revised[14]. In this sense, learning is a process of continuous feedback.

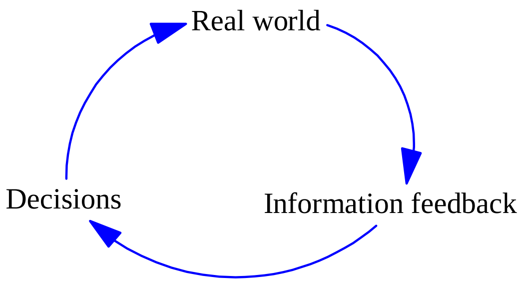

Figure 2.1: Single loop learning

Single loop learning is the simplest form of learning, and it represents the decision-making processes associated with *drift* as opposed to *design*, as it involves no strategy formulation in the complete absence of long-term assumptions about the future state (or states) of the system. Design, successful or not, involves assumptions to be made about the future and action to be taken upon these. In this view, assumptions, and the way these come about, can best be understood through the concept of *mental models*. Sterman (2000) defines mental models in the following way:

"[…] the term "mental model" includes our beliefs about the networks of causes and effects that describes how a system operates, along with the boundary of the model (which variables are included and which are excluded) and the time horizon we consider relevant – our framing and articulation or articulation of a problem.[15]"

When making decisions, our mental models govern the way we apply decision rule and policy to information about the world, as we perceive it[16]. As opposed to single loop learning, this is a two-way process, in which information feedback about the world fundamentally alters our mental models through *double loop learning* (see figure 2.2). When double loop learning occurs, our assumptions

[13] Although much of this discussion is beyond the scope of this report, the term 'real world', as it is used here, refers to the implicit assumption that a system of causes and effects exist independently of our perception of it. The term is thus used as an 'opposite' to perceived models; mental, conceptual, mathematical etc.
[14] Sterman 2000: 15
[15] Sterman 2000: 16
[16] At this point, it is necessary to develop a more precise terminology of systems. Following Fahey et al (1998:141), a system can be defined as a set of two or more interrelated elements of any kind. To further specify this definition I will use the term variables to describe the elements of a system. Following Neuman (2000:17), variables are defined by their ability to change between two or more values when influenced by other variables in a system. At any given time, the values of a variable are called its attributes. The interrelationships between variables consist of causal links through which a change in the attributes one variable directly causes a change in the attributes of another. Systems are thus composed of a network of causal links connecting their constituent variables (Sterman 2000:139). In this sense, strategic assumptions about the future are ultimately about the number of variables, physical, economic, technological or otherwise, and the interconnections between them, which we consider relevant to strategic decision-making.

about the world are revised in the sense that the same information input yields a different set of assumptions and lead to revised decisions. The rate of learning, and thereby the future validity of assumptions drawn from experience, is determined by the effectiveness of double loop learning. The effectiveness of each of the links shown in figure 2.2, determines how fast we cycle around the two loops relative to the rate at which changes in the real world render our existing assumptions obsolete[17]. Herbert Simon recognises the central role of mental models in strategic decision-making, stating that:

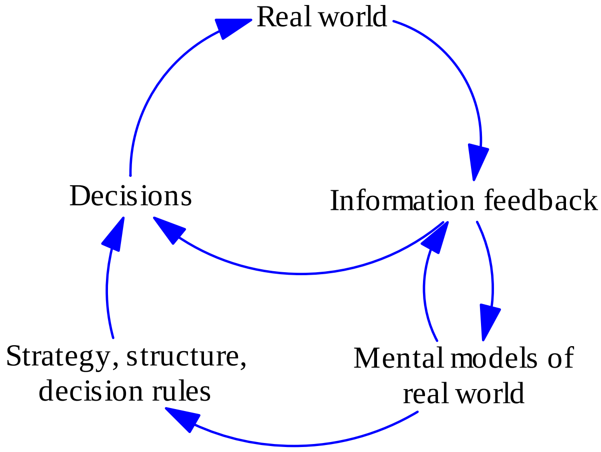

Figure 2.2: Double loop learning

"The intended rationality of an actor requires him to construct a simplified model of the real situation in order to deal with it. He behaves rationally in respect to this model, and such behaviour is not even approximately optimal with respect to the real world. [18]"

The validity of strategic assumptions, and thus the foundation of rational action, is determined by the ability of actors' *mental models* to mimic the operation of the real world system - a process whose importance cannot be overestimated. Diverging mental models are the source of heterogeneous outlooks upon, and expectations about, the future. Industry actors are only behaving rationally with respect to their mental models. But why is it so difficult to foresee the future state of the real world system and make accurate and homogeneous strategic assumptions?

2.3 The inherent uncertainty of complex problems

The problem of making accurate strategic assumptions over long time horizons falls into the class of problems known in decision science as *complex problems*, also termed *wicked problems*. The challenges posed by complex problems are well known in many areas of science. They have been encountered and described in various fields, such as systems theory (see Sterman 2000 and RAND 2003), theoretical math (see Casti 1990), futures studies (see Bell 2003), sociology (see Neuman 2000), game theory (see Camerer 2003) earth sciences (see Sarewitz *et al* 2000) and strategy (see Mercer 1998 and Heijden 1996). Consistent with this significant body of literature, it is possible to outline the major sources of uncertainty, connected to complex problems in strategic decision-making:

[17] Sterman 2000: 18
[18] Herbert Simon quoted in Sarewitz *et al* 2000:301

- *Combinatorial complexity:* Perhaps the most visible source of uncertainty encountered when making strategic assumptions is the accelerating rate of change and the increasing complexity in the environments surrounding decision-makers today. When making strategic decisions, a very large amount of variables must be considered at multiple levels of aggregation and over long time horizons. This gives rise to, what in systems theory is known as, *combinatorial complexity*. This type of complexity arises from large numbers of variables and interconnections in open systems[19] - in other words, most of the real world.
- *Dynamic complexity:* Strategic assumptions must include both the consequences of changes in an increasingly complex environment upon the success of strategic choices, but also the consequences of changes in the environment imposed by the strategy itself. In this sense, strategic assumptions must include several *feedbacks* between the strategy and the environment in which it is to play out. These feedbacks give rise to *dynamic complexity*, which can arise from relatively simple systems with low combinatorial complexity. The term *dynamism* accounts for the types and rates of change which can occur within the system regardless of the number of variables[20]. When feedback occurs, an initial change in a variable is fed back to itself through a number of mediating variables in a system. The initial change is then either balanced out or reinforced through the loop[21]. Through feedback, even very small changes in a variable can have a massive impact upon the state of the system as a whole. Vice versa, large changes in a variable can be completely absorbed by the system. This is also known as “policy resistance” (see Richardson 1991). The concept of positive and negative feedback will be further elaborated in Chapter 3.
- *Chaos:* A third source of uncertainty connected to strategic decision-making is *chaos*, also known as *sensitivity to initial conditions*. Chaos arises from the effects of multiple feedback loops causing dynamic complexity as described above. Because of feedback, however, even very small initial changes can be reinforced through the system causing radical shifts. This makes the *exact* initial condition of the system very important when attempting to foresee future outcomes. Strategic decision-making requires accurate assumptions about the *current state* of the situation. Even the smallest discrepancy between assumptions about the current state of the system and its actual state can multiply over time, making predictions about the future state of the system obsolete[22].
- *Self-altering prophecy:* The fourth major source of uncertainty is well known in the social sciences, studying sentient agents such as humans, organisations and societies. This is the

[19] Sterman 2000:21
[20] Fahey *et al* 1998:140
[21] Sterman 2002:12
[22] Casti 1990:53-76

problem of *self-fulfilling* or *self-negating prophecies*. These are situations in which the prophecy itself alters the conditions under which it is made[23]. This is particularly relevant in strategic decision-making where predictions made by a competitor might cause others to behave differently than they would otherwise have done, because of the prediction. This phenomenon is especially well established in game theory (see Camerer 2003).

Following Krauss (2005), complex problems set themselves apart from the problems often studied by conventional science[24] in that it is not possible, in advance, to definitively determine the relevant number of variables to consider - and thus *the boundary* of the system. Likewise, it is not possible to definitively determine the dominant relationships between the variables in the system - and thus *the structure* of the system[25]. Logically, this gives rise to two forms of ambiguity:

- *Ambiguousness of boundary:* The choice of the boundaries of a system determines what part of the real world is considered to be *inside* the system and what part of the real world is left out. The competitive environment of the wind turbine industry is an *open subsystem*, intricately connected to political systems, environmental systems, technological systems, etc. Any definite boundary drawn around such systems is entirely artificial and subjective.

- *Ambiguousness of structure:* Ambiguousness of structure refers to uncertainty about the variables, parameters and relationships that are used to describe a given phenomenon within the chosen boundaries of that system. Uncertainty about the structure of the system implies that several, equally legitimate, although partial, interpretations of the relevant relationships within the real world system can exist.

In reality, the *strategically relevant* boundaries and structure of the system constituting the competitive environment of the wind turbine industry are in a constant state of flux and cannot be permanently pinned down. As described in section 2.2 above, assumptions about the relevant boundary and structure of such systems are based on mental models built from past experiences with the operation of the system. The accuracy of these assumptions depends upon the speed and effectiveness of *double loop learning*, relative to the rate at which changes in the real world system render existing assumptions obsolete. As a consequence, there exists a plurality of different, equally legitimate and plausible perspectives on both the boundary and the structure of real world systems

[23] Bell 2003:229
[24] Conventional sciences is understood here as reductionist positivism.
[25] Krauss 2005:24-25

considered *relevant* to strategic decision-making and thus, when facing complex problems the following considerations apply[26]:

- There is not one problem, but a tangled web of related problems;
- The underlying processes interact with one another in some sort of hierarchy;
- The dynamics of the systems studied are not necessarily regular, but are characterised by synergistic and/or antagonistic relationships, indirect relationships, long delay periods between cause and effect, thresholds or non-linear behaviours;
- The issues lie across or at the intersection of many disciplines, i.e., it has economic, environmental, socio-cultural and political dimensions;
- There are a number of different equally legitimate and plausible perspectives on how the problem should be conceived.

It is clear that any assumption about the competitive environment of the wind turbine industry a decade from now will be subject to the major sources of uncertainty described above. This does not, however, mean that everything is equally unpredictable. Following Krauss (2005), a continuum containing several categories of uncertainty can be identified based on our knowledge (or ignorance as it may be) about the future operation of the system in which strategies are meant to play out:

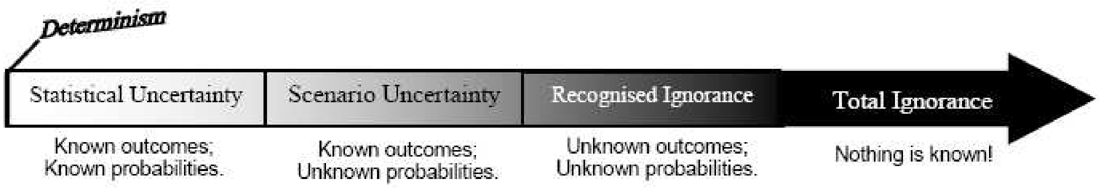

Figure 2.3: The levels of uncertainty (adopted from Krauss 2005:27)

Determinism refers to the situation in which everything is known exactly and with absolute certainty, while *statistical uncertainty* describes the situation in which there exist solid grounds for the assignment of discrete probabilities to each of a well-defined set of outcomes. Potential outcomes can be described as a finite set of discrete outcomes or a single continuous range of outcomes. *Scenario uncertainty* describes the state where all of the possible outcomes are known, but where it is acknowledged that there is no reliable basis for the assignment of probability distributions. *Recognised ignorance* describes the state where there are neither grounds for the assignment of probabilities, nor even the basis for defining a complete set of potential outcomes. *Total ignorance* is the other extreme opposite from determinism on the scale of uncertainty, to the extent that it is not

[26] See Krauss 2005:24-25

even known that knowledge is lacking[27]. In this view, uncertainty is a synonym for ignorance of the operation of the real world system.

Although these categories appear discrete, it is important to note that they are arbitrary points on a fluid continuum from absolute certainty to complete and unrecognised ignorance and thus total uncertainty. To the far left of the spectrum, we find what is often known in scenario planning as *trends, constants* or *predetermineds*. These can be *slow-changing phenomena* such as the growth of populations, *constrained situations* in which there is a limited number of outcomes, *processes already in the pipeline* such as the age of a 10 year old two years from now, or *inevitable collisions* such as the steady depletion of a finite resource[28]. Deterministic events, or events characterised by statistical uncertainty, can thus be defined as future events determined by a *known* number of variables whose future values can be assessed in the form of probabilities.

Scenario uncertainty is often termed *critical uncertainty*. Big strategic questions often fall under this category, as the vital importance of the question is often known, or at least knowable, but the answer is not[29]. Events characterised by scenario uncertainty can be defined as possible future events determined by a *known* number of variables but where the future values of these are *unknown*.

While some level of prediction or at least anticipation is possible in the case of statistical uncertainty and scenario uncertainty, this is not the case for recognised and total ignorance. The information is simply not in existence in the present. RAND (2003) uses the term *deep uncertainty* to describe the characteristics of such events[30]. While our ignorance about these events is partially recognised, it is impossible to assess the extent of our ignorance[31]. Events characterised by ignorance can be defined as future events determined by an *unknown* number of variables whose future values are equally *unknown*.

Based on this understanding of uncertainty, our ignorance about the future is not total. Our ability to make valid strategic assumptions about the future state of the real world system becomes a matter of degree, determined by our knowledge about the variables that condition the outcome of future events. As we extend the time-horizon, more and more events flow to the right along the continuum; from statistical uncertainty to scenario uncertainty, towards various levels of ignorance. In reverse, as we

[27] Krauss 2005:27-30
[28] Schwartz 1998:109-112, see also Heijden 1996:87, and Wack 1985:77
[29] Schwartz 1998:114-117, see also Heijden 1996:85-86 and wack 1985:77
[30] RAND 2003:24
[31] Krauss 2005:30

progress toward a future point in time, more and more events will move left from scenario uncertainty to statistical uncertainty while the events we are ignorant about will gradually be revealed to us as key strategic questions in form of scenario uncertainties. At any given point in time, our knowledge of the relevant variables and their interconnections and thus the future state of the system is thus incomplete.

2.4 Consequences for strategic foresight

This approach to strategic foresight has a number of methodological implications for answering the research question posed in this report. Closely related to the above considerations, answering the research question necessarily involves the explicit establishment of a number of *strategic assumptions* about:

1. The *relevant variables and interconnections* constituting the competitive environment of the wind turbine industry, taking into consideration the ambiguity of the boundary and structure of this system;
2. The impact of the *forces of change* upon the competitive environment over the coming decade, taking into consideration the various levels of uncertainty related to these;
3. The *strategic consequences* of a changing competitive environment for wind turbine manufacturers, taking into consideration the possibility of pre-emption, adaptation and early warning.

Corresponding to these *three major tasks*, this report has been divided into *three parts* addressing each one in turn:

<u>Part I</u> of this report will thus make explicit assumptions about the *relevant variables and interconnections* constituting the competitive environment of the wind turbine industry. Taking strategic theory as its point of departure, Chapter 3 will aim to establish and make explicit a number of initial theoretical propositions about competitive environments. Chapter 4 will then be concerned with grounding these generic propositions in empirical measurements and analysis specific to the competitive environment of the wind turbine industry. Finally, Chapter 5 will be concerned with assembling these propositions into an *explicit* and *internally consistent* single *integrated conceptual model* of the relevant variables and interconnections constituting the competitive environment of the wind turbine industry.

<u>Part II</u> will be concerned with identifying the major *known forces of change*, which are believed to shape the competitive environment of the wind turbine industry over the coming decade. Chapter 6 will aim to identify the major *predetermineds*, while Chapter 7 will be concerned with identifying the major *critical uncertainties* influencing the competitive environment of the wind turbine industry

over the coming decade. The integrated conceptual model constructed in Part I will form the basis against which the impact these forces upon the competitive environment of the wind turbine industry is systematically explored.

Part III of this report will be concerned with exploring the *strategic consequences* of a changing competitive environment for wind turbine manufacturers. Chapter 8 will thus be concerned with establishing a typology of the *strategic groups* of wind turbine manufacturers against which the *strategic consequences* of the known forces of change will be assessed, allowing adaptation and pre-emption. Subsequently, Chapter 9 will consider the *strategic consequence of deep uncertainty* along with the options for *early warning* of surprising events.

For ease of reference and readability, more specific theoretical and methodological considerations connected to each of these tasks are made in the chapters in which they are relevant.

- Part I -

Chapter 3: Understanding competitive environments

As the term is understood in the context of this report, *the competitive environment* is the environment with which wind turbine manufacturers interact competitively in order to fulfil the most basic premise of their existence: to earn a profit in excess of the cost of capital. Designing a future in which this basic premise holds true involves farsighted strategic decision-making. As we have seen, such decisions are inevitably based on strategic assumptions about the variables and the interconnections between them, which are considered *relevant* to strategic decision-making. This chapter will be concerned with identifying and making explicit the initial *theoretical propositions* about the relevant variables and interconnections constituting competitive environments. This will be done on the basis of *strategic theory*, suggesting how competitive environments should *theoretically* be constructed. These theoretical propositions will be made explicit through the construction of a number of *influence diagrams*.

3.1 The schools of strategy

In a Kuhnian sense[32], there is no single overarching theoretical paradigm in the field of strategic behaviour in competitive industry environments. Numerous opposing and complimentary schools of thought exist. The existence of multiple schools of thought reflects disputes about the relevant *boundaries* and *structures* of the systems constituting competitive environments. As described in the previous chapter, the complexity of these real world systems far surpasses that proposed by any theory. Additionally, the boundaries and structures of these real world systems are in a constant state of flux and differ from industry to industry and from time to time. The ability of any strategic theory to adequately describe the operation of such complex and diverse real world systems is therefore inherently limited. It is not possible to objectively identify the *relevant* boundary and structure of competitive environments and there are thus a number of different, equally legitimate and plausible perspectives on how the problem of strategic decision-making should be conceived. At the outset it must be realised that no strategic assumption can possibly contain them all.

Minzberg *et al* (1998) identifies ten major schools of thought in the field of strategy (see table 3.1 below). The *relevant* strategic school can only be determined with respect to the way the problem of strategic decision-making is initially framed in the research question posed in Chapter 1. It is in relation to this specific approach to the problem of strategic decision-making that considerations of relevance must be made.

[32] See Kuhn (1996)

Main focus:	Name of school:	View on strategy formulation:
How strategies *should* be formulated:	The Design School:	Strategy as conception
	The Planning School:	Strategy as formal process
	The Positioning School:	Strategy as analytical process
How strategies *are* formulated:	The Entrepreneurial School:	Strategy as visionary process
	The Cognitive School:	Strategy as mental process
	The Learning School:	Strategy as emergent process
	The Power School:	Strategy as negotiation
	The Cultural School:	Strategy as collective process
	The Environmental School:	Strategy as reactive process
Integrative approach:	The Configuration School:	Strategy as transformation

Table 3.1: Strategic Schools of Thought. Adapted from Minzberg *et al* 1998:5-6

The problem of strategic decision-making framed in the research question of this report must be characterised as *prescriptive* in that it is concerned with how strategies *should* be formulated rather than with how they necessarily *do* form[33]. It is the aim of this report to improve strategy formulation rather than to investigate how they are currently formulated. As illustrated in table 3.1, just three schools of thought adopt a prescriptive approach to strategy formulation: *the design school, the planning school* and *the positioning school*.

The design school emerged in the 1960s and laid the groundwork for the other two schools through its view of strategy as a process of informal conception. The planning school developed in parallel in the 1960s with its view on strategy as a systematic process of formal design. This school gave birth to *corporate planning* with its reliance upon linear extrapolation along with its predict-and-control paradigm, which was briefly mentioned in Chapter 1. The planning school peaked in the 1970s and was somewhat displaced in the 1980s by the third prescriptive school: the positioning school[34]. The positioning school retains many of the traits of the two previous schools. It applies the basic approach of the design school to the external industry environment and builds on the concept *strategy as design*. The procedures of the positioning school are closely related to those of the planning school in that it sees strategy formulation as a systematic and formal process[35]. The breakthrough of the positioning school can be traced directly to Michael E. Porter's *Competitive Strategy* published in 1980[36]. This seminal work formed (and still forms) the basis of the positioning school. In this work, Porter introduces the *Five Forces Framework*, aimed at explaining the function of competitive environments through the concept of *industry structure*, which is determined by the strength of the five determining forces.

[33] Minzberg *et al* 1998:5
[34] Ibid.
[35] Minzberg *et al* 1998:100
[36] Porter 1980

For the purposes of this report, I have chosen the positioning school as the theoretical basis for the initial assumptions about the variables and interconnections constituting competitive environments based on the following considerations:

- The positioning school is *prescriptive* in that it proposes ways in which to formulate strategy rather then investigating how strategies currently form.
- The positioning school sees strategy as *plan intended* and thus allows a forward-looking viewpoint. In this capacity, the positioning school is compatible with the notion of strategic foresight as a basis for *design*.
- The positioning school is concerned with *business strategy* and thus with the question of *how* to compete and thus falls within the scope of the problem addressed by this report.
- The focus of the positioning school is *industry-wide* seeking to explain the dynamics of multiple competitors rather than that of a single competitor.
- The positioning school is directly and explicitly concerned with *the competitive environment* of industries through its concept of *industry structure*.

As explained above, the ability of any strategic theory to describe the operation of the real world system is inherently limited. The Five Forces Framework of the positioning school is no exception. Following Minzberg *et al* (1998), several such limitations have been pointed out[37]:

- The positioning school is biased toward the role of *economic variables* rather than political variables (the critique of the power school);
- The positioning school is biased towards *matured and established industries* rather than newly forming industries (the critique of the entrepreneurial school);
- The positioning school is biased towards the *external environment* rather than internal capabilities (the critique of the cultural school);
- The positioning school emphasises *formal and detached strategy formulation* rather than personal learning and insight (the critique of the learning school);
- The positioning school is focused on choosing between *generic strategies* rather than the formulation of unique strategies (the critique of the cognitive school).

In many ways these limitations confirm the view of the differing schools of thought as equally legitimate, although inherently partial descriptions of the real world system. In the words of Minzberg:

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[37] See Minzberg *et al* 1998:112-121

"[…] the positioning school has not been wrong so much as narrow.[38]"

In essence, the main critique raised against the positioning school is *its inability to be the other schools*. What sets the positioning school apart from other descriptions of the competitive environment, are the variables and the interconnections between them, which it considers relevant to strategic decision-making. These in turn determine the boundary and structure of the model with which the theory seeks to describe the real world system.

As I will argue, the practice of strategic foresight in general, and the research question guiding the efforts of this report in particular, may nonetheless fit well into the 'narrow' focus of the positioning school. Firstly, competitors and industries alike are ruled by the *economic imperative*, stating that they must earn a rate of profit in excess of their cost of capital in order to survive. The bias of the positioning school toward economic rather than political variables may therefore be well warranted. Secondly, the wind turbine industry must, at this point in its development, be considered an *established industry* as opposed to a loose set of entrepreneurial ideas. Thirdly, identifying the forces, which are likely to affect this industry over the coming decade, necessarily entails adopting the broader view of the *external industry environment*, from where such forces are likely to origin, rather than that of a single competitor and its resources. And finally, accepting the notion - or perhaps ideal - of strategy formulation as a formal and detached process rather than an emotional and intuitive one, entails an optimistic - perhaps positivist - view of the ability of the strategist to 'decode the game' just well enough to give meaning to such concepts as *conscious pre-emption and design*. This is, in my view, both intrinsic to the value added through the practice of strategic foresight and the basis of any prospect of significant further advancement of this field inquiry beyond its current state.

In choosing the positioning school as a basis for understanding the competitive environment of the wind turbine industry, it is nonetheless important to recognize that the inherent limitations, which inevitably apply to the positioning school, will also apply to its description of the competitive environment of the wind turbine industry.

3.2 Making theoretical assumptions explicit

Any theory is essentially composed of a number of variables (usually termed *concepts*) and a network of causalities between them (usually termed *relationships*), with which the theory proposes to adequately describe a part of the real world[39]. In this respect, the positioning school is no exception.

[38] Minzberg *et al* 1998:112
[39] Neuman 2000:42-51

The five central concepts with which the positioning school seeks to describe the nature of competitive environments of industries are: (1) The threat of new entrants, (2) the intensity of rivalry among incumbents, (3) the pressure from substitute products, (4) the bargaining power of buyers and (5) the bargaining power of suppliers. The impact of these five forces constitutes the *structure* of the industry and thus the nature of its competitive environment[40]. From the viewpoint of *corporate strategy*, the collective strength of these five forces determines the ultimate *profit potential* measured as long-term return on invested capital in an industry, and thus the overall *attractiveness* of that industry[41]. From the viewpoint of *business strategy*, the five forces determine the ability of individual competitors to earn a profit above the industry average and thus the *nature of competition* in an industry. Whether a competitor earns a profit in excess its cost of capital is determined by its ability to create a *defendable position* against the five forces relative to its competitors[42]. The positioning school proposes an explanation for why some industries and competitors are more profitable than others and thereby which variables are to be considered *strategically relevant*.

From this point of departure, the first step in making explicit the initial theoretical assumptions about competitive environments is the identification of the *variables*, with which the positioning school seeks to describe competitive environments, thus defining the *boundary* of the real world system proposed by the theory. Variables, in the form of concepts proposed by the positioning school, were first and foremost identified from Porter (1980)[43], and supported by cooperating texts clarifying, and in some cases elaborating, the original theory. In addition to Porter (1980), these supporting texts included Porter (1985)[44], Grant (1998)[45], and Johnson & Scholes (2002)[46].

The identification of variables was centred on each of the central five forces and their determinants, as they were made explicit in the original theory and supporting texts. Variables were identified using an approach developed by Burchill and Fine (1997)[47]. Exemplifying this process, in the following quote, Porter (1980) describes the determinants of the intensity of rivalry between

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[40] Porter 1980 5-6
[41] Porter 1980:3
[42] Porter 1980:29
[43] The identification of variables from Porter (1980) was focused on the chapters directly concerned with the function and evolution of the competitive environments. These included: Chapter 1: *The structural analysis of industries*.
[44] The identification of variables from Porter (1985) was focused on Porter's elaboration of the five forces framework. This included Chapter 1: *Competitive Strategy: The Core Concepts.*
[45] The identification of variables from Grant (1998) was focused on Chapter 3: *Analysing the Industry Environment*.
[46] The identification of variables from Johnson & Scholes (2002) was focused in Part II: *Sources of Competition: The Five Forces Framework.*
[47] This approach was originally developed for variable identification from transcribed interview data, but in this context it was used to identify variables from Porter's original text.

competitors in an industry (one of the five forces constituting the competitive environment of industries):

"Intense rivalry[1] is the result of a number of interacting structural factors. […] Numerous or Equally balanced competitors[2]. […] Slow Industry Growth[3]. […] High Fixed or Storage Costs[4]. […] Lack of differentiation or Switching Costs[5]. […] Capacity Augmented in Large increments[6]. […] Diverse Competitors[7]. […] High Strategic Stakes[8]. […] High Exit Barriers[9]. […] Entry Barriers[10]. […].[48]"

Porter (1985) and Johnson & Scholes (2002) support these original nine determinants of intense competition[49], while Grant (1998) proposes six major determinants of the overall intensity of rivalry in an industry:

"Six factors play an important role in determining the nature and intensity of competition between established firms: concentration[1], the diversity of competitors[2], product differentiation[3], excess capacity[4], exit barriers[5], and cost conditions[6].[50]"

Grant (1998) further breaks down '*cost conditions*' into '*scale economies and the ratio of fixed to variable costs*[51]', elaborating upon the original nine determinants by adding three more. From these descriptions, a total of *fifteen* generic structural factors are proposed as determinants of intense rivalry among incumbent competitors (see table 3.2 below).

Following Sterman (2000), these original terms were modified and in some cases separated for the purposes of clarity. Variable names suited for influence diagramming should be *nouns* or *noun phrases* and must have a clear sense of *positive direction*. Moreover, as described in the definition of variables in Chapter 2; variables are defined by their ability to attain more then one value. Hence, variable names must indicate the possibility of an *increase* or a *decrease* in its value[52]. This should not alter the meaning or logic of the words as they are used in the context of the original theory, but rather capture the implicit logic proposed by the theory. The modification of the variable names identified in the above example is shown in table 3.2 below:

Structural determinants of intensity of rivalry			
Original concept name		**Modified concept name**	
1	Intense rivalry	1	Intensity of rivalry
2	Numerous or equally balanced competitors	2	Number of competitors
		3	Equality of competitor size and resources
3	Slow industry growth	4	Industry growth rate
4	High fixed or storage costs	5	Storage costs
		6	Fixed to variable cost ratio
5	Lack of differentiation or switching costs	7	Level of product differentiation

48 Porter 1980:17-23
49 See Porter 1985, Chapter 1 and Johnson & Scholes 2002:118
50 Grant 1998:61
51 Grant 1998:63
52 See Sterman 2000:152-153

		8	Buyers’ switching costs
6	Capacity augmented in large increments	9	Size of capacity augments
7	Diverse competitors	10	Diversity of competitors
8	High strategic stakes	11	Strategic stakes in the industry
9	High exit barriers	12	Height of exit barriers
10	Entry barriers	13	Height of entry barriers
11	Scale economies	14	Economies of scale in production
12	Concentration	15	Industry concentration ratio
13	Excess capacity	16	Excess production capacity

Table 3.2: Modifying variable names

The language of *influence diagramming* was used to illustrate the *direction* and the *polarity* of the interrelationships between the identified variables, again, in accordance with the original theoretical propositions. As an example, Porter (1980) describes the relationship between the industry growth rate and the intensity of rivalry between incumbent competitors in the following way:

“Slow industry growth turns competition into a market share game for firms seeking expansion. Market share competition is a great deal more volatile than is the situation in which rapid industry growth insures that firms can improve by just keeping up with the industry, and where all their financial and managerial resources may be consumed by expanding with the industry.[53]”

Following Burchill and Fine (1997), the *direction* and *polarity* of the relationship between the industry growth and the intensity of rivalry can thus be captured in the following expression:

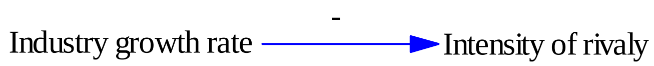

Figure 3.1: An example of a proposed relationship

The *direction* of the relationship is thus made explicit through the direction of the arrow from the *cause* variable (industry growth rate) to the *effect* variable (intensity of rivalry). The assignment of either a positive or negative *polarity* indicated by a ‘+’ or a ‘–’ respectively illustrates the *nature* of the relationship between the two variables. Following Sterman (2000), the implications of polarities can be defined as follows[54]:

- A *positive* causality between two variables means that if the cause **increases**, the effect **increases** *above what it would otherwise have been*, and if the cause **decreases**, the effect **decreases** *below what it would otherwise have been* (see figure 3.2a)
- A *negative* causality between two variables means that of the cause **increases**, the effect **decreases** *below what it would otherwise have been*, and if the cause **decreases**, the effect **increases** *above what it would otherwise have been* (see figure 3.2b).

It is important to note that the polarity of the causalities between the variables describe the *structure* of the system, not the *behaviour* of the variables. That is, they describe what would happen **if** there were a change. In addition, note the phrase ‘*above (or below) what it otherwise would have been*’ in

[53] Porter 1980:18
[54] Sterman 2000:139

the definition of polarities. A change in a cause variable does not necessarily mean a *net* change in the effect variable; only a *gross* change because more than one causality might be influencing the effect variable.

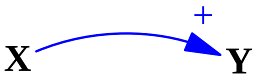

Fig. 3.2a

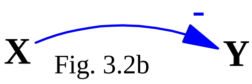

Fig. 3.2b

In this sense, the causal relationships between the identified variables should be seen as *hypothetical propositions*, meaning that they are theoretical statements that specify the connection between the variables informing us how variation in one concept is accounted for by variation in another, *all else being equal*[55]. This form of *ceteris paribus* experimentation is a central feature of causal diagramming.

In addition, a central part of the language of influence diagramming is its ability to capture the logic of *feedback loops*. The concept of feedback was briefly touched upon in Chapter 2. Feedback occurs when an initial change in a variable is fed back to itself through one or more relay variables. When this occurs, the initial change can either be reinforced or balanced out through several iterations around the loop. If the initial change is amplified through the loop, it is called a ‘reinforcing’ or ‘positive’ feedback loop. Conversely, if the initial change is cancelled out through the loop, it is called a ‘balancing’ or ‘negative’ feedback loop. Reinforcing feedback results in exponential growth (or decline) as the initial change is continuously reinforced while balancing feedback loops are goal seeking, striving to achieve a state of equilibrium as the initial change is decreased through the loop[56]. The existence of feedback loops does not imply that they work without restraints imposed by the system in which they operate. Exponential growth will eventually level off as limiting mechanisms compensate while states of equilibrium can be disturbed, causing overshoot and oscillation. In this respect it is important to see feedback loops as part of the system in which they operate. As described in Chapter 2, all dynamics arise from the interaction of these two kinds of loops[57]. Several feedback loops were identified in the relationships between the variables determining the five forces. The following proposition from Porter (1980) exemplifies a *balancing feedback loop* in which an initial change in the profitability of an industry is cancelled out through negative feedback:

“The threat of entry into an industry can be eliminated if incumbent firms choose or are forced by competition to price below [the entry deterring price]. If they price above it, gains in terms of profitability may be short-lived because they will be dissipated by the cost of fighting or coexisting with new entrants.[58]”

[55] Neuman 2000:47
[56] Sterman 2000:108-113
[57] Sterman 2000:12-13
[58] Porter 1980:14

Following Burchill and Fine (1997), in the language of influence diagramming, the logic of this statement can be captured in the expression illustrated in figure 3.3. This balancing loop captures the way in which industry profitability is kept in check by the threat of new entrants. An initial change in

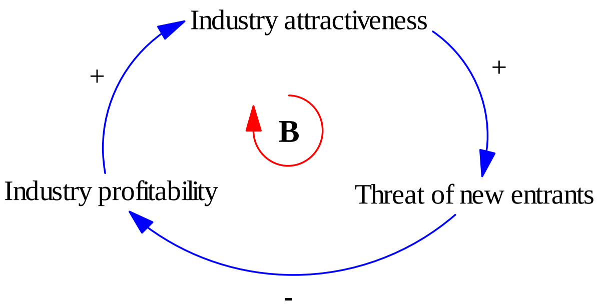

Figure 3.3: An example of a balancing feedback loop

the profitability of the industry is balanced out through the loop and equilibrium is found. As it can be imagined, more explanatory variables could be added to this basic diagram, but in its current form, it captures the essential meaning of the theoretical proposition. Here, the balancing feedback loop is indicated by circular arrow surrounding a '**B**'. Conversely, reinforcing loops will be indicated by an '**R**'. This practice will be exercised throughout this report.

Using Vensim PLE[59], the relationships between the identified variables were made explicit through the development influence diagrams for each of the five forces, showing the relationships between these and their determining variables in accordance with the original theoretical propositions as described above. These are illustrated in figure 3.4 to 3.8 below. Note that nature and significance of the individual variables are elaborated in appendix A related to Chapter 4.

Causal diagrams like the one above will be dotted throughout this thesis and forms the analytical backbone of my chain of reasoning. They are, however, presented as *exhibits* and do not need to (but can) be 'read' in any great detail to understand the message of this report. I have taken care to comment on the substance conveyed by these diagrams as they are presented.

The first force: The threat of new entrants

The *entry barriers* that a potential entrant must overcome to enter an industry along with the *expected reaction* of incumbent competitors determine the immediate threat level posed by would-be entrants. Porter (1980) sums up this balance through the concept of the *entry deterring price* - the price which just balances the potential rewards from entry with the expected cost entering the industry[60].

[59] This modelling program is freely available from www.vensim.com.
[60] Porter 1980:14

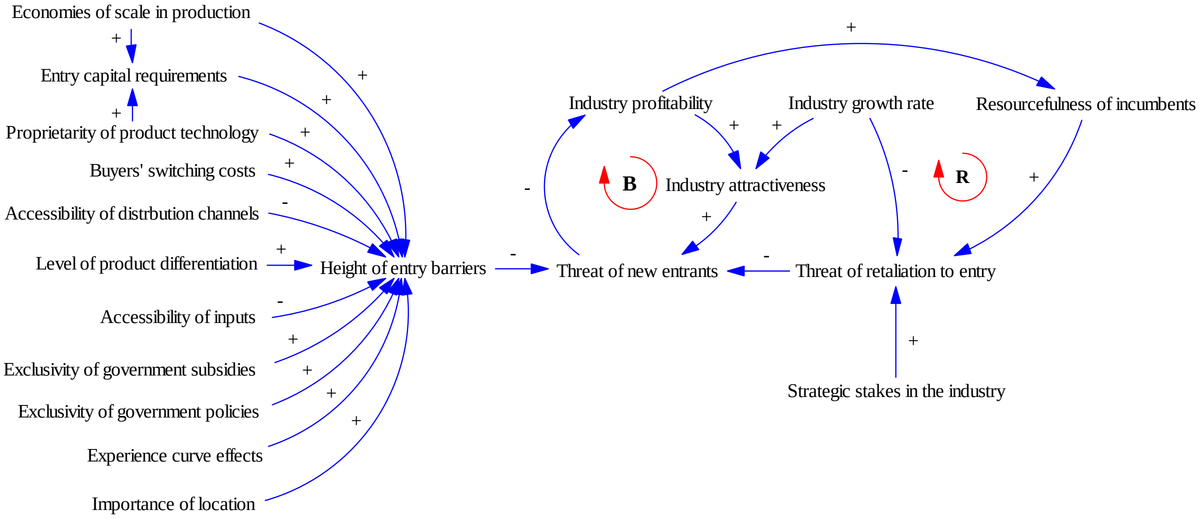

Figure 3.4: The determinants of the threat of new entrants

As figure 3.4 illustrates[61], a large number of variables determine the threat posed by potential new entrants into an industry. The variables determining the height of entry barriers are displayed on the left side of the diagram, while the determinants of the threat retaliation to entry posed by incumbents are displayed on the right. As it can be seen, the threat posed by new would-be entrants is determined by a careful balance between what potential entrants stand to gain from entering the industry and the barriers they must overcome to do so. In this way, the threat of new entrants imposes a limit upon the overall profitability of an industry. Should profitability rise to significantly higher level than that of comparable industries, the potential rewards for entry into the industry will surpass the cost of surmounting entry barriers and new competitors will flock to the industry, eventually competing down profitability. As described in the example above, this is illustrated by the balancing feedback loop between the threat of new entrants, the industry profitability and industry attractiveness. The reinforcing feedback loop illustrates how the overall profitability of the industry increases the resourcefulness of incumbents and that this in itself is a determinant of the threat of retaliation to entry they pose to new entrants. Naturally, potential entrants are not only drawn to industries, which are currently profitable, but also by expectations about future profitability. This is captured by the influence of the industry growth rate upon the overall attractiveness of the industry[62]. Notice also the how proprietarity of product technology and economies of scale are the main drivers behind the overall entry capital requirements faced by entrants[63]. Again, it is possible to imagine that many more explanatory variables could be included, but the above diagram adequately seems to capture the essence of the theoretical proposition.

[61] Notice that all polarities are indicated by a '+' or a '-' *above* the arrow. This practice will be exercised throughout this report.
[62] Porter 1980:14
[63] Johnson & Scholes 2002:114

The second force: The intensity of rivalry

Intense rivalry between incumbent competitors significantly drives down industry profitability as competitors' margins are spent on price wars, advertising and jockeying for position within the industry. As illustrated on figure 3.5, the intensity of rivalry in an industry is determined by the interplay of several variables increasing or decreasing the intensity of rivalry.

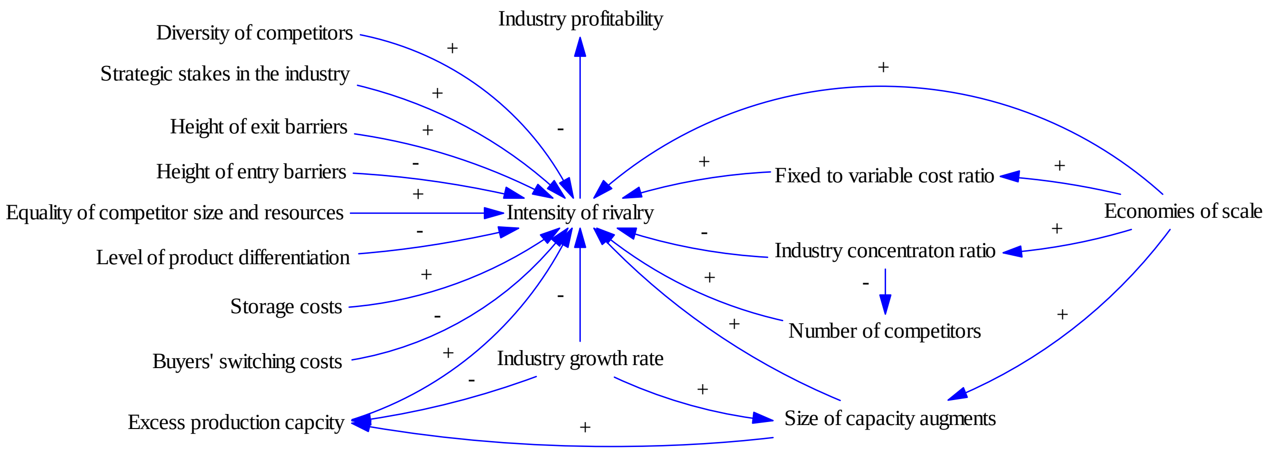

Figure 3.5: The determinants of the intensity of rivalry

As already described in the example of variable identification and clarification above, several variables were added from Grant (1998) to those originally proposed by Porter (1980). These included *level of product differentiation*, *economies of scale*, *industry concentration ratio* and *excess production capacity*[64]. Notice here the central role of economies of scale. In addition to being a direct determinant of the intensity of rivalry, this variable also influences the fixed to variable cost ratio and the industry concentration ratio[65] along with the size of capacity augments, which in turn influences the excess production capacity. Notice also how the industry growth rate influences the excess production capacity and the size of capacity augments[66].

The third force: The competitiveness of substitutes

Competitors in an industry are not only competing amongst themselves within the boundaries of a particular industry. In the broader scope, they are competing against any product capable of performing the same *function*, *need* or occupying the same *product category* as the product of that

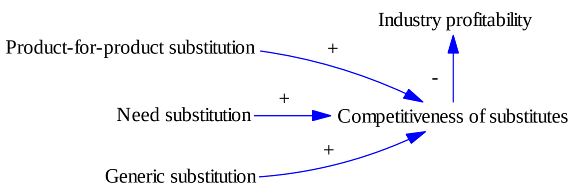

Figure 3.6: The determinants of the competitiveness of substitutes

[64] See Grant 1998:61
[65] See grant 1998:63
[66] See Porter 1980:19

particular industry. The competitiveness of substitutes thus limits the overall profitability of an industry in that margins earned by incumbents cannot exceed the point at which buyers' preferences switch to a substitute[67]. Note that the original description in Porter (1980) was elaborated from Johnson & Scholes (2002), differentiating between three separate forms of substitution as illustrated in figure 3.6 above[68].

The fourth force: The power of buyers

The power of buyers determines the ability of an industry's customers to demand lower prices and/or better quality from incumbents along with their ability to play competitors against each other, squeezing the margins and lowering the overall profitability of the industry. As illustrated on figure 3.7 below, the power of buyers is determined by their price sensitivity and their relative bargaining power. This structure is a partial elaboration of Porter (1980) from Grant (1998), suggesting these two mediating and explanatory variables through which Porter's determinants influence the power of buyers. Likewise, Grant (1998) suggests the *intensity of rivalry* among incumbents as a further determinant of buyers' price sensitivity[69].

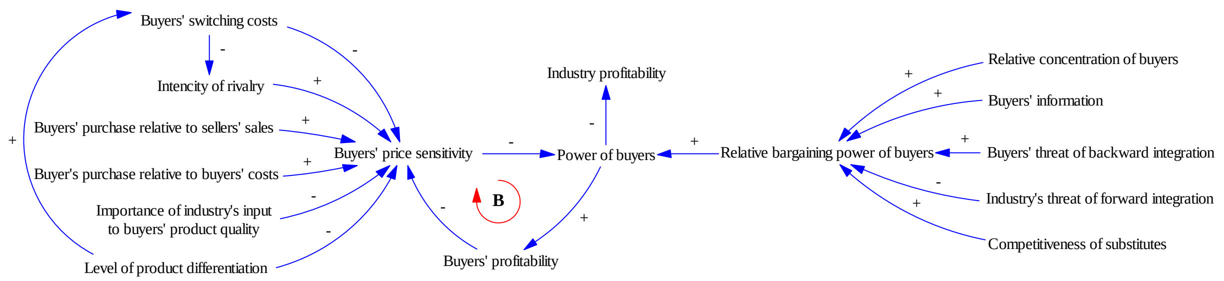

Figure 3.7: Determinants of the power of buyers

Buyers exercise their power to secure a greater part of the value added through the industry's production chain, thus increasing their own profitability. As the buyers' profitability is in itself a determinant of their price sensitivity, this creates a balancing feedback loop as illustrated above. This loop illustrates that the added power which buyers obtain through exercising price sensitivity eventually increases their profitability, thus making them less price sensitive *all else being equal*. Conversely, the added power forgone by buyers not exercising price sensitivity will eventually decrease their profitability, again raising their emphasis on price *all else being equal*. The loop thus seeks equilibrium. Notice also the interconnections between the determinants of price sensitivity in

[67] Porter 1980:23
[68] See Johnson & Scholes 2002:115-116
[69] See Grant 1998:63-64. Porter likewise proposes price sensitivity along with buyers' profitability as a source of buyer power (Porter 1980:25)

which the industry's level of product differentiation influences buyers' switching costs[70] which in turn influence the intensity of rivalry among incumbents[71].

The fifth force: The power of suppliers

Like buyers, powerful suppliers can exert their power over an industry through raising prices and/or lowering quality of their products to raise their own profitability. As illustrated in figure 3.8, the determinants of the power of suppliers are equivalent to those determining the power of buyers, capturing the fact that, to its suppliers, an industry is a buyer and that its power as a buyer represents one of the five forces in the suppliers' industry. As above, I adopt the mediating variables *industry's price sensitivity* and *relative bargaining power of suppliers* from Grant (1998).

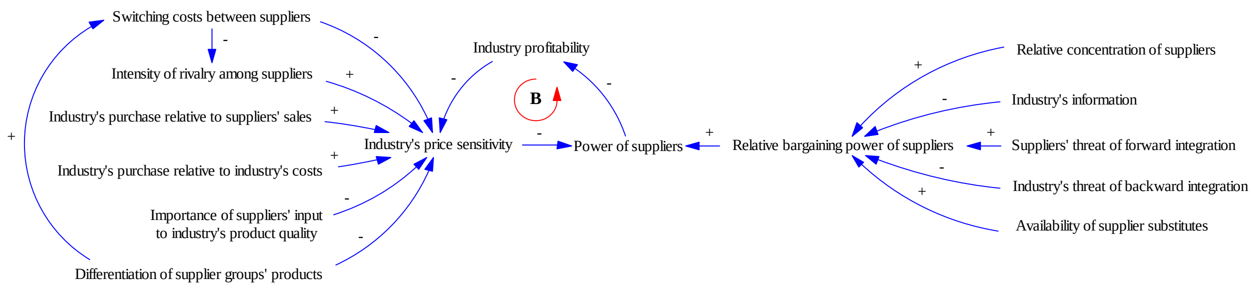

Figure 3.8: The determinants of the power of suppliers

The balancing feedback loop between the power of suppliers, industry profitability and industry's price sensitivity is the inverse of the balancing loop identified in the theoretical proposition about the power of buyers. The loop illustrates that the added power which industries obtain through exercising price sensitivity eventually increases its profitability, thus making it less price sensitive *all else being equal*. Conversely, the added power forgone by industries not exercising price sensitivity will eventually decrease their profitability, again raising their emphasis on price *all else being equal*. Notice that to its suppliers, an industry is in itself a buyer. For this reason the above diagram is consistent with the diagram developed for the power of buyers.

3.3 From words to diagram

Identifying and making explicit the theoretical assumptions of the positioning school through influence diagrams is essentially a process of *translation* of the proposed variables and their relationships expressed in *words*, into logically consistent *influence diagrams*. Like most theories outside of the natural sciences, the variables and causalities proposed by the positioning school are expressed in *inexact words* rather than *exact mathematical equations*. As we shall see, this is a

[70] See Porter 1980:9
[71] See Porter 1980:19

necessity arising from the inherent uncertainty and variability of the type of systems the theory seeks to describe.

Describing the total number of variables and relationships constituting competitive environments is a daunting task. This number is astronomical and as described in Chapter 2, it is not possible to objectively define the boundary and structure of such systems. To adequately describe systems of such extreme levels of combinatorial complexity, any description must necessarily be limited to a sufficiently high *level of abstraction*. In this sense, the level of abstraction can be thought of as a continuum from the most concrete to the most abstract. The most concrete concepts refer to measurable variables of physical objects (height, age, weight, etc.), while highly abstract concepts refer to variables that we do not directly observe (bargaining power, intensity of rivalry, speed of technological development, etc.) [72].

As a direct consequence of high levels of combinatorial complexity, the description of the system proposed by the positioning school is raised to a sufficiently high level of abstraction, in essence aggregating whole subsystems composed of variables at lower levels of abstraction. In doing so, the theory reduces combinatorial complexity to manageable levels, while remaining relevant to the problem under study – in this case, the profitability of industries and firms. The relevant variables and relationships proposed by the theory are therefore only able to describe the operation of the real world system at the level of abstraction considered relevant by the theory. Also, the high level of abstraction imposes serious limitations on the possibility of quantification. As it is clearly evident from the highly abstract variables illustrated in figures 3.4 to 3.8 above, these are aggregations of numerous variables at lower (and more measurable) levels of abstraction. In essence, there is no single '*unit'* in which the values of highly abstract variables can be adequately expressed. For this reason, the positioning school is limited to expressing its variables and causalities in the inexact language of words rather than in the exact language of math.

Following Goodman, influence diagramming, as it is used here, constitutes a *language* with its simple set of 'syntactical' rules in which complex issues can be expressed[73]. Influence diagramming is a language significantly *more* precise than that of English although significantly *less* precise than that of math. Influence diagramming of the theoretical variables and causalities thus holds the opportunity to use a more exact language than the one in which theory was originally expressed. By not aspiring to mathematical exactness, influence diagrams make a trade-off between being able to say '*what*' at the cost of being able to say '*how much*'. Influence diagrams are thus able to indicate a

[72] Neuman 2000:43
[73] TST 2006

change in the form of an increase or decrease, but can only indicate the size of this change qualitatively. By making this trade-off, influence diagramming bypasses the problem of quantification of highly abstract variables faced by mathematical models, while retaining the ability to capture the logic of complex problems in an explicit and consistent manner. This ability will be further explored and exploited in subsequent chapters.

3.4 From theory to empery

The theoretical assumptions about competitive environments expressed in the influence diagrams developed above do not constitute a valid description of the competitive environment of the wind turbine industry. These theoretical propositions are *generic* in that the variables and relationships proposed are meant to describe how *competitive environments* should theoretically be constructed. They are not specific to the unique conditions of any *specific* competitive environment. It cannot therefore be assumed that variables and causalities proposed here are able to mimic the operation of the real world system even at the high level of abstraction proposed by the positioning school. This problem will be addressed in the following chapter where the theoretical assumptions developed here will be empirically grounded in the unique context of the competitive environment of the wind turbine industry.

- Part I -

Chapter 4: The competitive environment of the wind turbine industry

The competitive environment of any industry is unique. This is no less true about the wind turbine industry. A wind turbine is in itself a production technology, producing a highly politically charged and increasingly demanded product: electricity. Obviously, theoretical propositions based on a generic theory are unlikely to adequately describe the operation of the competitive environment of such an industry in the absence of empirical grounding. The aim of this chapter is to ground theoretical assumptions about the competitive environment developed in empirical measurements and analysis of the operation of the competitive environment *specific* to that of the wind turbine industry.

4.1 The wind turbine industry

The aim of the Five Forces Framework of the positioning school is to describe the *structure* of an industry, which determines the nature of competition and thus the *competitive environment*. A relevant initial question in this regard is whether the wind turbine industry can be considered a single industry. Significant attention has been given to this topic in strategic literature[74].

An *industry* can be defined as a group of firms supplying a market. Hence the key to defining industry boundaries is defining the *relevant market*. The boundaries of markets are in turn defined by *substitutability of products*, both on the demand and supply side. The same considerations apply to defining whether the wind turbine industry is a single global industry or a series of nationally distinct industries. The former is true if customers are willing and able to substitute turbines available on different national markets, and/or if manufacturers are willing and able to divert their output among different countries to take account of different margins[75].

When looking at the wind turbine industry, it is clear that this form of substitution is present in both supply and demand, and has been, for quite a number of years. On the demand side, wind turbine buyers are indeed capable of substituting turbines on different national markets, taking advantage of differing margins, whereas suppliers are equally capable of diverting their output among different markets[76]. This form of substitution must be considered paramount to the nature of the competitive environment of the industry. A global view of the competitive environment of the wind turbine industry does not entail the assumption that national and regional differences in supply and demand

[74] See Grant 1998 and Johnson & Scholes 2002
[75] Grant1998:69-70
[76] BTM 2005a:17-19

does not exist. Rather, it assumes that the overall structure of competitive environment of the wind turbine industry as a whole is the *aggregated product* of such differences. Also, the global industry environment seems the appropriate perspective for strategic considerations over extended time horizons as long as a decade. Based on these considerations, the wind turbine industry will be considered as a *single global market supplied by a single global industry*.

Adopting this perspective, the global wind turbine industry currently employs in the vicinity of 120,000 people worldwide with an estimated annual turnover in excess of €12 billion. It is the fastest growing energy technology industry in the world with an annual growth rate of more than 30% over the past 8 years[77]. Continued growth over the coming five years is estimated at around 15-20% annually[78]. Germany and Spain are the key markets, accounting for 75% of the annual growth experienced by the industry up until today[79]. In excess of 85,000 turbines are installed worldwide, with a total capacity of around 58,000 MW, meeting the electricity demand of some 25 million households. As a whole, the industry is concentrated in Europe, where 70% of this capacity is installed[80].

On the supply side, the business models of wind turbine manufactures vary significantly. Depending on their level of integration, manufacturers are to varying degrees active across the following five vertical activities: component manufacturing, turbine assembly, project development, service and maintenance and to a lesser extent; project ownership and operation[81]. Although the term 'wind turbine manufacturer' includes highly diverse business models, in the context of this report, wind turbine manufacturers will be defined as *firms supplying grid connectable wind turbines to the global wind turbine market.*

The competitors performing these activities are highly concentrated around five major suppliers with a total market share of some 85-95%. The major players[82] are: Vestas (DK), Gamesa (ES), Enercon (GE), GE Wind (US) and Siemens (GE/DK)[83]. At year-end 2004, these five suppliers held a total market share of 85.5%[84]. The industry is thus highly oligopolistic[85]. In addition to these major

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[77] EREC 2006
[78] Morgan Stanley 2005:11
[79] Morgan Stanley 2005:11
[80] EREC 2006
[81] Danske Equities 2003:8-12
[82] What is considered a 'major player' by the industry itself is based not only on current market share, but also on their potential for gaining more. Siemens currently holds a market share of only 6.2%, but is still considered 'major' because of its competitive potential.
[83] Morgan Stanley 2005:10
[84] BTM 2005a:16
[85] Morgan Stanley 2005:7

internationalised and internationalising players, a host of smaller manufacturers exist; none with a market share in excess of 4%. The smaller manufacturers are highly dependent upon single national markets where several hold prominent positions[86].

4.2 Grounding theoretical propositions

In grounding the theoretical propositions developed in the previous chapter, I have drawn extensively upon empirical studies and other industry literature covering analysis, empirical measurements, observations and assessments about the competitive environment of the wind turbine industry. The variables and interconnections suggested by the theoretical propositions developed in the previous chapter formed the framework guiding a desk study of existing industry literature[87]. Through the proposed variables and their relationships, the theoretical propositions suggest empirical information, which is initially relevant to understanding competitive environments as described in Appendix A. The process of grounding the theoretical assumptions will focus on achieving the following two principal tasks:

1. *Excluding* variables and relationships suggested by the positioning school, which are *non-existent* in the unique context of the competitive environment of the wind turbine industry.
2. *Including* relevant variables and relationships not suggested by the positioning school, which are *unique* in the context of the competitive environment of the wind turbine industry.

In this sense, the empirical grounding of the theoretical propositions is a significantly *less rigorous* process than empirically testing the proposed causalities through linear regression analysis and establishing mathematical relationship coefficients. As described in Chapter 3, the high level of combinatorial complexity imposes serious limits upon the possibility of such quantification. Grounding is thus a process of empirically eliminating, validating and modifying the theoretical propositions to suit the specific conditions of the wind turbine industry. The grounded propositions developed in this chapter can thus be considered *empirically informed but not empirically tested.*

In the following, I will consider each of the five structural forces and their determining variables in terms of their influence upon the competitive environment of the wind turbine industry. The systematic investigation of each variable can be found in appendix A.

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[86] BTM 2005a:16-19

[87] The desk study initially identified a 'core body' of industry literature by a number of consultants and observers of the industry such as BTM Consult, Danske Equities, Morgan Stanley and Carnegie Securities Research along with The International Energy Agency. Using these sources, the identified variables were assessed in terms of their relevance and effect upon the competitive environment of the wind turbine industry. The variables not addressed in the core literature formed the basis of lines of enquiry into more specialised literature and empirical studies such as Takeuchi and Ancona & McVeigh, addressing the relevance and effect of more specific variables proposed in Chapter 3.

4.3 The first force: The threat of new entrants

From the investigation of the variables determining the height of entry barriers, it is clear that the entry barriers that a potential entrant must overcome to enter the wind turbine industry are extremely high. Economies of scale force potential entrants to enter *in force*, considerably increasing the height of entry barriers, capital requirements and financial risks[88]. Opportunities for entry are further limited by proprietary of product technology and both tangible and intangible switching costs, linking buyers of wind turbines to incumbent manufacturers. In addition, the desk study revealed that accessibility of inputs is a significant entry barrier around incumbents, as reliable component manufacturers with sufficient capacity are scarce[89].

These factors make buying an existing manufacturer the most plausible route of entry into the wind turbine industry, offering the opportunity to gain direct access to technology and a proven track record of previous successful wind turbine projects. This mode of entry is nonetheless a risky venture. Warranty provisions issued by incumbents extend as far as 10-12 years into the future. The extent to which an incumbent is bound by such obligations - along with their ability to meet them - is largely unknown to a potential buyer of an incumbent manufacturer. Warranties could therefore lead to substantial compensation claims and thus present an unknown level of financial risk to potential entrants[90].

In addition, competitors in the wind turbine industry must generally be considered highly resourceful and pose a credible threat of forceful retaliation. Major manufacturers have significant long-term strategic stakes this high-growth and high-expectation industry. This would indicate that incumbents pose a highly credible threat of retaliation to potential entrants. However, in light of the current and expected growth rate, which has turned part of the global wind turbine market into a seller's market[91], the impact of a new competitor entering the industry through buying an incumbent may not warrant such costly retaliation - at least not while the industry growth rate remains sufficiently high.

A further factor discouraging entry into several national markets is various forms of protectionism, such as domestic manufacturing content requirements, preferential tax breaks, exclusive or preferential access to national R&D funds, favourable treatment by planning authorities and political contacts[92].

Although the entry barriers to the wind turbine industry are significant, recent history shows that they are not high enough to eliminate the threat from potential new entrants. The central theme of entry into the wind turbine industry has thus far been large diversified utility companies integrating

[88] Danske Equities 2003:14-16
[89] Takeuchi 2003:44
[90] Stephen Rammer, analyst, Handelsbanken in Berlinske Tidende, February 2006
[91] Carnegie Securities Research 2005:3
[92] See e.g. CRS 2006

backwards into wind turbine manufacturing, bringing with them significant financial and technological resources. The entry of General Electric through the acquisition of Enron Wind Corp in 2002, and the entry of Siemens through the acquisition of Bonus Energy in 2004 are recent examples[93]. BTM Consult foresees a continuation of this pattern over the coming years[94]. It is unclear whether outsiders will purchase more incumbents in the near future, but stock market speculation about the potential takeover of Vestas Wind Systems by Royal Dutch/Shell reappeared as late as February of this year (2006). With Vestas being the only major single-business manufacturer in the industry, this company takes up a special position with regard to outside purchase. Although analysts question the validity of these rumours, speculation remains[95]. In spite of significant entry barriers, recent examples of successful entry into the industry exist, and as the industry consolidates and the technology matures, the threat of entry into the industry remains substantial[96].

Based on the investigation of the determining variables, the theoretical assumptions about the threat of entry developed in the previous chapter are modified as shown in figure 4.2 below:

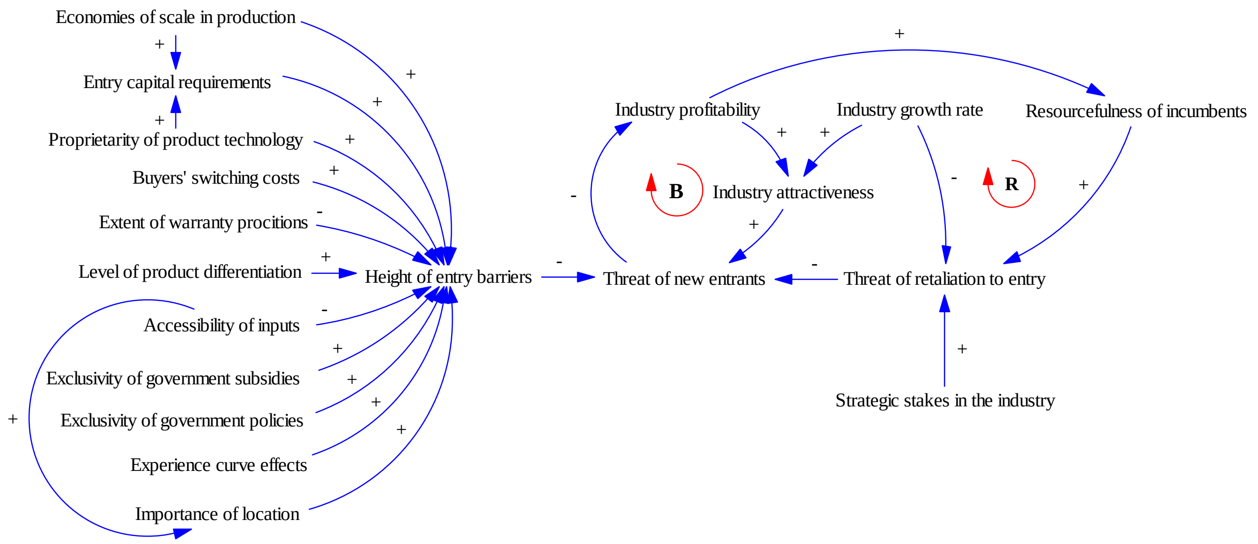

Figure 4.1: Empirically grounded determinants of threat of new entrants

In accordance with the investigation of the significance of the individual variables described in appendix A, the following changes were made to the theoretical propositions developed in the previous chapter. Firstly the variable *Accessibility of distribution channels* was eliminated as a determinant of the height of entry barriers. As described in appendix A, project developers are the only occasional intermediaries between wind manufacturers and the final owners of wind projects, and in this role, they are not markedly different from other large buyers of wind projects. Secondly,

[93] DWIA 2006
[94] BTM 2005a:20
[95] Jakob Risom, Berlinske Tidende, February 2006
[96] BTM 2005a:20

the variable *Extent of warranty provisions* was included as a significant determinant of the height of entry barriers as warranty provisions significantly raises financial risk of entry as described in appendix A. Finally, a relationship was added between *Accessibility of inputs* and *Importance of location*, as transport costs and the increasing necessity of close development partnerships between wind turbine manufacturers have become increasingly significant.

4.4 The second force: The intensity of rivalry

It is striking how many variables determining the intensity of rivalry among incumbent manufacturers remain latent because of high industry growth. Annual growth rates in excess of 30% over the past eight years[97] and expected growth rates of 15-20% over the coming five years[98] have significantly limited the intensity of rivalry in several major markets. Among the latent sources of intense rivalry are potentially high exit barriers, high fixed to variable cost ratios, large capacity augments, high storage costs along with the potential for significant excess production capacity. These are all significant triggers of intense competition in low-growth industries, as described in appendix A. In addition, the intensity of rivalry among manufacturers is further kept in check by a limited number of highly concentrated competitors protected by substantial entry barriers described above.

In spite of high industry growth, current levels of rivalry is spurred by the absence of a clear market leader to direct competition and the relative equality in terms of size and resources of the largest manufacturers - as least in terms of resources dedicated to wind turbine manufacturing[99]. Because of favourable market conditions, the intensity of rivalry in the wind turbine industry generally remains moderate. However, the economic structure of the industry would indicate that should the industry growth rate decline; the intensity of rivalry would be fierce as many of the latent variables are likely to step into force.

[97] EREC 2006
[98] Morgan Stanley 2005:11
[99] Danske Equities 2003:16

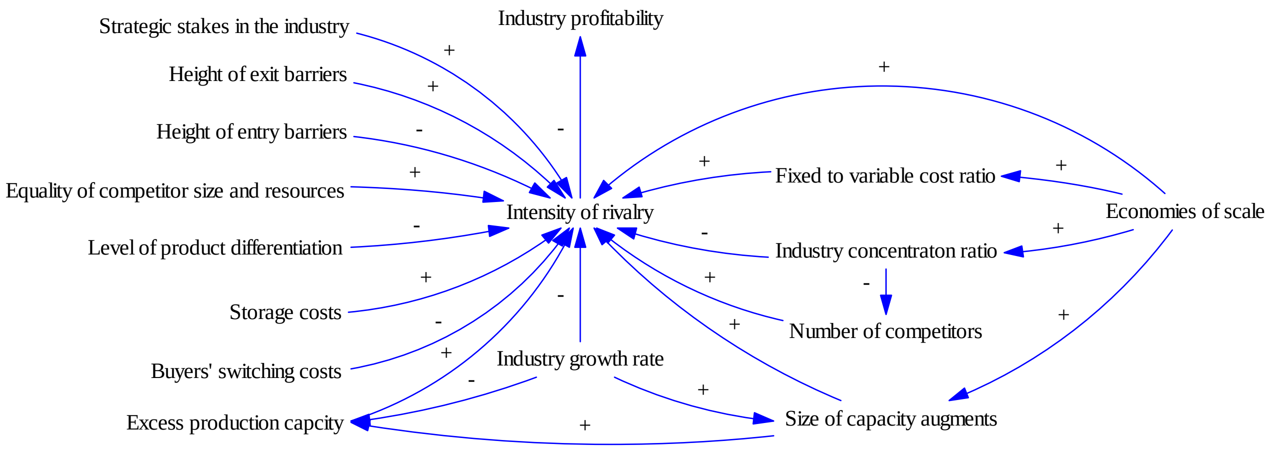

Figure 4.2: Empirically grounded determinants of intensity of rivalry

Based on the investigation of the determining variables, the theoretical assumptions about the threat of entry are thus modified as shown in figure 4.2 below:

As illustrated on figure 4.2 above, empirical evidence could be found supporting the relevance of most of the determinants of intense rivalry suggested by the positioning school. With the exception of the effect of *Diversity of competitors* upon the intensity of rivalry between incumbents for which no empirical evidence could be found, the investigation of the determinants showed that the theoretical proposition developed in the previous chapter seems to adequately describe the determinants of intense rivalry among incumbent wind turbine manufacturers.

4.5 The third force: The competitiveness of substitutes

Wind technology is only one amongst a wide range of renewable energy technologies, which in turn is part of a still wider range of energy technologies, constituting the total energy *technology stock* available to energy suppliers. In principal, any energy technology capable of producing electricity is a potential substitute for wind energy. The competitive environment of the wind turbine industry is thus subject to various levels of need substitution from three major technology groups: *fossil fuels*, *nuclear power* and *other renewables*. The relative competitiveness of any of these substitute technologies is subject to significant regional and periodic variation, depending on such factors as local resource availability, fuel prices, wind conditions, subsidies, base load flexibility etc.

Fossil fuels currently hold a dominant position with a share of the global electricity market of 67%. Of this share, coal is the largest contributor with an estimated market share of 39%, while gas and oil hold shares of 21% and 7% respectively. Looking ahead, the IEA estimates that coal and gas will take the major share of new capacity installations until 2030; taking up 39% and 28% respectively, while the share of oil in new capacity installations is expected to be some 8%[100]. The competitiveness of fossil fuels relative to wind energy is determined by the two major demand drivers; *climate concern* and *security of supply*. Many energy markets are highly motivated by environmental incentives. Historically, as well as today, government subsidies awarded for environmental performance plays a major role in substituting conventional energy technology with renewables[101]. The so-called *external cost* of power generation has become a key competitive parameter in several markets, seriously disadvantaging coal, oil and to a lesser extent natural gas[102]. The closest competitors to wind in terms of environmental performance are hydropower, nuclear and biomass, and to a lesser extent; solar and tidal/wave power, as these technologies are either CO_2-neutral or emit no CO_2 during operation[103]. On other environment parameters, (landscape preservation, waste disposal and particle emissions respectively), these substitutes are significantly disadvantaged. Also, from the first oil crisis in the early 70s till today, security of supply has become a major issue for conventional substitutes to wind such as natural gas and oil, benefiting role of energy technologies with stable or no fuel supply demands[104]. Due to recent increases in gas prices, the generation costs of wind is now generally lower than that of gas while comparable to the cost of coal[105].

The second major technology group is nuclear power which currently holds a share of the global electricity market of some 17%. A share that IEA (2004) expects to decrease significantly by 2030 to around 9%. Nuclear power is expected to take up only 3% of new capacity additions over this period[106]. Although benefiting from climate concerns, nuclear power is thus only a minor substitute for wind. In addition, nuclear power supplies base-load generation[107], a role not suited intermittent power sources. The generation cost of wind energy is generally significantly lower than that of nuclear power[108].

Other renewable energy sources constitute the third technology group. Renewable energy currently holds a share of the global electricity market of 18%, which is expected to increase by 2030 to about 19%. This comparatively small increase should be seen in the light of an average annual increase in total electricity demand of some 2.5% over the period. Currently, hydropower is the most competitive renewable energy technology with a share of the world renewable electricity market of

[100] IEA 2004:196:200
[101] See e.g. IETA 2006
[102] See BTM 2005a:41-43
[103] ExternE-Pol 2005:27
[104] See European Commission 2001
[105] Carnegie Securities Research 2005:10
[106] IEA 2004:200
[107] WNA 2006
[108] IEA 2004:195

89%, with biomass as a distant second, holding a share of 7%. Wind takes up a shared third place along with geothermal, both with a share of 2%. According to IEA (2004) this picture is expected to change significantly by 2030. Hydropower will decline by as much as 20 percentage points to 69%, mainly at the expense of wind and biomass increasing to 15% and 10% respectively. Tidal/wave energy and solar power are expected to rise from currently insignificant shares to about 1% and 2% respectively. In terms of cost developments of renewable energy, the capital and total cost of both on- and offshore wind power is expected to decline significantly along with geothermal and biomass, which will remain largely cost-competitive with wind energy. Conversely, the cost hydropower is expected to increase significantly due to lack of suitable sites[109].

Although wind energy is generally cost-competitive with its major substitutes, wind technology suffers from a number of unique disadvantages, generally making the technology dependent upon favourable energy planning regimes. Wind is an intermittent power source and cannot therefore substitute base-load generation technologies. Wind capacity requires flexible backup generation capacity for periods of insufficient wind[110]. In addition, wind turbines are often located in the periphery of the energy system and must therefore be connected to the grid at low-voltage levels. This adds to the complexity of the energy system, which in turn increases installation costs where weak grids must be reinforced[111]. This requires flexible energy systems and equally flexible energy planning[112]. Also, wind turbines are highly visible and their operation entails considerable noise emissions. Due to minimum wind-speed requirements, turbines are often placed rural areas, and thus frequently conflict with natural conservation and recreational interests. A major issue for the industry is increasingly well-organised local opposition to wind projects[113]. Several such cases have illustrated how dissatisfaction with the placement of onshore wind projects has led to increasingly restrictive planning requirements[114].

In terms of future competitiveness, the rate at which new products emerge to keep potential need substitutes at bay is a significant factor determining the overall competitiveness of wind power relative to potential substitutes. However, the rate of new product discovery also increases product-by product substitution. This form of substitution determines the rate at which existing turbines are made obsolete by more cost-effective models. This has a tendency to make buyers more hesitant to invest in current models, in the expectation of imminent improvements. In the context of the wind

[109] IEA 2004:192-233
[110] IEA 2004:235
[111] Carnegie Securities Research 2005:6
[112] IEA 2004:235
[113] See Morgan Stanley 2006
[114] See BWEA 2006

turbine industry, this phenomenon was demonstrated in the mid 80s where rapid up scaling caused turbine designs to become obsolete at an unprofitable rate[115]. This form of substitution is the essence of an industrial technology race. Throughout the history of the wind turbine industry, product-by-product substitution has been synonymous with up scaling, but advances in offshore technology and specialised low wind-speed turbines along with new composite materials have likewise become important sources of new product discovery[116]. Neij *et al* (2003) found that eight successive generations (in terms of size) of wind turbines emerged in the period 1980-2000, equalling an average time interval of 2.5 years between generations[117]. Given these figures, the rate of new product discovery in the wind turbine industry is a significant factor lowering the competitiveness of substitutes - but also the profitability of wind turbine manufacturers.

When investigating the determining variables described in appendix A, it is clear that the competitiveness of substitutes significantly influences the competitive environment of the wind turbine industry in defining the overall limit to its profitability. In accordance with the investigation of the significance of the individual variables, 12 specific variables were identified *in addition* to those suggested in the theoretical proposition developed in Chapter 3. The proposed relationships between these variables and the competitiveness of substitutes are illustrated in figure 4.3 below:

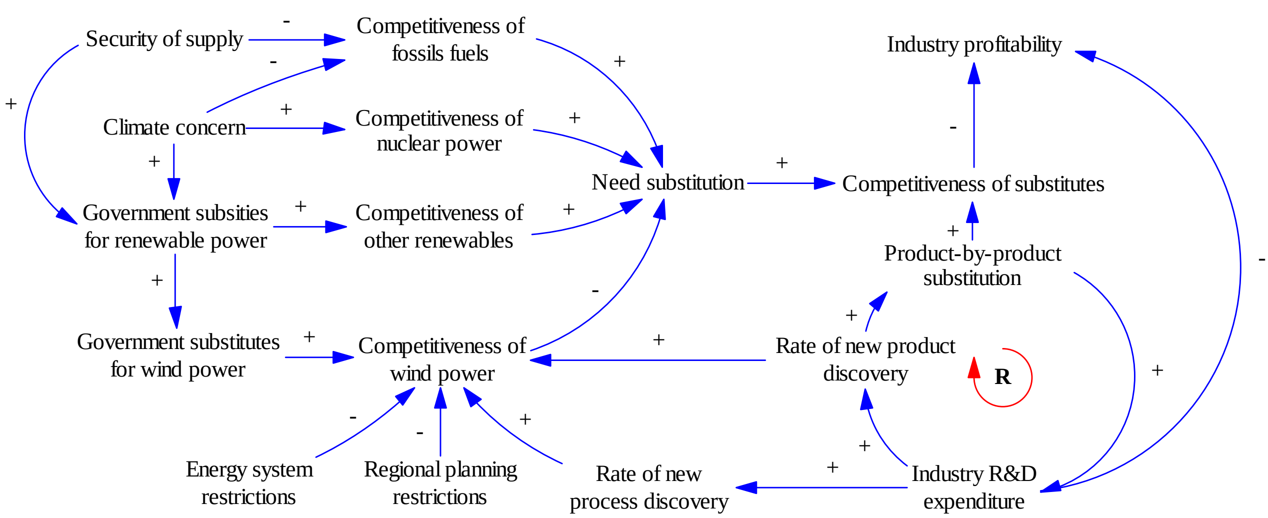

Figure 4.3: Empirically grounded determinants of competitiveness of substitutes

As illustrated on figure 4.3 above, significant modifications has been made to the theoretical proposition developed in the previous chapter. The major part of these modifications is related to the fact that a wind turbine is in itself a production technology. The determinants of *Need substitution* are illustrated on the left side of the diagram, dividing the major substitutes to wind power into three

[115] See Kjær 1988:20
[116] See EWEA 2005b
[117] See Neij *et al* 2003: 38-42

broad categories: F*ossil fuels, Nuclear power* and *Other renewables*. The competitiveness of wind power relative to these substitutes is in turn determined by the major demand drivers; *Security of supply* and *Climate concern*, which in turn influences *Government subsidies* for renewable energy. It is important to note that not all types of government subsidies lead to increased competitiveness of new technologies as has, to some extent, been the case with fixed feed-in tariffs[118]. These tariffs have lead to considerable capacity instalments, but have not necessarily created an incentive to lessen the dependency of the technology upon the subsidy. Other subsidies such as green certificate markets[119] or competitive bidding[120] have had greater success in creating incentives for increased technological competitiveness, but often at the cost of installed capacity. This goes to say that the causality between *government subsidies for wind power* and the *competitiveness of wind power* proposed in figure 4.3 may be true only in a strictly economic sense and may not lead to lasting technological competitiveness. Notice the dual role of *industry R&D expenditure* upon both *need*- and *product-by-product substitution*. The reinforcing feedback loop illustrates the dynamics of technological rivalry (or technology race) between manufacturers - as existing turbines are made obsolete by new designs introduced by competitors. Increased R&D expenditure thus becomes a necessary competitive parameter, which again increases *product-by-product substitution*. Notice also the relationship between climate concern and the competitiveness of nuclear power further elaborated in appendix A. As described in section 3 in appendix A, no empirical evidence could be found supporting the relevance of *Generic substitution* to the competitive environment of the wind turbine industry. This variable was thus eliminated as a determinant of competitiveness of substitutes.

4.6 The fourth force: The bargaining power of buyers

Historically, the market for wind turbines has been divided into four major buyer segments: *Individually owned turbines* such as single turbines supplying individual farms or businesses; turbines held by *local investor cooperatives*, larger wind farms owned by *utility companies*, and finally *developers*, functioning as an intermediary between manufacturers and utility companies. The importance and market share of each of these four segments has varied periodically and from country to country; often in response to changing subsidies and tax breaks. With the increasing globalisation

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[118] Although feed-in tariffs vary considerably between planning regimes, this form of support is usually constructed around a fixed government subsidy paid to the supplier for every KWh of electricity sold at the market price. This form of subsidy has been dominant in Denmark, Germany and Spain.

[119] Green certificate markets are constructed around issuing a certificate to a supplier for each MWh of electricity sold at the market price. These certificates are financial assets, which can be sold to utility companies obligated to present certificates equaling a certain (and often increasing) percentage of their sales at year-end. This form of subsidy has been dominant in England, Wales, Scotland and Ireland.

[120] Various competitive bidding schemes are constructed to reward manufacturers able to install the needed MW capacity requiring the least amount of subsidy through competitive bidding. This form of subsidy has been dominant in the U.S.

of the industry and still larger wind projects, the two latter segments have by far become the most significant[121].

Modern wind turbine projects are increasingly seen by buyers as large, long-term investments in new generating capacity, increasingly comparable to conventional power plants. As the size of both individual turbines and entire wind projects has increased, so has the size of orders relative to both manufacturers’ sales and buyers’ costs. The individual order has become more important to both manufacturers and buyers. This has increased buyers’ price sensitivity. Although price per MW installed is a central competitive parameter; reliability, and thus the quality of the turbines are equally important to the operational economy of wind turbine projects. As the size of wind projects have increased, manufacturers have been forced to share the risk of serial faults in wind projects through extended warranty provisions. This has become an increasingly important part of winning large orders[122] and wind turbine manufacturers are thus able to differentiate themselves through demonstrated performance and turbine reliability[123]. This opens the opportunity of raising switching costs by rewarding repeat buyers through expanding existing service contracts and warranties on favourable terms.

As buyers of wind project have become increasingly consolidated, professional and informed, they have been able to exert pressure on the profitability of wind turbine manufacturers. The ongoing concentration of the wind turbine industry has been matched by rapid concentration among the buyers of wind turbines. As described above, large utility companies and developers have by far become the most important buyers of wind projects, taking over from smaller private buyers and local investor groups. Recent years have likewise seen rapid consolidation among major developers. These developments have significantly increased the bargaining power of buyers, leading to increased demands on manufacturers to co-invest, co-manage and even operate large projects as a requirement to win large orders[124]. Also, these increasingly sophisticated buyers are better able to play manufacturers against each other to lower prices and raise quality through competitive bidding for projects[125].

The highly competitive substitutes for wind energy described above are a further factor increasing buyers’ bargaining power. Any technology capable of generating electricity is a potential substitute

[121] Skytte *et al* 2004:22. See also BTM 2005a:21
[122] BTM 2005a:20-21
[123] Danske Equities 2003:13, see also Alfred Berg 2006:12
[124] BTM 2005a:21
[125] See Carnegie Securities Research 2005

for wind power, and utility companied can choose from among a wide technology stock when expanding generating capacity. Although additional competitive parameters such as environmental performance, security of supply and government substitutes have favoured wind power in some markets, the competitiveness of substitutes is a significant factor increasing buyers' bargaining power.

Through the investigation of the determining variables, it is clear that powerful buyers are a significant factor shaping the competitive environment of the wind turbine industry. In accordance with the investigation of the significance of the individual variables described in appendix A, the following changes were made to the theoretical propositions developed in Chapter 3:

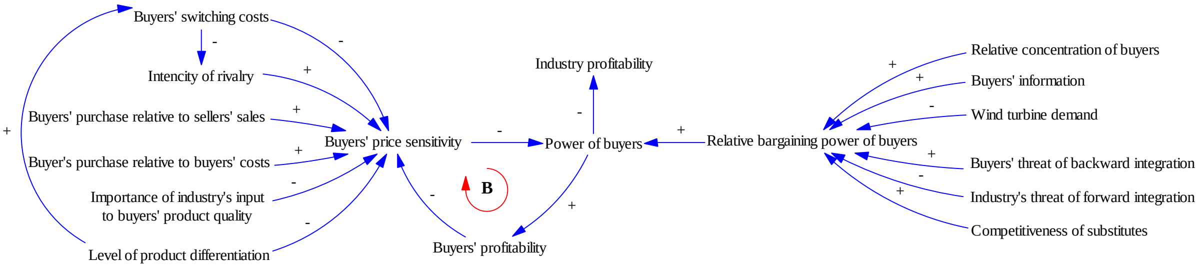

Figure 4.4: Empirically grounded determinants of the power of buyers

As illustrated on figure 4.4 above, empirical evidence could be found supporting the relevance of all of the determinants suggested by the theoretical proposition developed in the previous chapter. In addition to the variables proposed by the positioning school, the variable *Wind turbine demand* was identified as a significant determinant of the relative bargaining power of buyers.

4.7 The fifth force: The bargaining power of suppliers

Today, a wide range of subcontractors is available to the wind turbine industry[126]. In principle it is possible to assemble a turbine entirely from prefabricated components[127]. In spite of this, all the major wind turbine manufacturers are to some extent involved in component manufacturing. None of them are, however, producing all the needed components in-house. Wind turbine manufacturers have thus struck a balance between being in the business of *component manufacturing* and *wind turbine assembly*. As described above, the business models of wind turbine manufacturers are highly diverse. The degree to which wind turbine manufacturers are vertically integrated varies significantly, as does the cost of procuring outsourced components incurred by the individual manufacturer. The most

[126] See DWIA 2005:48-57 and Danske Equities 2003:11-12
[127] Danske Equities 2003:13, see also Alfred Berg 2006:12

vertically integrated manufacturers are Gamesa, Siemens[128] and Enercon[129] while GE and Vestas have adopted a lighter model[130].

The most expensive components of a wind turbine are the rotor and the nacelle and machinery, composing 20-23% and 25% respectively of the total cost of a turbine. Gearbox and drive train composes 10-15%, while generator systems and towers compose around 5-15% and 10-15% respectively[131]. Generally, blades, nacelles and control systems are the most specialised and vital components in terms of turbine efficiency. These are usually manufactured in-house, whereas generators, gearboxes and towers are more often outsourced to suppliers[132].

Although wind turbine manufacturers are generally in a good bargaining position relative to component suppliers, they are notoriously sensitive to the high quality and timely delivery of key components. Serial faults in components for larger wind projects are equally serious as wind turbine manufacturers often bear the financial liability for the quality of turbines through warranty provisions[133]. Delays in component delivery are likewise extremely costly to wind turbine projects[134]. In addition, high industry growth and the relative 'newness' of the industry have made component shortages commonplace in the industry as a bottleneck high industry growth[135]. For these reasons, component suppliers are often able link a certain manufacturer to them through raising switching costs. If a manufacturer wishes to replace a supplier, this often requires lengthy certification to qualify the new supplier's input along with extensive testing to ensure reliability and compatibility of new components. Hence, phasing in a new component is a time-consuming and expensive process entailing significant switching costs. Also, due to manufacturers' differing technical solutions and patent rights, components are increasingly customised to the individual manufacturer rather than standardised. This further adds to the cost and complexity of switching between suppliers. In addition, the physical location of component suppliers near major markets has become an issue. As the size of components have grown larger, minimising transport costs have become increasingly important and strained the availability of suppliers with sufficient capacity near major markets. Also, components such as generators, blades, control systems, towers etc. cannot be directly substituted by alternatives. Only Enercon has successfully substituted gearboxes, developing a product range of gearless turbines based on its ring generator technology[136]. In addition to significant switching costs,

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[128] See Morgan Stanley 2005:19
[129] See Danske Equities 2003:8
[130] See Morgan Stanley 2005:19. It is worth noting that several manufacturers organise their sourcing strategies to allow in-house component manufacturers to compete with external manufacturers to increase efficiency. This picture of the vertical integration of major manufacturer is thus indicative rather than static.
[131] Ancona & McVeigh 2001:2
[132] See Morgan Stanley 2005:18 and Danske Equities 2003:8
[133] See e.g. Vestas Annual Report 2005
[134] See e.g. Vestas' First Quarter Report 2006
[135] Takeuchi 2003:44
[136] Takeuchi 2003:43-56

substantial technological and financial entry barriers around component industries - especially gearboxes, generators, blades and control systems - further limit rivalry between component supplies[137].

In spite of the opportunities for suppliers to raise such switching costs, the relative bargaining power of buyers most be considered comparatively weak. This is especially due to the high relative concentration of the wind turbine industry, making component manufacturers dependent on only a few large customers. Even small changes in a major manufacturer's sourcing strategy can have serious implications for a supplier's revenue. The increasing size of both turbines and wind projects has amplified this dependency. As the size of single orders has increased relative to both suppliers' sales and manufacturers' costs, the importance of the individual order from a manufacturer has been emphasised[138].

Exploiting this advantage, manufacturers are often disloyal to individual suppliers and are reluctant to rely too heavily upon any single component manufacturer, favouring various types of hybrid sourcing[139]. Several wind turbine manufacturers are themselves highly active in many areas of component manufacturing. This is especially true for diversified manufacturers such as Gamesa, Siemens and General Electric, giving these companies hands-on experience with the production of a wider range of energy technologies and/or components. Manufacturers are generally least active in the production of generators and gearboxes, which are highly complicated to make. In spite of this, GE Wind, and Gamesa both have in-house production of generators[140] and Vestas recently integrated backwards into generator manufacturing in China to ensure accessibility and quality of inputs[141]. The varying degree of vertical integration among turbine manufacturers would likewise suggest that wind turbine manufacturers pose a highly credible threat of backward integration into several areas of component manufacturing. Such a threat decreases the bargaining power of suppliers in that they have to meet the deterring price – the price that just balances out manufacturers' potential rewards of entry[142]. Generally, technological and financial entry barriers into component manufacturing for wind turbines are significant[143], but this is only relative to the deterring price, as manufacturers perceive it.

As previously described, the primary threat of new entrants into the wind turbine industry has been posed by buyers integrating backwards into wind turbine manufacturing. However, FKI plc., a

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[137] Danske Equities 2003:11
[138] BTM 2005a:20
[139] Takeuchi 2003:46
[140] Danske Equities 2003:9
[141] See Vestas Stock Announcement 2006
[142] Porter 1980:14
[143] Danske equities 2003:11

producer of turbo generators, recently took over the German wind turbine manufacturer Dewind, demonstrating that suppliers too are able to pose a credible threat of forward integration[144]. However, because of the significant entry barriers protecting incumbent wind turbine manufacturers, few component suppliers pose any credible threat of forward integration and wind turbine manufacturers remain highly informed and sophisticated buyers of components.

When looking at the determining variables, it is clear that the power of suppliers is not a major factor decreasing the profitability of wind turbine manufacturers. Danske Equities (2003) considers component manufacturing the least attractive business model related to the wind turbine industry, only protected by substantial entry barriers[145]. In accordance with the investigation of the significance of the individual variables described in appendix A, the following changes were made to the theoretical propositions in figure 3.8, Chapter 3:

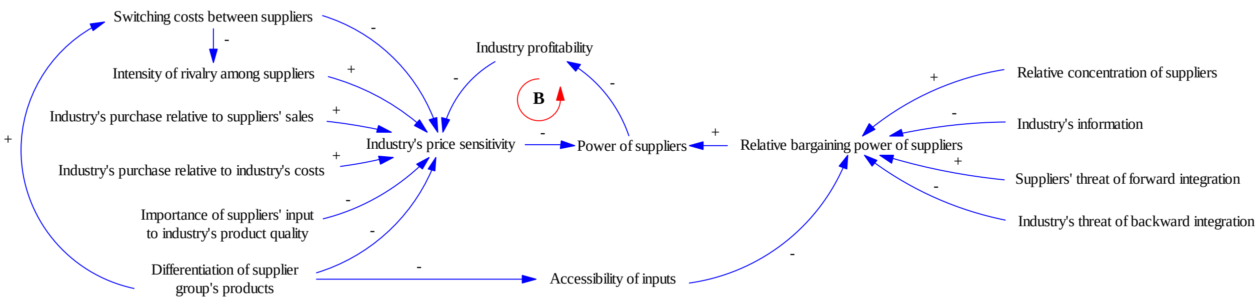


Figure 4.5: The determinants of the bargaining power of suppliers

As illustrated on figure 4.5 above, two major modifications were made to the theoretical proposition developed in the previous chapter. The variable *Availability of supplier substitutes* was excluded as no empirical evidence could be found supporting its relevance, while the variable *Accessibility of inputs* was included as a determinant of the relative bargaining power of suppliers.

4.8 The structure of the wind turbine industry

Based on the investigation of the determining variables described in appendix A, it is clear that powerful, well-informed and price sensitive buyers along with a wide range of highly competitive substitute technologies are the main competitive forces currently influencing the competitive environment of the wind turbine industry. In spite of the high technical and financial entry barriers protecting incumbent manufacturers, the threat of new entrants remains credible although not at a level at which the overall industry profitability is significantly decreased. Also, the intensity of rivalry among manufacturers is kept moderate by high industry growth rates offsetting many of the

[144] Takeuchi 2003:43
[145] Danske equities:11

potential sources of competitive conflict currently present in the economic structure of the industry. Due to high industry growth rates and the relative 'newness' of the industry, accessibility of components remains a problem for wind turbine manufacturers. In spite of this, the bargaining power of suppliers is kept moderate, as the wind turbine industry is highly concentrated around just a few major manufacturers, posing a highly credible threat of backward integration into broad areas of component manufacturing.

From the viewpoint of *corporate strategy*, powerful buyers and highly competitive substitute technologies are the main factors driving down the profit potential of the wind turbine industry. Likewise, from the viewpoint of *business strategy*, it is the ability of the individual manufacturer to create a *defendable position* against these major forces, which determines its ability to earn a profit in excess of its cost of capital relative to the industry average.

Table 4.1: Summary of modifications
Included variables
Extent of warranty provisions
Accessibility of inputs
Importance of location
Competitiveness of fossil fuels
Competitiveness of nuclear power
Competitiveness of other renewables
Competitiveness of wind power
Security of supply
Climate concern
Government subsidies
Government subsidies for renewable power
Government subsidies
Industry R&D expenditure
Wind turbine demand
Energy system restrictions
Regional planning restrictions
Excluded variables
Accessibility of distribution channels
Diversity of competitors
Generic substitution
Availability of supplier substitutes

In addition to identifying a number of unique variables, the investigation of the five structural forces and their determinants revealed, that not all variables and relationships proposed by the positioning school apply equally well to the specific competitive environment of the wind turbine industry. The empirical grounding of the theoretical propositions resulted in the elimination of 4 variables, while 16 variables, specific to the competitive environment of the wind turbine industry, were identified and added to the original propositions. These are summarised in Table 4.1. Through these ex- and inclusions, the theoretical propositions have been grounded in a number of additional assumptions from empirical measurements and analysis of the operation of the competitive environment *specific* to that of the wind turbine industry.

In this chapter each of the five structural forces was considered in isolation from one another. However, this is clearly not a true representation of the competitive environment of the wind turbine industry, in which a change in one structural force or its determinants may affect other structural forces and thus the competitive environment as a whole. Taking this into consideration, the following chapter will be concerned with the *interconnectedness* of five structural forces and the way these operate in concert as part of the competitive environment of the wind turbine industry.

- Part I -

Chapter 5: Building an integrated conceptual model

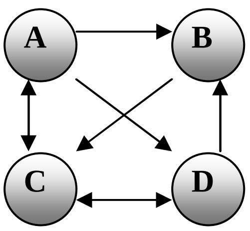
The five empirically grounded propositions about the competitive environment of the wind turbine industry developed in the previous chapter are clearly not operating in isolation from one another. A change in one structural force or its determinants could potentially trickle through the system, causing one or more structural forces to change, thus affecting the competitive environment as a whole. Taking this into consideration, this chapter will be concerned with systematically identifying and making explicit the interconnections between the five propositions. Consequently, the five grounded propositions will be assembled into a single *integrated strategic assumption* about the variables and interconnections constituting the competitive environment of the wind turbine industry at the chosen level of abstraction.

5.1 The interconnectedness of the structural forces

The first clue to the interrelationships between the five structural forces lies in the fact that several of the identified variables appear *more than once* across the five propositions. The variables displayed in box 5.1 appear in more than one of the propositions developed in the previous chapter. On the basis of these nine variables, the first interrelationships between the five structural forces can be unambiguously drawn, by simply eliminating duplicate variables. These, however, are only the most obvious interrelationships between the structural forces and their determinants. To systematically take into consideration the full number of potential interrelationships between the structural forces and their determinants, it is necessary to consider the *totality*[146] of possible relationships between the 69 identified variables. Following Miles *et al* (2003), this was achieved by representing the five influence diagrams in the form of a single *direct influence matrix* (DIM) in which all potential interrelationships could be systematically explored. See figure 5.1 below.

Box 5.1: Variables appearing more than once:

1. Industry profitability
2. Height of entry barriers
3. Strategic stakes in the industry
4. Buyers' switching costs
5. Level of product differentiation
6. Industry growth rate
7. Economies of scale in production
8. Intensity of rivalry
9. Accessibility of inputs



This simple system composed of four variables and eight causalities can be represented in the form of *direct influence matrix.*

Direct Influence Matrix

	A	B	C	D	Tot. I
A		1	1	1	3
B	0		1	0	1
C	1	0		1	2
D	0	1	1		2
Tot. D	1	2	3	2	8

Figure 5.1: Example of the construction of a direct influence matrix. Adapted from Miles *et al* (2003:52).

[146] See Zwicky 1969

As it is illustrated in figure 5.1 above, direct influence matrices are representations of causalities between variables composed of 1s and 0s. In this context, DIMs are identical to the language of influence diagramming, using the same syntactical rules described in Chapter 3, although in a different format. A one (1) indicates that a causal relationship is proposed between a pair of variables, while a zero (0) indicates that no causal relationship is proposed.
The sum of a row represents the *total direct influence* that a specific variable exerts over the system (i.e. number '3' at the end of the first row in figure 5 indicates that variable A has three direct causal influences over the system). The evolution of highly influential variables will have the greatest impact upon the system. On the other hand, the sum of a column represents the *total direct dependency* that a specific variable has on the system (i.e. number one at the bottom of the first column indicates that there is one causal relationship through which the system can influence variable A). Dependent variables are those that are most sensitive to the evolution of the system[147]. I will return to the significance of the influentiality and dependency of individual variables later in this chapter.

The 69 variables contained in the five propositions were thus paired in the DIM and the 107 causalities already identified in Chapter 4 were plotted into the matrix. Pairing the identified variables in this manner yields 4,585 *potential* causalities in the matrix structure *in addition* to those already identified in the previous chapter (4585 = (69 x 69) - 69 - 107)[148]. Following Godet (1994), the following questions were posed and answered for each blank square[149]:

1. Does variable *i* influence variable *j*, or is this relationship the other way round, i.e. *j* to *i*?
2. Does *i* influence *j*, or does some co-linearity exist, i.e. a third variable *k* influences both *i* and *j*?
3. Is the relationship between *i* and *j* direct, or does it operate through another listed variable?

Resulting from this procedure an initial list of 21 *potential* causalities was identified between the five propositions of which the following 17 could be empirically, theoretically or logically substantiated. Although rigorous and exhaustive, Godet's method is obviously not exact. It is, however, explicit and leaves a clear audit trail, bringing underlying assumptions to light. The proposed relationships shown in table 5.1 are discussed in appendix B.

Cause variable	**Polarity**	**Effect variable**
Height of exit barriers	+	Strategic stakes in the industry
Industry concentration ratio	-	Relative concentration of buyers
Industry concentration ratio	-	Relative concentration of suppliers

[147] Miles *et al* 2003:52
[148] No variable influences itself directly (although this often happens indirectly through feedback). This leaves a diagonal line of 69 blank cells from the top left to the bottom right of the matrix as illustrated in figure 5.1, while 105 causalities were already previously identified in Chapter 4.
[149] See Godet 1994:87

Relative bargaining power of buyers	+	Extent of warranty provisions
Industry growth rate	-	Accessibility of inputs
Extent of warranty provisions	+	Importance of suppliers' input to industry's product quality
Wind turbine demand	+	Industry growth rate
Competitiveness of wind power	+	Wind turbine demand
Experience curve effects	+	Competitiveness of wind power
Threat of new entrants	+	Buyers' threat of backward integration
Threat of new entrants	+	Suppliers' threat of forward integration
Need substitution	-	Wind turbine demand
Wind turbine demand	+	Experience curve effects
Rate of new product discovery	+	Proprietarity of product technology
Rate of new process discovery	+	Experience curve effects
Industry concentration ratio	+	Resourcefulness of incumbents
Threat of new entrants	+	Intensity of rivalry

Table 5.1: Additional causal relationships identified from cross impact analysis

On the basis of the identification of these relationships, it is possible to assemble the five propositions about the structural forces and their determinants; creating an *integrated conceptual model* (ICM) of the competitive environment of the wind turbine industry. This model is displayed in the form of a single influence diagram illustrated in figure 5.2 below[150]. Note that the ICM is displayed here for illustrative purposes only and is not meant to be 'read' in detail. Following Mercer (1998), a model can thus be broadly defined as:

"[…] anything which claims to describe the relationships between the factors (the variables) involved or at least a set of assumptions about these relationships which it is believed will explain them[151]"

ICM thus makes explicit the theoretical and empirically grounded assumptions about the competitive environment of the wind turbine industry at the chosen level of abstraction. As discussed in Chapter 2, the boundary and structure of the model are inevitably ambiguous and cannot be definitively established. It is clear the variables and interrelationships proposed by the model could be expended *ad infinitum*.

[150] Note that whenever possible polarities are indicated *above the centre* of each arrow. This practice will be exercised throughout this report.
[151] Mercer 1998:125

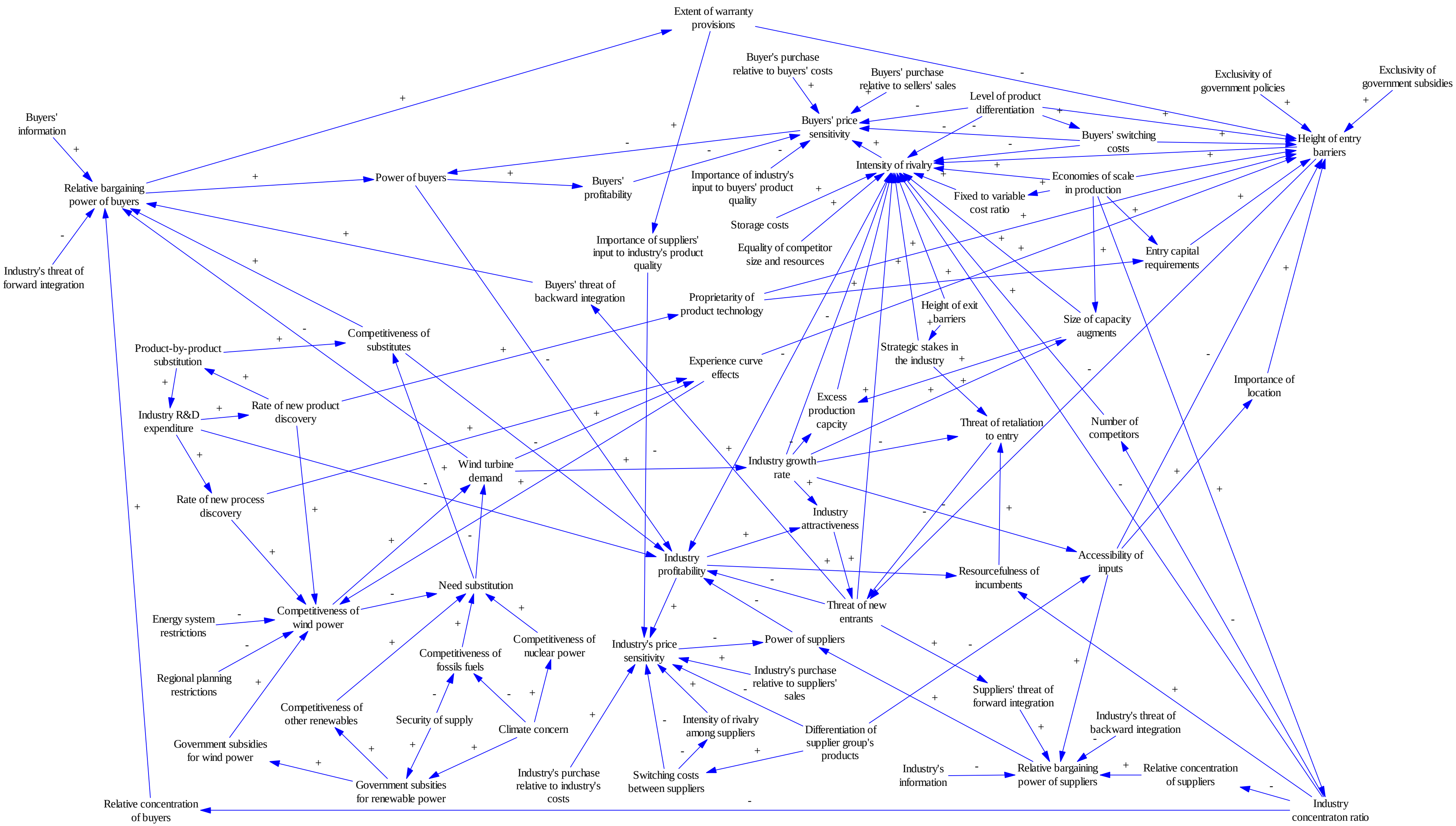


Figure 5.2: The assembled integrated conceptual model (ICM)

Horizontally, the boundaries of the model could be expanded to include competing energy technology industries or political systems involved in granting subsidies to renewable energy. However, because of the chosen level of abstraction, this would increase the level of combinatorial complexity beyond manageable levels. Even if this was accomplished; another ambiguous boundary would necessarily have to be drawn at the end of this effort, inevitably leaving other influential subsystems outside the scope of the model. This limitation does not mean that changes outside the boundaries of the model must be ignored, but rather that such changes appear as *external* forces influencing the competitive environment of the wind turbine industry from outside the scope of the model.

Vertically, each variable contained in the model could be broken down into a larger number of variables at lower levels of abstraction or conversely grouped into fewer and more highly aggregated variables. A variable such as *Intensity of rivalry* could be broken down into various types and frequencies of competitive efforts between subgroups of manufacturers, while the *Competitiveness of fossil fuels* could be subdivided into the cost structures of various types of oil, gas and coal technologies. Again, this limitation does not mean that changes at higher or lower levels of abstraction must ignored, but rather that their effects are taken into account at the level of abstraction at which the model seeks to describe the competitive environment.

It is important to note that these limitations do not only apply when constructing explicit influence diagrams like the one depicted in figure 5.2. *Any* strategic assumption involves a trade-off between (1) its level of abstraction and thus its attention to detail and accuracy and (2) the extent of its boundaries and thus what is considered *inside* the scope of relevance. Depicting strategic assumptions in the language of influence diagrams makes these limitations *explicit* and maintains *internal consistency*. It is thus not the aim of the ICM to look as much like the real competitive environment as possible. It would obviously be futile to depict the interaction of hundreds of thousands of people, organisations and devices by drawing arrows between lines of text.

5.2 Analysing the structure of the integrated conceptual model

As described in the example given in figure 5.1 above, the representation of the ICM, in the form of a direct influence matrix, reveals the total number of influences and dependencies of each variable. As described, the total number of *direct influences* of each variable is indicated by the sum of each row, while the sum of each column indicates the total number of *direct dependencies*.

Following Godet (1994), the *influentiality* and *dependency* of each variable in the ICM can be represented in the form of a *direct influence-dependency chart* as illustrated in figure 5.3 below:

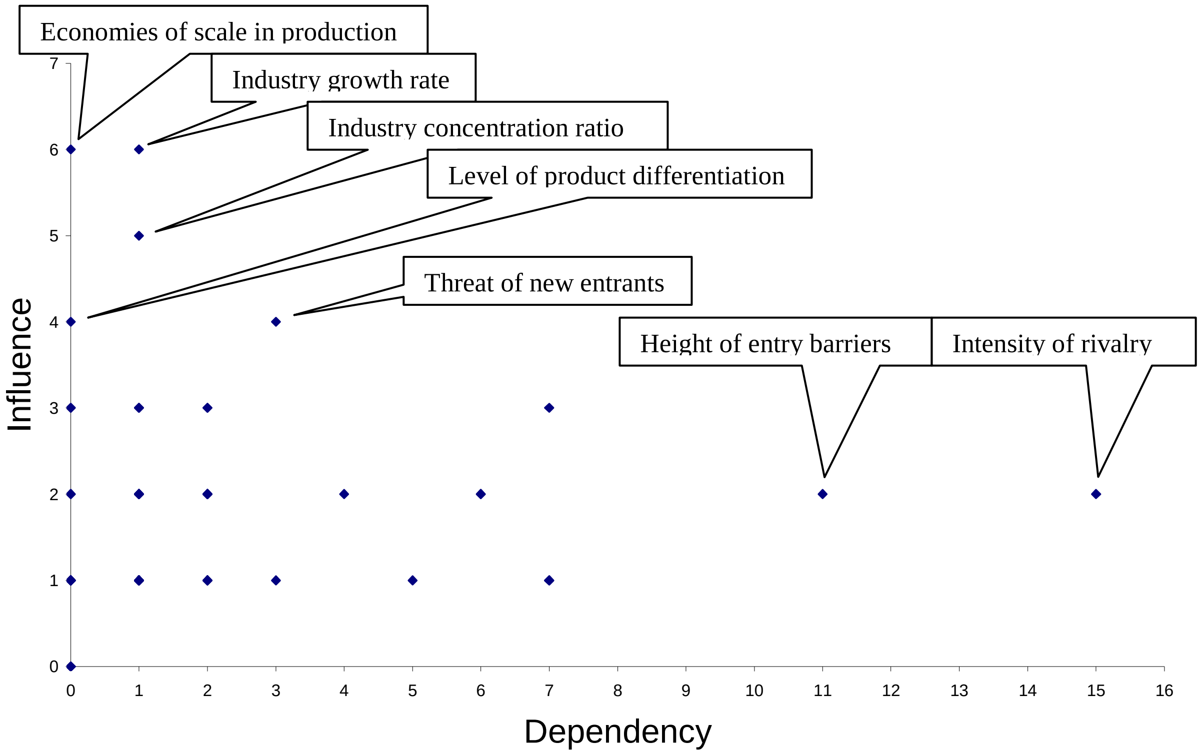


Figure 5.3: Direct influence-dependency chart

The influentiality and dependency of each variable can thus be understood from its position in the influence-dependency chart. In this respect, the chart itself can be divided into four principal regions[152]:

The top left region of the chart contains *determinant variables*. These high influence/low dependency variables condition the rest of the system. As it can be seen, the presence of economies of scale, industry growth rate and industry concentration along with the level of product differentiation falls into this region of the chart[153]. The top right region of the chart contains *relay variables*. These high influence/high dependency variables are unstable by nature, as any change in these variables will have repercussions for other variables as the initial change is fed through them and back to the relay variables. As it can be seen, no variables fall into this region. The bottom right region contains *resultant variables*. These low influence/high dependency variables are highly dependent upon both the determinant and relay variables. As illustrated, the intensity of rivalry among wind turbine manufacturers and the height of entry barriers fall into this region. The bottom left region contains *semi-autonomous variables*. These low influence/low dependency variables are less intricately

[152] Godet 1994:99

[153] Notice that the variables with an influence or dependency rating *higher than the median* are indicated by name. This practice will be exercised throughout this report. Notice also that as several variables share the same coordinate, the chart thus appears to contain less than 69 dots.

connected to the system than the variables in the three other regions. As it can be seen, the remaining 63 variables of the ICM fall into this region.

The distribution of the variables across the four regions of the influence-dependency chart indicates that the ICM is a relatively stable system. Following Godet (1994), a low number of relay variables confer relative stability to the system. In unstable systems the variables tend to cluster along the main diagonal of the chart, while the variables in stable systems tend to distribute themselves in an 'L'-shape along the x and y axes[154]. In terms of *direct* influences and dependencies of the ICM, the latter seems to be the case.

Beyond direct relationships

In addition to the direct relationships taken into consideration above, the ICM contains numerous *indirect* relationships in which one variable influences, or is influenced by, another over several intermediaries. These can be taken into account through a *structural analysis*.

Following Godet (1994), the indirect relationships can be taken into account by multiplying the original direct influence matrix described in figure 5.1 by itself, thus raising the matrix to a higher power. This operation is illustrated in figure 5.4 below:

Direct Influence Matrix

	A	**B**	**C**	**D**
A		1	1	1
B	0		1	0
C	1	0		1
D	0	1	1	

X

Direct Influence Matrix

	A	**B**	**C**	**D**
A		1	1	1
B	0		1	0
C	1	0		1
D	0	1	1	

=

Indirect Influence Matrix (DIM^2)

	A	**B**	**C**	**D**	**Tot. I**
A	1	1	2	1	5
B	1	0	0	1	2
C	0	2	2	1	5
D	1	0	1	1	3
Tot. D	3	3	4	5	**15**

Figure 5.4: Example of the construction of an indirect influence matrix. Adapted from Miles *et al* (2003:54).

The direct influence matrix takes into consideration the *direct* influence and dependency of each variable (**DIM = A → B**). By multiplying the direct influence matrix by itself, *all paths and loops* of length 2 are taken into account in the sum of each row and column as shown in figure 5.4 above (**DIM^2 = A → B → C**). By further raising the power of the DIM, paths of increasing length are taken into account (**DIM^n = A → n… → K**). Each time the DIM is raised to a higher power, a new hierarchy can be deduced in terms of the most influential and dependent variables displayed on an influence-dependency chart. When raised to a certain power, a stable hierarchy is found. Godet (1994) terms and trademarks this hierarchy; the MICMAC® classification[155].

[154] See Godet 1994:100
[155] See Godet 1994:94-95

Resulting from the structural analysis performed on the ICM illustrated in figure 5.1, a stable hierarchy was found when raising the direct influence matrix developed earlier to the 7th power[156]. The MICMAC® classification of the ICM thus illustrates the influence and dependency of each variable, taking into account *six intermediaries*. The resulting influence-dependency chart is illustrated below:

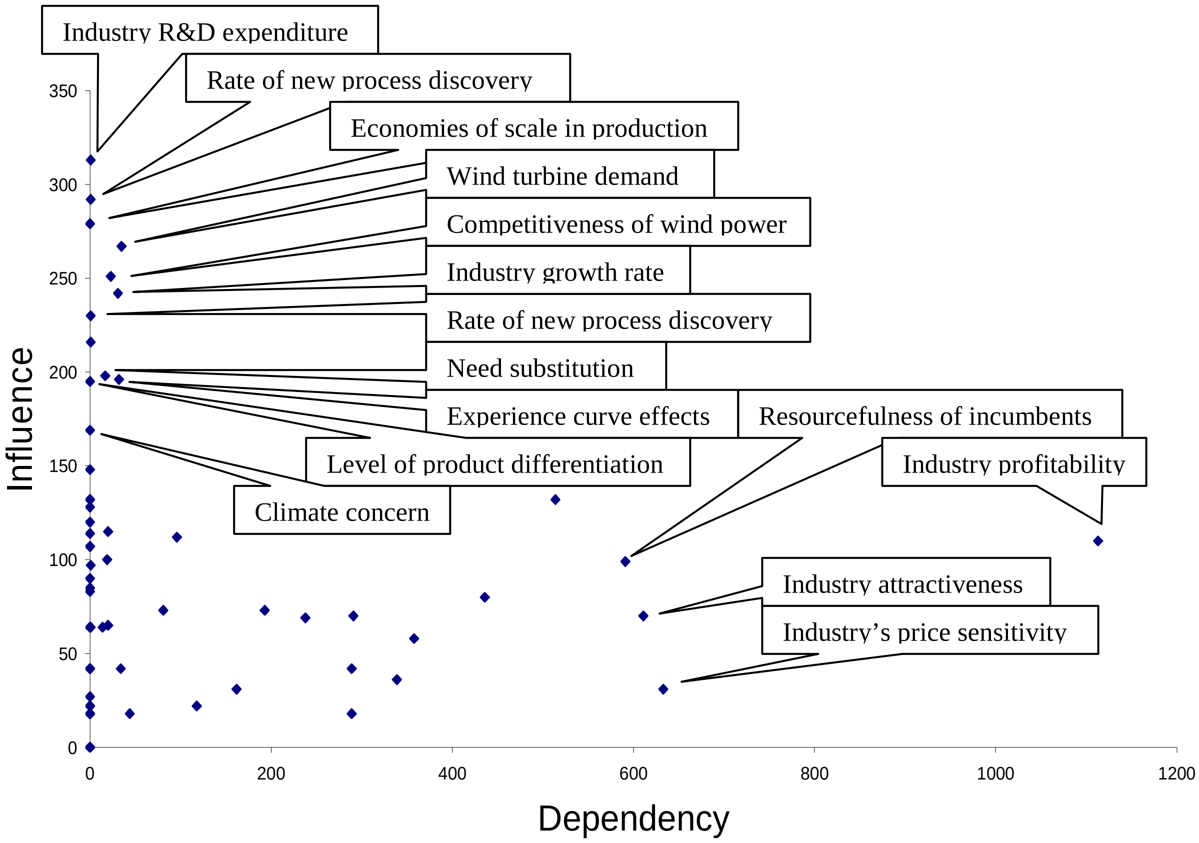


Figure 5.5: Indirect influence/dependency chart (DIM^7)

As illustrated above, taking the *indirect* influences and dependencies of each variable into account significantly alters distribution of the variables across the chart. In contrast to figure 5.4 above, R&D-related variables are now the most influential along with several demand drivers and important sources of cost reductions. The ICM suggests that these are the *determining* variables conditioning the competitive environment of the wind turbine industry *through* the five structural forces proposed by the positioning school. In terms of *relay* variables, the characteristic 'L'-shape of the variable distribution again suggests a relatively stable system in the absence of relay variables. The most dependent variables are those closely related to the profitability of wind turbine manufacturers and thus the industry as a whole. This is not surprising, as the drivers of industry profitability is focus of the Five Forces Theory, the logic of

[156] For the purposes of this analysis I have developed an Excel program (the AutoDIM), which performs this operation.

which is captured in the ICM. As described above, these are the *resultant* variables in the sense that they are the *outcomes* of the state of the determining variables.

The structural analysis of the ICM implies that manufacturers controlling one or more of the most influential variables are able to influence the competitive environment, thus creating a profitable position. From this perspective, wind turbine manufacturers claiming R&D leadership within process- and/or product discovery, while attaining sufficient market share to take advantage of economies of scale are in the best position to influence the nature of competition. A number of tradeoffs naturally limit any one manufacturer from achieving a position of such superiority.
In a competitive environment, no competitor single-handedly controls the influential variables. Instead, these are the major competitive parameters, which incumbents compete to influence. In addition, several of the highly influential variables are clearly outside the direct control of wind turbine manufacturers. Highly influential determinants such as the competitiveness of wind power relative to its substitutes, and thus the level of need substitution and wind turbine demand, along with climate concern and the overall industry growth rate, are clearly influenced by forces beyond the competitive environment itself. Other determinants such as product-by-product substitution are highly contested through technology rivalry to the point where it is outside the control of any single competitor. As described in Chapter 2, the evolution of these highly influential variables and thus the competitive environment as a whole is subject to various levels of uncertainty. Addressing the various levels of uncertainty connected to the development of the competitive environment of the wind turbine industry will thus be the topic of the subsequent chapters.

The construction of the ICM concludes Part I of this report. The three preceding chapters have been concerned with theoretically and empirically investigating the competitive environment of the wind turbine industry and formulating an *explicit and internally consistent strategic assumption* about the variables and the interrelationships between them, considered relevant to strategic decision-making. In Part II, the ICM will form the basis against which the impact of the major forces of change influencing the competitive environment over the coming decade can be explored.

- Part II -

Chapter 6: Predetermineds - what we know (we think) we know

This chapter will be concerned with identifying the major *known* predetermineds influencing the competitive environment of the wind turbine industry over the coming decade. At the outset, it is clear that we cannot limit our view to the variables and interconnections proposed in Part I. The competitive environment of the wind turbine industry is an intricate part of other social and natural subsystems beyond the boundaries of the explicit strategic assumption developed so far. The identification of predetermineds will therefore be explorative, drawing upon theory, industry literature and a number of interviews with industry observers and participants. The ICM will then form the basis against which the impact of each predetermined upon the competitive environment is explored.

6.1 What is predetermined?

For reasons described in Chapter 2, very few developments are truly predetermined - in the literal sense of the word. In the context of this report, the term *predetermined* is used with regard to *phenomena about which we can justify the assumption that we have sufficient knowledge to predict their direction over a given time period*. As described in Chapter 2, there can be various justifications behind such an assumption. The phenomena can be slow-changing, naturally constrained, already in the pipeline or downright inevitable[157] - given the chosen time period. In spite of such justifications, it is almost always possible to imagine low-probability-high-impact events, which could make any such assumption wrong. For this reason, predetermineds can be considered *developments with a single anticipated high-probability outcome or direction*.

6.2 Identifying predetermineds

As described in Chapter 2, any strategic decision is based upon assumptions about the future in which it is to play out. The importance of such expectations to an industry becomes obvious when studying industry literature and talking to industry observers and participants – expectations are everywhere[158]. From the viewpoint of the positioning school, the strategic relevance of any predetermined is determined by its impact upon the five forces constituting the structure of the wind turbine industry. A further assumption is that the impact of any predetermined should be taken into consideration at the level of abstraction proposed by the positioning school. These are the underlying assumptions embedded in the ICM. As previously described, this does not entail that predetermineds identified at comparatively higher or lower levels of abstraction or outside the scope of the model

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[157] Schwartz 1998:109-112, see also Heijden 1996:87, and Wack 1985:77
[158] See Selin 2006 for a recent dissertation on the importance and impact of expectations.

must be ignored. Such predetermineds are either taken into account at the level of abstraction at which the model seeks to describe the competitive environment, or will appear as *external* forces influencing the competitive environment from outside the scope of the model.

Following Porter (1985), the identification of predetermineds took as its point of departure *expectations* related to the five competitive forces proposed by the positioning school[159]. Drawing upon seven in-depth interviews[160] with industry observers and participants from a broad spectrum of the industry, a number of loosely formulated expectations were compiled about the development of the industry over the coming decade[161]. These expectations were subsequently specified and empirically justified, as described below. Resulting from this process, the following four predetermineds could be identified:

1. Buyers of wind projects will become larger, more professional and geographically diversified, demanding still larger wind projects.
2. The wind turbine industry will continue to consolidate around fewer, larger and increasingly globalised wind turbine manufacturers, emphasising economies of scale and scope.
3. Wind power will enter the mainstream of energy technologies as it matures, shifting emphasis from product to process discovery as the key source of cost reductions.
4. Wind turbine manufacturers will become less backward integrated and will increasingly emphasise partnerships with increasingly shared, specialised and independent component manufacturers.

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[159] Porter 1985:448

[160] The list of respondents, the interview guide and general considerations can be found in Appendix C. The interview data used in this Chapter corresponds to the answers to questions 1-5, excluding subsequent doubts clarified through question 6.

[161] In spite of the efforts made to create an atmosphere inductive to ‘free thinking’, and selecting interviewees from heterogeneous institutions and relations to the wind turbine industry (see appendix C), *situational bias* is likely to have played a significant role among even the most liberal-minded interviewees. The interviewees necessarily form part of the general mindset and established conventions of the industry, inevitably creating blind spots and presupposed and unquestioned ‘truths’ about the future development of the industry (Heijden 1998; Gilad 2004). In scenario literature, it is still far from clear how to address this problem. A common answer is seeking out ‘remarkable people’ with a ‘unique’ outlook upon future developments (Schwartz 1998). This approach, however, raises issues about how to identify such individuals and if these unique outlooks have any special legitimacy other than the fact that they differ from consensus. No such attempt has been made in this report and I therefore accept situational bias as an inherent weakness of the method.

Overcoming potential obstacles to openness and honesty about expectations to industry developments involved a trade-off against accountability. In the context of this report, interviewees are not quoted directly or indirectly in a manner, which allows statements to be linked to a particular interviewee. Nor are their views to be interpreted as the ‘official policy’ of their respective organisations but as their personal assessments only. It was found that these conditions greatly improved the quality of the interview data (see appendix C).

Following Kahn & Wiener (1967), these four predetermineds constitute a *multifold trend* for the anticipated development of the competitive environment of the wind turbine industry over the coming decade. As such, these four predetermineds do not operate in isolation from one another, but can be seen as part of a *common complex trend of interacting elements*[162]. Moreover, it is clear that alternative categorisations of the identified predetermineds at both higher and lower levels of abstraction are possible. This should not, however, affect the assessment of the impact of the multifold trend upon industry structure as a whole[163]. The most important consideration with regard to each predetermined is the justifiable assumption that it is likely to continue to influence the industry for at least another decade[164]. In the following, I will account for the justification behind this assumption for each predetermined, and explore its impact upon the competitive environment of the wind turbine industry.

6.3 The first fold

The first predetermined assumes that over the coming decade, buyers of wind projects will become larger, more professional and geographically diversified, demanding still larger wind projects. The assumption about the continuation of this fold is perhaps the most widely held among the industry observers and participants interviewed for this report. As we shall see, this belief may be justified both in terms of historical precedence and assumptions about the underlying drivers of industry development. The increasing size and sophistication of buyers of wind projects have been ongoing throughout the history of the industry. Historically, buyers have changed from ideologically motivated individuals, buying experimental turbines for farms and businesses, over local investor cooperatives exploiting subsidies and tax breaks, to national utility companies responding to environmental incentives for cleaner energy production[165]. Today, this trend continues uninterrupted in the form of consolidating international utility companies hedging against global uncertainties of supply, increasing climate concerns and CO_2 burden sharing[166].

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[162] Kahn & Wiener 1967:6

[163] The derivation of the four folds from the interview data was done on the basis of Heijden (1998) in which the issues touched upon during each interview were initially listed. These issues were subsequently pooled and re-categorised to achieve the broadest possible 'fit' representing the collective concerns of the interviewees. Perhaps the most important consideration is that *representation* of all expressed expectations in the categories rather than areas of *consensus* were the focus of this exercise. It is inherent to this interpretation of interview data that this cannot be cone objectively and that other legitimate categorisations are possible.

[164] The construction of a multifold trend consisting from mutually interacting elements can be seen as the solution to the methodological problems facing the identification of the so-called *root cause* predetermineds, e.g. as suggested by Porter (1985:453-455). Dividing a number of identified predetermineds into '*independent*' and '*dependent*' forces give rise to numerous 'chicken-or-the-egg' discussions when searching for fundamentally *determining* variables. As suggested by the presence of feedback loops, such determining variables may not even be present as variables can be *mutually determining* through positive or negative feedback as described in Chapter 3.

[165] Skytte *et al* 2004:22

[166] See e.g. BTM 2005a:11

This development has occurred as a result of the increasing size of both individual turbines and entire wind projects. Up scaling of the individual turbine has been the primary source of cost reductions both in terms of installed capacity and final cost of electricity production[167]. The parallel increase in the size of wind projects has been spurred by the need to spread fixed costs of installation and operation over multiple turbines[168], profiting from economies of scale in project size. These developments have increased the *minimum profitable scale* of wind projects and thus driven up the initial investments necessary for owning a profitable wind project. As a consequence, the buyer segmentation of the wind turbine market has shifted; favouring larger and more professional buyers able to handle larger investments and assess financial risks connected to volatile energy markets[169]. The industry observers and participants interviewed for this report expected buyers to become more conservative in their assessment of financial risk, considering wind projects on increasingly similar terms with traditional energy technologies. An added factor in the increased professionalism of buyers is the growing experience and professionalism of utilities handling entire portfolios of operational wind projects. These repeat buyers will have a continuously improving basis for comparison and assessment of bids from competing wind turbine manufacturers. The trend toward major buyers owning large fleets of wind projects is also the basis for anticipations about the increasing importance of service agreements[170] and repowering[171] as future sources of revenue for the industry. In addition, a commonly held expectation in industry literature is that, as a function of the first fold, developers will eventually disappear as an intermediary between wind turbine manufacturers and final owners of wind projects. As the size and professionalism of final buyers increase, it is proposed, they will take over the development wind projects themselves; cutting out independent developers[172]. This view is, however, contested by the industry observers and participants interviewed for this report. The general expectation is that although smaller developers will disappear over the coming decade, the specialised skills of larger developers will continue to be in demand. Historically, large utilities have not been sufficiently competent in gaining local and political support for large wind projects. This has given rise to organised local resistance to several wind projects. Developers specialising in these skills are expected to prosper over the coming decade. Current developments are inconclusive on this issue beyond the observation that developers follow the general pattern of buyers; undergoing rapid concentration and consolidation into fewer,

[167] See e.g. Kjær 1988:37 and EWEA 2004
[168] See EWEA 2004:65-69
[169] See BTM 2005a:11
[170] Danske Equities 2003:9
[171] BTM 2005a:49-50. The term repowering covers the replacement of older wind turbines with newer ones (usually larger) thus reusing the site.
[172] See e.g. Danske Equities: 12

larger and more professional firms[173]. The extent to which wind turbine manufacturers will integrate further forward into electricity sales remains uncertain as the potentials of this business model is largely unexploited among current manufacturers[174]. The future of private investor groups as large buyers of wind projects are expected to be heavily dependent on the ability of wind turbine manufacturers to guarantee the quality and decrease financial risks of large projects to a level where these less professional buyers feel confident enough to invest. It is still unclear if this will be achieved over the coming decade, but as discussed in the third fold below, developments in this direction are ongoing.

The assumption behind the continuation of the trend toward larger and more professional buyers, demanding still larger wind turbine projects is thus thoroughly based in historical precedence. In addition, this trend is based on assumptions about the continued effects of various types of economies of scale intrinsic to the physical activities of the industry and its product. These include economies of turbine size, economies of project size, economies of scale in production and economies of order size. In spite of these powerful economies of scale evident in many activities of the industry and its customers, it is clear that these developments will not continue indefinitely, but are likely to pass through an inflexion point, following the familiar S-curve. Near saturation of economies of turbine size has been predicted for decades but has continuously been proven wrong, as still larger turbine designs have proven technological and commercial successes[175]. Today, onshore planning restraints and organised local opposition to the visual impact of wind projects seem more likely to limit the size of individual turbines and projects than limits to technological feasibility and economic viability[176]. The general expectation among the industry observers and participants interviewed for this report is that such limitations are now visible for most onshore projects. Should these restrains seriously limit onshore developments, it is likely that emphasis will shift to the largely untapped offshore resource, where diseconomies of turbine- and project-size are not yet in sight[177]. As a function of this development, financial demands on buyers of wind projects are thus assumed to increase, continuing the historical trend of larger and more professional buyers – at least over the coming decade.

Beyond larger and more professional buyers of still larger wind projects, this fold assumes continuing geographical diversification of demand. Historically, small national niche markets and a

[173] See BTM 2005a:20-21
[174] BTM 2005b:41
[175] EWEA 2004:14
[176] See e.g. Morgan Stanley 2006
[177] EWEA 2004:28

few, large international markets have driven the growth of the wind turbine industry. The Californian market played an instrumental role in the internationalisation of early wind turbine manufacturers and later the Spanish and German markets emerged as the main drivers of industry growth. This fold of the multifold trend expects this to change significantly over the coming decade, as a wider range of large, international markets will become available to the industry[178]. Outside of Europe, which has traditionally been the largest market, India, the US, Japan and China have emerged in recent years as new prominent markets and more are expected to join them in the years to come[179].

The primary drivers of this development are four-fold. Firstly, environmental concern followed by government support favouring environmental performance has penetrated and spurred growth in a wider range of national markets worldwide[180]. Secondly, uncertainty about security of supply, especially with regard to oil and natural gas has led to increased emphasis and support for energy sources with stable or no fuel demands[181]. Thirdly, wind power has matured and become increasingly competitive with conventional energy technologies and has thus diffused and penetrated the mainstream of globally available energy technologies[182]. And fourthly, global electricity demand is expected to rise steadily by some 2.5% annually over the coming quarter of a century[183]. The continuation of the former two drivers - environmental concern and security of supply - may be considered highly probable over the coming decade, although far from inevitable[184], while the growing electricity demand and maturity of wind technology are considered to be *predetermined.* The latter of these will be considered in more detail as part of the *third fold* of the multifold trend later in this chapter. Even if environmental concern or security of supply (or potentially both) levelled off in one or more large markets, the trend toward geographical diversification of buyers are likely to strengthen rather than stagnate, as the search for alternative markets intensify. It is thus assumed that the geographical diversification of major markets will continue over the coming decade.

[178] Morgan Stanley 2005:11
[179] BTM 2005a:17., Morgan Stanley 2005:13, BTM 2005b:11
[180] See e.g. IETA 2006
[181] See European Commission 2001
[182] Carnegie Securities Research 2005:10. See also Morthorst & Chandler 2004
[183] IEA 2004:68-69 and 192
[184] Environmental concern and security of supply were instrumental to the emergence of the wind turbine industry in the 70s and their continuation seemed assured. However, in the 80s, oil prices once again settled at a historical low and demand for wind turbines levelled off, only to recover well into the 90s, with the emergence of Germany and Spain as major markets (see Skytte et al 2004:17-18). This goes to say the reversal of these drivers cannot be excluded as a possibility in the coming decade.

Exploring the impact of the first fold upon the competitive environment

The strategic relevance of the first fold of the multifold trend is determined by its impact upon the competitive environment of the wind turbine industry. Using the methodology described in Chapter 5, the influence of the first fold upon the ICM was systematically investigated using a direct impact matrix (Godet 1994). On the basis of the above considerations, the first fold of the multifold trend was systematically paired against the variables of the ICM. Resulting from this process, *seven* proposed impacts could be theoretically, empirically or logically justified. These propositions are made explicit in figure 6.1 below. Given these proposed *first order effects*, the ICM proposes a number of *second and third order effects* through the causal tree[185]. The causal tree does not 'prove' that these effects will follow from the progression of the first fold, but provides an *explicit* and *internally consistent* hypothesis based on currently available information. Although the methodology allows the exploration of higher order effects, the exploration will be limited to the first, second third order effects of each fold[186]. Also, it is important to note, that as described in Chapter 3, the polarities of the causal tree describe *the structure* - not the behaviour - of the causal tree. As an example, the causal tree implies that **if** the first fold of the multifold trend were to increase (as anticipated), the relative concentration of buyers would move in the *same direction* as the first fold, *all else being equal*.

[185] The term 'first order effect' thus signifies the *direct impact* of the fold upon the ICM, while 'second and third order effect' signifies the secondary and tertiary effects respectively.
[186] As the exploration takes into consideration higher orders of impact, the number of effects to be considered grows exponentially until a point of saturation, beyond which only repetitive feedback loops exist.

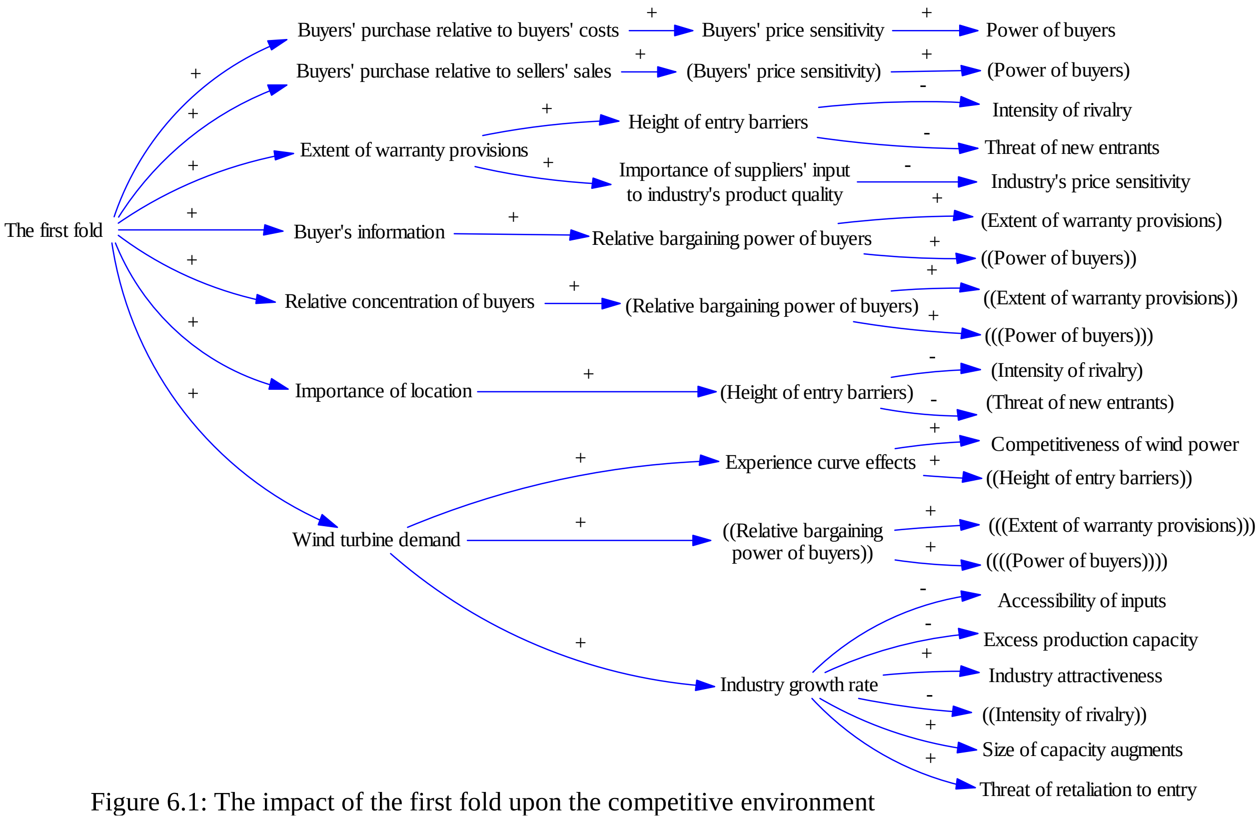

Figure 6.1: The impact of the first fold upon the competitive environment

As illustrated above[187], seven impacts are proposed through which the first fold of the multifold trend influences the competitive environment of the wind turbine industry. The first three of these imply that as the multifold trend progresses, so will *Buyers' purchase relative to buyers' costs*, *Buyers' purchase relative to sellers' sales* and the *Extent of warranty provisions*, all else being equal. These three impacts are proposed as a consequence of the anticipated increase in the size of wind projects as described above. Secondly, the impact of the first fold upon *Buyers' information* and the *Relative concentration of buyers* are related to the expectation of increasing size and professionalism of buyers, while the impact upon the *Importance of location* and *Wind turbine demand* is related to the increasingly geographically diversified buyers. As a wider range of geographically dispersed markets become available, wind turbine manufacturers are increasingly required to have a global presence.

Given these seven impacts upon the competitive environment, the ICM proposes that, as a function of the first fold, buyers of wind turbines are likely to become increasingly powerful and price sensitive over the coming decade. Firstly, as buyers gain experience from several operational wind projects, they will be in a better position to compare and evaluate bids from manufacturers, thus improving their bargaining position. Secondly, as the size of wind projects increase, the individual

[187] The bracketed variables indicate that they are influenced more than once through the causal tree. Note also that the polarities are indicated *above* the arrows as will be practiced throughout this report.

order will become more important to wind turbine manufacturers. And thirdly, the ICM suggests that this relative improvement in bargaining position is further amplified as buyers of wind turbines become fewer and larger over the coming decade.
As a result of the increasing financial risk related to larger projects, especially with regard to serial faults, buyers will become more conservative in their assessment of financial risk. In addition, buyers are likely to use their improved bargaining position to limit their financial risk by demanding extended warranties from manufacturers. Warranty provisions are therefore likely become an increasingly important part of winning orders. This will likewise strengthen the role of warranties as a means of increasing entry barriers around the wind turbine industry. The ICM proposes that this tendency will increase the dependency of wind turbine manufacturers upon the product quality of component suppliers' input. Wind turbine manufacturers will become less price sensitive when dealing with component suppliers; favouring proven reliability, closer cooperation and/or legally binding quality guarantees. The first fold illustrates the increasing sensitivity of wind turbine manufacturers to serial faults, as they bear an increasing financial risk of defect components purchased from outsourced suppliers.

As a function of the first fold, a wider range of geographically dispersed markets will become available to the wind turbine industry. The major beneficiaries of this development will be wind turbine manufacturers with a global presence. These will be in a better position to decrease transport costs and hedge against volatile currency rates and domestic supply content requirements along with other forms of protectionism. The ICM proposes that the importance of a global presence will increase the height of entry barriers around the industry, as potential newcomers are forced to enter globally to avoid competing at a disadvantage. Another effect of the geographical diversification of markets is increasing demand for wind turbines from a still wider range of buyers. Potentially to a point where accessibility of inputs will continue to be the major bottleneck for manufacturers as new markets emerge.

High demand is also likely to moderate the bargaining power of individual buyers in periods where demand outstrips supply. The ICM proposes that, higher unit output spurred by increased demand will likewise have a positive impact on experience curve effects - and thus the long-term competitiveness of wind energy. This in turn will raise the technological standards that a potential entrant will have to meet; raising entry barriers around the industry. Conversely, high demand will likewise increase the attractiveness of the industry to potential entrants and may likewise hamper the willingness of incumbents to retaliate. This sequence of effects indicates that, in spite of high and continuously increasing entry barriers, the wind turbine industry remains highly attractive to potential newcomers in periods of high growth. As a further effect, the ICM proposes that continued growth is the prerequisite for preventing excess production capacity and limiting the intensity of rivalry among manufactures. This sensitivity to demand fluctuations was touched upon in Chapter 4 and is likely to be amplified over the coming decade as a function of the first fold of the multifold trend.

6.4 The second fold

The second fold of the multifold trend assumes that over the coming decade, the wind turbine industry will continue to consolidate around fewer, larger and increasingly globalised wind turbine manufacturers, emphasising of economies of scale and scope. Like the previous fold, the second fold of the multifold trend assumes the continuation of well-documented historical patterns of development and thus takes historical precedence as its point of departure.

Historical studies of the Danish wind turbine industry suggest that the number of Danish manufacturers peaked around 1988, at which time the national market supported as many as 21 manufacturers. By 1998, that number was reduced to four[188]. Today that number is further reduced to somewhere between one and two[189]. This development has, to a large extent, been matched internationally where, in 1990, some 70 manufacturers existed, of which the top five manufacturers held a market share of just 53%[190], compared to the present day 85.5%[191]; the hallmarks of a significantly less concentrated industry. The reasons behind this historical development, along with the assumption that it is likely to continue over the coming decade, are closely related to the mechanisms behind the first fold of the multifold trend described above.

Economies - and thus advantages - of scale can be present at many levels of the activities of an industry[192]. As the size of both individual turbines and wind turbine projects has increased, so has the minimum efficient size of wind turbine manufacturers. The presence of economies of scale means that there is a *positive correlation* between the market share of a wind turbine manufacturer and its profitability. Increasing minimum requirements to financial strength, production capacity and extensive R&D capabilities along with an impressive track record of prior operational wind projects have significantly disadvantaged smaller manufacturers faced with larger and more professional buyers[193]. As described in relation to the first fold, the demand for larger and more cost-efficient

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188 See Skytte et al 2004:121
189 Depending on whether Siemens (former Bonus) is included.
190 BTM 2005b:35
191 BTM 2005a:16
192 See e.g. Porter 1980:7-9
193 Danske Equities:14

wind projects is assumed to continue over the coming decade. In terms of continued consolidation, the industry observers and participants interviewed for this report considered the current number of five large international wind turbine manufacturers a 'ceiling', and all interviewees considered lower numbers feasible within the coming decade. Many smaller manufacturers not saved by privileged home market positions or high growth rates are expected to be bought or go out of business, increasing the distance between large and small manufacturers[194]. This expectation is widely supported by industry literature[195] and longitudinal studies of industry populations[196]. A recent theory of industry evolution suggests that, if left purely to considerations of economic efficiency, industries will eventually reach a state in which only three major competitors have taken over all activities in which significant economies of scale and scope exist[197]. Although this can be considered nothing more than a 'rule of thumb'[198], this eventuality cannot be ruled out in the case of the wind turbine industry over the coming decade.

Closely related to advantages of scale, a key driver behind the continued consolidation of the wind turbine industry is the necessity of a global presence in response to increasingly geographically diverse buyers. To fully utilize economies of scale in production, a geographically well-diversified customer base is a key requirement for achieving stable operating margins and to avoid dependency upon a single market[199], particular currency rates and to lower transport costs[200]. This is currently a major risk factor of many smaller manufacturers. The geographical diversification of buyers described in the first fold has been matched by increasing globalisation of wind turbine manufactures. By 2004, wind turbine manufacturers exported on average 60.5% of their total production (measured in MW capacity) outside of their respective home markets[201]. This figure rose from 51.9% in 2002[202]. Although these figures cover significant variation between individual manufacturers, the general tendency moves the industry away from home- and single market dependency towards an increasingly globalised industry[203]. As it is to be expected, the least globalised manufacturers are those located in attractive home markets such as Spanish Gamesa (12.5% export share), Indian Suzlon (0%) and German Enercon (34.9%). By contrast, Danish Vestas

194 BTM 2004b:41
195 See BTM 2005b:41, Morgan Stanley 2005: 12 and Danske Equities 2003:19
196 See e.g. Geroski & Mazzucato 2001 and Geroski & Mata 2001
197 See Sheth & Sisodia 2002
198 The wind turbine industry is by no means left purely to considerations of economic efficiency in that it markets a highly regulated, subsidised product influenced by many distorting factors such a patents and protectionism in national markets. Taking such exceptions into consideration, very few industries are left 'purely' to considerations of economic efficiency.
199 Morgan Stanley 2005:12
200 See e.g. Vestas Annual Report 2005:21
201 BTM 2005a:19
202 BTM 2003:19
203 See e.g. Morgan Stanley 2005:6

(99.9%) is by far the most globalised wind turbine manufacturer[204]. The assumptions behind the continuation of the second fold of the multifold trend are thus based on historical precedence, but also on the continued parallel and interacting development of buyers and suppliers of wind turbines in response to underlying economies of scale and scope.

Exploring the impact of the second fold upon the competitive environment

As illustrated in figure 6.2 below, by systematically paring the second fold of the multifold trend with the constituent variables of the ICM, two impacts are proposed on the basis of the above considerations, through which the second fold of the multifold trend influences the competitive environment of the wind turbine industry over the coming decade.

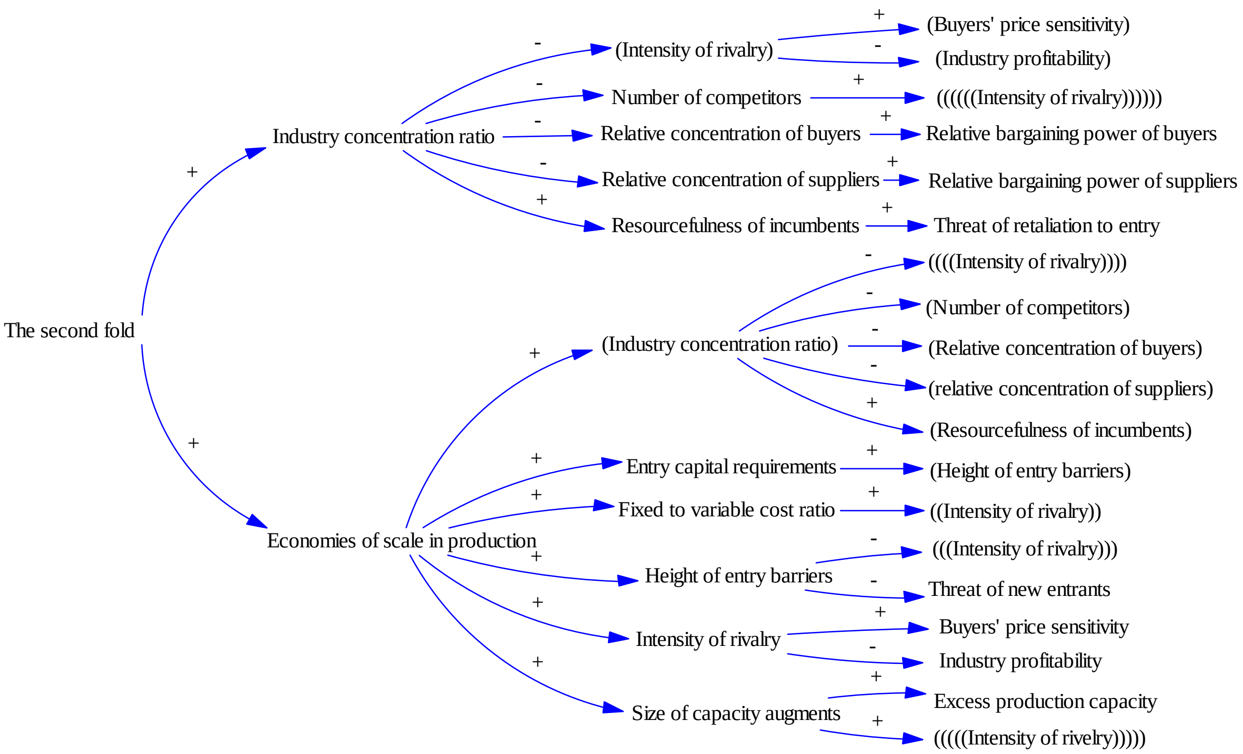

Figure 6.2: The impact of the second fold upon the competitive environment

As illustrated above, as a function of the increasing *Industry concentration ratio*, the ICM proposes a number of second and third order effects. The most consistent of these is the decreasing intensity of rivalry among fewer and larger wind turbine manufacturers, as cooperation between manufacturers to keep prices stable becomes easier. Also, the lower number of dominant manufacturers will be better able to exercise direction to the industry and avoid prolonged price wars – at least while growth remains stable. As a third order effect, the ICM proposes that the lowered intensity of rivalry and improved cooperation between manufactures will lessen buyers' ability to play manufacturers against

[204] BTM 2005a:19

each other, lowering buyers' price sensitivity and increasing the profitability of the industry. This effect is further amplified as the concentration of the wind turbine industry increases relative to both buyers and suppliers, all else being equal. The ICM also proposes that as the wind turbine industry consolidates, more resourceful and consolidated manufacturers will pose a greater threat of forceful and coordinated retaliation against potential entrants into the industry. Seen in isolation, the ICM proposes that the consolidation of the industry will have a potentially highly beneficial impact upon the structure of the industry - especially with regard to countering powerful buyers. From this consideration, it is clear that the first and second fold of the multifold trend are highly interdependent.

The increasing emphasis on *Economies of scale in production* similarly produces a number of second and third order effects upon the structure of the industry. The first of these is the amplification of the industry concentration ratio and thus further emphasises the effects described above. Moreover, the ICM proposes that, as a result of this anticipated development, the entry barriers around the wind turbine industry are likely to heighten over the coming decade as entry capital requirements are increased substantially from their already significant level. As the industry globalises, potential entrants will increasingly be forced to enter the industry both in scale and in scope and thus at considerable financial risk, or must face a significant disadvantage relative to incumbents.
Another interesting second order effect of the continuation of this fold of the multifold trend is the increasing fixed to variable cost ratio of the industry, combined with the increasing size of capacity augments – both spurred by economies of scale. As suggested by the ICM, both of these effects are likely to increase the intensity of rivalry in the industry. If currently high industry growth rates are not maintained, the heightened fixed to variable cost ratios and increased size of capacity augments are likely to lead to excess production capacity coupled with the urgent need to fill this capacity. This is the recipe for extended price wars and low profitability and thus increased sensitivity of the industry as a whole to volatile demand. This amplifies the sensitivities underlined as part of the first fold above. As suggested by the ICM, the increasing emphasis on economies of scale in production and thus the transition of wind turbine manufacturing into a volume driven industry is in itself a catalyst for more intense rivalry among manufacturers.

6.5 The third fold

The third fold assumes that over the coming decade, wind power will enter the mainstream of energy technologies as it matures; shifting emphasis from product to process discovery as the key source of cost reductions. This fold assumes the continuation of the technological and economic improvement of wind technology over the coming decade. This optimistic outlook held by the industry observers and participants interviewed for this report is widely supported in industry literature concluding that wind technology has yet to reach its final form and that opportunities for further cost reductions through increased industrialisation remain plentiful[205].

Historical advancements in wind technology have been impressive. Empirical studies suggest that the cost of wind power has declined by as much as 80% since 1980. In terms of learning curve effects, this means a cost reduction of some 15% (Price/kWh) every time the accumulative production doubles[206]. The current cost of electricity generation from wind depends on a number of factors specific to the individual wind project and any measurement therefore relies on a number of broad, and often disputed, assumptions. Historical progress has nonetheless improved the competitiveness of wind technology to a point where Carnegie Securities Research (2005) estimates that the production cost of wind is now lower than that of gas and fully comparable to the cost of coal[207]. This fold of the multifold trend assumes that, as a function of continued technological advancements, over the coming decade, wind power will continue its entry into the mainstream of energy generation technologies.

Based on this historically steep learning curve, a number of extrapolations have been made about the future cost of wind power. It follows that the future cost of electricity generation depends on even greater number of factors than the current one, many of which are inherently uncertain. Based on 20 years of depreciations, a 6% interest rate and an average wind speed of 5.4 metres per second, Vestas estimates the current price per kWh electricity at EUR 0.03, and expects this price to fall to EUR 0.02 within the next ten to 15 years[208] - an impressive, although hardly impartial figure. EWEA estimates a cost reduction from EUR 0.05-0.06 from 2002 to around EUR 0.044-0.056 by 2010. This is assuming a cost reduction of 9-17% (Price/kWh) for every doubling of cumulative installation and an annual growth rate of installation of 7% and a medium sized wind turbine (850-1,500 kW) installed in medium wind[209]. This kind of extrapolation based on experience curves is likewise a dubious affair[210]. It is worth noting the number of fixed assumptions upon which these extrapolations are based. As uncertain as these assumptions may be, they are indicators of expectations of continued progress. In the context of this fold of the multifold trend, the most important assumption is, that over

[205] See e.g. EWEA 2004:37 and Danske Equities 2003:4
[206] Carnegie Securities Research 2005:5
[207] Carnegie Securities Research 2005:10
[208] Danske Equities 2003:13
[209] EWEA 2004:106-107
[210] Extrapolations based on the experience curve methodology hold the inbuilt paradox that the future cost of a technology depends on its cumulative production or installation, which in turn depends on its future cost. In essence, to know one variable you have to know the other variable, which in turn depends on the first variable. For this reason, most extrapolations based on historical progress ratios assume that the cumulative production is a given, independent of future cost – as here, where a fixed annual growth rate in installation of 7 percent is assumed. Important price thresholds at which demand and thus production could change rapidly are thus ignored.

the coming decade, cost reductions will continue and that wind turbine technology will become increasingly comparable with mainstream energy technologies - an assumption widely shared in industry literature[211].

A widely held notion among the industry observers and participants interviewed for this report is the expectation of a shifting emphasis from product to process discovery as the key source of cost reductions. This expectation corresponds to the pattern of development first proposed by Abernathy & Utterback (1975). This model suggests that as the product technology of an industry matures, a dominant design is eventually found and the rate of radical product innovations declines as improvements become incremental. As the product design becomes less volatile, the process through which it is produced can now be optimised - first through radical process innovations, which eventually also decline to incremental ones[212]. The competition among rival product designs in the wind turbine industry has taken place along numerous design parameters: vertical or horizontal axis, number of wings, pitch versus stall regulation, fixed or variable speed, etc. The emergence of a dominant product design is widely agreed to have taken place in the 1980s, in the form of the three-bladed, fixed speed, stall regulated turbine. Although wind technology has developed enormously since then, this basic design has remained dominant until today[213]. Because of the powerful economies of scale in wind turbine production, along with emerging onshore limits to up scaling this fold assumes that, over the coming decade, emphasis will gradually shift to the optimisation of wind turbine production. According to Klepper & Simons (1997), this tendency will significantly amplify the effects of the first and second fold, in that the value of a reduction in average cost will be proportional to a firm’s level of output. Larger firms therefore earn greater returns from process discovery than do smaller firms; strengthening the tendency of the wind turbine industry and its buyers to consolidate[214]. This shift is an important factor in changing the wind turbine manufacturers to industrialise their means of production and become increasingly volume-driven. As we shall see, this development is further related to those proposed in the fourth fold described below.

Exploring the impact of the third fold upon the competitive environment

As illustrated in figure 6.3 below, by systematically paring the third fold of the multifold trend with the constituent variables of the ICM on the basis of the above considerations, four impacts are proposed through which the third fold of the multifold trend influences the competitive environment of the wind turbine industry over the coming decade.

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[211] BTM 2005b:69-70
[212] See Abernathy & Utterback 1975
[213] EWEA 2004:7-17
[214] Klepper & Simons 1997:9

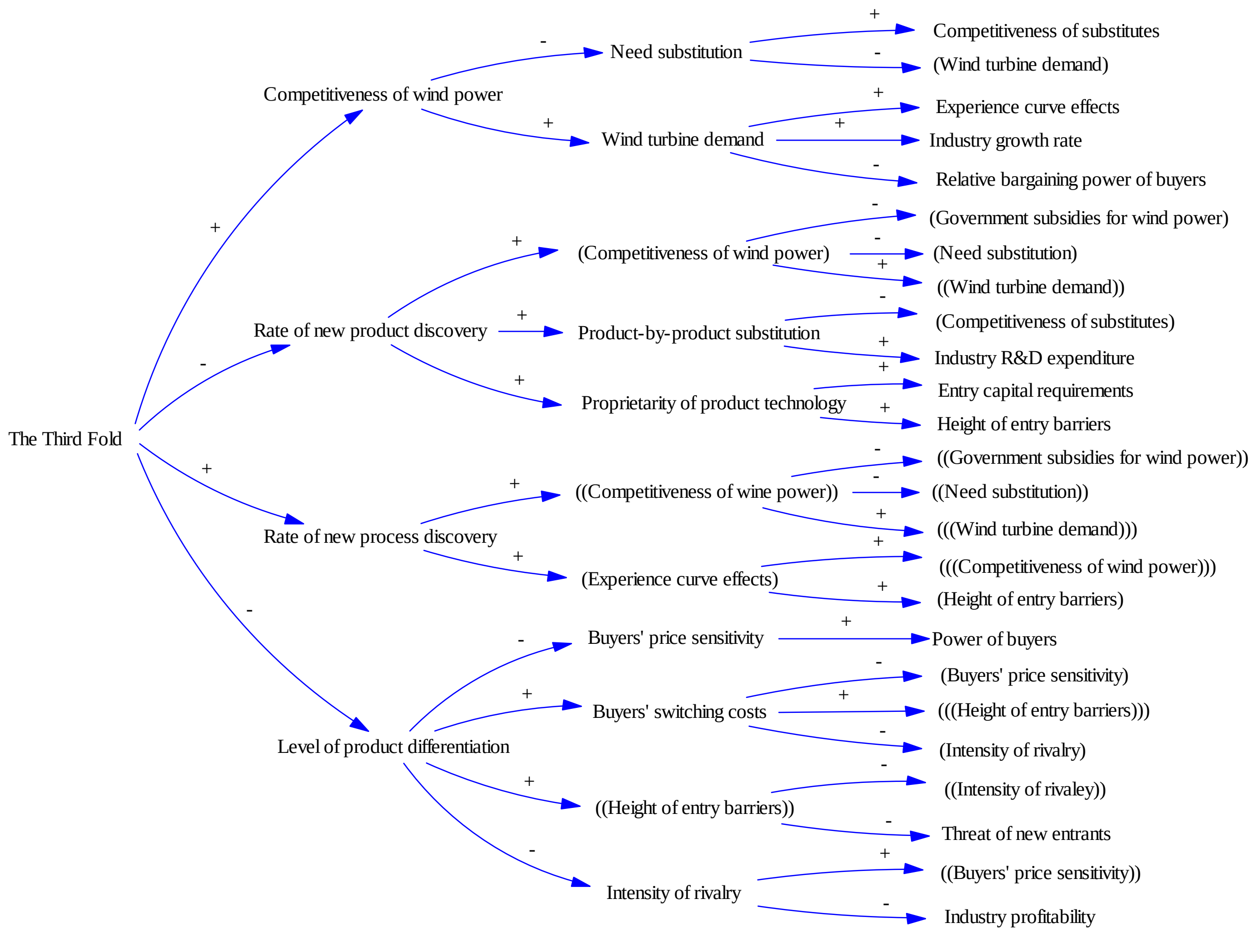

Figure 6.3: The impact of the third fold upon the competitive environment

As illustrated above, based on these four impacts, the ICM proposes a number of second and third order effects. As a consequence of the assumption of continued technological and economic improvement of wind technology it is proposed that, in absolute terms, the *Competitiveness of wind power* will increase over the coming decade. As in the first fold, increasing demand and high industry growth will limit the relative bargaining power of otherwise powerful. As a consequence of the expected shift from product to process discovery, it is proposed that the *Rate of new product discovery* will decline while the *Rate of new process discovery* increases. As a fourth effect, it is proposed that the *Level of product differentiation* will decline as the technology matures and the product becomes increasingly standardised.

The parallel shift from product to process discovery as a key source of cost reductions will likely lead to positive effects on R&D expenditure as the lifetime of products are extended. Also, increased focus on improving the production process will have positive impacts experience curve effects as a source of competitiveness, as the industry becomes more volume driven. On the other hand, the ICM proposes that proprietarity of wind turbine technology is expected to decline as wind turbines

become increasingly standardised. This is likely to lower the technological entry barriers around the industry, giving way to increased licensing and imitation of product technology.
As a consequence declining product differentiation, the ICM proposes a number of adverse second order effects, especially with regard to the industry's bargaining position relative to buyers of wind turbines. Increasingly standardised turbine designs will increase buyers' price sensitivity while lowering switching costs as products become increasingly similar. Closely related to these developments is the increasing intensity of rivalry among manufacturers, as price is emphasised and the number of competitive parameters decline.

6.6 The fourth fold

The fourth fold of the multifold trend assumes that over the coming decade, wind turbine manufacturers will become less backward integrated and will increasingly emphasise partnerships with increasingly shared, specialised and independent component manufacturers.
In terms of vertical integration, there is significant variation among the business models of wind turbine manufacturers. Among the major manufacturers, the most vertically integrated are Gamesa, Siemens[215] and Enercon[216] relative to GE and Vestas[217]. Blades, nacelles and control systems are the most specialised and vital components in terms of turbine efficiency and are usually manufactured in-house whereas generators, gearboxes and towers are more often outsourced[218]. These general sourcing strategies cover significant nuances, especially with regard to so-called *hybrid sourcing*, in which wind turbine manufacturers combine in-house and outsourced production of certain components. This allows benchmarking of the manufacturer's own performance against that of a specialised supplier while improving the manufacturer's bargaining position relative to that supplier. To further improve their bargaining position, wind turbine manufacturers actively avoid reliance upon any single component manufacturer, often playing suppliers against each other[219]. According to several industry observers and participants interviewed for this report, this has created an atmosphere of distrust between manufacturers and component suppliers and has contributed significantly to decreasing the attractiveness of specialised component manufacturing for the wind turbine industry[220]. This development has hampered component manufacturers' commitment to the wind turbine industry and may have delayed the development of the industry's value chain as a whole.

[215] See Morgan Stanley 2005:19
[216] See Danske Equities 2003:8
[217] See Morgan Stanley 2005:19
[218] See Morgan Stanley 2005:18 and Danske Equities 2003:8
[219] Takeuchi 2003:46
[220] Danske equities:11

The industry observers and participants interviewed for this report proposes that, as manufacturers industrialise over the coming decade as a function of the third fold, wind turbine manufacturers will generally become less backward integrated. In doing so, they draw upon a historical analogy to the development of the automobile industry – a widely held notion throughout the industry. The justifications behind this assumption are closely related to the developments proposed in both the second and third fold. These two folds assume an increasing emphasis on economies of scale and scope, paralleled by shifting emphasis from process to product discovery along with an increasing standardisation of wind turbine technology.

As a function of these developments, the fourth fold of the multifold trend assumes that the increasing scale of the industry will allow component manufacturers to profitably commit to the industry, increasingly customising their components to the needs of the wind turbine industry[221]. This tendency is visible in several areas of component manufacturing today[222]. Moreover, the increasing standardisation of wind turbine technology will allow increasing utilisation of economies of scale and scope in specialised component production - *beyond those available to any single wind turbine manufacturer*. As wind turbine manufacturers internationalise with the progression of the second fold, component suppliers will increase their market scope by locating production near major markets forming so-called *supplier parks*. Coordinating such efforts will in itself require increased cooperation. These advantages are already exploited in several areas of component production, the most obvious example being the strategy of the specialised blade manufacturer LM Glasfiber[223]. The expectations of the industry observers and participants interviewed for this report, are widely supported in industry literature and are closely connected to the increasing industrialisation of wind turbine manufacturing[224]. Morgan Stanley (2005) assesses that the absence of a network of specialised component suppliers has been the primary reason for the adoption of highly integrated business models among incumbent wind turbine manufacturers, and goes on to conclude that when such a network develops, most manufacturers will become less vertically integrated[225]. By analogy, this proposed pattern of development has been documented in a number of other industries such as the automobile industry and IT hardware industries, where the impact of standardisation on vertical integration has become apparent[226]. This fold of the multifold trend thus assumes that the utilisation

[221] In this sense, the term ‘specialised’ component supplier is intended to imply that the supplied component is customised (and therefore optimised) to the needs of the wind turbine industry, as opposed to standardised to suit the requirements of a wider range of industries.
[222] Takeuchi 2003:56
[223] See http://www.lmglasfiber.com/About/Strategy.aspx, last accessed 11/08/06
[224] See e.g.Andersen & Drejer 2006
[225] Morgan Stanley 2005:20
[226] See Christensen et al. 2001

of economies of scale in component production will lead to less vertical integration and increased sharing of a of specialised component suppliers among wind turbine manufacturers.

Exploring the impact of the fourth fold upon the competitive environment

As illustrated in figure 6.4 below, by systematically paring the fourth fold of the multifold trend with the constituent variables of the ICM on the basis of the above considerations, seven impacts are proposed through which the fourth fold of the multifold trend influences the competitive environment of the wind turbine industry over the coming decade.

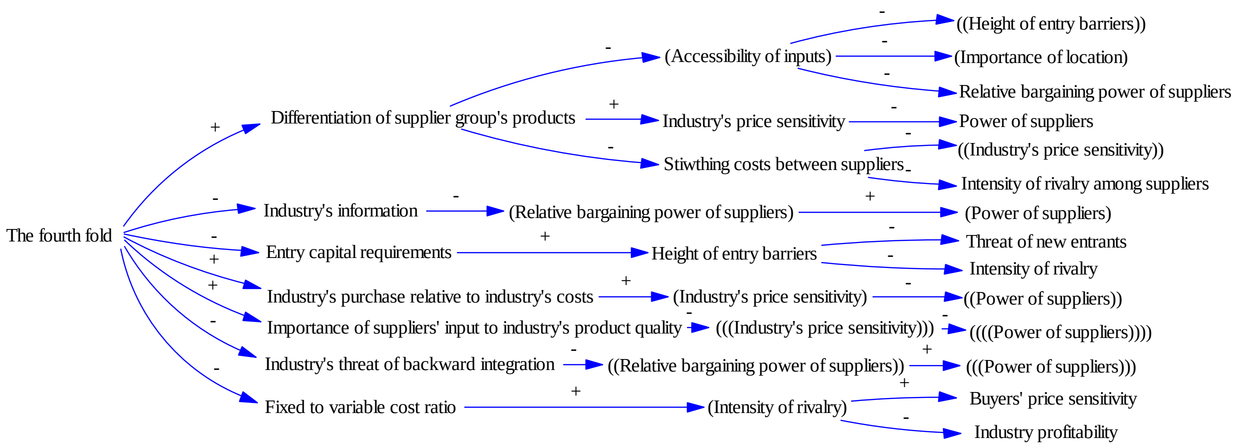

Figure 6.4: The impact of the fourth fold upon the competitive environment

The first two impacts are proposed as a function of the increasing specialisation and customisation of suppliers' input to wind turbine manufacturers. The transition from standardised to specialised components will increase the *Differentiation of supplier group's products* as suppliers will increasingly be able to offer components tailored for the needs of the industry. Also, as suppliers become increasingly specialised, the *Industry's information* about the specialised processes of component manufacturing is likely to decline in these areas. The latter five causalities are proposed as a function of decreasing vertical integration of wind turbine manufacturers. Firstly the *Entry capital requirements* will decline, all else being equal, as the necessity of entering several stages of the supply chain as well as that of wind turbine assembly declines. The second effect is the increase of *Industry's purchase relative to industry's costs* as the proportion of outsourced components increases. The third impact is closely related to the second - as the proportion of outsourced components increases, so will wind turbine manufacturers' dependency on the input of specialised suppliers. Consequently, the *Importance of suppliers' input to industry's product quality* will increase. Fourthly, as a function of the general tendency of less vertical integration among wind turbine manufacturers, the *Industry's threat of backward integration* will decrease in several areas of component manufacturing. Finally, the decreasing vertical integration of wind turbine manufacturers into various areas of component manufacturing is assumed to decrease the *Fixed to variable cost ratio*, as the necessary production capacity is now shared with specialised component manufacturers.

Assuming these seven impacts, the ICM proposes a number of second and third order effects. These effects would suggest that as a function of the fourth fold, the bargaining power of suppliers would improve significantly over the coning decade. As the supply network of the industry develops it may no longer be necessary for a new entrant to enter several areas of component manufacturing as well as that of wind turbine assembly. This will lower entry barriers around the industry and potentially spur increased rivalry among manufacturers. Also, as suppliers' products become more specialised and differentiated, the opportunities for manufacturers to sustain hybrid sourcing are likely to become fewer. The tendency toward more powerful and independent component suppliers is emphasised as manufacturers' price sensitivity declines and switching costs between suppliers increase. The ICM further proposes that suppliers' opportunity to build switching costs through product differentiation will lessen rivalry among suppliers and hamper wind turbine manufacturers' ability to play suppliers against each other. In addition, the bargaining power of wind turbine manufacturers is further limited as they become less informed about the production costs of increasingly specialised suppliers.

6.7 Summing up: The anticipated structure of the wind turbine industry

Based on the exploration of the impact of the four folds of the multifold trend upon the competitive environment of the wind turbine industry, it is clear that powerful buyers will continue to dominate the strategic agenda of wind turbine manufacturers over the coming decade. Large, well-informed and price sensitive buyers, placing large orders will be in a continuously improving bargaining position relative to wind turbine manufacturers. These buyers will be highly conservative with regard to financial risk, demanding extended warranties and will consider wind projects on similar terms with conventional investments in electricity generation capacity. Although potentially high demand and the parallel concentration of the wind turbine industry will to some extent counter this development, powerful buyers will have limit the profit potential of the wind turbine industry over the coming decade, especially in the absence of high industry growth. Based on the continuation of the multifold trend, rivalry among wind turbine manufacturers to service these powerful customers will intensify over the coming decade as manufacturers industrialise and product differentiation declines and economies of scale and scope become increasingly important. Large capacity augments and high fixed costs will create a powerful incentive to fill excess production capacity in times of volatile demand, creating fertile ground for intensified price competition. Although less vertical integration will allow wind turbine manufacturers to share this risk with specialised component manufacturers, the sensitivity of the industry to volatile demand will increase significantly over the coming decade as a function of the progression of the multifold trend. The major competitive parameters emphasised by these developments will be price per installed MW capacity, quality guarantees backed by a flawless track record of successful projects, and a global delivery system. These requirements will ensure that the barriers around the wind turbine industry will remain a significant deterrent to potential entrants over the coming decade. Increasing requirements to a global presence, utilisation of economies of scale, a track record of prior projects and increasing size and resourcefulness of incumbents are all significant challenges to potential new entrants. The ICM proposes that the height of entry barriers will be limited by continued technological standardisation and thus decreasing proprietarity of wind technology along with the decreasing vertical integration of the industry, allowing new rivals to successfully enter the industry without being vertically integrated. In spite of significant barriers to entry, these factors, coupled with periods of high industry growth, will sustain the threat posed by new entrants over the coming decade.

As a further consequence of the multifold trend, suppliers will become increasingly specialised and more powerful as manufacturers industrialise their production and outsource components. Their opportunity to raise wind turbine manufacturers' switching costs through increased customisation and specialisation of their input will become greater as component suppliers commit to the industry. Their bargaining position will be further improved by wind turbine manufacturers' decreasing threat of backward integration. Wind turbine manufacturers will, however, generally maintain their role as powerful and price sensitive customers as they become fewer and larger and, as a function of less integration, will be placing still larger orders for components relative to their total costs. This tendency may be amplified as manufacturers with narrow product ranges become less vertically integrated in response to an increasingly developed supplier network.

In terms of substitutes, the effects of the multifold trend are inconclusive. It is assumed that the competitiveness of wind technology will continue to improve and that over the coming decade it will enter the main stream of energy technologies. This development merely suggests that current competitive pressures will be replaced by others, as wind technology loses its privileged position as a new and promising energy technology and enters the more level playing field of conventional technologies.

Through this chapter, drawing upon personally held expectations, empirical observations and assessments, and theoretical propositions, a complex of explicit and justifiable expectations was established in the form of the multifold trend. This exploration was necessarily limited to *anticipated* changes in the competitive environment, leaving the out the major questions about changes that *might* occur. The following chapter will thus be concerned with the impact of major critical uncertainties facing the industry over the coming decade.

- Part II -

Chapter 7: Critical uncertainty - what we know we don't know

The previous chapter established a complex of explicit expectations about the forces influencing the competitive environment of the wind turbine industry over the coming decade. This chapter will be concerned with identifying and exploring the impact of major *known uncertainties* upon the competitive environment. The identification of uncertainties will be explorative, drawing upon theory, industry literature and a number of interviews with industry observers and participants. The ICM will then form the basis against which the impact of each critical uncertainty upon the competitive environment is explored.

7.1 What is critically uncertain?

At the outset, it is clear that a very wide range of developments can, to some extent, be considered uncertain. From the viewpoint of the positioning school, the degree to which an uncertainty is *critical* is determined by its impact upon the five forces constituting the structure of the wind turbine industry. Important strategic questions often fall under this category. In this sense, the question - and therefore the uncertainty - is *recognised*, but the answer remains uncertain. In the context of this report, the term *critical uncertainty* will thus refer to what can be identified as *recognised and strategically relevant uncertainties*.

7.2 Identifying critical uncertainties

Following Porter (1985), the identification of critical uncertainties took as its point of departure *uncertainties and principal questions* related to the five competitive forces proposed by the positioning school[227]. Drawing upon the seven in-depth interviews with industry observers and participants, a number of loosely formulated questions were compiled about the development of the industry over the coming decade[228]. These uncertainties were subsequently specified and empirically justified, as described below. Resulting from this process, the following two critical uncertainties could be identified:

1. Will the growth rate of the wind turbine industry change significantly over the coming decade?
2. Will one or more major new competitors emerge or enter into the wind turbine industry over the coming decade?

[227] See Porter 1985:448

[228] The list of respondents, the interview guide and general considerations can be found in Appendix C. The interview data used in this Chapter corresponds to the answers to questions 6 and 7, including doubts and important questions raised through questions 1-5.

Using the terms of Kahn & Wiener (1967), the *principal outcomes* of these critical uncertainties can be considered *canonical variations* of the multifold trend[229]. In this sense, the impact of the possible outcomes of these uncertainties should not be assessed against the wind turbine industry as it appears today, but against its *expected development* as captured by multifold trend. Canonical variations essentially view the progression of the multifold trend *in light of a number of strategically relevant contingencies.* Other categorisations than the ones chosen here are clearly possible at both higher and lower levels of abstraction, but this should not fundamentally alter the assessment of their impact upon the competitive environment of the wind turbine industry[230]. In the following, I will consider the principal outcomes of these critical uncertainties and their impact upon the competitive environment of the wind turbine industry. The critical uncertainties identified here do not, of course, capture the full range of uncertainties faced by the wind turbine industry over the time horizon of a decade. Some of these are *unknowable* in the present. The critical uncertainties investigated here are chosen because they address a wide range *known* uncertainties *at their point of impact*. That is to say; there is a wide range of *known* uncertainties which may affect the growth rate of the wind turbine industry, but that impact of these can be meaningfully considered by examining the effect of volatile growth upon the competitive environment. The critical uncertainties investigated in this chapter have thus been chosen because they address the major questions about the competitive environment asked industry observers and participants interviewed for this report, at their point of impact. Through these questions, it is demonstrate how the ICM could be used as an exploratory tool to systematically investigate a wider range of critical uncertainties in an explicit and consistent manner.

7.3 Growth – Stability, fluctuation or stagnation?

In spite of highly positive, medium-term expectations found in industry literature, some of the most serious and widespread concerns among the industry observers and participants interviewed for this report are closely related to the long-term stability of growth and major growth drivers. In addition, several interviewees expressed concern that the industry may be experiencing somewhat of a ‘growth-hype’, and that wishful thinking and over-optimism may cloud the judgement of investors as well as forecasters. Although interviewees, to some degree, share the short- and medium-term optimism of industry analysts, they are uniformly careful when projecting growth rates into the latter half of the coming decade and all recognise the possibility of unexpected and prolonged growth

[229] Kahn & Wiener 1967:9

[230] The derivation of the two critical uncertainties from the interview data was done on the basis of Heijden (1998) in which the principal questions touched upon during each interview were initially listed. These issues were subsequently pooled and re-categorised to achieve the broadest possible ‘fit’ representing the collective concerns of the interviewees. As in Chapter 6, perhaps the most important consideration is that *representation* of all expressed doubts in the categories rather than areas of *consensus* were the focus of this exercise. It is inherent to this interpretation of interview data that this cannot be cone objectively and that other legitimate categorisations are necessarily possible.

fluctuations in major markets. In the following, I will explore a number of potential sources of volatile growth, which may influence the wind turbine industry over the coming decade.

Exploring causes of volatile growth

Using the assumptions of the ICM, figure 7.1 below explores potential causes of volatile industry growth through a *reversed causal tree*. As illustrated, a reversed causal tree proposes the potential causes of change by illustrating a number of determinants of a chosen variable[231] - in this case, the industry growth rate.

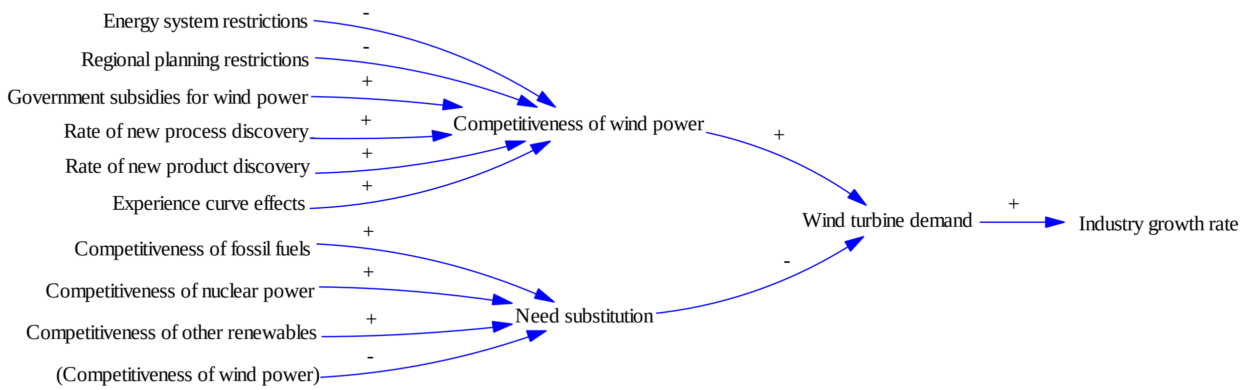

Figure 7.1: Determinants of industry growth rate

As illustrated above, the ICM proposes that the industry growth rate is determined by demand, which in turn is determined by the competitiveness of wind power relative to its need substitutes. The first three determinants of the competitiveness of wind power are closely related to the dependency of the wind turbine industry upon the political sphere. Historically, the growth of the wind turbine industry has generally been high, although highly volatile. The most serious fluctuation was the collapse of the Californian market, causing demand to drop by as much as 75% over a period of just two years from 1985-87[232]. Since 1992, the annually installed wind capacity worldwide has, on average, grown by some 22%[233]. This figure covers significant variation over the period. The years 1995, 1997 and 2001 saw growth rates in excess of 40%, while 1996, 1998 and 2004 experienced zero or slightly negative growth. The major cause of these fluctuations can be largely attributed to the dependency of the wind turbine industry upon the political sphere and the highly politicised nature of the energy sector as a whole[234]. The Californian Fluctuation as well as the emergence of the German and Spanish markets, and more recently, the Chinese, Indian and Japanese markets can be ascribed to

[231] Otherwise, reversed causal trees follow the standard syntactical rules of influence diagrams described in Chapters 3 and 6.
[232] Kjær 1988:18
[233] Calculated on the basis of EWEA 2004:119
[234] Political risk is notoriously present in all energy forecasting. See e.g. IEA 2004:53

various forms of political support[235]. Political intervention through subsidies, tax breaks and other forms of support have thus been instrumental in both the emergence and collapse of major markets, causing highly volatile growth. This phenomenon is known in the industry as *political risk*[236]. The volatility of political support was most recently demonstrated by prolonged US indecision about the extension of the Production Tax Credit (PTC), causing overall negative growth in 2004[237]. Thoroughly rooted in historical precedence, the industry observers and participants interviewed for this report raised significant questions about the long-term stability of political support for wind energy in nearly every major existing and emerging market.

The remaining three determinants of the competitiveness of wind power proposed by the ICM are related to its continued technological development. These variables were characterised by considerable uncertainty during the early development of the technology, where no dominant design existed, and where technological failure was frequent. As described in Chapter 6, the continuation of technological development, is now presumed to be *predetermined*, as part of the third fold of the multifold trend. The multifold trend assumes that over the coming decade, the emphasis of technological development will shift from process to process innovation as the primary source of cost reductions, and that wind technology will enter the mainstream of energy generation technologies. Although technological failure[238] of wind technology, at this stage of its development, must be considered highly unlikely, the industry observers and participants considers the continued technological development, especially offshore, a potential source of unexpectedly *high* growth rates over the coming decade.

In accordance with some of the most widely cited critical uncertainties by the industry observers and participants interviewed for this report, the ICM proposes the possibility of the emergence - or re-emergence - of a significant competitive substitute to wind power over the coming decade. The four principal determinants of need substitution proposed by the ICM are the competitiveness of fossil fuels, nuclear power or another renewable technology. In terms of fossil fuels, coal and natural gas are forecast to be the major rivals of wind power over the coming decade. Of these, natural gas is the major uncertainty in terms of security of supply[239]. Due to unstable supply of natural gas and CO_2 reduction policies, the cost of wind power is currently assessed to be lower than that of natural gas[240]. Several industry observers and participants interviewed for this report expressed concern that an

[235] BTM 2005a:6-8
[236] EWEA 2004:116
[237] BTM 2005a:6
[238] Technological failure, as the term is understood here, implies the widespread abandonment of the technological principles of exploiting kinetic energy in moving masses of air for electricity generation.
[239] IEA 2004:195
[240] Carnegie Securities Research 2005:10

improved supply situation, resulting from negotiations with Russia and/or a stabilisation of the Middle East, might well bring natural gas prices back down to competitive levels, within a time frame of a decade[241]. The possibility of an unexpected fossil fuel renaissance is thoroughly based in historical precedence, as this occurred in the mid 80s with significant implications for the wind turbine industry. These uncertainties might of course also *decrease* the competitiveness of fossil fuels over the coming decade, as recent developments in Russia[242], the Middle East[243] and the widespread ratification of the Kyoto Protocol would imply, positively affecting industry growth.

In addition to uncertainty about fossil fuels, a widespread concern among the industry observers and participants interviewed for this report is the emergence of a competitive nuclear substitute to wind power over the coming decade. On the basis of IEA (2004), it is difficult to construct a plausible scenario in which nuclear power can be considered a *known uncertainty* with regard to industry growth over a time horizon of just a decade. This is true both in terms of expected cost reductions, share of new capacity installations and, perhaps most importantly, diffusion time[244]. Although considerations about a highly competitive nuclear substitute may be prudent over longer time horizons, taking this eventuality into consideration over the time horizon explored in this report seems overly alarmist.

In terms of renewable substitutes, the IEA (2004) proposes that biomass and hydropower to be the most significant competitors to wind power both in terms of their cumulative capacity, share of new capacity instalments and expected cost reductions. This is somewhat contrary to the concerns of industry observers and participants, proposing photovoltaic (PV) technology as their main concern. According to the IEA, PV will grow from a currently insignificant share of the renewable electricity market to a mere 2% by 2030. By comparison, wind power is expected to increase its current share of 2% to some 15% over the same period[245]. Although one or more radical breakthroughs or unexpected diffusion of a renewable substitute remains a possibility, it is highly uncertain if this will have an adverse effect on the growth of the wind turbine industry, as renewable energy technologies are not necessarily mutually exclusive. Conversely, the *lack* of a competitive renewable substitute may cause unexpectedly *high* growth rates under generally favourable conditions.

[241] The IEA proposes a stabilisation of gas prices below current levels. See IEA 2004:146
[242] With referral to the Russian de-facto nationalisation of Gazprom and increasing utilisation of its natural gas resource as a political asset, leading to the recent tensions between Russia and Ukraine, and later between Russia and the EU, over the price and security of supply of natural gas. See IEA 2004, Chapter 9.
[243] With referral to the many ethnic, religious and political tensions in the region currently emphasised by developments in Iraq, Iran, the unsettled Palestinian situation, and most recently, the war between Israel and Hezbollah/Lebanon, ongoing at the time of this writing.
[244] See IEA 2004:195 and 200-202
[245] IEA 2004:204

In light of these considerations, it is clear that a number of known uncertainties are related to the future growth rate of the wind turbine industry. Volatility of political support in one or more major markets, potentially spurred by volatile of fossil fuel prices, are the most obvious uncertainties influencing the growth rate of the wind turbine industry. In addition, one or more breakthroughs and/or rapid diffusion (or lack of same), of a renewable substitute may also affect the growth rate of the wind turbine industry. However, given current expectations and diffusion times this must be considered significantly less likely eventuality. Having explored a number of potential sources of volatile industry growth, in the following, I will consider the impact of unexpectedly *high* or *low* growth upon the competitive environment of the wind turbine industry.

Exploring the impact of volatile growth

Figure 7.2 below illustrates a number of first, second and third order effects of industry growth upon the competitive environment of the wind turbine industry, as proposed by the ICM.

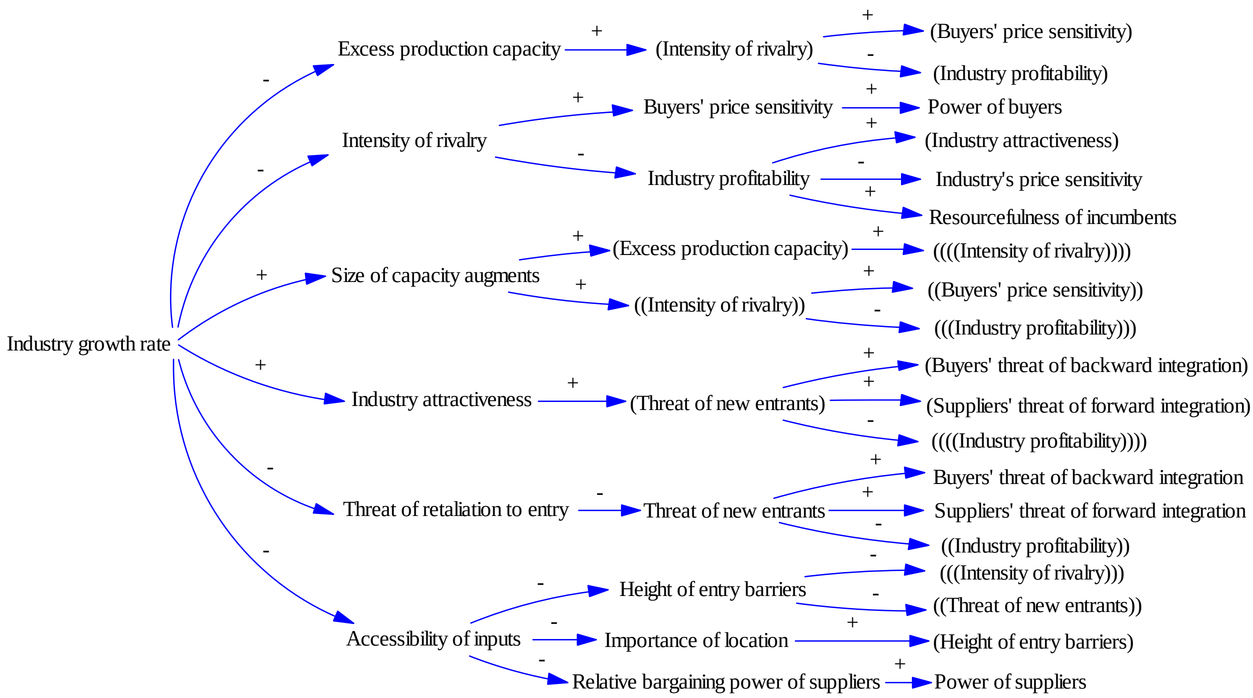

Figure 7.2: The impact of the industry growth rate upon the competitive environment

From the assumptions expressed in the above causal tree, it is possible to explore the low- and high-growth canonical variations of the multifold trend, and their respective impacts upon the competitive environment of the wind turbine industry.

7.5 The first canonical variation: The impact of low industry growth

Chapter 4 initially implied that the *current* economic structure of the industry holds significant potential for intense and prolonged rivalry, but that rivalry remains moderate because of high growth.

Seeing this canonical variation in light of the progression of the multifold trend, it becomes clear, that over the coming decade, the industry will become increasingly sensitive to volatile growth. The wind turbine industry will shift to more capital-intensive and volume-based means of production. This will increase the fixed-to-variable cost ratio of wind turbine manufacturers along with the minimum size of capacity augments coupled with powerful incentives to fill excess production capacity in times of low growth. This implies that the potential impact of a growth fluctuation will *increase* with the progression of the multifold trend over the coming decade.

As illustrated above, the ICM proposes that a significant change in the industry growth rate will have a substantial impact upon the competitive environment. The upper three first order impacts are directly related to the fact that low growth is a major catalyst for intense rivalry among manufacturers. As excess production capacity increases, while fixed costs remain high, manufacturers will be forced to compromise their margins and become more price-competitive. The ICM proposes that the major beneficiaries of intense rivalry among manufacturers will be powerful buyers. This tendency will be amplified by the progression of the multifold trend, as buyers become larger, more professional and geographically diversified, demanding still larger wind projects. This will significantly improve their ability to take advantage of rivalling manufacturers during a growth fluctuation.

The next two first order impacts of low industry growth are related to the effect of growth on the attractiveness of the industry to new entrants, and the likeliness that incumbents will retaliate forcefully to such newcomers. In case of low or highly volatile growth, the wind turbine industry will become less attractive to potential entrants as its profitability declines. Also, as market share becomes scarcer, incumbents become more likely to retaliate forcefully to intrusion. The ICM thus proposes that low growth may provide a shield against new or emerging competitors – in essence, affecting the *second critical uncertainty* explored in this chapter. From these considerations, it is clear that the two critical uncertainties are somewhat interrelated, in that entry is significantly more likely to occur if growth rates are high – and vice versa. The last impact, proposed by the ICM is related to the role of the accessibility of inputs as a current bottleneck for high industry growth. The ICM proposes that in case of highly volatile growth, the accessibility of inputs is likely to improve, strengthening the bargaining position of manufacturers relative to suppliers. Low growth will therefore simultaneously strengthen buyers and weaken suppliers of wind turbine manufacturers. These effects are likely to be amplified with the progression of the multifold trend. In addition, a low-growth variation is likely to speed up the internationalisation of wind turbine manufacturers, as access to alternative markets becomes a key competitive parameter.

7.6 The second canonical variation: The impact of high industry growth

This canonical variation can be thought of as a complete reversal of the above. This canonical variation is comparatively insensitive to the progression of the multifold trend, as many of its effects will be nullified or diminished by unexpectedly high growth.

In this variation, annual growth rates of 25-40% are commonplace and excess production capacity is a near impossibility. Both rivalry among manufacturers and the bargaining power of buyers are kept thoroughly in check as demand outstrips supply. Rooted in historical precedence, the ICM proposes that accessibility of inputs may continue to be the bottleneck for such extreme industry growth, limiting the size of capacity augments and strengthening the bargaining power of suppliers. The attractiveness of the industry to potential entrants will increase as its profitability rises. In addition, as excess demand and market share increases, the threat of retaliation to entry posed by incumbents will decline, as there will be plenty of orders to go around. In this variation of the multifold trend, the entrance or emergence of one or more major new competitors is highly probable. A high-growth variation may delay the consolidation of the wind turbine industry, as even small manufacturers, unable to take advantage of economics of scale, will face little direct price competition in this market of plenty.

As we have seen, periods of unexpectedly high or low growth will significantly impact the competitive environment of the industry. Furthermore, the growth rate will also affect the likeliness of the emergence or entry of a new major competitor over the coming decade. This critical uncertainty will be considered in the following.

7.7 New competitors: Cooperation or antagonism?

The other critical uncertainty repeatedly voiced by industry observers and participants interviewed for this report, is the possibility and consequences of the emergence[246] or entrance[247] of one or more major new competitors over the coming decade. In spite of substantial entry barriers around the industry, recent years have seen the entrance of a number of new and resourceful competitors. Industry observers and participants are especially concerned by the prospect of the emergence of one or more Asian low-price manufacturers, aided by highly favourable home-market advantages. This notion is widely shared in industry literature[248]. In the following, I will explore a number of potential causes of entry.

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[246] The term 'emergence' is understood here as an existing competitor significantly expanding its market share through extensive capital investments and aggressive competitive behaviour and/or through merging with one or more existing incumbents.

[247] As the term 'entrance' implies the introduction of a de-facto new competitor, either (a) created from scratch (which is very improbable in the context of the wind turbine industry) or by (b) outside takeover of one or more existing incumbents.

[248] BTM 2005:11

Exploring causes of entry

Figure 7.3 below illustrates the assumptions embedded in the ICM about potential causes of entry into the wind turbine industry through a reversed causal tree.

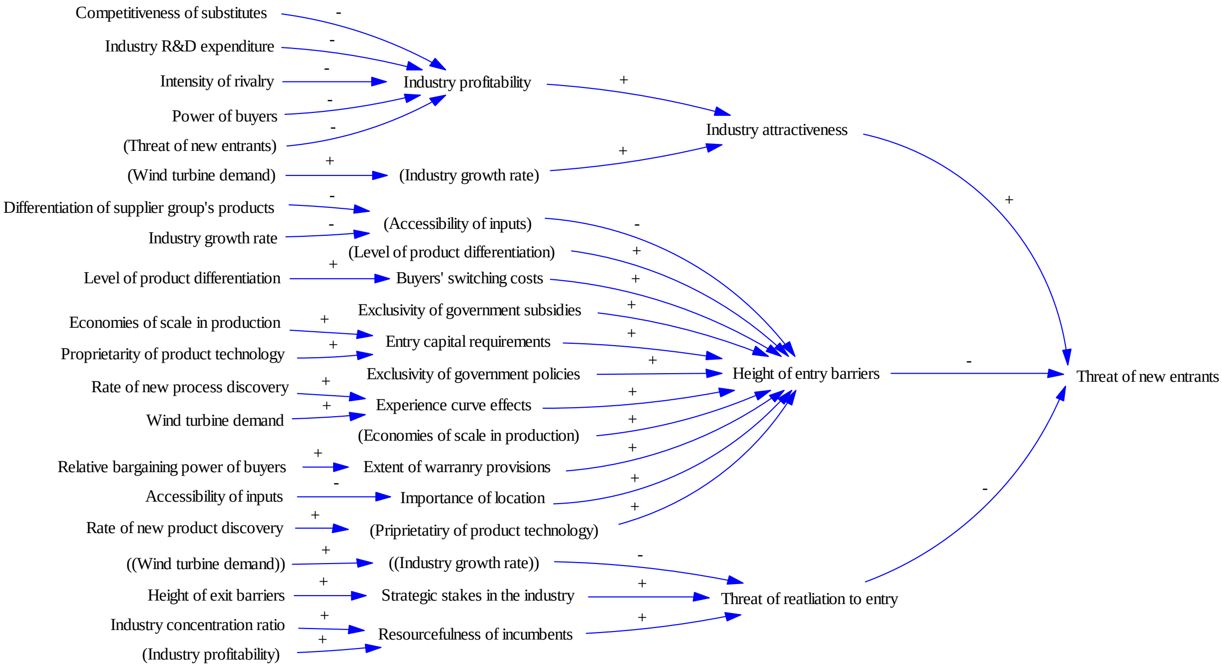

Figure 7.3: Determinants of threat of new entry

The ICM proposes that the level of threat from new entrants is determined by the overall attractiveness of the industry, the height of the entry barriers to be traversed, and the threat of forceful retaliation posed by incumbents. As illustrated, each of these causes is in turn determined by a number of second and third order determinants.

The attractiveness of the wind turbine industry is primarily a result of current and expected profitability and growth rates. Looking at profitability, wind turbine manufacturers have not been one-sidedly profitable in recent years. The EBIT margin for the major wind turbine manufacturers in the period 2001-2004, was on average 13.5%. This figure covers significant variation among individual manufacturers (As low as 4.6% for Vestas 2003 to as high as 23.4% for Suzlon in 2001) indicating that, at present, the industry is not one-sidedly profitable, compared to similar production industries[249]. Conversely, the growth rate of the wind turbine industry has been high, although highly volatile. Expectations to continued growth and future profitability are the major determinants of the attractiveness of the wind turbine industry. As we have seen, these determinants are subject to considerable uncertainty over the coming decade. The attractiveness of the wind turbine industry to

[249] Morgan Stanley 2005:18

potential newcomers may therefore prove a significant source of either unexpectedly high or *low* threat of entry.

The height of entry barriers is likewise a significant determinant of the threat of new entrants. As we have seen in Chapter 4, incumbent manufacturers are well-protected by both tangible and intangible entry barriers. These barriers must be considered very stable and, as a function of the multifold trend, the height of entry barriers is expected to increase further as economies of scale become more significant and as the industry internationalises. Increasing technological standardisation may, however, make the product technology less proprietarity and this weakness may be exploitable by resourceful entrants. The entry barriers around the wind turbine industry are likely to remain substantial over the coming decade and are unlikely to prove a source of unexpectedly high level of entry. Successful entry barriers may, however, prove to be a source of an unexpectedly *low* level of entry into the industry.

The third major determinant of the threat of new entrants faced by incumbents is their ability and willingness to retaliate to potential newcomers. As illustrated in figure 7.3, the industry growth rate again plays an important role. Although wind turbine manufacturers will become larger and more resourceful over the coming decade, unexpectedly high growth rates could hamper their willingness to retaliate forcefully to a resourceful entrant. Several large markets are currently sold out[250], and under such conditions, it is difficult for incumbents to mount an effective retaliation. New entrants may simply absorb excess demand, facing little direct competition from incumbents. Furthermore, a determined entrant, sufficiently resourceful to overcome the substantial entry barriers, may successfully deter retaliation by convincing incumbents, in advance, that it cannot be forced to exit the industry. In periods of volatile or low growth, this is less likely as rivalry intensifies; lowering industry attractiveness, while incumbents become more defensive about their market shares. The threat of retaliation to potential entrants must therefore be considered a potential source of both an unexpectedly *high* or *low* threat-level over the coming decade.

In light of these considerations, it is clear that a number of known uncertainties exist with regard to the future entrance of emergence of major new competitors into the wind turbine industry. The perceived attractiveness of the industry along the credibility of the threat of forceful retaliation posed by incumbents must be considered the main sources of uncertainty over the coming decade. In the following, I will consider the impact of both a *high* and a *low* level of new entrants upon the competitive environment of the wind turbine industry.

[250] Carnegie Securities Research 2005:3

Exploring the impact of entry

Figure 7.4 below illustrates the impact of entry upon the competitive environment of the wind turbine industry as proposed by the ICM.

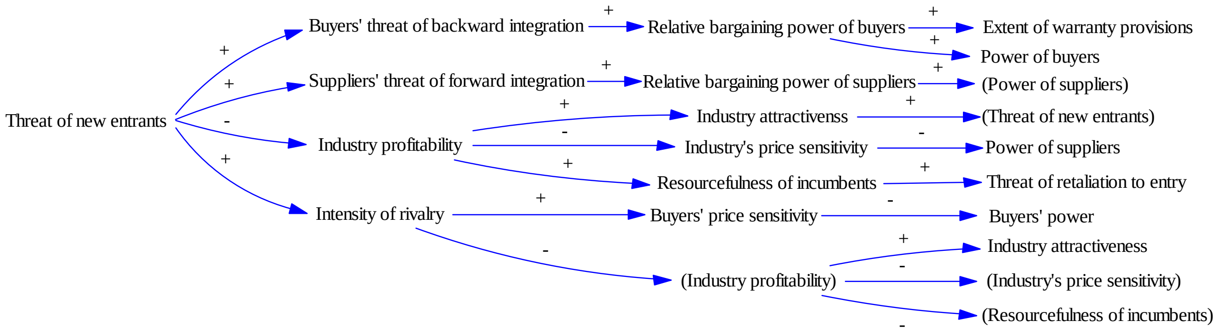

Figure 7.4: The impact of entrance upon the competitive environment

On the basis of the causal tree in figure 7.4, it is possible to explore the high- and low-threat canonical variations of the multifold trend, and their respective impacts upon the competitive environment of the wind turbine industry.

7.8 The third canonical variation: The impact of a high threat level

Seeing this canonical variation in light of the multifold trend, it is clear that the height of the entry barriers around the wind turbine industry will increase substantially over the coming decade. This will occur as a function of the progression of the second fold of the multifold trend, anticipating that wind turbine manufacturers will continue to consolidate around fewer, larger and increasingly globalised wind turbine manufacturers, emphasising economies of scale and scope. Increasing minimum size of production and requirements of a global presence will present a significant obstacle to all but the most resourceful entrants. Moderating the height of entry barriers, the fourth fold proposes that, as the industry becomes less vertically integrated, sufficiently resourceful entrants will not necessarily be forced to enter several successive stages of the production chain. In addition, as the multifold trend progresses, larger and more resourceful incumbents will be better able to retaliate forcefully to newcomers. These consequences of the progression of the multifold trend suggest that entrants overcoming the continuously increasing entry barriers over the coming decade will be extremely resourceful, potentially enough so to permanently change the competitive environment of the industry.

As illustrated in figure 7.4 above, the ICM first proposes that an increase in the threat of new entrants is most likely to apply to existing buyers and suppliers. Before this threat is realised, the buyers or suppliers (or potentially both) posing a credible threat of entry, are able to significantly increase their bargaining power relative to incumbents. The ICM proposes that, in the case of buyers, this is likely to result in demands of increased quality guarantees and extended warranty provisions as well as lower prices. In addition, a generally increased threat of entry is likely to more broadly affect the profitability of the industry as a whole. This will occur as threatened incumbents will attempt to price *below the entry deterring price*, in an attempt to lower the attractiveness of the industry – pre-empting entry. The ICM thus proposes that the in periods of increased threat of entry, the wind turbine industry will be significantly less profitable, both as a function of the specific threat from buyers and suppliers, but also as a function of incumbents' expected attempts to lower the general attractiveness of the industry to deter entry. Based on historical precedence, resourceful and well-informed buyers of wind turbines are likely to be the first to seize the opportunity to integrate backward into wind turbine manufacturing. This mode of entry is likely to occur by means of a takeover of one or more existing manufacturers as described in Chapter 4. As illustrated in figure 7.4, the ICM proposes that the entry of a new competitor will increase the intensity of rivalry in the industry. This will increase the power of buyers of wind turbines, while lowering the profitability of the industry. As illustrated above, increased competition resulting from new entrants will eventually lower the attractiveness of the industry to a point where the threat of still more entrants becomes insignificant. One or more successful entrants may therefore deter subsequent entrants as industry attractiveness finds a new equilibrium.

These considerations imply that the impact of the high-threat canonical variation upon the competitive environment is substantial. Firstly, an increased threat of entry will markedly lower the profitability of the industry, whether that threat is realised or not. And secondly, if the threat is realised, the increasingly high entry barriers will ensure that successful entrants are highly resourceful, having significant long-term implications for the competitive environment of the industry.

7.9 The fourth canonical variation: The impact of a low threat level

The low-threat canonical variation basically implies the *absence* of the high-threat variation, and will thus be treated in less detail. This variation of the multifold trend assumes that the increasing entry barriers around the wind turbine industry will be largely successful in deterring significant entry over the coming decade. In this canonical variation, the adverse effects of a high threat of entry described above will not markedly affect the competitive environment.

The identification of the four canonical variations and the exploration of their impact upon the competitive environment conclude Part II of this report. Through the preceding two chapters, I have identified a number of *known forces of change* in the form of predetermineds and critical uncertainties, which will shape the competitive environment of the wind turbine industry over the coming decade. The following part of this report will be concerned with exploring the *strategic consequences* of a changing competitive environment for wind turbine manufacturers.

- Part III -

Chapter 8: Strategic consequences - adaptation & pre-emption

The third part of this report will be concerned with exploring the strategic consequences and implications of the known forces of change identified in the preceding chapters. In this chapter I will develop a typology of the *strategic groups* in the wind turbine industry against which the *strategic consequences* of known changes in the competitive environment will be explored along with opportunities for adaptation and pre-emption.

8.1 Establishing a typology of strategic groups

The strategic consequences of any change in the competitive environment will necessarily be unique to each wind turbine manufacturer, depending on the particular sensitivities of its business model at the time at which change occurs. Ideally, each manufacturer will be the best judge of the particular implications of any recognised change in its environment. In the context of an industry-wide strategic foresight, it is, however, necessary to resort to useful generalisations, accepting the dangers of lumping diverse competitors together into broader explanatory categories. This reasoning lies at the heart of the positioning school, assuming that although each competitor has unique features, they can be usefully categorised according to the way in which they seek to fulfil the economic imperative – dealing with the five structural forces. Each such category is termed a *strategic group*. A strategic group thus works as an intermediate frame of reference between looking at the industry as a whole and considering each competitor separately[251]. There is, of course, no *universal* distinction between competitors in an industry. In the context of strategic foresight, any meaningful distinction between strategic groups must aim to provide the greatest *explanatory power* in terms the *strategic consequences* of known forces of change in the competitive environment. To this end, I will make distinctions between competitors in the wind turbine industry based on two basic features: the *products offered* and the *market served*. Establishing a typology of strategic groups in the wind turbine industry necessarily involves choosing meaningful *axes* illustrating these basic differences. Related to the *products offered*, the first explanatory axis adopted here is proposed by Morgan Stanley (2005) emphasising the importance of the following distinction[252]:

1. Manufacturers offering a *full, differentiated and technologically demanding* product range.
2. Manufacturers offering a *narrow, low-priced and technologically standardised* product range.

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[251] Porter 1980:132
[252] Morgan Stanley 2005:18-23 emphasised the principal nature of this distinction when comparing the business models of Gamesa Eólica and Vestas Wind Systems.

Often proposed in various guises in strategic theory, this distinction is closely related to the two generic strategies; *cost leadership* and *differentiation*, proposed by Porter (1980)[253] as well as the distinction between *generalists* and *specialists* proposed by Sheth & Sisodia (2002)[254]. As is the case for many production industries, this distinction seems no less relevant in the context of the wind turbine industry. Distributing current top-ten manufacturers[255] along this axis, it is clear that Vestas Wind systems, followed by Enercon, are by far the manufacturers with the broadest and most differentiated product ranges, being represented in all turbine size categories[256]. Both these manufacturers aspire to technological leadership on- as well as offshore, across their product ranges[257]. Also Spanish Ecotécnia and German Nordex offer relatively wide product ranges in spite of their small market shares[258]. German REpower and Indian Suzlon holds positions near the centre; REpower with the more differentiated product range of the two, being represented in the mainstream segment (with four models)[259] and offering the largest turbine (5 MW) on the market[260]. Suzlon is mainly represented in the small-sized segment (four models), with a single model in the mainstream segment[261]. At the opposite end of the axis we find Gamesa Eólica, GE Wind and Siemens, having narrow product ranges, gravitating toward the mainstream segment, offering little product specialisation[262]. These manufacturers are often characterised as ‘followers’ in terms of product technology[263]. Mitsubishi constitutes a ‘pole’ on this axis, narrowly offering only two models in the small-sized segment[264].

I terms of *market served*, BTM (2005b) emphasises the highly oligopolistic nature of the wind turbine industry, distinguishing between global oligarchs and the host of smaller domestic and regional players. BTM distributes manufacturers along the following explanatory axis[265]:

1. Manufacturers with a *global market scope*, supplying all major markets.
2. Manufacturers with a *selective market scope*, supplying only limited domestic or regional markets.

[253] Porter 1980: Chapter 2
[254] Sheth & Sisodia 2002: Chapter 3
[255] Established on the basis of total market share ultimo 2004 from BTM 2005a:16
[256] BTM 2005a:23
[257] Morgan Stanley 2005:18
[258] See Ecotécnia 2006 and Nordex 2006 respectively.
[259] See REpower 2006
[260] BTM 2005a:22
[261] See Suzlon 2006
[262] Morgan Stanley 2005:18
[263] Morgan Stanley 2005:18
[264] See Mitsubishi 2006
[265] BTM 2005b:42-43

Again, this distinction resonates in strategic literature, resembling not only the *focus* strategies proposed by Porter (1980)[266], but also Sheth & Sisodia's (2002) distinction between *generalists* and *market specialists*[267]. Among current top-ten manufacturers, BTM (2005b) recognises only a single global competitor, Vestas Wind Systems, but emphasises the rapid emergence of Siemens, GE Wind, Enercon and Gamesa, into this category. Among the host of smaller selective competitors, BTM ranks Nordex AG, Mitsubishi MHI, REpower, Suzlon and Ecotécnia. In addition to these, BTM identifies a number even smaller of manufacturers holding highly selective positions on their specific national markets[268].

When pairing these two axes, it is possible to illustrate the joint positions of the top-ten wind turbine manufacturers in the space between them. These are illustrated in Figure 8.1. As it can be seen from the ranking of the manufacturers, three *principal strategic groups* can be distinguished along these two axes. From their approximate positions in the chart, I term these groups, *narrow-line industrialists*, *full-line differentiators* and *selective market specialists*.

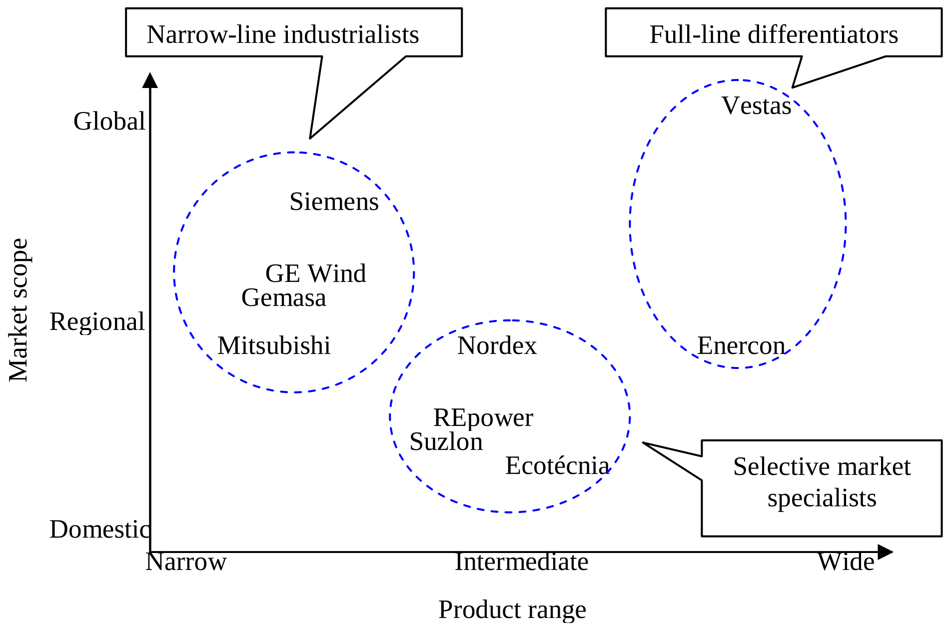

Figure 8.1: Three principal strategic groups

As it can be seen from the distribution of manufactures across the chart, the distinction between full-line and narrow-line manufacturers is much clearer among global competitors than domestic and regional market specialists. One reason for this may be that manufacturers limited to selective markets will not generally see it as an aim in itself to offer a wide or narrow product range, but will offer the particular product categories demanded by their markets – whatever this may be. Manufacturers with a global market scope, on the other hand, can afford a wider degree of specialisation as a full- or narrow-line manufacturer, without spreading efforts too thinly or sacrificing volume. I will return to this and other tradeoffs between the strategic groups later in this chapter.

266 Porter 1980: Chapter 2
267 Sheth & Sisodia 2002: Chapter 3
268 BTM 2005b:42-43

Figure 8.1 is necessarily a highly idealised picture of competitive strategies, and it is clear that more explanatory axes could be added to the analysis, further subdividing the three strategic groups. Experimentation with additional explanatory axes; *market share* and *ownership*[269], however, revealed that very little extra explanatory power was added through these efforts[270].

In the context of strategic foresight, an additional consideration is needed with regard to strategic groups; time. Traditional analysis of strategic groups, for the purposes of strategic decision-making, aims to provide a 'snapshot' of the positions of competitors in an industry. Over a time horizon of a decade, it is possible (and highly likely) that competitors will migrate between these strategic groups, perhaps to the extent that one or more groups will be abandoned altogether. This process is integral to industry evolution. Over the time horizon investigated in this report, the identified strategic groups will therefore be analysed as *archetypes*. Although no competitor is ever fully archetypical – e.g. sharing all the features of a 'pure' market specialist - it may, through strategic choice, strive to achieve such features. In the following I will consider the characteristics of each strategic group.

8.2 The full-line differentiator

The first archetypical strategic group considered here is the full-line differentiator. When looking at the current representatives of this group, they are set apart by their wide and differentiated product ranges relative to their competitors. Vestas and Enercon are represented in every size category and offer a range of highly specialised products outside of mainstream[271]. These include turbine designs optimised for low-wind areas[272], inaccessible sites[273] as well as offshore sites[274]. Enercon's product range is further set apart by its ring generator technology, making its entire product range gearless, as well as offering specialised diesel-wind off-grid systems[275]. A key characteristic - and necessity - of full-line differentiators, is attaining and maintaining technological leadership to sustain proprietarity and product differentiation relative to competitors[276]. Differentiation is a central advantage of this strategic group as a way of dealing with powerful buyers. Facing little direct competition, full-line differentiators are able to offer technologically advanced wind projects at inaccessible sites - offers not easily imitated by competitors. As ideal onshore sites are gradually exhausted and restrictions to size and location increase in major markets, this capability may prove essential.

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[269] Distinguishing between diversified and single business manufacturers.
[270] *Market share* is highly correlated with *market scope*, while ownership merely emphasise the fact the Vestas Wind Systems is the only single business among the major manufacturers – a feature it shares a few smaller manufacturers.
[271] See Enercon 2006 and Vestas 2006
[272] Vestas' V82, V90-1.8 and V100, and Enercon's E-53
[273] Vestas' V52 and Enercon's E-33
[274] Vestas' V120 and Enercon's E-82
[275] See Enercon 2006
[276] Morgan Stanley 2005:18-19

Attaining and sustaining a position as a full-line differentiator is a demanding task. To sustain differentiation and technological leadership, both Enercon and Vestas are integrated backwards into many areas of component manufacturing and maintain extensive R&D efforts in a number of core component areas. This feature significantly increases the fixed costs of their business models[277]. Furthermore, the downside of technologically pioneering projects is the need to share the increased financial risk with risk adverse developers and buyers. This involves issuing extensive warranty provisions and a willingness to face substantial liabilities in case of product failure. Vestas is a prime example of this, issuing warranties of up to twelve years[278] and incurred a loss of some €38 million in 2002 after a serial flaw in its pioneering offshore installation at Horns Reef, Denmark[279]. Substantial financial risk, high level of backward integration and the need to maintain significant R&D activities indicates a high minimum efficient scale - and thus the need for internationalisation. These factors also suggests that significant advantages could be obtained from being part of a diversified company, lending financial stability to the business model along with the possibility of leveraging technologies from other divisions to sustain product diversification.

Full-line differentiators are thus seeking to influence the competitive environment of the wind turbine industry through three principal variables: their *level of product differentiation*, their *rate of new product discovery* and the *extent of their warranty provisions*. The strategic consequences of this are explored through the assumptions imbedded in the ICM as illustrated in figure 8.2 below:

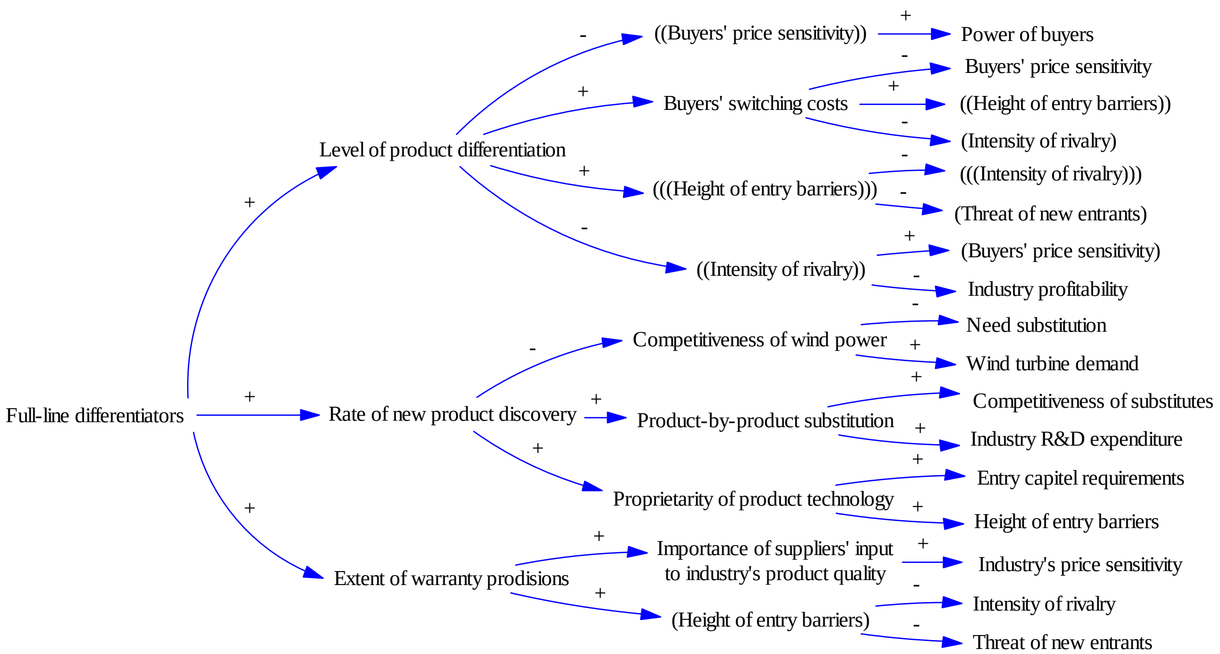

Figure 8.2: Key variables influenced by full-line differentiators

[277] See Danske Equities 2003
[278] Stephen Rammer, analyst, Handelsbanken in Berlinske Tidende, February 2006
[279] Morgan Stanley 2005:18

The ICM emphasises the role of product differentiation in dealing with powerful buyers, moderating their bargaining power and price sensitivity, while raising switching costs. Also, through their emphasis on product innovation, full-line differentiators take up a central role as technological pioneers of the industry, increasing the competitiveness of wind power relative to its substitutes. The ICM proposes that the highly differentiated and technologically proprietary products along with extensive warranties are all sources of substantial mobility barriers[280] around this strategic group. Although extensive warranties make full-line differentiators financially risky for potential entrants to take over, they also increase reliance of this business model upon high quality inputs from suppliers. The ICM further suggests that competition among full-line differentiators take the form of technological rivalry, as the rapid emergence of new products increases product-by-product substitution. This suggests a continuation of the historical pattern of high rate obsolescence among existing products within this strategic group.

8.3 The narrow-line industrialist

The second strategic group considered here is the narrow-line industrialist. The four representatives of this group illustrated in figure 8.1 are characterised by their focus upon a relatively narrow, mainstream product range and a fairly broad market scope. Unlike full-line differentiators, the primary focus of the narrow-line industrialists is cost - and over time - cost reduction. Low price and highly reliable products are the central capabilities through which narrow-line industrialists deal with the economic imperative. Perhaps the most important ingredient in achieving cost leadership is volume and predictability in production, which would underline the need for either an attractive home market or a global presence. Gamesa has achieved the highest volume through a global market share of some 18.1% (making it the second largest manufacturer in the world), with an export share of a mere 12.5%, giving testament to the attractiveness of its Spanish home market[281]. Gamesa has, however, undertaken successful internationalisation initiatives and is set to increase its export share significantly in the years to come[282]. In terms of volume, Gamesa is followed by GE Wind and Siemens, holding market shares of 11.3% and 6.2%, and export shares of 75.8% and 98.8 respectively. Mitsubishi has, so far, attained the least volume among current narrow-line industrialists, with a market share of just 2.6%. A significant share, 65.6%, of this output is exported outside its Japanese home market[283]. The most obvious advantage of volume is economies of scale in production, which is a significant factor in wind turbine manufacturing[284]. A second advantage is the

[280] Mobility barriers are the equivalents of entry barriers when discussed at the level of strategic groups. See Porter 1980: Chapter 7.
[281] BTM 2005a:16-19
[282] Morgan Stanley 2005:5
[283] BTM 2005a:16-19
[284] Danske Equities 2003:14-16 and Morgan Stanley 2005:12

benefits of cost reductions attained through process innovation, which are proportional to a firm's level of output. Spreading an average cost reduction over a large production volume yields the greater absolute benefit[285]. For this reason, process innovation as a means of sustaining cost leadership is a major feature of this strategic group.

Unlike full-line differentiators, the manufacturers in this group are followers in terms of product innovation; favouring reliable and standardised mainstream turbines[286]. This lessens the need to issue extensive warranties and thus the financial risk shared with buyers.

In terms of backward integration, Gamesa seems to be the exception, being active across all main components categories, while the remaining narrow-line industrialists favour significantly lighter models than those of the full-line differentiators[287].

Narrow-line industrialists are thus seeking to influence the competitive environment of the wind turbine industry through two principal variables: Attaining *economies of scale in production* and maintaining a high *rate of process innovation*. The strategic consequences of this are explored through the assumptions imbedded in the ICM as illustrated in figure 8.3 below:

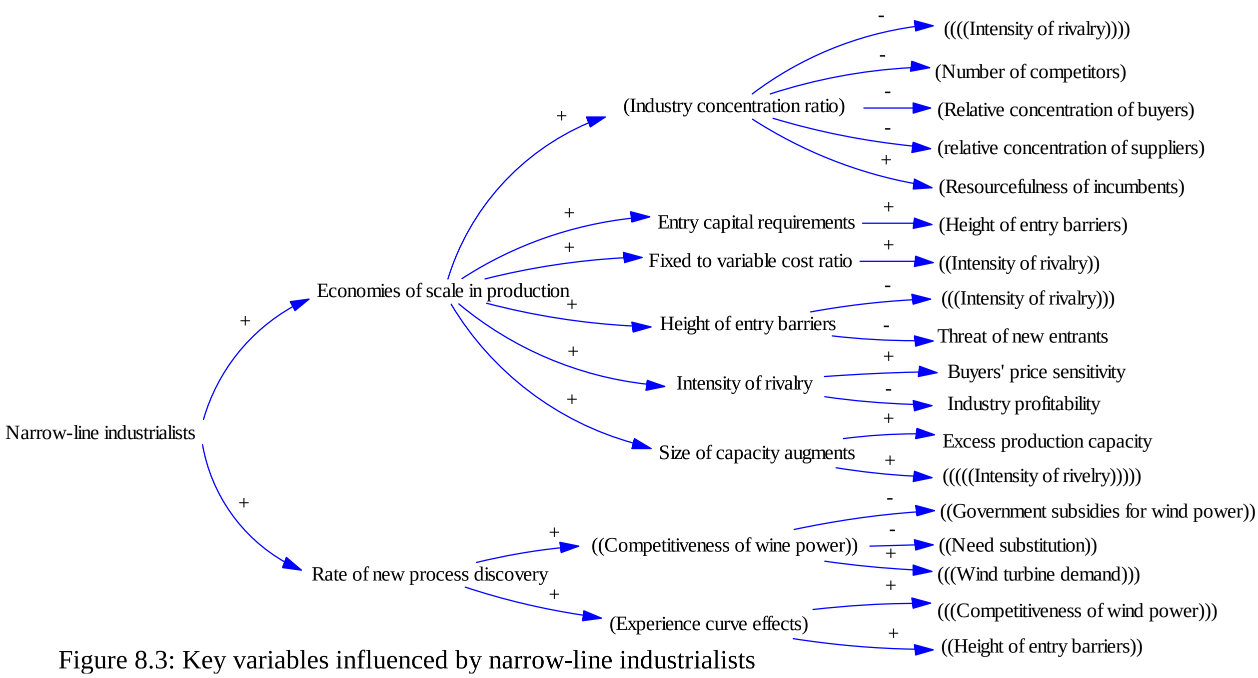

Figure 8.3: Key variables influenced by narrow-line industrialists

The ICM emphasises the determining role of economies of scale in production as a means of building mobility barriers around this strategic group and in setting minimum standards for the size of narrow-line industrialists. Size in particular is essential in dealing with powerful buyers as a means of lessening the importance of individual orders. The ICM also proposes that competition between

[285] Klepper & Simons 1997:9
[286] See e.g. Morgan Stanley 2005:18
[287] See Danske Equities 2003:8 and Morgan Stanley 2005:18

manufacturers in this strategic group takes the form of struggles for market share to achieve volume, and aggressive price wars in times of failing demand. Through the emphasis of narrow-line industrialists upon process discovery and product reliability, this strategic group takes up the role of ‘mainstreamers’ in the industry, improving the price competitiveness of wind turbine technology relative to substitutes.

8.4 The selective market specialist

The third strategic group considered are the selective market specialists. These manufacturers are characterised by their limited market scope and their ability to tailor their product range to the needs of their selective domestic or regional market(s). It is important to note that more manufacturers exist in this strategic group than illustrated in figure 8.1, accounting only for top-ten manufacturers[288]. When looking at the top-ten representatives of this group, it is clear that Indian Suzlon, Chinese Goldwind and Spanish Ecotécnia are the most outspoken examples of selective market specialists. These manufacturers’ presence is exclusive to their home markets, holding domestic market shares of 42.8%, 20.1% and 9.4% respectively[289]. Both Suzlon and Goldwind focuses on narrow product ranges favouring the smaller turbines traditionally demanded in their home markets, while Ecotécnia offers a wider range of models on its selected market[290]. REpower and Nordex are based in the attractive German market, where the larger part of their turbines is sold[291]. Both these manufacturers have product ranges focused on the mainstream segment[292], which may account for their ability to attain minor market shares in a number of other - primarily European - markets[293]. If these two manufacturers continue to increase their market scope to attain volume, they may eventually migrate out of this strategic group and become narrow-line industrialists.

As the name implies, careful selection of markets and the attainment of ‘home court’ advantage is the instrument through which selective market specialists deal with the economic imperative. Beyond the technological and economic necessity of a specialised product range ideally suited for the conditions of the selected market(s), various forms of protectionism are likewise part of creating home market advantages. Domestic manufacturing content requirements, preferential tax breaks, exclusive or preferential access to national R&D funds, favourable treatment by planning authorities and political contacts are all part of the competition in various national wind turbine markets[294]. Such policies

288 In fact, the remaining wind turbine manufacturers outside top-tem can be considered representatives of this strategic group.
289 BTM 2005a:Appentix A
290 See Suzlon 2006, Goldwind 2006 and Ecotécnia 2006 respectively.
291 BTM 2005a:63
292 See REpower 2006 and Nordex 2006 respectively.
293 BTM 2005a:Appentix A
294 See e.g. CRS 2006

present significant mobility barriers to potential entrants into this strategic group[295]. Also less tangible factors, such as seniority with buyers, cultural insight, etiquette and linguistic skills may equally play a role when locally based buyers decide between bids for wind projects.
Selective market specialists are thus seeking to influence the competitive environment of the wind turbine industry through three principal variables: *importance of location*, *exclusivity of government subsidies* and *exclusivity of government policies*. The strategic consequences of this are explored through the assumptions imbedded in the ICM as illustrated in figure 8.4 below:

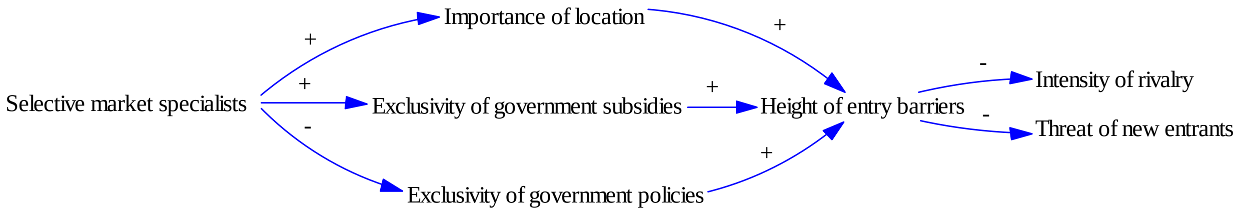

Figure 8.4: Key variables influenced by selective market specialists

As illustrated in figure 8.4, the ICM suggests that the variables influenced by selective market specialists all have the same essential effect: to raise entry barriers around their selective market(s). In the absence of highly differentiated products or full price competitiveness, selective market specialists seek to lower the intensity of rivalry in their home markets, while keeping potential entrants at bay.

8.5 The strategic consequences of the forces of change

It is clear that the strategic groups identified here are – and will be – in very different positions with regard to dealing with the challenges posed by industry change over the coming decade. The strategic consequences of change upon the strategic groups are illustrated in figure 8.5 below.

[295] See Windbitz 2006

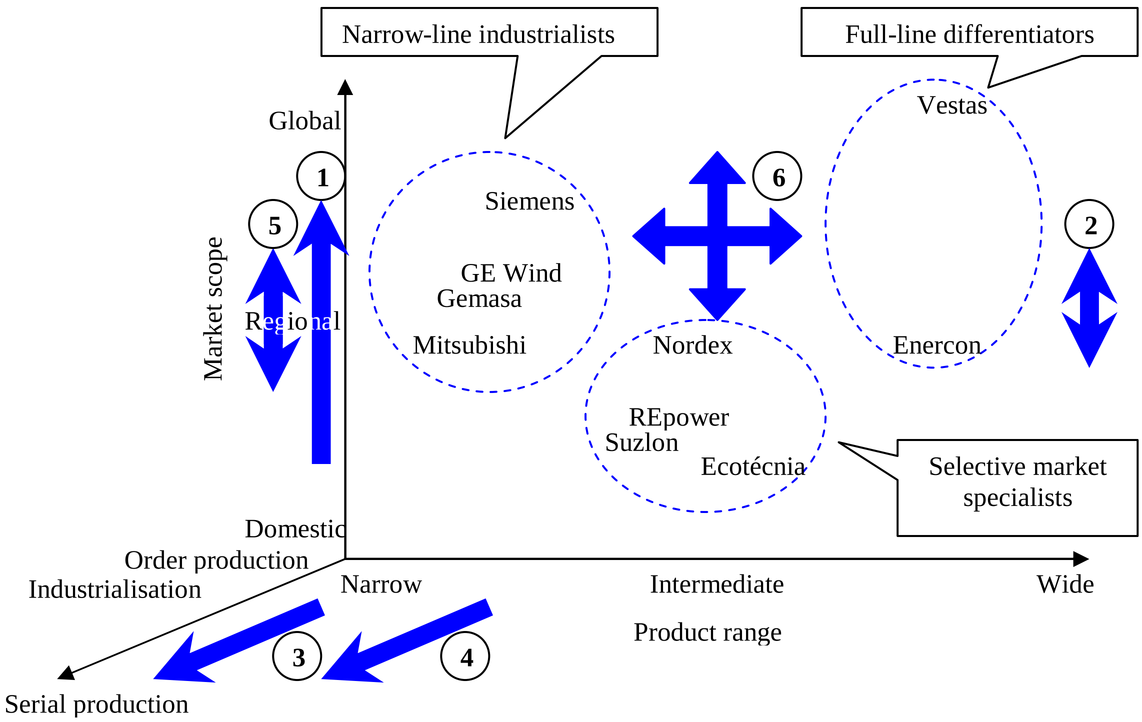

Figure 8.2: The strategic groups and the forces of change

In figure 8.5, the four folds of the multifold trend and the two critical uncertainties are symbolised by arrows 1-4 and 5-6 respectively. The first fold towards more conservative, professional and geographically diverse buyers of large wind projects will cause a gradually widening market scope over the coming decade (arrow 1). The second fold towards increasing importance of scale and scope in wind turbine manufacturing, is a separating force (arrow 2) increasing the gap between the few truly globalised wind turbine manufactures and their regionally and nationally based competitors. The third and fourth folds of the multifold trend (arrows 3 and 4) are depicted along an additional axis which will be of growing importance to wind turbine manufacturers; *industrialisation*. Increasing standardisation and maturity of wind technology and the development of an increasingly specialised and independent supplier network will push the strategic groups toward serial rather than order production and increased outsourcing. These two forces are likely to be instrumental in the final phase of the transition of the wind turbine industry from entrepreneurial order production to industrial serial production as described in chapter 6. The major critical uncertainties are likewise represented in figure 8.5 above. During the coming decade, volatile industry growth could cause unexpected drops or increases in market scope as new or existing markets develop or stagnate (arrow 5). Also, the possible entry or emergence of new competitors (arrow 6), can occur as existing competitors fortify their position within their strategic group through a strategic alliance or buyout by another company and/or if they decide to abandon their current group and enter into another.

In the following I will consider these strategic consequences in light of the circumstances of each group. Such explorative considerations must necessarily be speculative, and for the individual manufacturer the options outlined here will naturally involve many more considerations specific to their particular circumstances.

Strategic consequences for full-line differentiators

The progression of the multifold trend and the canonical variations pose a number of unique challenges to this strategic group. A major issue for full-line differentiators is maintaining product differentiation in the face of increasingly conservative buyers and ongoing technological standardisation.

Professional buyers will increasingly consider investments in wind large wind projects on similar terms with other long-term investments in generating capacity. These buyers will likely not pay a premium for wind projects *because* they are differentiated (gearless, offshore, large, etc.), but because they are cheaper or more reliable *through* technological differentiation. The trade-off between proprietarity and reliability of differentiated and pioneering projects has been, and is likely to remain, an important issue for full-line differentiators dealing with powerful buyers. In this context, extensive warranty provisions will continue to be imperative as a way for full-line differentiators to offer to share increased financial risk with risk adverse buyers.

With the ongoing standardisation of wind turbine technology and the development of an independent supplier network, full-line differentiators may benefit from rethinking their relationship with component suppliers. An obvious opportunity for full-line differentiators is to lower both cost and fixed costs by outsourcing components which do not directly contribute to product differentiation. In doing so, it will be vital to retain in-house production of a selected number of R&D-heavy and proprietary core components to maintain differentiation and technological leadership. The line between in-housed core components and outsourced standardised components need not be sharply defined. Development partnerships between manufacturers and independent component suppliers will become more common over the coming decade as multifold trend progresses. Such partnerships may prove an important instrument for full-line differentiators, not only as a means of sharing R&D expenditures and risk with suppliers, but also in improving product quality. Because of extensive warranties, full-line differentiators have a strong incentive to induce a ‘culture of accuracy’ upon component suppliers – as well as upon themselves.

Although full-line differentiators are highly sensitive to periods of low or volatile growth - because relatively high fixed costs - they do, however, have a number of unique options open to them. Because of their wide product ranges, they have the option to shift emphasis from one product segment to another, or alternatively; adapt their product range to the conditions of a more promising

market. Also, in periods of high growth they are able to fully utilise a seller's market across their entire product range. One interviewee commented that the recent stagnation of the offshore market was in fact caused by growth in the onshore/mainstream segments. The 'safer' onshore projects are usually preferred by manufacturers in times of high growth. Should this situation be reversed; manufacturers with broad product ranges and offshore capabilities are able to shift their emphasis, while narrow-liners are stuck. The ability to retain flexibility across wide product ranges and markets is likewise an important instrument in hedging against emerging or entering competitors. As one product segment or market becomes unprofitable, full-line differentiators has the option to last it out using profits from other segments or markets - or by shifting emphasis altogether. Seen in this light, there is little doubt that the technologically challenging offshore potential is *the* major opportunity for full-line differentiators over the coming decade - a market that highlights the relative advantages of this strategic group. The offshore segment is an opportunity to continue the historical up scaling of the turbine and to maintain focus on product discovery - in spite of ongoing standardisation.
Full-line differentiators are perhaps the strategic group with the most to gain from integrating forward into project development - a possibility remaining largely unexploited among wind turbine manufacturers today[296]. Being a developer opens the possibility to demonstrate pioneering technology in self-developed projects, which can then be sold on under warranty then (if) reliability and profitability has been demonstrated. A further option is hedging against cancelled orders – an attractive option for manufacturers with high fixed costs – by installing these turbines in ones own projects. It is clear that influencing the competitive environment through rapid product discovery, product differentiation and warranties will become increasingly challenging over the coming decade.

Strategic consequences for narrow-line industrialists

It would seem that narrow-line industrialists are the major beneficiaries of the progression of the multifold trend. Powerful, professional and conservative buyers will emphasise price and reliability over other criteria, and this is what narrow-line industrialists are designed to deliver. The geographical diversification of wind turbine markets and the increasing size of orders are likely to emphasise advantages of scale in wind turbine manufacturing as wall as continued internationalisation. These tendencies are both opportunities and requirements for narrow-line industrialists. Market share and market scope will be imperative in achieving volume of production and reliability of demand, while hedging against currency rate fluctuations and low or volatile growth. Also, the ongoing standardisation of wind turbine technology will allow narrow-line industrialists to reduce cost and streamline assembly and production.

[296] Only Gamesa is active in project development.

Outsourcing components and R&D expenditures to independent component suppliers is likewise an opportunity to lower fixed- and capital costs. This may be especially relevant for narrow-line industrialists seeking to internationalise without the necessary means to build their own production facilities abroad. As narrow-line industrialists exploit the opportunity to become ‘efficient assemblers’ of mainstream wind turbines, an important issue will be dealing with increasingly powerful component suppliers. Placing large single orders, while maintaining partial in-house component production, will be important tools with which to improve their bargaining position.

As a consequence of the progression of the multifold trend, the most significant opportunity for narrow-line industrialists over the coming decade may be a partial or full shift from order production to serial production[297]. Crossing this barrier may prove a cardinal shift in the history of the wind turbine industry as new ‘unbeatable’ cost records are set. The risks involved in this form of production are related to storing large amounts of turbines in the *expectation* of future sales. Product-by-product substitution may render stored turbines obsolete, or a low-growth canonical variation may cause storage costs to rise to unacceptable levels. In both events, serial producers will be forced to sell the stored turbines at a discount. This is the prototype for the initial stages of a prolonged price war. As price is already a central competitive parameter in the main stream segment, narrow-line industrialists are particularly sensitive to prolonged price wars as an instrument to defend market share in periods of low demand or against new competitors. In terms of the latter, increasingly standardised technology and the development of an independent supplier network are perhaps the most important factors allowing new major competitors to enter or emerge into the wind turbine industry over the coming decade.

Another opportunity for narrow-line industrialists over the coming decade lies in their role as ‘mainstreamers’ of the industry. By emphasising standardised and reliable products, they gain the confidence of less professional and more risk adverse buyers such as private investor groups, not available to full-line differentiators and selective market specialists.

Industry evolution seems to favour narrow-line industrialists seeking to influence the competitive environment through process discovery and achieving economies of scale.

Strategic consequences for selective market specialists

At face value, the challenges posed by the progression of the multifold trend and the canonical variations seem to present the greatest threats and the fewest opportunities to the selective market specialist. During the coming decade, manufactures in this strategic group will have to meet the challenge of maintaining a home court advantage in the face of increasingly global competition. The

[297] Order production is scheduled after incoming orders, while serial production aims at a constant or otherwise optimal production flow.

forces of change identified in this report would indicate that this will become significantly more difficult in the years to come.

As buyers become increasingly professional, economic considerations, rather than national affiliation, will likely play a greater role in placing orders. This may disadvantage selective market specialists as their ability to utilise economies of scale and scope will be limited to the confines of their home market. Also, as large wind turbine manufacturers globalise; the risk of entry into the home markets of selective market specialists increases. This consideration will especially relevant for market specialists located in highly attractive markets, experiencing a prolonged high-growth canonical variation – or the mere expectation of one. Also, the increasing size of orders - in financial terms as well as MW capacity - will disadvantage smaller manufacturers relative to their global competitors. Many of these may find that they lack the financial backing and production capacity to complete for them. The most lucrative - and most demanding - buyer segments may thus move out of reach and revenues will have to be generated from what remains. Discovering and specialising to the requirements of such remaining demand – segments considered too small, special or otherwise inaccessible for global manufacturers – are likely to be primary opportunities for selective market specialists facing global competition. Pre-empting entry may require selective market specialists to emphasise political lobbyism as a means of maintaining entry barriers around their domestic markets. Several governments have explicitly expressed their desire to sustain national wind turbine industries in the face of global competition. Although direct industry support is usually prohibited, various indirect forms of protectionism and preferential treatment are already advantages commonly exploited by selective market specialists. Systemising efforts to maximise this advantage seems a natural response to increased global competitive pressure.

From the viewpoint of selective market specialists, the increasing standardisation of wind turbine technology and the ongoing development of the component supplier network are more positive developments. As more components, customised for the needs of the wind turbine industry, will become available from independent suppliers; backward integration into several areas of component manufacturing will be less of a requirement. Outsourcing R&D and capital intensive components, such as blades and control systems presents an obvious opportunity for smaller manufacturers to lessen capital requirements as well as fixed costs. Likewise, cancelled orders may well be ‘wiped off’ on suppliers with positive effects on the financial risks of small manufacturers undertaking uncertain or large projects. Emphasising wind turbine assembly rather than production will allow increased focus on locating and serving selected market segments - which is where the competitive advantage of this business model lies. The ability to bargain with independent component suppliers to achieve these advantages will likely be an important issue for small manufacturers over the coming decade.

A low-growth variation is a particularly serious event for any selective market specialist, as they are less able to 'retreat' to more attractive markets. Volatile or low demand may, however, have some longer-term positive effects for this strategic group. Deterring global competitors from entering their market(s) is a key priority for a selective market specialist. Volatile or low growth keeps potential entrants at bay and is likely to make future entrants more hesitant if uncertainty about growth is prolonged or perhaps even permanent. Taking advantage of uncertain demand, while deterring competitors may be achieved if market specialists are able to last out a low-growth period and take advantage of a subsequent upswing, facing less competitive pressure. Hedging against a low-growth canonical variation is a primary reason for this strategic group to lower fixed costs by outsourcing components. This eventuality also highlights the potential benefit for small manufacturers of engaging in a supplementary business, which may generate survival revenue in low-growth periods. Nonetheless, influencing the competitive environment through a favourable home market, while enjoying exclusivity of government support and policies will become increasingly challenge over the coming decade.

8.6 Pre-emption: Fortification, mobility or exit?

Thus far, I have considered strategic consequences for wind turbine manufacturers determined to defend *status quo*. A perfectly valid conclusion, however, of a wind turbine manufacturer, having considered the forces of change, may be to pre-empt and abandon its current strategy. In this event, a number of options present themselves to each strategic group.

Because of the substantial capital requirements, financial risk and extensive R&D activities needed to maintain product proprietarity, discovery, differentiation and warranties; some full-line differentiations will likely see it as an opportunity to become part of a larger diversified company. Vestas is an obvious candidate for this possibility. Conversely, this would indicate that large diversified narrow-line industrialists, such as GE Wind and Siemens, are obvious candidates for entry into this strategic group. Because of their versatile skills, a number of more direct mobility strategies are likewise open to full-line differentiators seeking to abandon their strategic group. The most obvious of these would be to spin off peripheral product lines, streamline production, cut back on R&D expenditure and outsource component production - and become a narrow-line industrialist. Investigating the option of redirecting R&D and know-how to process discovery and taking advantage of scale may in all cases be time well spent for full-line differentiators. Conversely, it is more difficult to imagine an already globalised manufacturer intentionally limiting its market scope to become a selective market specialist - this option is nonetheless available. Another option open to backward integrated manufacturers with large existing R&D competences, is to become an independent component supplier in an area of particular competence. The particular capabilities of a full-line differentiator failing to be profitable in the face of change may be well suited for this role.

In spite of the relative attractiveness of this strategic group, some narrow-line industrialists may feel that their capabilities are more fully utilised elsewhere. As described above, this may particularly be the case for large, diversified firms which are able to leverage extensive R&D resources across many divisions. A widely held notion in the industry is that if GE Wind and Siemens decide to commit fully to the wind turbine industry, they will expand their existing product lines; perhaps to the point where they could more rightfully be considered full-line differentiators. Developing proprietary, path breaking product technology while using their financial strength to bear the risk may grant these manufacturers greater relative advantages than the in the 'dogfight' among industry mainstreamers. As is the case for full-line differentiators, it is difficult to imagine internationalising narrow-line industrialists intentionally limiting their activities to a few selective markets in order to become selective market specialists. This option seems particularly prohibitive for narrow-line industrialists seeking to achieve advantages of scale in production.

Mobility or exit strategies seem a particularly worth wile consideration for selective market specialists seeking to improve their prospects in the face of unfavourable change. A selective market specialist may attempt to internationalise to more fully utilise advantages of scale and scope, and seek to become a full-line differentiator or a narrow line industrialist. These options naturally require substantial resources and, as the oligopolistic nature of the industry would suggest, there is only room for a very limited number of global manufacturers. In a decade from now, there may well be room for fewer than today. Although these options will prove prohibitively resource demanding for the majority of small manufacturers, it may be a relevant option for selective market specialists supported by an attractive home market and backed by a larger parent company. Establishing a strategic alliance with a larger company may be forces upon many selective market specialists seeking to internationalise. Suzlon is an obvious example of a candidate for becoming a narrow-line specialist. It seems much harder to identify likely candidates for entry into the full-line differentiators' strategic group. More realistic strategies for most selective market specialists may be to retreat vertically into either project development or component manufacturing. The former option seems the most obvious way for a selective market specialist to redeploy its proprietary knowledge of its selected market by becoming a domestic developer. Local knowledge of legislation, regional planning, public perception and culture are much needed skills for international utility companies seeking public backing for wind projects. Backward integrated selective market specialists may likewise exploit proprietary knowledge to become an independent component supplier. In either of these positions, the firm would no longer be a direct competitor to global wind turbine manufacturers in its domestic market – but a potential customer.

In this chapter I have considered a number of strategic consequences of the progression of the multifold trend and of the canonical variations established in Part II. At this point, it is important to realise that these forces of change represent only the major anticipations and questions which are *known*, or believed to be known, in the present. In fact, it would be highly surprising if no surprising changes occurred in the competitive environment of the wind turbine industry over the coming decade. In the following chapter, I will consider the strategic consequences of the forces of change which we have yet to recognise.

- Part III -

Chapter 9: Deep uncertainty - what we don't know we don't know

This chapter will concern itself with all the strategically relevant information that was missed, forgotten, wrongfully omitted, not recognised, or otherwise ignored so far. Because of the influence of combinatorial and dynamic complexity, sensitivity to initial conditions, and self-altering prophesy, this report is likely to have merely scratched the surface of how the future will unfold over the coming decade. Strategic foresight must necessarily be limited to what is known or believed to be relevant at the time at which the foresight is made. In this chapter I will consider the possibility of mitigating the strategic consequences of such unrecognised uncertainty through monitoring and early warning.

9.1 What is known, and what is not

As we progress toward some future point in time – roughly the year 2016 in the context of this report – more information about the final state of the system at that time is gradually made available. Immediately before transpiration of that point in time, information about the final state of the system will be near-perfect and we can regard nearly all process of change as deterministic. As we pass that point in time, the state of the system finally becomes history and is rendered utterly unalterable. This is a gradual process through which expectations are confirmed or disconfirmed, questions are answered, and previously unrecognised issues are introduced. As the point in time considered in the context of this report is still a decade away, it is clear that much information about the state of the competitive environment is inaccurate, uncertain or unknown. In recognition of this, it is the purpose of monitoring and early warning efforts to discover new, strategically relevant information as the earliest possible time at which it becomes available.

9.2 Monitoring and early warning

The perpetual question arising when searching for signs of change, which have yet to be recognised, is what to look for. Some common answers have been unfocused environmental scanning[298], various forms of sensitivity and risk analysis[299] and competitor monitoring[300]. An alternative to these approaches is presented by the explicit establishment of the multifold trend and its canonical variations. Having made recognised expectations and major questions about the future explicit provides a natural focus for obtaining new, strategically relevant information.

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[298] See Van Wyk 1997
[299] See Gilad 2004
[300] See Porter 1980

Monitoring the progress and pace of the individual folds of the multifold trend provides a systematic basis for continuously verifying and updating strategic expectations about the competitive environment. As new information becomes available, folds that are no longer strategically relevant can be excluded from the multifold trend, while new expectations can be included. Folds progressing unexpectedly (reversing, oscillating, changing pace, etc.), proving the initial expectation wrong, can be reconsidered as a canonical variation. Conversely, monitoring canonical variations provides a systematic basis for continuously verifying and updating strategically relevant eventualities worth hedging against. Clarified canonical variations can thus be included in the multifold trend as predetermineds, while outcomes of new strategic questions can be taken into account as new canonical variations.

In recognition of the existence of deep uncertainty, the multifold trend and the canonical variations identified and explored in this report are not static constructs which will remain equally relevant for strategic decision making throughout the coming decade. Rather, they form a basis for strategic decision making *in the present*, and provide a framework for systematically and explicitly verifying and updating assumptions about forces of change and their strategic consequences over time. This concludes Part III of this report.

Chapter 10: Conclusions & Perspectives

Through Part I of this report, I first made explicit a number of assumptions about the variables and interconnections relevant to strategic decision-making in the competitive environment of the wind turbine industry. Part II identified a number of known forces of change assumed to influence the competitive environment over the coming decade. Part III then explored the strategic consequences of these forces for wind turbine manufacturers. On that basis, this chapter will be concerned with answering the research question posed in Chapter 1, as well as discussing the perspectives of strategic foresight in general and the one contained in this report in particular.

10.1 Answering the research question

So, what forces will shape the competitive environment in the global wind turbine industry over the coming 10 years and, what will be the strategic consequences for wind turbine manufacturers? Briefly, the known forces of change identified in Part II can be summarised as a number of challenges posed to wind turbine manufacturers over the coming decade. These include:

- The challenge of concentrated, conservative, professional and international buyers of still larger wind projects
- The challenge of increasing importance of scale and scope in wind turbine manufacturing
- The challenge of increasing standardisation and maturity of wind technology and the increasing emphasis on process discovery
- The challenge of the increasingly specialised and independent supplier network
- The challenge of volatile industry growth and market scope
- The challenge of entry or emergence of new competitors

As described in Part III, wind turbine manufacturers are – and will be – in very different positions with regard to meeting these challenges and their strategic consequences over the coming decade:

- Full-line differentiators must maintain cost advantage through product differentiation and technological leadership in the face of an increasingly mature technology and standardised components. Exploiting the emerging offshore market while seriously considering becoming part of a larger differentiated company, are the key opportunities for this type of manufacturer. Failure to do this can be favourably pre-empted by becoming a narrow-line industrialist or by retreating backward into component manufacturing.
- Narrow-line industrialists must streamline their production to cut cost and increase reliability, taking advantage of the developing supplier network, while seeking scale, scope and volume in production. Achieving full serially optimised production is the key opportunity for this type of manufacturer. Narrow-line industrialists with extensive R&D capabilities may favourably pre-empt by becoming a full-line differentiator.

- Selective market specialists must maintain entry barriers around their selected national and/or regional markets in the face of increasing global competitors exploiting superior advantages of scale, scope and technological capability. Identifying and specialising to market segments which are unattractive or inaccessible to larger competitors, while forming protectionist alliances with governments, are the key opportunities for this type of manufacturer. Selective market specialists can pre-empt this development by increasing their market scope and become a full-line differentiator or a narrow-line industrialist. Alternatively, the proprietary market knowledge possessed by selective market specialists may be redeployed through becoming a developer.

10.2 Perspectives

A valid question, first posed in Chapter 2, is whether the research question of this report can even be answered in any meaningful way. Given the constraints imposed by the major sources of uncertainty on any attempt to consider the long-term future, it is clear that no current answer to the research question can be exhaustive. Hence, the findings of this report are necessarily incomplete - but are they meaningful, and to whom?

It is implicit to the findings that they should, in some manner, be meaningful to decision-makers faced with the problem of designing business or governance systems over the coming decade. In saying this, it should be noted that this report is subject to academic standards appropriate to that of a master thesis, and would no doubt have looked very different if written directly to specific industry decision-makers. Although theoretical and methodological considerations would have been marginalised and practical use of the findings emphasised and specified, the substance of the report would have remained.

Through the somewhat experimental method employed here, the substance of this report is a systematic exploration of the strategic consequences of the expectations and major questions currently held by industry observers and participants about the future of their industry. Imbedded in such an exercise is both a principal strength and a weakness. On the one hand, the expectations and major questions explored are the *industry's own*, and must therefore hold intrinsic meaning and relevance to that industry. On the other hand, for the very same reason, the expectations and major questions may be inherently rooted in the existing mental models of the industry, and therefore be firmly 'inside the box'.

The same argument can equally be directed at the rigorousness of the method employed in the systematic exploration of expectations and major questions. The ICM too is firmly rooted in a specific – and inherently limited – mindset; that of the five forces framework. A valid, question is weather five forces are enough to meaningfully describe a competitive environment as complex as the wind turbine industry - an industry firmly set in political systems as well as economic ones. Likewise, there may well be a trade-off between the systematic rigorousness of the method and the intuitive imagination, which would otherwise take its place. Unstructured participatory methods or, more commonly, unaided intuition does not, however, guarantee an unlimited and sufficiently imaginative mindset. Rather, as it is often the case, the reasoning remains implicit, leaving no audit trail and little internal consistency.

Failing to take into consideration the truly unexpected events for which business and governance systems are unprepared, and which is currently considered ‘off design’, is a danger implicit to all assumptions about the long-term future. Such assumptions are nonetheless an unavoidable part of decision-making, whether made implicit and intuitively or explicit and systematically. As I will argue, it is the role of strategic foresight to provide a rationally defendable basis for thinking imaginatively and playfully about strategic choices over the long-term future.

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Appendix A: Variables, terms & descriptions

This appendix accounts for the desk study through which the variables identified in Chapter 3 was empirically grounded in Chapter 4. The desk study initially identified a 'core body' of industry literature by a number of consultants and observers of the industry such as BTM Consult, Danske Equities, Morgan Stanley and Carnegie Securities Research along with The International Energy Agency. Using these sources, the identified variables were assessed in terms of their relevance and effect upon the competitive environment of the wind turbine industry. The variables not addressed in the core literature formed the basis of lines of enquiry into more specialised literature and empirical studies such as Takeuchi and Ancona & McVeigh, addressing the relevance and effect of more specific variables proposed in Chapter 3. Throughout the desk study, variables considered important to the competitive environment but not proposed in Chapter 3 were considered and included. As described in Chapter 4, the aims of this process of empirical grounding were two-fold:

1. *Excluding* variables and relationships suggested by the positioning school, which are *non-existent* in the unique context of the competitive environment of the wind turbine industry.

2. *Including* relevant variables and relationships not suggested by the positioning school, which are *unique* in the context of the competitive environment of the wind turbine industry.

In the following, each of the variables considered in the context of this report are outlined in order of their impact upon each of the five forces.

1. Determinants of the threat of new entrants

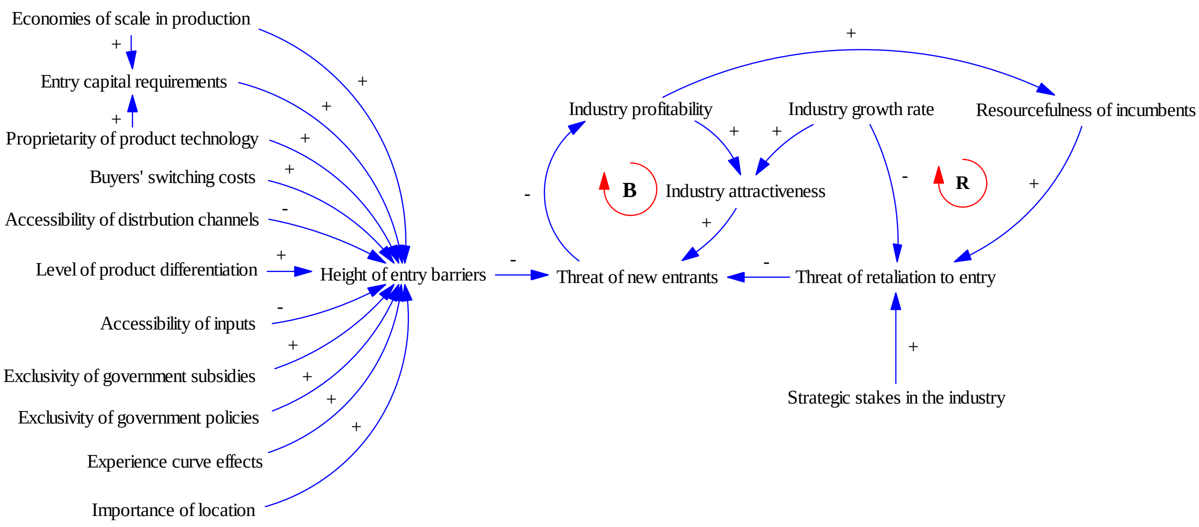

Figure 3.4: The determinants of the threat of new entrants

Economies of scale in production: The existence of economies of scale implies that the cost of a product, operation or function declines as the absolute volume per period increases[301]. Like many manufacturing industries, economies of scale are significant in wind turbine manufacturing, making market share a central prerequisite for long-term profitability[302]. In addition to advantages of joint operations and specialisation, the sheer size of the orders to be filled puts minimum requirements on

[301] Porter 1980:7
[302] Danske Equities 2003:14-16

the viable size of turbine manufacturers. Economies of scale therefore present a significant entry barrier to potential entrants and smaller incumbents[303].

Level of product differentiation: Differentiated products imply product familiarity and thus a certain degree of product loyalty to incumbents' products. This can present a significant entry barrier to potential entrants. In wind turbine manufacturing, the main parameters of differentiation identified were: turbine size, reliability, deployment (onshore/offshore), wind speed specialisation, warranties and after sales service. Of these parameters, reliability has proven especially important. Although the entry barriers for assembling wind turbines from prefabricated components bought from subcontractors are low; product reliability and a proven track record of prior successful projects are a key selection criteria among the increasingly informed and sophisticated buyers of wind turbines. In the absence of a solid track record, buyers will be reluctant and financing will be considered risky and therefore expensive. For these reasons, product differentiation is an effective entry barrier around the industry[304]. See also switching costs below.

Entry capital requirements: An entry capital requirement is the initial investment necessary to enter an industry in absolute terms. High entry capital requirements lower the number of potential entrants willing and able to make the necessary investments for successful entry into the industry[305]. Economies of scale (described above) and propriety of capitel requirements (described below) significantly increases capital requirements for successful entry, forcing potential new entrants to enter the industry *in force*, thus limiting the number of potential entrants and increasing financial risk. Entry capital requirements for successful entry into the wind turbine industry must be considered a very significant entry barrier around the industry.

Buyers' switching costs: The total costs borne by buyers; including time, effort, capital, risk etc. involved in switching between competing sellers of a product. As already mentioned, demonstrated performance and turbine reliability are major competitive parameters in wind turbine manufacturing[306]. These are the major sources of brand identification and customer loyalty. In addition to these 'intangible' switching costs, a loyal buyer can obtain a number of negotiating advantages through repeated orders to the same manufacturer. Utilising the same turbine technology opens the possibility of economies of scale in monitoring and maintenance of the turbine fleet. Existing service contracts and warranties with a manufacturer can often be extended on favourable terms in connection with subsequent orders. Tangible and intangible switching costs related to changing manufacturer and thus turbine technology, presents a significant barrier to potential entrants.

Accessibility of distribution channels: Logistical access to points of distribution to the final buyer. Occasionally, third party project developers act as a mediating link between wind turbine manufacturers and the final owners of wind projects. Project developers locate suitable sites for wind projects and negotiate with wind turbine manufacturers and develop the project[307]. When operational, the wind project is finally sold off to the final buyer/utility companies[308]. However, in this respect, developers are no different than other large buyers of wind turbines. For this reason, accessibility of distribution channels cannot be considered in isolation as an entry barrier.

Proprietarity of product technology: The difficulty (total effort) involved in imitating the features of a product for commercial benefit. A single modern wind turbine is estimated to contain more than

[303] Morgan Stanley 2005:12
[304] Danske Equities 2003:13, see also Alfred Berg 2006:12
[305] See Johnson & Scholes 2002:114
[306] See also description of the significance of warranty provisions below.
[307] Danske Equities 2003:12
[308] BTM 2005a:20

10.000 highly specialised components[309]. Modern wind farms are composed of multiple turbines required to operate as a single power plant with minimum maintenance for up to 25 years. This requires specialised knowledge in many fields of science not easily found in adjacent industries[310]. Experiences with new entrants into the industry suggest that developing cheap and reliable turbine technology from scratch to a level where it is competitive with current standards is implausible. All recent entry into the industry was done through purchase of existing manufacturers (GE bought Enron Wind Corp, Siemens bought Bonus Energy) or by creating a joint venture with existing players (Gamesa set up a venture with Vestas)[311]. Proprietarity of product technology must therefore be considered a major entry barrier around the wind turbine industry.

Accessibility of inputs: The outsourcing options available to an industry or a firm. Today, a wide range of subcontractors is available to the wind turbine industry[312], and in principal it is possible to assemble a turbine entirely from prefabricated components[313]. This, however, is not sufficient to guarantee accessibility to required inputs. Because of high growth rates in the industry as a whole, component shortages are commonplace. The wind turbine industry is notoriously sensitive to the quality and timely delivery of key components. Delays in component delivery are extremely costly to wind turbine projects[314]. Type faults in components for larger wind projects are equally serious as wind turbine manufacturers bear the financial responsibility for the quality of turbines through warranty provisions[315] (see below). Accessibility of inputs is a significant problem for experienced incumbent competitors[316], especially those with a lesser extent of vertical integration such as Vestas and GE Wind[317], and must therefore also be considered a significant entry barrier to potential newcomers. Access to components also significantly affects the importance of location (see below) for wind turbine manufacturers. As components increase in size along with continued up scaling of turbines, transport costs has become an increasingly important component in the cost of large components. In addition, a close physical location to major component suppliers is also an advantage in terms of R&D cooperation and partnerships between subcontractors and wind turbine manufacturers[318].

Exclusivity of government subsidies: The degree to which one or more national governments, through subsidies, are able to exclude or disadvantage non-domestic firms. Although government subsidies provided for the production of renewable energy in national markets are not directly exclusive to incumbents, research grants, and resources of government institutions such as research centres and educational facilities can significantly influence an incumbent's competitiveness in its home market. This was to a large extent the case in Denmark where the resources of Risø National Laboratory played a central role in the development of the industry[319].

Exclusivity of government policies: The degree to which one or more national governments, through policy or legislation, are able to exclude or disadvantage non-domestic firms. Local manufacturing content requirements, preferential tax breaks for domestic manufacturers, exclusive or preferential access to national R&D funds, favourable treatment by planning authorities and political contacts are all part of the competition in various national turbine markets[320]. Such policies present a significant

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309 Vestas Wind Systems, www.vestas.dk
310 See Risø National Laboratory, http://www.risoe.dk/vea/
311 Morgan Stanley 2005:12
312 See DWIA 2005:48-57 and Danske Equities 2003:11-12
313 Danske Equities 2003:13, see also Alfred Berg 2006:12
314 See e.g. Vestas' First Quarter Report 2006
315 See e.g. Vestas Annual Report 2005
316 Takeuchi 2003:44
317 Morgan Stanley 2005:19
318 Takeuchi 2003:50-51
319 See Skytte 2004:19
320 See e.g. CRS 2006

barrier to potential entrants[321]. This picture is confirmed when looking at the dominant position attained by certain manufacturers in their home markets such as Gamesa in Spain, Enercon in Germany and Suzlon in India[322].

Experience curve effects: The relative cost reduction per unit for every doubling of accumulative production. Empirical studies suggest that the cost of wind power has declined by 80% since 1980. In terms of learning curve effects, this means a cost reduction by as much as 15% (Price/MWh) when the accumulative production doubles[323]. This finding is backed by studies of the historical importance of experience curve advantages in the wind turbine industry[324]. Powerful experience curve effects significantly benefits experienced incumbents and constitutes a significant entry barrier not easily overcome by potential entrants.

Importance of location: The relative competitive advantage of locating the activities of a firm in a specific geographical location. Domestic manufacturing content requirements, import restrictions and other forms of protectionism along with varying currency rates and transport costs are important incentives for turbine manufacturers to locate production facilities in or near certain markets. This has been a long-standing issue for European manufactures seeking access to Asian and American markets[325] and must be considered a significant entry barrier for potential entrants, placing extended requirements on where to locate production facilities. Being located near major component manufacturers is also a significant advantage in terms of accessibility to inputs (see above) and R&D partnerships.

Height of entry barriers: The total effort involved in entering an industry. As illustrated in figure 3.4 Chapter 3, the height of the entry barriers around the industry is determined the interplay of the eleven variables described above. Economies of scale and experience curve effects forces potential entrants to enter in force considerably increasing entry capital requirements. Opportunities for entry are further limited by proprietarity of product technology and switching costs, which forces potential entrants into buying existing manufacturers to gain access to technology and a proven track record of previous successful wind turbine projects. For these reasons, the entry barriers around the wind turbine industry must be considered extremely high.

Industry growth rate: The industry growth, measured as the difference in percentage between one or more growth indicators (total revenue, MW installed etc.) from one year to the next. Industry growth may thus be negative. All else being equal, high growth industries are more attractive to potential entrants than low growth industries. In addition, the industry growth rate determines an industry's ability to absorb new entrant without depressing incumbent's sales and financial performance[326]. As described above, the wind turbine industry is a high-growth industry, which over the past eight years grew by more then 30% annually[327] and with an expected growth rate of 15-20% over the coming five years[328]. High industry growth must therefore be considered a significant contributing factor to the ability of the industry to absorb potential new entrants and therefore also a limiting factor in terms of incumbent's threat of retaliation. This picture is confirmed in some of the fastest growing markets such as the U.S. where several vendors are reported to have sold out[329]. Incumbent's threat of retaliation to entry in such market conditions must be considered limited.

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[321] See Windbitz 2006
[322] BTM 2005a:17
[323] Carnegie Securities Research 2006:5
[324] See Neij *et al* 2003
[325] See Windbitz 2006
[326] Porter 1980:14
[327] EREC 2006
[328] Morgan Stanley 2005:11
[329] Carnegie Securities Research 2005:20

Resourcefulness of incumbents: Incumbent's threat of retaliation to new entrants is significantly enforced if incumbents can deploy substantial resources to counter would-be entrants. Such resources could include excess cash, unused borrowing capacity, adequate excess capacity to meet all future needs or great leverage with distribution channels or customers[330]. As described above, the wind turbine industry is a highly concentrated industry dominated by a few large competitors. This would in itself indicate that should determined retaliation occur, it could involve significant resources. In addition, several of the major incumbents are part of larger diversified energy companies. These include GE Wind, Siemens, Enercon and Gamesa with the noticeable exception of Vestas. The resourcefulness of these diversified competitors are increased by the fact that they have the option of drawing resources from their parent companies. Incumbents in the wind turbine industry must be considered resourceful.

Strategic stakes in the industry: In the broadest sense; incumbents' commitment (emotional, financial etc.) to the industry. Incumbent's threat of retaliation to new entrants is increased if incumbents are highly committed to succeeding in the industry. High expectations to future growth and profitability of the wind turbine industry significantly contribute to heightened strategic stakes. This in turn increases the determination among competitors to defend or strengthen their position in the industry and this increases the intensity if rivalry. Although the specific strategic stakes in the wind turbine industry vary between individual competitors, the overall stakes in the industry is closely related to the high future growth prospects of the wind turbine industry[331].

Threat of retaliation to entry: Potential entrants' knowledge of the probability that incumbents will expend resources to actively defend market share against a newcomer. The threat of retaliation to entry is determined the interplay of the three previous variables described above. Incumbent competitors in the wind turbine industry must generally be considered resourceful and their long-term strategic stakes in this high-growth industry are significant. This would indicate incumbents pose a credible threat of retaliation to potential entrants. However, in light of the current and expected growth rate, turning part of the global wind turbine market into a seller's market, the impact of a new competitor entering the industry by buying a smaller incumbent may not warrant a forceful retaliation. At least not while the industry growth rate remains sufficiently high.

Industry attractiveness: The assessment of a potential newcomer about the size of the entry deterring price relative to the size of its expected benefits of entering the industry. The attractiveness of an industry is determined by its current and future profitability. Profitable industries work like a magnet for potential entrants. The same is true for industries *expected* to become profitable. The EBIT margin for the major wind turbine manufacturers in the period 2001-2004 was on average 13.5%. This figure covers significant variation among individual manufacturers (As low as 4.6% for Vestas 2003 to as high as 23.4% for Suzlon in 2001) indicating that, at present, the industry is not one-sidedly profitable compared to other production industries[332]. The expectation of future industry and market growth described below, and thus the potential future profitability, is a significant incentive for potential entrants to overcome entry barriers.

In addition to the variables included in the theoretical propositions suggested by the positioning school, the following additional variables were identified:

Extent of warranty provisions: The number of turbines under warranty and the time period covered by warranties. As described above, based on the history of entrants to the wind turbine industry, the most likely route of entry would be to buy an incumbent manufacturer. A significant barrier to

[330] Porter 1980:14
[331] Carnegie Securities Research 2005:3
[332] Morgan Stanley 2005:18

buying incumbent wind turbine manufacturers is the assessment of long-term risk of such a venture. Many incumbents have issued long-term warranties on wind turbine projects extending as much as 10-12 years into the future. The extent to which an incumbent is bound by such obligations along with their ability to meet them is unknown to potential entrants. Extensive warranties could therefore lead to serious compensation claims and thus presents an unknown level of risk to potential entrants[333].

2. Determinants of the intensity of rivalry

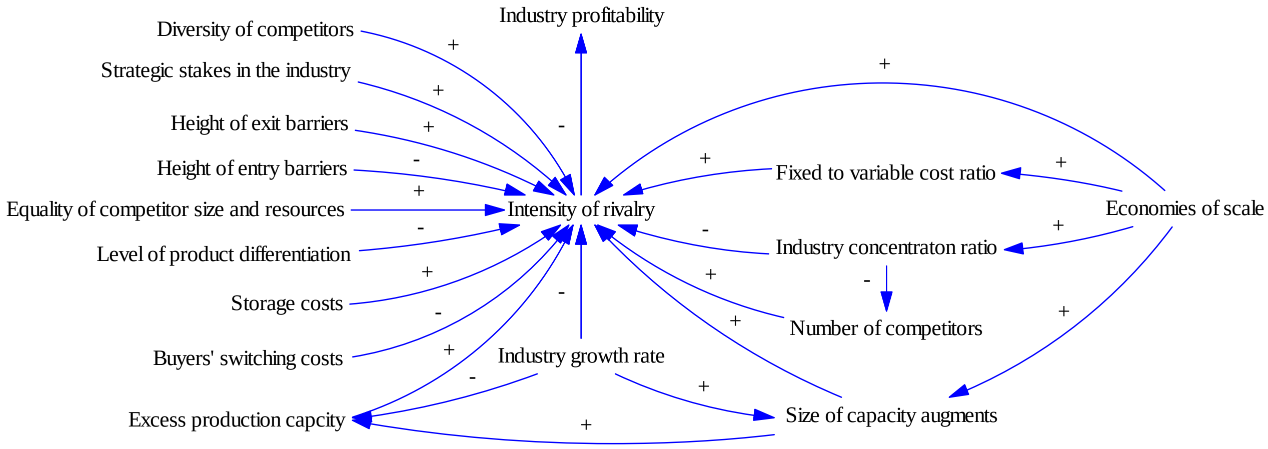

Figure 3.5: The determinants of the intensity of rivalry

<u>*Number of competitors*</u>: The number of significant competitors in an industry. Industries populated by numerous competitors are more prone to intense competition, driving down profitability[334]. Cooperation to keep prices stable and to avoid prolonged price wars is difficult to sustain among many competitors. Also, competitors' ability to keep track of each other is usually lower, increasing the incentive to make covert moves to undercut competition, thus igniting competitive wars. As described above, the wind turbine industry is oligopolistic and highly concentrated among only a few truly global players. The major part of the wind turbine market is divided between five main competitors; Vestas (34.1%), Gamesa (18.1%), Enercon (15.8%) GE Wind (11.3%) and Siemens (6.2%)[335]. From the point of view of the positioning school, this is significant factor limiting the intensity of rivalry in the wind turbine industry.

<u>*Diversity of competitors*</u>: Strategically diverse competitors with highly different backgrounds, goals and assumptions about the industry in which they compete, are more prone to intense competition for similar reasons as industries populated by numerous competitors. It is more difficult to read intentions and cooperate to keep prices stable among highly diverse competitors[336]. Although the diversity of business models is high in the wind turbine industry, no empirical evidence could be found that this factor contributes significantly to the intensity of rivalry among incumbent wind turbine manufacturers.

<u>*Strategic stakes in the industry*</u>: As described above, competitors' strategic stakes in the wind turbine industry are related to the promising future growth prospects of the industry. High strategic stakes

[333] Stephen Rammer, analyst, Handelsbanken in Berlinske Tidende, February 2006
[334] Porter 1980:18
[335] BTM 2005a:16
[336] Porter 1980:19-20

must be considered a significant contributor to the commitment of incumbents to the industry and therefore also to the intensity of rivalry between them.

Height of entry barriers: As described above, the entry barriers around the wind turbine industry are very significant by any standards. Although they do not completely eliminate the threat posed by potential new entrants, they do ensure that entry into the industry is rare and that the number of competitors is kept relatively low and that potential entrants are forced to enter in force and usually by means of buying an incumbent. The height of the entry barriers is a significantly limiting factor for the intensity of rivalry in the wind turbine industry.

Height of exit barriers: The total cost involved in leaving the industry. High exit barriers indicate that excess capacity is slow to leave the industry, thus raising the probability of extended price wars among competitors as supply exceeds demand[337]. Given current expectations to industry growth of around 15-20% over the coming five years[338], along with the history of buy-outs as a means to entering the industry, leaving the wind turbine industry is not likely to be costly as long as growth prospects remain high. According to BTM Consult, several potential entrants would be prepared to buy their way into the industry should such an opportunity present itself[339]. General Electric's takeover of Enron Wind is a recent example. High exit barriers cannot be considered a major contributor to the intensity of rivalry.

Equality of competitor size and resources: The diversity of the resourcefulness of incumbents (see above). Equal competitors are more prone to intense competition because they have yet to establish a clear balance of power. Equal competitors mutually have the resources for sustained price competition, prolonging price wars until equilibrium is found[340]. Although Vestas is usually considered the market leader in the wind turbine industry, based on its higher market share and first mover status, a balance of power has yet to be found among the major competitors in the industry[341]. Equality of size and resources among the largest competitors in the wind turbine industry is therefore likely to be a major factor contributing to the intensity of rivalry in the wind turbine industry.

Level of product differentiation: As described above, the main parameters of differentiation identified were: turbine size, reliability, placement (onshore/offshore), wind speed specialisation, warranties and after sales service. Although some level of differentiation exists along these parameters[342], the overriding factor is price per MW installed[343] and for this reason, product differentiation is not likely to be a major limiting factor in terms is rivalry, as product-by-product substitution remains high (see below).

Storage costs: The total cost of storing a product per time unit. High storage costs create a powerful incentive to sell products as soon as they are produced. In times of overcapacity, this leads to price wars to avoid storage. The sheer size of wind turbines make them expensive to store, making storage costs a significant contributing factor for the intensity of rivalry in case of low demand.

Buyers' switching costs: As described above, buyers are faced with both tangible and intangible switching costs in the form of demonstrated performance, reliability, brand identification and decreased bargaining power when changing between manufacturers. In terms of intensity of rivalry, this must be considered a limiting factor.

[337] Porter 1980:20-21
[338] Morgan Stanley 2005:11
[339] BTM 2005a:20
[340] Porter 1980:18
[341] Danske Equities 2003:16
[342] See Danske Equities 2003: 8
[343] Morgan Stanley 2005:35

Industry growth rate: High industry growth offsets competition because it turns competition into a plus-sum game. Wining an order does not necessarily mean that competitors will have to loose it. This is most clearly exemplified by the recent transition to a seller's market in the U.S., where several vendors are reported to have sold out and manufacturers have successfully raised prices in response to increased demand[344]. As described above, the wind turbine industry is a high growth industry, a fact that contributes significantly to lowering the intensity of rivalry among manufacturers and in effect offsetting many of the contributing factors outlined here. As described above, this has significantly lowered the risk of price competition and thus the intensity of rivalry in the industry[345].

Fixed to variable cost ratio: The size of fixed costs (costs that cannot readily be reduced) relative to variable costs. High fixed operating costs creates a powerful incentive to fill capacity, which leads to price wars when excess capacity is spent[346]. This is also true for the wind turbine industry, where fixed production costs are high, increasing manufacturers' sensitivity to timely component delivery (as described above) along with their sensitivity to seasonal variations in demand. Increased demand at the end of the year, in response to the winter season, remains a capacity utilisation problem for several manufacturers[347]. High fixed to variable cost ratios of wind turbine manufacturers must therefore be considered a significant contributor to the intensity of rivalry, should wind turbine demand decline.

Industry concentration ratio: In this context of this report; the total market share held by the top-five manufacturers relative to the rest. Closely related to the number of competitors described above, highly concentrated industries are less prone to intense competition because coordination of pricing decisions are more easily maintained among fewer competitors. Dominant competitors can thus exercise direction and avoid prolonged price wars[348]. As previously mentioned, the wind turbine industry is highly concentrated around five major competitors.

Size of capacity augments: The size of the increments in which new production capacity is added. Competitors adding production capacity in large increments run the risk of creating a situation of temporary overcapacity and thus price-cutting to fill capacity[349]. This must be considered a significant factor in wind turbine manufacturing, where economies of scale and capacity utilization both play a major role. Although a potential catalyst for intense rivalry, this variable is largely offset by industry growth rates as high as 15-20% annually, meaning that large capacity augments are necessary just to follow the market. This might significantly change should the industry growth rate decline.

Excess production capacity: The production capacity in excess of a firm's market share. Due to economies of scale and high fixed to variable cost ratios described above, wind turbine manufacturers are highly sensitive to excess production capacity. Like the size of capacity augments, this variable could be a serious catalyst for intense rivalry should the industry growth rate decline. In this situation, manufacturers have a powerful incentive to increase capacity utilisation through lowering prices.

Economies of scale: The strength of the correlation between incumbents' market share and profits. Economies of scale may create a powerful incentive compete on price and market share to attain

[344] Carnegie Securities Research 2005:20
[345] Carnegie Securities Research 2005:20
[346] Porter 1980:18
[347] See e.g. Vestas Annual Report 2005
[348] Grant 1998:61
[349] Porter 1980:19

greater volume in production[350]. The need for market share along with strong incentives for efficient capacity utilisation must be considered a significant factor contributing to increased rivalry among wind turbine manufacturers. However, as it is the case with the size of capacity augments and excess production capacity, economies of scale as a catalyst of intense competition is limited by high industry growth.

3. Determinants of the competitiveness of substitutes

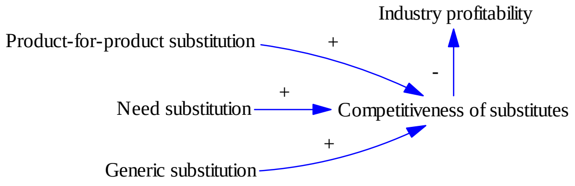

Figure 3.6: The determinants of the competitiveness of substitutes

Product-by-product substitution: This form of substitution occurs when a product is substituted by another performing the same function, only cheaper or better[351]. As wind turbines are the only plausible means by which electricity can be generated from wind, product-by-product substitution happens when one turbine generation substitutes another. Due to the high rate of new product discovery, this form of substitution is a significant factor determining the profitability of the industry as a whole. See industry R&D expenditure and rate of new product discovery below. This phenomenon was demonstrated in the mid 80s where rapid up scaling caused turbine designs to become obsolete at an unprofitable rate[352].

Need substitution: This form of substitution occurs when a new product or service fulfilling the same *need* renders an existing product or service redundant[353]. The primary function of wind turbines is the generation of electricity, and in this sense, wind technology is only one amongst a wide range of renewable energy technologies, which in turn is part of a still wider range of energy technologies, constituting the total energy technology stock available to energy suppliers. Depending on the context, any energy technology capable of producing electricity is a potential substitute for wind energy. This is the primary form of substitution with which wind turbine manufacturers should be concerned.

Generic substitution: This form of substitution occurs where products or services compete for the same portion of buyers' disposable income[354]. As wind projects are in themselves considered objects of investment, rather than a portion of disposable income, generic substitution is not relevant in terms of the wind turbine industry.

In addition to the variables included in the theoretical propositions suggested by the positioning school, the following additional variables were identified:

Competitiveness of wind power: The degree to which wind power is preferred over its substitutes. The major need substituting technologies to wind include coal, oil, gas, nuclear, biomass and hydro[355]. The relative competitiveness of any of these substitute technologies is subject to significant

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[350] Grant 1998:63
[351] Johnson & Scholes 2002:115
[352] See Kjær 1988:20
[353] Johnson & Scholes 2002:115
[354] Johnson & Scholes 2002:116
[355] IEA 2006

regional and periodic variation, depending on such factors as local resource availability, fuel prices, wind conditions, subsidies, base load flexibility etc. Due to significant increases in gas prices, the generation costs of wind is now lower than that of gas and fully comparable to the cost of coal[356], while significantly lower than that of nuclear power[357]. Although wind power enjoys substantial advantages along the major competitive parameters identified here, it is clear that significant competitive pressures exist from a wide range of substitute technologies. In terms of price competition between energy technologies, IEA (2004) notes that although *total* costs remain comparable, the *cost* structure varies significantly. In terms of cost structure, wind power generally has high transmission costs and carries the need for backup capacity (see energy planning restriction below)[358].

Rate of new product discovery: The rate at which new products emerge to keep potential need substitutes at bay is an important factor determining the overall competitiveness of substitutes. However, the rate of new product discovery also increases product-by product substitution, making existing turbines obsolete. Throughout the history of the wind turbine industry, this has been synonymous with up scaling, but advances in offshore technology and specialised low-wind turbines along with new composite materials have become equally important sources of new product discovery[359]. Neij *et al* (2003) found that eight successive generations of wind turbines emerged in the period 1980-2000, equalling an average time interval of 2.5 years between generations[360]. Given these figures, the rate of new product discovery is a major factor lowering the competitiveness of substitutes.

Rate of new process discovery: The rate at which new processes emerge to improve the production of the product. This variable is closely related to economies of scale and experience curve effects described above. New production processes has significantly contributed to cost reductions and thus to the competitiveness of wind turbine technology[361].

Industry R&D expenditure: Usually measured as the percentage of revenues used for research and development. The rate of new product and process discovery described above is in turn determined by the industry's R&D expenditure. In addition to competitors' own R&D expenditures[362], considerable public R&D funds have been channelled onto the wind turbine industry throughout the history of the industry[363] contributing significantly to the technological development and cost reductions of wind technology.

Government subsidies for renewable- and wind power: The extent to which government subsidies influence the competitiveness of renewable power. Historically, government subsidies for renewable energy production have been a major factor in creating an emerging market for wind technology[364]. Price/KWh electricity generated is still *the* major competitive parameter in electricity production and in this respect; wind power does not enjoy undisputed cost leadership[365]. Various forms of government subsidies continue to be an important factor in the competitiveness of wind power, especially relative to conventional energy technologies such as coal, gas and to some extent nuclear[366].

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[356] Carnegie Securities Research 2005:10
[357] IEA 2004:195
[358] IEA 2004:195
[359] See EWEA 2005B
[360] See Neij *et al* 2003: 38:42
[361] See Neij *et al* 2003
[362] Danske Equities 2003:8
[363] See Skytte *et al* 2004 and Neij *et al* 2003
[364] See Skytte *et al* 2004
[365] Carnegie Securities Research 2005:10
[366] BTM 2005a:47-48

Competitiveness of fossil fuels: The degree to which fossil fuels are preferred over their substitutes. When looking at the global market for electricity production, fossil fuels hold a dominant position with a total market share of 67%. Of this share, coal is the largest contributor with an estimated market share of 39% in 2002, while gas and oil held shares of 21% and 7% respectively. Looking ahead to 2030, coal and gas will hold the major share of new capacity installations, taking up 39% and 28% respectively, while the share of oil in new capacity installations is expected to be around 8%[367]. The competitiveness of fossil fuels is therefore likely to remain a major contributor to need substitution in the global energy market. In terms of cost structure, combined cycle natural gas has the lowest investment costs but the highest variable costs, as the price of natural gas varies significantly (see security of supply below). The investment cost of coal plants is relatively high but fuel costs account only for a smaller part of the total costs. In addition, coal prices are significantly more stable than gas prices[368].

Security of supply: The perceived probability of the conditions of energy supply remaining within acceptable limits. The price of fuel is a critical parameter in the competitiveness of substitutes to wind power. From the first oil crisis in the early 70s till today, security of supply has become a major issue for conventional substitutes to wind such as gas and oil, emphasising the role of energy technologies with stable or no fuel supply demands[369]. Guaranteed security of supply is a major competitive advantage of wind power in that it required no fuel. The closest substitute technologies with respect to high supply security are coal, hydro and biomass technologies[370].

Competitiveness of nuclear power: The degree to which nuclear power is preferred over its substitutes. Nuclear power currently holds a share of the global electricity market of around 17%, which is expected to decline significantly to 9% by 2030. Nuclear power thus takes up only 3% of new capacity installations. In terms of cost structure, the investment cost for nuclear power is high although running costs are very low[371]. In addition, nuclear power has almost zero CO_2-emmissions, which could become an increasingly important competitive parameter (see climate concern below). As a substitute for wind power, however, nuclear power supplies base-load generation[372], a role not suited intermittent power sources like wind, limiting the role of nuclear as a need substitute for wind energy.

Competitiveness of other renewables: The degree to which renewables are preferred over their substitutes. Renewable energy has a share of the global electricity market of 18%, which is expected to increase to 19% by 2030. Currently, hydropower is the most competitive renewable energy technology with a share of the world renewable electricity market of 89% with biomass as a distant second with a share of 7%. Wind takes up a shared third place along with geothermal, both with a share of 2%. According to IEA (2004) this picture will change significantly to 2030 as hydropower will decline to 69%, mainly at the expense of wind and biomass increasing to 10% and 15% respectively. Tidal/wave energy and solar power are expected to rise from currently insignificant shares to 1% and 2% respectively[373]. In terms of cost developments, the capital and total cost of both on- and offshore wind power is expected to decline significantly along with geothermal and biomass which will remain largely cost-competitive with wind energy, while the cost hydropower is expected to increase significantly due to lack of suitable sites[374].

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[367] IEA 2004:196:200
[368] IEA 2004:195
[369] See European Commission 2001
[370] Carnegie Securities Research 2005:4
[371] IEA 2004:195
[372] WNA 2006
[373] IEA 2004:204
[374] IEA 2004:233

Climate concern: The perceived importance of potential changes in the climate. Many energy markets are highly motivated by environmental incentives mainly linked to climate concerns about continued CO_2 emissions. Government subsidies supplied for environmental performance plays a major role in substituting conventional energy technology with renewables[375]. The so-called *external cost* of power generation from has become a key competitive parameter in several markets[376], seriously disadvantaging coal, oil and to a lesser extent natural gas. The closest competitors to wind in terms of CO_2 emissions are nuclear, hydropower and biomass, claiming comparatively high performance[377].

Regional planning restrictions: Physical and legal constraints to the design of wind projects. Not only is wind power highly dependent upon favourable energy planning, but also on favourable landscape planning regimes. Wind turbines are highly visible and their operation is connected with considerable noise emissions. Due to minimum wind speed requirements, turbines are often placed rural areas, and thus frequently conflicts with natural conservation and recreation interests. Several cases have illustrated how dissatisfaction with the placement of onshore wind projects has led to increasingly restrictive planning requirements[378]. This is a major reason for the further development of offshore wind technology, where continued up scaling of turbines is possible.

Energy planning restrictions: Physical and legal constraints to the integration of wind power into the broader energy system. Compared to most substitute technologies, wind power suffers from a number of unique disadvantages making the technology highly dependent upon favourable energy planning regimes. Wind is an intermittent power source and cannot therefore substitute base-load generation technologies and thus requires flexible backup generation capacity for periods with insufficient wind. IEA (2004) estimates the additional cost of backup capacity to be in the range of $5 to $10 per MWh[379]. In addition, wind turbines are often located in the periphery of the energy system and must therefore be connected to the grid at low-voltage levels. This adds to the complexity of the system, which in turn increases installation costs where weak grids must be reinforced[380]. This requires flexible energy systems and equally flexible energy planning. IEA (2004) estimates added grid costs to be $2.5 to $4 per MWh[381]. Grid connection has been a major obstacle in Spain, one of the most important wind power markets[382]. In spite of these disadvantages, recent studies have indicated that it is possible to integrate considerable wind capacity in national energy systems without any fundamental alterations in the existing grid structure[383].

4. Determinants of the power of buyers

[375] See e.g. IETA 2006
[376] See BTM 2005a:41-43
[377] ExternE-Pol 2005:27
[378] See BWEA 2006
[379] IEA 2004:235
[380] Carnegie Securities Research 2005:6
[381] IEA 2004:235
[382] BTM 2005a:6
[383] See EWEA 2005a

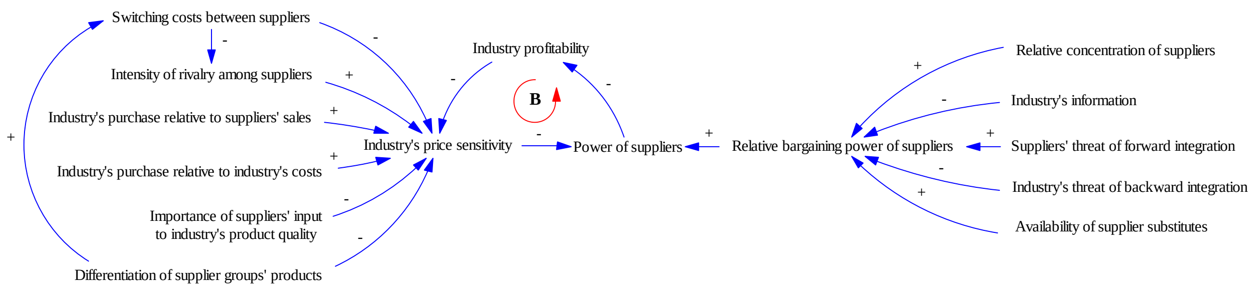

Figure 3.8: The determinants of the power of suppliers

Buyers' switching costs: As described above, it is possible for wind turbine manufacturers to impose both tangible and intangible switching costs when buyers change between wind turbine manufacturers. Switching costs therefore decrease the bargaining power of buyers.

Intensity of rivalry: The proportion of profits absorbed by various competitive activities. As discussed above, the intensity of rivalry among wind turbine manufacturers remains moderate because of high growth. However, large orders for wind turbine are won or lost in a process of competitive bidding and negotiation[384] in which price per installed MW capacity is the major competitive parameter. Although the intensity of rivalry among manufacturers is decreased by high demand, the intensity of rivalry, especially for larger projects, must be considered a significant factor increasing the bargaining power of buyers.

Buyers' purchase relative to sellers' sales: The proportion of total sales attributed to a single buyer over a given time period. As the size of turbines, wind projects and buyers of turbines has increased so has the size of orders[385]. As this trend continues, the individual order has become increasingly important to manufacturers thus increasing buyers' price sensitivity.

Buyers' purchase relative to buyers' costs: The proportion of a buyers' total costs attributed to a single purchase over a given time period. A buyer, who considers a wind turbine project a major investment relative to other investments, will demand more in terms of lowering risks and guaranteeing returns. In this respect, the wind turbine industry has seen two simultaneous movements. Buyers have changed from individuals to major power companies while wind projects have gone from single KW size turbines to marks of multi MW turbines. In spite of the changing size of customers, a modern wind turbine project is a significant long-term investment. Consequently, such an investment will be subject to the scrutiny and increased demands of a major investment, increasing bargaining power of buyers.

Level of product differentiation: If buyers can purchase the same product everywhere their bargaining position is significantly improved as they can easily switch between competitors. As described above, differences between manufacturers are marked enough to create significant switching costs between manufacturers. Additional differences in terms of turbine size, reliability, placement (onshore/offshore), wind-speed specialisation, warranties and after sales service means that product differentiation decreases the bargaining power of buyers.

Importance of industry's input buyers' product quality: The degree to which buyers' profits are affected by the quality of an industry's products. When the quality of buyers' product is affected by the industry's product, buyers' are generally less price sensitive[386]. The quality and thus the reliability of wind turbines are of primary importance to the operational economy of wind projects.

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[384] See Carnegie Securities Research 2005
[385] BTM 2005a:20
[386] Porter 1980:25

As wind projects have grown bigger, wind manufacturers have increasingly been forced to share the risk of serial faults in wind projects through extended warranty provisions[387]. The importance of quality to buyers has therefore lowered buyer's price sensitivity only at the expense of extended warranty provisions.

Buyers' profitability: Buyer's gains minus buyers' losses. Lower profits increase buyers' price sensitivity as they attempt to cut costs[388]. In recent years, major energy markets in Europe and the U.S. has been deregulated and privatised and competition between power suppliers has increased significantly[389], driving down the profitability of buyers' of wind turbines. Also, the introduction of government subsidies directly or indirectly rewarding the cheapest renewable technologies has made buyers increasingly price sensitive.

Buyers' price sensitivity: The degree to which buyers' value price over other product features. When taking the seven determining variables investigated above into consideration, buyer's price sensitivity is a major factor increasing the power of buyers. Modern wind turbine projects are increasingly seen as large, long-term investments purchased by highly concentrated and informed buyers. These in turn market renewable energy on increasingly competitive power markets, price sensitivity of buyers is further increased[390].

Relative concentration of buyers: The size and number of buyers. The ongoing concentration and consolidation of the wind turbine industry has to a large extent been matched rapid concentration on the buyers' side. As described above, large utility companies and developers have become by far the most important buyers of wind projects, taking over from smaller private buyers and local investor groups. In addition, recent years have seen consolidation among major developers and increased attention from major utility companies starting to take wind power seriously[391]. These developments have significantly increased the concentration of buyers, increasing their relative bargaining power, leading to increased demands on manufacturers to co-invest, co-manage and even operate large projects in order to win large contracts[392].

Buyers' information: The accuracy of buyers' information about the production cost of their purchase. As described above, the increasing sophistication of buyers also increases their ability to play manufacturers against each other to lower prices and raise quality through competitive bidding for projects[393]. Buyers with significant experience with a wide range of energy technologies including past wind projects are better informed when choosing one energy technology over another and also when choosing one turbine manufacturer over another. This increases the emphasis on the operational characteristics of the wind project such as price, durability and the extent of production and operational guarantees the manufacturer is willing to issue with the project. The increasing sophistication of buyers increases their and their ability to play manufacturers against each other to lower prices and raise quality through competitive bidding for projects[394].

Buyers' threat of backward integration: Wind turbine manufacturers' knowledge of buyers' assessment of the entry deterring price relative to the actual benefits of integrating backwards. As described above, major buyers integrating backwards into wind turbine manufacturing have been the primary mode of entry into the industry and therefore also the primary threat. Due to the significant

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[387] BTM 2005a:21
[388] Porter 1980:25
[389] See e.g. VanDoren 1998
[390] Morgan Stanley 2005:35
[391] BTM 2005a:21
[392] BTM 2005a:21
[393] See Carnegie Securities Research 2005
[394] See Carnegie Securities Research 2005

entry barriers around the wind turbine industry, this is a threat posed by only a very small minority of buyers and can therefore not be considered a general means by which buyers can increase their bargaining power with regard to the individual project.

Industry's threat of forward integration: Buyers' knowledge of wind turbine manufacturers' assessment of the entry deterring price relative to the actual benefits of integrating forward. In the business of wind turbine manufacturing, it is worth differentiating between two levels of forward integration: integration in to wind project *development* and wind turbine *operation and ownership*. In terms of project development, Gamesa is the most highly active of the major manufacturers, but also GE Wind and Vestas have development activities. Involvement in project development may become significantly more common for wind turbine manufacturers in the years to come, although not as a function of the threat manufacturers pose to established developers, as described above. In terms of project ownership, only Gemesa has significant activities, indicating that the threat of forward integration posed by wind turbine manufacturers does not significantly decrease the bargaining power of buyers[395].

Competitiveness of substitutes: In the broadest sense of the word; the degree to which substitutes are preferred over of wind power. As described above, any technology capable of generating electricity is a potential substitute for wind power. Although additional competitive parameters such as environmental performance, security of supply and government substitutes narrow the range of potential substitutes in some markets, this must be considered is a significant factor empowering buyers.

Relative bargaining power of buyers: The degree to which buyers' are able to demand lower prices or better quality from sellers. As described above, the relative bargaining power of buyers of wind turbine is substantial. As buyers of wind project have become increasing consolidated, professional and informed they have been able to exert significant pressure on the profitability of wind turbine manufacturers. In addition, as wind turbine projects have increased in size, winning individual large orders has become increasingly important, further increasing buyers' bargaining power.

In addition to the variables included in the theoretical propositions suggested by the positioning school, the following additional variables were identified:

Wind turbine demand: The number or value of turbines demanded by a market over a give time period. Closely related to high historic and expected industry growth rates, rapidly increasing demand due to political support for renewable energy, especially in the U.S. market has turned it into a seller's market as several vendors in the U.S. are reported to have sold out for 2006, effectively raising prices[396]. High demand is thus a factor decreasing both the bargaining power and the price sensitivity of buyers.

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395 Danske Equities 2003;8
396 Carnegie Securities Research 2005:3

5. Determinants of the power of suppliers

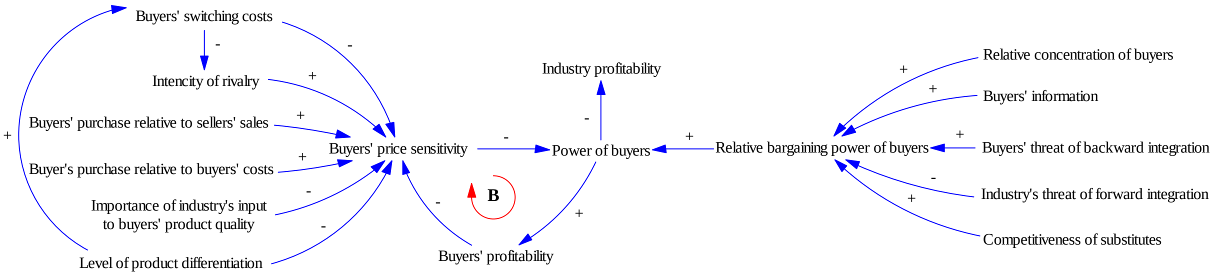

Figure 3.7: Determinants of the power of buyers

Switching costs between suppliers: The total costs involved in switching from one supplier to another. Wind turbine manufacturers are highly dependent upon their suppliers due to high sensitivity to timely delivery and high product quality, as described above. Switching between suppler and thus components often requires certification to qualify the supplier's input along with significant testing to ensure reliability and compatibility. Phasing in a new component is a time consuming and expensive process entailing significant switching costs[397]. Also, due to manufacturers' differing technical solutions and patent rights, components are often customised the rather than standardised[398], further adding to the cost and complexity of switching between suppliers. In addition, the physical location of component suppliers near major markets have become increasingly important as the size of components have grown larger adding to transport costs. This has made available suppliers with sufficient capacity scarcer[399]. Switching costs between suppliers must be considered a significant factor decreasing the price sensitivity of wind turbine manufacturers.

Intensity of rivalry between suppliers: The proportion of supplier's profits absorbed by competitive activity. As described above, the opportunity to create substantial switching costs for manufacturers lessens the intensity of rivalry among component suppliers. Also, because of high industry growth, reliable component suppliers and sufficient capacity is a scarce resource resulting in prolonged component shortages for wind turbine manufacturers. In addition, both technological and financial entry barriers around component manufacturing (gearboxes, generators, blades, control systems etc) are substantial[400]. Although these factors decrease the intensity of rivalry among component suppliers, wind turbine manufacturers are often disloyal to individual suppliers and are reluctant to rely too heavily upon any single component manufacturer[401]. Also, because of the high level of concentration of the wind turbine industry, component suppliers are highly dependent upon only a few customers and are therefore also highly sensitive to changes in manufacturers' sourcing strategy[402].

Industry's purchase relative to suppliers' sales: Suppliers will experience more price sensitive customers when large orders are placed relative to the suppliers' total sales. As the concentration of the wind turbine industry is increased along with the size of wind projects, manufacturers' purchase relative to suppliers' sales have likewise increased significantly. This development has made the individual order more important to suppliers, thus increasing the industry's price sensitivity.

[397] Takeuchi 2003:46
[398] Takeuchi 2003:56
[399] Takeuchi 2003:44
[400] Danske Equities 2003:11
[401] Takeuchi 2003:46
[402] Danske Equities 2003:11

Industry's purchase relative to industry's costs: The proportion of an industry's total costs attributed to a single purchase over a given time period. As above, suppliers' customers will be more price sensitive when suppliers' input is a large portion of buyers' total costs. As discussed above, the degree to which wind turbine manufacturers are vertically integrated varies significantly and so does the cost of procuring outsourced components. The most vertically integrated manufacturers are Gamesa, Siemens[403] and Enercon[404] while GE and Vestas have adopted a lighter model[405]. In addition, some components represent a larger proportion of the total cost of the turbine than others. Wind turbine components can be grouped in the following way: Rotor (20-30% of total cost), Nacelle and machinery (25%), Gearbox and drive train (10-15%), generator systems (5-15%) and tower (10-15%)[406]. Blades, nacelles and control systems are the most specialised and vital components in terms of turbine efficiency and are usually manufactured in-house whereas generators, gearboxes and towers are often outsourced[407]. Manufacturers' purchase relative to their total costs must therefore be considered a significant factor influencing manufacturers' price sensitivity.

Differentiation of supplier group's products: The substitutability of the products from particular suppliers. As described above, wind turbine manufacturers manufacture the most highly specialised components themselves, while outsourcing more standardised components to suppliers. However, as we have seen, customisation of components to the suit the needs of individual manufacturers are not uncommon, allowing suppliers to differentiate themselves from their competitors[408]. Also, product quality and reliability along with timely delivery are important parameters of differentiation valued by manufacturers. Differentiation of suppliers' products must therefore be considered a significant factor influencing manufacturers' price sensitivity.

Importance of suppliers' input to industry's product quality: The degree to which an industry's profitability is affected by the quality of suppliers' products. As described above, quality and reliability of components are essential to the quality of the final turbine. Because of extended warranty provisions, wind turbine manufacturers bear a significant part of the financial risk connected to serial faults. Suppliers' input is therefore of very high importance to the quality of manufacturers' product quality significantly decreasing the price sensitivity of manufacturers.

Industry's price sensitivity: The degree to which an industry values price over other features of suppliers' products. Based on the investigation of the six above variables, the price sensitivity of wind turbine manufacturers are significantly limited by high switching costs and the importance of suppliers' input to manufacturers' product quality. The price sensitivity of manufacturers is however improved as the size and thus the importance of the individual order increases. The low price sensitivity of wnd turbine manufacturers must therefore be considered a significant factor decreasing their profitability.

Relative concentration of suppliers: The size and number of suppliers relative to the wind turbine industry. The wind turbine industry is highly concentrated around only a few major manufacturers and so is the demand for components. The relatively low concentration of suppliers means that component manufacturers have only a few customers and that even small changes in a single manufacturer's sourcing strategy can have major implications for demand and thereby suppliers' earnings[409]. In addition, manufacturers may demand component specifications suited to their specific

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403 See Morgan Stanley 2005:19
404 See Danske Equities 2003:8
405 See Morgan Stanley 2005:19
406 Ancona & McVeigh 2001:2
407 See Morgan Stanley 2005:18 and Danske Equities 2003:8
408 See Takeuchi 2003:47
409 Danske Equities 2003:11

turbine models, which cannot therefore be sold to other manufacturers in case of failing demand. The low relative concentration of suppliers is a significant factor decreasing suppliers' bargaining power.

Industry's information: The accuracy of the wind turbine industry's information about the production cost of outsourced components. As described above, several wind turbine manufacturers are partially or wholly vertically integrated into component manufacturing. This is especially true for diversified manufacturers such as Gamesa, Siemens and General Electric giving them hands-on experiences with the production of a wide range of energy technologies and components. Manufacturers' are generally least informed about generators and gearboxes, which are highly complicated to make and where only a few reliable suppliers exist. In spite of this, GE Wind and Gamesa both have in-house production of generators[410]. Wind turbine manufacturers must therefore be considered highly informed buyers.

Suppliers' threat of forward integration: The knowledge of the wind turbine industry about the assessment of suppliers of the entry deterring price relative to the actual benefits of entering integrating forward. As described previously, buyers integrating backwards into manufacturing have posed the primary threat of entry into the wind turbine industry. However, FKI plc, a producer of turbo generators recently took over the German Wind turbine manufacturer Dewind, demonstrating that suppliers too pose a credible threat of forward integration[411]. Because of the significant entry barriers protecting wind turbine manufacturers, this cannot generally be considered a major leverage for suppliers in terms of bargaining power.

Industry's threat of backward integration: Suppliers' knowledge about wind turbine manufacturers' assessment of the entry deterring price relative to the actual benefits of integrating backwards. The varying degree of vertical integration among turbine manufacturers also suggests a credible threat of backward integration posed by manufacturers into several areas component manufacturing. Such a threat decreases the bargaining power of suppliers in that they have to meet the deterring price, being the price that just balances out manufacturers' potential rewards of entry[412]. Generally, technological and financial entry barriers into wind turbine component manufacturing (gearboxes, generators, blades, control systems etc) are considered rather high[413], but this is only relative to the deterring price, as manufacturers perceive it and as we have seen, wind turbine several wind turbine manufacturers have significant know-how in many areas of component manufacturing. The threat of backward integration is a significant factor decreasing the bargaining power of suppliers.

Availability of supplier substitutes: The ability of wind turbine manufacturers to substitute suppliers' inputs with a principal alternative. Components such as generators, blades, control systems, towers etc. cannot be directly substituted with alternatives. Only Enercon has successfully substituted gearboxes, developing a gearless turbine based on ring generator technology[414]. In spite of this, in the sense that this term is used in Porter (1980), it is not meaningful to discuss supplier substitutes in the context of the wind turbine industry.

In addition to the variables included in the theoretical propositions suggested by the positioning school, the following additional variables were identified:

Availability of inputs: Wind turbine manufacturers' ability to purchase outsourced components. As previously described, component shortages are commonplace in the wind turbine industry. Wind turbine manufacturers are notoriously sensitive to the quality and timely delivery of key components.

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[410] Danske Equities 2003:9
[411] Takeuchi 2003:43
[412] Porter 1980:14
[413] Danske equities:11
[414] Takeuchi 2003:43

Delays in component delivery are extremely costly to wind turbine projects[415]. Type faults in components for larger wind projects are equally serious as wind turbine manufacturers bear the financial responsibility for the quality of turbines through warranty provisions[416]. Accessibility of inputs is a significant problem for experienced incumbent competitors[417], especially those with a lesser extent of vertical integration such as Vestas and GE Wind[418]

[415] See e.g. Vestas' First Quarter Report 2006
[416] See e.g. Vestas Annual Report 2005
[417] Takeuchi 2003:44
[418] Morgan Stanley 2005:19

Appendix B: Relationships

This appendix contains descriptions and consideration of the 17 additional causal relationships proposed through the cross impact analysis in Chapter 5. The *ceteris paribus* argumentation used here is elaborated in Chapter 3.

Height of exit barriers → + *strategic stakes in the industry*: This relationship is proposed by Porter (1980). From the viewpoint of the positioning school, the exit barriers around an industry is a determinant of the price of failure and thus the need to succeed in an industry. High exit barriers thus imply high strategic stakes, all else being equal.

Industry concentration ratio → - *Relative concentration of buyers*: This relationship is proposed on the grounds of the inevitable logic that, as an industry concentrates into fewer and larger firms, the relative concentration ratio of its buyers are bound to decrease, all else being equal.

Industry concentration ratio → - *Relative concentration of suppliers*: As above, this relationship is proposed on the grounds of the inevitable logic that as an industry concentrates into fewer and larger firms, the relative concentration of its suppliers are bound to decrease, all else being equal.

Relative bargaining power of buyers → + *Extent of warranty provisions*: As the size of wind projects have increased, so has the bargaining power of individual buyers relative to wind turbine manufacturers. As a consequence, manufacturers have increasingly been forced to share the risk of serial faults in wind projects through extended warranty provisions as an increasingly important part of winning large orders[419] as described in Chapter 4.

Industry growth rate → + *accessibility of inputs*: Unexpectedly high industry growth rate coupled with high sensitivity to component shortages has been the principal cause of industry wide component shortages as described in appendix A above – see *accessibility of inputs* in section 1 in said appendix.

Extent of warranty provisions → + *importance of suppliers' input to industry's product quality*: As described in appendix A above, wind turbine manufacturers are notoriously sensitive to the quality of components because they bear the financial risk of type and serial faults through warranty provisions. Extended warranties thus increase the importance of the quality of components as manufacturers bear the financial risk of technical flaws.

Wind turbine demand → + *Industry growth rate*: Logically, an increase in the growth rate of an industry presupposes an increase in demand, all else being equal.

Competitiveness of wind power → + *wind turbine demand*: Under normal market conditions, an increase in the competitiveness of a product will lead to an increase in demand, all else being equal. Wind turbines are considered no exception.

Experience curve effects → + *Competitiveness of wind power*: Experience curve effects are felt through cost reductions as a function of cumulative output. Cost reductions will improve the competitiveness of a product, all else being equal.

Threat of new entrants → + *Buyers' threat of backward integration*: As described in Chapter 4, buyers have posed the principal threat of entry into the wind turbine industry. As the general threat of

[419] See e.g. BTM 2005a:21

entry changes, so does the threat posed by buyers, all else being equal. The causes of the general threat level are presented in Chapter 7.

Threat of new entrants → + *suppliers' threat of forward integration*: Following the same logic as above, as the general threat of entry changes, so does the threat posed by suppliers, all else being equal.

Need substitution → - *wind turbine demand*: As described in Chapter 4, the level of need substitution indicates the degree to which a substitute is able to fulfil the same need as the product of an industry. Need substitution is thus a determinant of demand, all else being equal.

Wind turbine demand → + *experience curve effects*: As experience and thus cost reductions are gained as a function of cumulative output, it follows that demand is a determinant of experience gained, all else being equal.

Rate of new process discovery → + *Experience curve effects*: An increased or decreased rate of new process discovery will affect the *progress ratio* of a conventional experience curve[420] and thus the effect of experience gained as a function of cumulative output, all else being equal.

Rate of new product discovery → + *Proprietarity of product technology*: A rapidly advancing product technology is more proprietary and visa versa. New product discovery produces the need to 'keep up'. This involves specific costs borne by innovators and imitating followers that would not have existed otherwise. These costs increase proprietarity of the product technology, all else being equal.

Industry concentration ratio → + *Resourcefulness of incumbents*: As an industry consolidates around fewer and larger competitors, it follows that the resourcefulness of each of these competitors in terms of retaliatory power to a new entrant will increase, and visa versa. The *market power* of a competitor is thus equal to its relative market share.

Threat of new entrants → + *Intensity of rivalry*: Any threat of new entrants faced by incumbents is ultimately the threat that more competitors will enter the industry with which they must share profits and market share as described in Chapter 7. The threat level is thus equal to the potential profits forgone by entry multiplied by the probability of entry in a given time period. Threatened industries have a higher probability of an increasing the intensity of rivalry than do none-threatened industries, all else being equal.

[420] See Neij *et al* 2003

Appendix C: Interviews – considerations, interviewees & questionnaire

This appendix accounts for the interviews conducted as part of Chapters 6 and 7.

Selection of interviewees
The industry observers and participants interviewed for this report were selected to represent the broadest possible spectrum of the industry given the limited resources available for the project. The larger part of interviewees represents major wind turbine manufacturers, willing and able to share their knowledge with the author. In addition to wind (a) turbine manufacturers, it was the aim of the selection of interviewees to cover representatives from (b) suppliers, (c) buyers in addition to (e) outside industry observers. These groups are represented in (X) interviewees listed below.

The protection of interviewees
Overcoming potential obstacles to openness and honesty about expectations to industry developments involved a trade-off against accountability. In the context of this report, interviewees are not quoted directly or indirectly in a manner, which allows statements to be linked to a particular interviewee. Nor are their views to be interpreted as the 'official policy' of their respective organisations but as their personal assessments only. It was found that these conditions greatly improved the quality of the interview data at the cost of a clear audit trail.

The interview process
With two exceptions, the interviews were conducted by phone in sessions lasting from half an hour to an hour and a half. Bjrane Lundager Jensen and Peter Niels Hauge Madsen were interviewed in person in one hour sessions. Notes were taken during the interviews and a full summary (usually one normal page) was returned to the respondents by e-mail. The interviewees were given the opportunity to correct, clarify and amend these summaries, aligning them with their expressed views, before final approval. Two thirds of the interviewees used this opportunity to modify the summaries before approval.

The interviewees
For the purposes of this report, the following 7 industry observers and participants were interviewed:

- Adrian Cronin, International Policy Advisor, Vestas wind systems
- Bjarne Lundager Jensen, Director of the Danish Wind Industry Association
- John Thomas Olesen, Assistant Vice President, Vestas Wind Systems
- Niels Møller Jensen, Manager, Technology & Projects, Vattenfall Generation Nordic Countries, Wind Power
- Per Hornung Pedersen, Managing Director, Suzlon Wind, Denmark
- Peter Niels Hauge Madsen, Consultant, Risø National Laboratory, and former long-term employee of Siemens Wind
- Steen Broust Nielsen, Head of Corporate Communications, LM Glasfiber

The interview considerations
The interview guide was designed on the basis of the principles outlined in Kvale (1996), Schwartz (1998), Heijden (1998) and Porter (1985). The aim of these principles are summarised in the following:

- To ensure that, although the interview necessarily has a point of departure, it remains open-ended and avoids prefixed conclusions;
- That the interviewee, to the widest possible extent, sets the agenda;
- That the questions are general and minded on free-flowing conversation;
- To ensure that the interviewer, to the widest possible extent, responds only in a reactive mode, restricted to elaborating questions, clarifications, and feedback to the interviewee;
- To allow the interviewee to reflect, contemplate and rephrase responses;
- To create an informal and relaxed atmosphere allowing, to the widest possible extent, free thinking and imagination in the absence of convention.

In spite of the efforts made to create an atmosphere inductive to ‘free thinking’, and selecting interviewees from heterogeneous institutions and relations to the wind turbine industry, *situational bias* is likely to have played a significant role among even the most liberal-minded interviewees. The interviewees necessarily form part of the general mindset and established conventions of the industry, inevitably creating blind spots and presupposed and unquestioned ‘truths’ about the future development of the industry (Heijden 1998). In scenario literature, it is still far from clear how to address this problem. A common answer is seeking out ‘remarkable people’ with a unique outlook upon future developments (Schwartz 1998). This approach, however, raises the issues of how to identify such individuals and if these unique outlooks have any special legitimacy other than the fact that they differ from consensus. No such attempt has been made in this report and I thus accept situational bias as an inherent weakness of the method.

The interview guide
Based on the above principles, the following questions were posed to interviewees in the order described below[421]:

1. What, in your opinion, will be the most important differences among the buyers of wind turbines over the coming decade compared to today, and what will be the consequences for wind turbine manufacturers?

2. What, in your opinion, will be the most important differences between what is required for winning an order over the coming decade compared to today, and what will be the consequences for wind turbine manufacturers?

3. What, in your opinion, will be the most important differences between the wind turbine manufacturers occupying the industry over the coming decade compared to today, and what will be the consequences for wind turbine manufacturers?

4. What, in your opinion, will be the most important differences between the subcontractors to the wind turbine industry over the coming decade compared to today, and what will be the consequences for wind turbine manufacturers?

5. What, in your opinion, will be the most important differences between the competitive pressure from substitutes to wind power over the coming decade compared to today, and what will be the consequences for wind turbine manufacturers?

6. What, in your opinion, are the most important uncertainties faced by the wind turbine industry over the coming decade – what could make you wrong?

[421] These questions were often posed in a more informal language than presented here according to the principles described above. This should not alter the essential meaning of each question.

7. If you were to pose three questions to an oracle about the development of the wind turbine industry over the coming decade, what would they be?

As described above, these general questions were each followed by elaboratory questions, probing the details and rationale of the general answer.