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Deriving Maintenance Strategies for Cooperative Alliances – A Value Chain Approach

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For my parents

and all supporters of my studies.

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Key to abbreviations

AHP	Analytic Hierarchy Process
C.R.	Consistency Ratio
C.I.	Consistency Index of matrix
R.I.	Consistency of randomly filled matrix
ECM	Effectiveness Centred Maintenance
EU	The European Union
IT	Information Technology
MADM	Multiple Attribute Decision-Making
MCDM	Multiple Criteria Decision-Making
MODM	Multiple Objective Decision-Making
OEM	Original Equipment Manufacturer
PdM	Predictive Maintenance
PLM	Product Lifecycle Management
PM	Preventive Maintenance
R&D	Research and Development
RCM	Reliability Centred Maintenance
SM	Scheduled Maintenance
TPM	Total Productive Maintenance

Key to symbols

λ_{max}	Maximum eigenvalue of matrix
A	Set of actions
a_n	Action n
e(a,z)	Function, combining scenario z and action a
g	Preference function
I	Indifference
J	Incomparability
n	Order of matrix
N; C	Number of all criteria
P	Preference
R_i	Rank of alternative i
U	Utility function
w_j ; v_j	Relative weight of j
x	Consequence of a decision
Z	Decision environment
z_n	Environmental scenario n

Introduction

Partnering with other companies, or even with competitors, to tackle arising maintenance challenges, can be a source of sustainable competitive advantage. This is the outcome of two expert interviews based on the derived decision-helping framework proposed by this diploma thesis.

In Germany, maintenance is regulated by standards such as DIN 31051 and DIN 13306. Most maintenance workgroups are formed by associations such as the Verein Deutscher Ingenieure (VDI) and the Verband Deutscher Maschinen- und Anlagenbau e.V. (VDMA). As a consequence maintenance is often regarded as an engineering topic. Because of this, it does not always get the management attention needed to unleash the power to create competitive advantage. This paper aims to link the engineering-based subject with contemporary management theory, enabling an excellence performance through the selection of a suitable maintenance strategy.

Strategy in this context is the "art of creating value" (Norman & Ramirez, 1993, p. 65). It involves "identifying and exploiting the resources and capabilities of the firm in the marketplace for the purpose of gaining competitive advantage and superior financial performance" (Tallman & Yip, 2003, p. 318).

The contribution of this work is to propose a decision-supporting framework of how to choose a maintenance strategy for firms forming a cooperative alliance. Thus, the research question is formulated as follows: "How can maintenance strategies be derived that fit the requirements of Value Chain oriented companies"?

Related work in the literature is discussed throughout the paper. The following, however, will provide an overview. Strategic alliances are thoroughly described by Sydow (2004) and Schonert (2008). Picot (2003, 2008) provides insight into how networks function. Porter (1985) first introduced the notion of the Value Chain and combined the concept with that of competitive advantage. Bovet & Martha (2000) proposed the Value Net, which is closely related to the modern concept of the Value Chain, as put forward by Walters & Rainbird (2007).

Garg & Deshmukh (2006) provide a good overview of contemporary literature in maintenance management. Ahuja & Khamba (2008) offer a literature review of Total

Productive Maintenance, an approach suggested by Nakajima (1988). Sherwin (2000) introduces different maintenance concepts. A series of three books by Kelly (2006) present a detailed introduction into selecting, implementing and controlling maintenance strategies. Mishra, Anand & Kodali (2007) provide an introduction to world-class maintenance and an overview of maintenance techniques.

Multiple criteria decision-making is outlined in books by Keeney & Raiffa (1976), Steuer (1986), Vincke (1992), Zimmermann & Gutsche (1991), Dinkelbach & Kleine (1996), Bamberg (2006), and Habenicht (1984).

Some authors described the selection of a maintenance strategy by using the Analytic Hierarchy Process. Labib et al. and Wang et al. described an AHP model with fuzzy criteria (Labib, Williams, & O'Connor, 1998; Wang, Chu, & Wu, 2007). Bertolini & Bevilacqua (2006) provide a combination of goal programming and AHP. Carneo (2006) provides a tool for managers, concentrating on the strategic selection of predictive maintenance rather than the underlying decision-making model. Other works modelled the organisational decisions associated with maintenance using AHP (Bertolini, Bevilacqua, Braglia, & Frosolini, 2004; HajShirmohammadi & Wedley, 2004).

In contrast to the works noted above, this paper will introduce a new dimension to maintenance strategy, namely that of maintenance reach. This describes why it could be advantageous to develop a maintenance system for the whole Value Chain, rather than concentrating on a single firm. The methodology used includes a literature review and discussion. The derived results were then tested in the form of expert interviews.

In order to answer the research question, this paper will construct a decision-helping framework. The first three chapters build the theoretical foundation for the decision-making process.

Chapter 1 is concerned with the different forms of cooperative alliances between independent companies. It starts by outlining the organisational forms of market and hierarchy and goes on to then delineate a concept that is of growing importance: business networks. Why such networks evolve and what forms are distinguished in the literature, is subsequently discussed. A modern approach to networks, the concept of virtual organisations is introduced. Integrating both, supply chain management and demand chain management, the Value Chain Approach is then outlined and discussed; showing that to achieve sustainable competitive advantage is the goal of Value Chain networks. How a company can gain such advantage by aligning customer value drivers and industry value drivers with its capabilities to satisfy stakeholder expectations concludes the chapter. An industry value driver, technology management can be a source of competitive advantage and is therefore put under further scrutiny. Being a part of technology management, a sound strategy for equipment maintenance could be a source of superiority over competitors.

Chapter 2 goes on to introduce the several different dimensions of maintenance strategies. First, the importance of maintenance is illustrated. Second, possible maintenance objectives are discussed. Lastly, the paper scrutinises the three dimensions of maintenance technique, maintenance organisation and maintenance reach. Putting the three dimensions together constitutes the alternative maintenance strategies the decision-maker can choose from.

Chapter 3 explains how decisions are made in a business context. Intuitive decisions are not sufficient; hence the decision has to be made based on a decision-making process. It is shown that decisions concerning technology management are complex and multiple criteria decision-making models need to be applied. The work commences in introducing models of multiple objective decision-making and multiple attribute decision-making. In discussing the advantages and shortcomings of those models for the given research question, the Analytic Hierarchy Process is selected to evaluate maintenance strategies in a Value Chain context.

Chapter 4 makes use of the previous three chapters and builds a decision-supporting framework by defining criteria, subcriteria and alternatives for selecting a maintenance strategy. The derived criteria and subcriteria are closely related to value drivers, capabilities and stakeholder expectations. This will enable the company making the decision to use the selected maintenance strategy as a source of sustainable competitive advantage.

Using the German wind turbine industry as an example, chapter 5 tests the derived decision-helping framework in the real world. The results from the expert interviews conducted with a wind turbine owner and a third-party service provider, are discussed and compared. An industry outlook concludes this section.

1 Cooperative Alliances and the Value Chain approach

The decision about making or buying goods and services has to be made at the beginning of all entrepreneurial ventures. Moreover these decisions will occur as long as the business exists, constantly demanding reconsideration. Modern management theory has added a third aspect, namely that of "cooperation". It also emphasises that the options are continuous rather than discrete (Schonert, 2008, pp. 79-83).

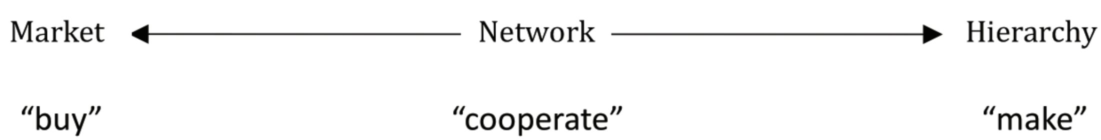

Figure 1: Strategic decisions of make, buy and cooperate (own design)

What follows will outline the implications of such decisions. It is the aim of this chapter to set a theoretical framework of how to derive the criteria needed to evaluate subsequent strategies. In order to do so, this chapter first demonstrates different forms of cooperation. It will be argued that network organisations have advantages in today's business environment. Secondly, the Value Chain network will be introduced as an example for virtual network organisations. Success factors, including value drivers, capabilities and stakeholder expectations will be introduced. Consequently, this chapter will define a part of the research question, namely "the requirements of Value Chain oriented companies".

1.1 Cooperative Alliances

According to the Oxford Dictionary, an alliance is an union or an association formed for mutual benefit (Hornby, 1995, p. 29). It unites two or more partners pursuing individual goals. A cooperation is such an alliance, but it is formed to work towards a common purpose (Hornby, 1995, p. 247).

It is the nature of business that different firms work together. The degree of involvement and cooperation, however, varies. Some companies work closely together forming supply chains; others perform one-off transactions only.

On the one hand, teaming up to expand internationally or to complement product offerings has become more viable today, due to advances in communication technology lowering transaction costs (Walters & Rainbird, 2007, p. 7). On the other hand, mergers and acquisitions are commonplace, using synergy effects and economies of scale.

This chapter will show the different forms of collaboration, why they have emerged and what implications they have. The organisational forms of market, network and hierarchy illustrate the strategic decisions, as suggested by Figure 1.

1.1.1 Market: Loosely involved transaction partners

The traditional representation of the "buy" decision is a market organisation. Schonert (2008, pp. 80-81) describes the aims, characteristics, advantages and limitations of this form of collaboration. Two or more business partners conduct transactions, while price is the only determinant of a successful settlement. Each company is pursuing individual interests: the buyer to minimise cost, the seller to maximise profits. The foundation is a (standardised) legal contract stating technical details, quality standards and delivery conditions. After the transaction, ties between the organisations disband, although further transactions may follow. Information asymmetries, free choice of partner and a short-term relationship are characteristic for market transactions. Typically, it involves the trade of standardised mass products.

Such transactions are relatively cheap, since no individual agreements need to be made. However, costs may increase, based on the availability of information about products and suppliers. The consequences of an unsatisfying transaction are rather short-term, since other suppliers can be used for further business. Unequally distributed power between organisations may, however, induce high efficiency pressure.

This organisation form may be ideal for goods that are strategically insignificant to the buyer (e.g. C-parts; such as lubricants, pressurised air, screws, etc.).

1.1.2 Hierarchy: Highly involved corporations

The other extreme is the "make" decision, which will be described in the following based on Schonert (2008, pp. 81-83). Within this organisational form, an organisation decides to produce goods and services on its own, rather than sourcing them from a third party. Based on orders, social relationships and standardised, frequent processes, this option is

Conclusion

The answer to the research question "how can maintenance strategies be derived that fit the requirements of Value Chain oriented companies?" was given by the introduction of a decision-helping framework, based on the Analytic Hierarchy Process.

How business networks are formed to overcome some of the problems of the traditional organisational forms of market and hierarchy was shown at the beginning of Chapter 1. While it remains vague as to how to distinguish the several forms of business networks, its advantages are evident: The overall capital requirements decrease, while network-wide knowledge, output and flexibility increase. To respond to the disadvantages inherent in networks, the virtual organisation or Value Chain approach was examined. This model suggests using transparent information and a close relationship between all network partners to tackle potential opportunistic behaviour. It emphasises that a partner only performs those activities it can do better than anyone else in the network.

Value Chain oriented companies require strategies to strive for sustainable competitive advantage. Integrating supply chain and demand chain analysis, Value Chain based networks ensure sustainable competitive advantage by aligning customer value drivers and industry value drivers with its capabilities in order to satisfy stakeholder expectations. Technology management is a value driver in many industries and often a source of competitive advantage. It was argued that equipment maintenance is an important part of technology management, and hence a maintenance strategy could be a source of superiority over competitors.

Following an outline of the importance of maintenance and its objectives, Chapter 2 introduced the components of maintenance strategies.

In general, three forms of *maintenance techniques* can be distinguished: reactive maintenance, proactive maintenance and aggressive maintenance. Whereas reactive techniques wait to perform maintenance tasks until the system broke down, proactive techniques try to predict the upcoming maintenance demand to reduce failure cost and time lost. Aggressive maintenance not only manages the equipment, it also strives to improve it. Team-oriented and trying to design-out maintenance requirements, it considers the whole lifecycle of a machine. A study in 2003 found that 11% of all manufactures in the UK engaged in aggressive maintenance, whereas 61% use preventive techniques (*World Class Manufacturing*, 2003, p. 25).

How to respond to occurring maintenance demands is the domain of *maintenance organisation*. Maintenance can either be conducted in-house with an own, rather large maintenance department. Peak demands could also be contracted to a third party service provider, lowering the fixed costs of the business. Outsourcing in turn implies maintenance is not considered a process that should be performed by the company at all. The responsibility and tasks associated with the equipment upkeep is therefore moved to the outsourcer. A study in 2001 found that 10% of Germany's manufacturers outsource their maintenance (Brinkmann, 2001, p. 182).

This work argued that a third dimension should be introduced: *maintenance reach*. This ensures that possibilities open to companies as a part of a network are exploited. The selected strategy could be implemented on a single-plant level. This is the option with the least cost for coordination. In contrast, company-wide strategies can make use of economies of scale while implementing a strategy. Strategies for all companies along the Value Chain bear the advantages of equipment standardisation and production process stability.

Putting the three dimensions of maintenance technique, organisation and reach together constitutes the alternative maintenance strategies the decision-maker can choose from.

Chapter 3 explains how decisions are made in a business context. It was discussed that decisions concerning technology management are complex and multiple criteria decision-making models need to be applied. After introducing multiple criteria decision-making models and discussing their advantages and shortcomings, the Analytic Hierarchy Process (AHP) was selected as a base to create a decision-helping framework to derive suitable maintenance strategies for cooperative alliances, such as the Value Chain network. The AHP provides a clear structure and an intuitive and comprehensible way of how weights and ratings are derived. To lower the time required for the pairwise comparisons, opting for software support was suggested.

An array of 22 subcriteria and 4 criteria, representing customer value drivers, the capabilities of a company and stakeholder expectations was proposed in Chapter 4. Combined they ensure that the selected maintenance strategy will achieve sustainable competitive advantage.

To test the decision-supporting framework, the German wind turbine industry was selected. Two expert interviews were conducted: one with a wind turbine owner and one with a maintenance-outsourcing provider. Both interviewees selected Option C as best suiting their needs. It represents an aggressive Value Chain wide maintenance strategy that is conducted by in-house personnel. This was interesting since in the industry common-practice is a proactive, outsourced, single-company approach. The results showed a clear effectiveness orientation for the outsourcer and an efficiency orientation for the equipment owner. Surely the two interviews just illustrate how a decision can be made. They are far from being representative for the whole industry.

Nevertheless, the idea behind Option C could be worthwhile examining. Implementing this strategy will be especially successful in maintenance-intensive industries, as the magnitude of the resulting competitive advantage will be high. Hence not only the wind turbine industry, but also the aircraft, energy generation, paper manufacturing and automotive should examine, if their maintenance performance could be improved by cooperating with Value Chain partners. Especially companies that already have trustful, long-term and profit sharing partnerships and a rather small equipment variety could profit from adopting such a policy.

As it was noted, the derived framework is aimed at helping to make a decision. As shown by the case of the wind turbine owner, the difference between the first and second-best alternative may not be very significant. Consequently, the final decision on a strategy will still need to be made by a team of experts.

This work has not been able to test the built decision-making framework based on maintenance data derived during a certain strategy was implemented. Only two interviews with industry experts were conducted, to make use of their experience. Further research should try to validate the framework empirically. Additionally, decisions on a maintenance strategy by more than one decision-maker could be a source of further studies. The dimensions of maintenance scheduling and maintenance control were omitted in Chapter 2, because they are decisions of maintenance tactics, rather than maintenance strategy. To implement a chosen strategy, however, they will need consideration. This can be a starting place for further research in this field.

This paper shows the importance of maintenance, a topic that often does not get the management attention it deserves. It can help a decision-maker to select a strategy that ensures his objective of achieving competitive advantage.

Abstract

Partnering with other companies or even with competitors, to tackle emerging maintenance challenges, can be a source of sustainable competitive advantage. This is the outcome of two expert interviews based on the derived decision-helping framework proposed by this diploma thesis. Three dimensions making up a maintenance strategy are introduced: maintenance technique, maintenance organisation and maintenance reach. Suggesting that the decision about maintenance strategy is made by applying the Analytical Hierarchy Process, this framework builds upon customer value drivers, industry value drivers, capabilities and stakeholder expectations to ensure sustainable competitive advantage for cooperative alliances.

References

Abele, T. (2006). *Verfahren für das Technologie-Roadmapping zur Unterstützung des strategischen Technologiemanagements*. Heimsheim: Jost-Jetter.

Adam, D. (1998). *Produktions-Management* (9., überarb. Aufl. ed.). Wiesbaden: Gabler.

Ahuja, I. P. S., & Khamba, J. S. (2008). Total productive maintenance: literature review and directions. *International Journal of Quality & Reliability Management, 25*(7), 709 - 756.

Anderson, J. C., & Narus, J. A. (1998). Business Marketing; Understand What Customers Value. *Harvard Business Review, November - December,* 5-15.

Bamberg, G. (2006). *Betriebswirtschaftliche Entscheidungslehre* (13., überarb. Aufl. ed.). München: Vahlen.

Barnes, D. (2001). Understanding Business: Processes. London, New York: Routledge.

Bertolini, M., & Bevilacqua, M. (2006). A combined goal programming-AHP approach to maintenance selection problem. *Reliability Engineering & System Safety, 91*(7), 839-848.

Bertolini, M., Bevilacqua, M., Braglia, M., & Frosolini, M. (2004). An analytical method for maintenance outsourcing service selection. *International Journal of Quality & Reliability Management, 21*(7), 772-788.

Bhushan, N. (2004). *Strategic decision making applying the analytic hierarchy process*. London Berlin Heidelberg: Springer.

BMW Group (2005). Kraft der zwei Herzen - BMW Group entwickelt in globaler Allianz innovativen Hybridantrieb. Retrieved December, 12, 2008, from http://www.bmwgroup.com/d/nav/index.html?http://www.bmwgroup.com/d/0_0_www_bmwgroup_com/forschung_entwicklung/science_club/veroeffentlichte_artikel/2005/news200524.html

Bogetoft, P. (1997). *Planning with multiple criteria investigation, communication and choice* (2. ed ed.). Copenhagen: Handelshøjskolens Forlag.

Boulton, R. E. S., & Libert, B. D. (2000). A business model for the new economy. *Journal of Business Strategy, 21*(4), 29.

Bovet, D., Martha, J., & Mercer Management Consulting. (2000). *Value nets : breaking the supply chain to unlock hidden profits*. New York: Wiley.

Brinkmann, F.-M. (2001). *Gestaltung von Funktionskostenrechnungen Theorie, Empirie und Praxisbeispiel einer Instandhaltungskostenrechnung*. Wiesbaden: Dt. Univ.-Verl.

Bundesverband WindEnergie, e. V. (2009). Investition- und Betriebskosten. Retrieved January, 21, 2009, from http://www.wind-energie.de/de/technik/projekte%5Cplanung/kosten/

Canever, M. D., Van Trijp, H. C. M., & Beers, G. (2008). The emergent demand chain management: key features and illustration from the beef business. *Supply Chain Management: An International Journal, 13*(2), 104-115.

Carnero, M. (2006). An evaluation system of the setting up of predictive maintenance programmes. *Reliability Engineering & System Safety, 91*(8), 945-963.

Chambers (2000). *Chambers 21st century dictionary* (updat. ed., repr. ed.). Edinburgh: Chambers.

Dekker, R. (1996). Applications of maintenance optimization models: a review and analysis. *Reliability Engineering & System Safety, 51*(3), 229-240.

Dinkelbach, W., & Kleine, A. (1996). *Elemente einer betriebswirtschaftlichen Entscheidungslehre mit 26 Tabellen*. Berlin Heidelberg [u.a.]: Springer.

Domeisen, N., Barreto, E., Wake, M., & Luwaga, A. (2005). From Canada to Uganda, Business Process Outsourcing. *International Trade Forum*(4), 14-15.

Drucker, P. (2001). Will the corporation survive? *Economist, 361*(8246), 14-18.

Dubois, T. (2007). Commercial: Iberia Maintenance is Hungry For More. *Aviation Maintenance.* Retrieved December 3, 2008, from http://www.aviationtoday.com/am/issue/cover/16092.html

Dyer, J. S. (1990). Remarks on the Analytic Hierarchy Process. *Management Science, 36*(3), 249-258.

Eisenführ, F. (2003). *Rationales Entscheiden mit 59 Tabellen* (4., neu bearb. Aufl. ed.). Berlin Heidelberg [u.a.]: Springer.

Faulkner, D. O., & de Rond, M. (2000). *Cooperative strategy economic, business, and organizational issues* (1. publ. ed.). Oxford [u.a.]: Oxford University Press.

Forman, E. (1990). Multi Criteria Decision Making and The Analytic Hierarchy Process. In C. Bana e Costa (Ed.), *Readings in multiple criteria decision aid* (pp. 295-318). Berlin Heidelberg [u.a.]: Springer.

Garg, A., & Deshmukh, S. G. (2006). Maintenance management: literature review and directions. *Journal of Quality in Maintenance Engineering, 12*(3), 205 - 238.

Gerybadze, A. (1995). Management der Schnittstellen innerhalb von Technologie-Allianzen. In E. Zahn (Ed.), *Handbuch Technologiemanagement*. Stuttgart: Schäffer-Poeschel.

Gits, C. W. (1992). Design of maintenance concepts. *International Journal of Production Economics, 24*(3), 217-226.

Global Wind Energy Council, G., & Greenpeace, I. (2008). Global Wind Energy Outlook 2008. Retrieved January, 21, 2009, from http://www.gwec.net/fileadmin/images/Logos/Corporate/GWEO_A4_2008_lowres.pdf

Habenicht, W. (1984). *Interaktive Lösungsverfahren für diskrete Vektoroptimierungsprobleme unter besonderer Berücksichtigung von Wegeproblemen in Graphen*. Königstein/Ts.: Verlagsgruppe Athenaeum Hain Hanstein.

Habenicht, W. (1990). Papers of the 18th Annual Meeting, 1989. In K.-P. Kistner, J. H. Ahrens, G. Feichtinger, J. Minnemann & L. Streitferdt (Eds.), *Operations research proceedings* (pp. 342-349): Springer-Verlag.

HajShirmohammadi, A., & Wedley, W. C. (2004). Maintenance management – an AHP application for centralization/decentralization. *Journal of Quality in Maintenance Engineering, 10*(1), 16-25.

Hamel, G., & Prahalad, C. K. (1994). *Competing for the future*. Boston, Mass.: Harvard Business School Press.

Hanlon, J. P. (1999). *Global airlines : competition in a transnational industry* (2nd ed.). Oxford: Butterworth-Heinemann.

Harker, P. (1989). The art and science of decision making: The Analytic Hierarchy Process. In B. Golden, E. Wasil & P. Harker (Eds.), *The analytic hierarchy process applications and studies* (pp. 3-36). Berlin Heidelberg [u.a.]: Springer.

Harker, P., & Vargas, L. (1987). The Theory of Ratio Scale Estimation: Saaty's Analytic Hierarchy Process. *Management Science, 33*(11), 1383-1403.

Hofstede, G. (1994). Management Scientists Are Human. *Management Science, 40*(1), 4-13.

Hornby, A. S. (1995). *Oxford advanced learner's dictionary of current English* (5. ed, 7th impr. / editor Jonathan Crowther ed.). Oxford [u.a.]: Oxford University Press.

Hwang, C.-L. (1979). *Multiple objective decision making methods and applications; a state-of-the-art survey*. Berlin Heidelberg [u.a.]: Springer.

Interessengemeinschaft Windkraft, Ö. (2003). Geringes Betriebsrisiko durch Vollwartungskonzepte. *Windenergie.* Retrieved January, 21, 2009, from http://www.igwindkraft.at/redsystem/mmedia/2004.12.30/1104421084.pdf

Kakumanu, P., & Portanova, A. (2006). Outsourcing: Its Benefits, Drawbacks and Other Related Issues. *Journal of American Academy of Business, Cambridge, 9*(2), 1-7.

Kanz, J., & Lam, D. (1996). Technology, Strategy, and Competitiveness. In G. H. Gaynor (Ed.), *Handbook of technology management* (Internat. ed. ed., pp. Chapter 6). New York [u.a.]: McGraw-Hill.

Kay, J. (1995). *Foundations of Corporate Success: How Business Strategies Add Value*. Oxford, New York: Oxford University Press.

Keeney, R. L., & Raiffa, H. (1976). *Decisions with multiple objectives preferences and value tradeoffs*. New York [u.a.]: Wiley.

Kelly, A. (2006). *Strategic maintenance planning* (1st ed.). Boston, MA: Elsevier.

Kilpi, J., & Vepsäläinen, A. P. J. (2004). Pooling of spare components between airlines. *Journal of Air Transport Management, 10*(2), 137-146.

Kjaer, C. (2008). Wind power. Retrieved January 21, 2009, from http://www.ewea.org/fileadmin/ewea_documents/documents/publications/articles/articles2008/EU16.pdf

Labib, A. W., Williams, G. B., & O'Connor, R. F. (1998). An Intelligent Maintenance Model (System): An Application of the Analytic Hierarchy Process and a Fuzzy Logic Rule-Based Controller. *The Journal of the Operational Research Society, 49*(7), 745-757.

Lacity, M., Willcocks, L., & Rottman, J. (2008). Global outsourcing of back office services: lessons, trends, and enduring challenges. *Strategic Outsourcing: An International Journal, 1*(1), 13-34.

Lee, S. G., Ma, Y. S., Thimm, G. L., & Verstraeten, J. (2008). Product lifecycle management in aviation maintenance, repair and overhaul. *Computers in Industry, 59*(2-3), 296-303.

Léger, J.-B., Neunreuther, B., Iung, B., & Morel, G. (1999). Integration of the Predictive Maintenance in Manufacturing System. In S. G. Tzafestas (Ed.), *Advances in manufacturing : decision, control, and information technology* (pp. 133-144). New York: Springer.

Martin, H. H. (1997). Contracting out maintenance and a plan for future research. *Journal of Quality in Maintenance Engineering, 3*(2), 81-90.

Martinez, V., & Bititci, U. (2006). Aligning value propositions in supply chains. *International Journal of Value Chain Management, 1*(1), 6-18.

McHugh, P., Merli, G., & Wheeler, W. A. (1995). *Beyond business process reengineering : towards the holonic enterprise*. Chichester ; New York: Wiley.

Meffert, H. (2008). *Marketing Grundlagen marktorientierter Unternehmensführung; Konzepte, Instrumente, Praxisbeispiele* (10., vollst. überarb. und erw. Aufl. ed.). Wiesbaden: Gabler.

Mishra, R. P., Anand, G., & Kodali, R. (2007). Strengths, weaknesses, opportunities, and threats analysis for frameworks of world-class maintenance. *Proceedings of the Institution of Mechanical Engineers -- Part B -- Engineering Manufacture, 221*(7), 1193-1208.

Nakajima, S. (1988). *Introduction to TPM total productive maintenance*. Cambridge,Mass. [u.a.]: Productivity Pr.

Norman, R., & Ramirez, R. (1993). From Value Chain to Value Constellation: Designing Interactive Strategy. *Harvard Business Review, 26*(6), 65-77.

Picot, A. (2003). *Die grenzenlose Unternehmung Information, Organisation und Management; Lehrbuch zur Unternehmensführung im Informationszeitalter* (5. aktualisierte Aufl. ed.). Wiesbaden: Gabler.

Picot, A. (2008). *Information, organization and management*. Berlin Heidelberg: Springer.

Porter, M. E. (1985). *Competitive advantage creating and sustaining superior performance*. New York [u.a.]: Free Pr. [u.a.].

Pratten, C. F. (1975). *Economies of scale in manufacturing industry* (Repr. ed.). Cambridge: Univ. Pr.

Pun, K.-F., Chin, K.-S., Chow, M.-F., & Lau, H. C. W. (2002). An effectiveness-centred approach to maintenance management: A case study. *Journal of Quality in Maintenance Engineering, 8*(4), 346 - 368.

Reuters (2008). Increasing Installed Capacity Drives European Wind Services Market. Retrieved January, 21, 2009, from http://www.reuters.com/article/pressRelease/idUS75126+01-Apr-2008+BW20080401

Rieple, A., & Helm, C. (2008). Outsourcing for competitive advantage: An examination of seven legacy airlines. *Journal of Air Transport Management, 14*(5), 280-285.

Saaty, T. L. (1994). How to Make a Decision: The Analytic Hierarchy Process. *Interfaces, 24*(6), 19-43.

Schlie, T. W. (1996). The contribution of technology to competitive advantage. In G. H. Gaynor (Ed.), *Handbook of technology management* (Internat. ed. ed., pp. Chapter 7). New York [u.a.]: McGraw-Hill.

Schmidt, A. G. (1995). *Der Einfluß der Unternehmensgröße auf die Rentabilität von Industrieunternehmen*. Wiesbaden: Gabler.

Schneeweiß, C. (1991). *Planung 1: Systemanalytische und entscheidungstheoretische Grundlagen*. Berlin Heidelberg: Springer.

Schonert, T. (2008). *Interorganisationale Wertschöpfungsnetzwerke in der deutschen Automobilindustrie die Ausgestaltung von Geschäftsbeziehungen am Beispiel internationaler Standortentscheidungen*. Wiesbaden: Gabler.

Sgrignoli, S. (2009). Sound Maintenance Strategies for Asset Preservation. *Journal of Property Management, 74*(1), 30-34.

Sharma, R. K., Kumar, D., & Kumar, P. (2005). FLM to select suitable maintenance strategy in process industries using MISO model. *Journal of Quality in Maintenance Engineering, 11*(4), 359 - 374.

Sherwin, D. (2000). A review of overall models for maintenance management. *Journal of Quality in Maintenance Engineering, 6*(3), 138 - 164.

Siebert, H. (2003). Ökonomische Analyse von Unternehmensnetzwerken. In J. Sydow (Ed.), *Management von Netzwerkorganisationen* (3 ed., pp. 7-27). Wiesbaden: Betriebswirtschaftlicher Verlag Dr. Th. Gabler.

Slywotzky, A. J., Morrison, D. J., & Andelman, B. (1997). *The profit zone : how strategic business design will lead you to tomorrow's profits* (1st ed.). New York: Times Business.

Steuer, R. E. (1986). *Multiple criteria optimization theory, computation, and application*. New York [u.a.]: Wiley.

Swanson, L. (2001). Linking maintenance strategies to performance. *International Journal of Production Economics, 70*(3), 237-244.

Sydow, J. (2004). *Produktion in Netzwerken make, buy & cooperate*. München: Vahlen.

Tallman, S., & Yip, G. (2003). *The Oxford handbook of international business* (Paperb. ed.). Oxford [u.a.]: Oxford Univ. Press.

Vigoroso, M. W., & Israel, M. (2006). *Collaborative Asset Maintenance Strategies - Redefining the Roles of Product Manufacturers and Operators in the Service Chain*: Aberdeen Group, Inc.

Vincke, P. (1992). *Multicriteria decision-aid*. Chichester [u.a.]: Wiley.

Waeyenbergh, G., & Pintelon, L. (2002). A framework for maintenance concept development. *International Journal of Production Economics, 77*(3), 299-313.

Wagner, S. M., & Bode, C. (2008). Dominant Risk and Risk Management Practices in Supply Chains. In G. Zsidisin & B. Ritchie (Eds.), *Supply chain risk a Handbook of assessment, management , and performance* (pp. 271-290). New York, NY: Springer.

Wald, G. (2003). *Prozessorientiertes Instandhaltungsmanagement*. Aachen: Shaker.

Walters, D., & Rainbird, M. (2007). *Strategic operations management : a value chain approach*. Basingstoke: Palgrave Macmillan.

Wang, L., Chu, J., & Wu, J. (2007). Selection of optimum maintenance strategies based on a fuzzy analytic hierarchy process. *International Journal of Production Economics, 107*(1), 151-163.

World Class Manufacturing (2003). The Manufacturer UK , SayOneMedia Ltd.

Yoon, K. (1995). *Multiple attribute decision making an introduction*. Thousand Oaks [u.a.]: Sage.

Zimmermann, H.-J., & Gutsche, L. (1991). *Multi-Criteria-Analyse Einführung in die Theorie der Entscheidungen bei Mehrfachzielsetzungen*. Berlin Heidelberg [u.a.]: Springer.

Zionts, S. (1980). Multiple criteria decision making, theory and application proceedings of the 3. conference, Hagen/Königswinter, West Germany, Aug. 20-24, 1979. In G. Fandel & T. Gal (Eds.), *Lecture notes in economics and mathematical systems* (pp. 540-570). Berlin Heidelberg: Springer.

Zsidisin, G., & Ritchie, B. (2008). Supply Chain Risk Management - Developments, Issues and Challenges. In G. Zsidisin & B. Ritchie (Eds.), *Supply chain risk a Handbook of assessment, management , and performance* (pp. XV, 349 S.). New York, NY: Springer.

Appendix

Properties of Option A, Option B and Option C

Subcriterion	Option A	Option B	Option C
Equipment lifecycle cost (per year)	High	Medium	Low
Relevance of investment to capabilities	Low	Medium	High
Availability of spare parts and tools	Low	Medium	High
Inventory holdings	Low	High	Medium
Bargaining power	Low	High	High
Quality of products	Low	Medium	High
Production cycle time	High	Low	Low
Responsiveness to maintenance demands	Low	Medium	High
Flexibility to change strategy	High	Medium	Low
Production process stability	Low	Medium	High
Benchmark with industry best-practice	Low	High	Medium
Amount of equipment	Low	Medium	High
Maintenance probability	High	Medium	Low
Maintenance time (per maintenance task)	High	Medium	Low
Equipment variety	Medium	High	Low
Maintainability of equipment	Low	Low	High
Transaction cost	Low	High	High
Personnel demand	Low	High	High
Safety of staff and environment	Low	Medium	High
Transparency of information	Low	High	High
Dependence on partners	Low	High	Medium
Financial risk of investment	High	Low	Medium

Table 9: Properties of the three alternatives from an outsourcer's point of view (own design)

Subcriterion	Option A	Option B	Option C
Equipment lifecycle cost (per year)	High	Low	Medium
Relevance of investment to capabilities	Low	High	Low
Availability of spare parts and tools	Low	High	Medium
Inventory holdings	Low	Low	Medium
Bargaining power	Low	Medium	High
Quality of products	High	High	High
Production cycle time	High	Low	Medium
Responsiveness to maintenance demands	Low	Medium	High
Flexibility to change strategy	Low	Low	High
Production process stability	Low	High	High
Benchmark with industry best-practice	Low	High	Medium
Amount of equipment	Low	High	Medium
Maintenance probability	High	Medium	Low
Maintenance time (per maintenance task)	High	Low	Low
Equipment variety	Medium	High	Low
Maintainability of equipment	Low	Medium	High
Transaction cost	Low	Medium	High
Personnel demand	Low	Low	High
Safety of staff and environment	Low	High	High
Transparency of information	Low	Low	High
Dependence on partners	Low	High	Medium
Financial risk of investment	High	Low	Medium

Table 10: Properties of the three alternatives from a wind turbine owner's perspective (own design)

Results of interview with an outsourcer

Asset Management

Equipment lifecycle cost (per year)				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/2	1/4	**0,143**
Option B	2	1	1/2	**0,286**
Option C	4	2	1	**0,571**
Inconsistency (C.R.) = 0,00				

Relevance of investment to capabilities				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/2	1/4	**0,143**
Option B	2	1	1/2	**0,286**
Option C	4	2	1	**0,571**
Inconsistency (C.R.) = 0,00				

Availability of spare parts and tools				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/9	**0,059**
Option B	7	1	1	**0,451**
Option C	9	1	1	**0,490**
Inconsistency (C.R.) = 0,01				

Inventory holdings of spare parts and tools				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	5	7	**0,731**
Option B	1/5	1	3	**0,188**
Option C	1/7	1/3	1	**0,081**
Inconsistency (C.R.) = 0,06				

Bargaining power				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/8	1/9	**0,054**
Option B	8	1	1/2	**0,357**
Option C	9	2	1	**0,589**
Inconsistency (C.R.) = 0,04				

Performance Management

Quality of products				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/9	**0,055**
Option B	7	1	1/3	**0,290**
Option C	9	3	1	**0,655**
Inconsistency (C.R.) = 0,08				

Production cycle time				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/9	**0,057**
Option B	7	1	1/2	**0,346**
Option C	9	2	1	**0,597**
Inconsistency (C.R.) = 0,02				

Flexibility to change strategy				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	5	1	**0,481**
Option B	1/5	1	1/3	**0,114**
Option C	1	3	1	**0,405**
Inconsistency (C.R.) = 0,03				

Responsiveness to maintenance demands				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/6	1/8	**0,062**
Option B	6	1	1/3	**0,285**
Option C	8	3	1	**0,653**
Inconsistency (C.R.) = 0,07				

Production process stability				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/6	1/8	**0,062**
Option B	6	1	1/3	**0,285**
Option C	8	3	1	**0,653**
Inconsistency (C.R.) = 0,07				

Benchmark with industry best-practice				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/2	**0,098**
Option B	7	1	4	**0,715**
Option C	2	1/4	1	**0,187**
Inconsistency (C.R.) = 0,00				

Table 11: Pairwise comparison of alternatives (own design)

Cost Management

Amount of equipment				
	Option A	Option B	Option C	Rating
Option A	1	1/3	1/7	**0,081**
Option B	3	1	1/5	**0,188**
Option C	7	5	1	**0,731**
Inconsistency (C.R.) = 0,06				

Maintenance probability				
	Option A	Option B	Option C	Rating
Option A	1	1/5	1/7	**0,072**
Option B	5	1	1/3	**0,279**
Option C	7	3	1	**0,649**
Inconsistency (C.R.) = 0,06				

Maintenance time (per maintenance task)				
	Option A	Option B	Option C	Rating
Option A	1	1/7	1/9	**0,057**
Option B	7	1	1/2	**0,346**
Option C	9	2	1	**0,597**
Inconsistency (C.R.) = 0,02				

Equipment variety				
	Option A	Option B	Option C	Rating
Option A	1	3	1/3	**0,231**
Option B	1/3	1	1/9	**0,077**
Option C	3	9	1	**0,692**
Inconsistency (C.R.) = 0,00				

Maintainability of equipment				
	Option A	Option B	Option C	Rating
Option A	1	1/3	1/9	**0,066**
Option B	3	1	1/7	**0,149**
Option C	9	7	1	**0,785**
Inconsistency (C.R.) = 0,08				

Transaction cost				
	Option A	Option B	Option C	Rating
Option A	1	9	9	**0,818**
Option B	1/9	1	1	**0,091**
Option C	1/9	1	1	**0,091**
Inconsistency (C.R.) = 0,00				

Personnel demand				
	Option A	Option B	Option C	Rating
Option A	1	7	8	**0,785**
Option B	1/7	1	1/2	**0,085**
Option C	1/8	2	1	**0,129**
Inconsistency (C.R.) = 0,07				

Risk Management

Safety of staff and environment				
	Option A	Option B	Option C	Rating
Option A	1	1/7	1/9	**0,055**
Option B	7	1	1/3	**0,290**
Option C	9	3	1	**0,655**
Inconsistency (C.R.) = 0,08				

Transparency of information				
	Option A	Option B	Option C	Rating
Option A	1	1/7	1/9	**0,055**
Option B	7	1	1/3	**0,290**
Option C	9	3	1	**0,655**
Inconsistency (C.R.) = 0,08				

Dependence on partners				
	Option A	Option B	Option C	Rating
Option A	1	7	9	**0,785**
Option B	1/7	1	3	**0,149**
Option C	1/9	1/3	1	**0,066**
Inconsistency (C.R.) = 0,08				

Financial risk of investment				
	Option A	Option B	Option C	Rating
Option A	1	1/7	1/3	**0,088**
Option B	7	1	3	**0,669**
Option C	3	1/3	1	**0,243**
Inconsistency (C.R.) = 0,01				

Table 12: Pairwise comparison of alternatives (cont'd) (own design)

Asset Management							
	Equipment lifecycle cost (per year)	Relevance of investment to capabilities	Availability of spare parts and tools	Inventory holdings of spare parts and tools	Bargaining power	Weight	Sensitivity threshold
Equipment lifecycle cost (per year)	1	1/7	1/7	1	1/9	**0,038**	n/a
Relevance of investment to capabilities	7	1	1	5	1/3	**0,209**	n/a
Availability of spare parts and tools	7	1	1	7	1/3	**0,224**	n/a
Inventory holdings of spare parts and tools	1	1/5	1/7	1	1/9	**0,040**	0,352
Bargaining power	9	3	3	9	1	**0,488**	n/a
Inconsistency (C.R.) = 0,02							

Performance Management								
	Quality of products	Production cycle time	Responsiveness to maintenance demands	Flexibility to change strategy	Production process stability	Benchmark with industry best-practice	Weight	Sensitivity threshold
Quality of products	1	1/9	1/5	1/3	1/9	1	**0,032**	n/a
Production cycle time	9	1	3	5	1	9	**0,346**	n./a
Responsiveness to maintenance demands	5	1/3	1	5	1/3	5	**0,174**	n/a
Flexibility to change strategy	3	1/5	1/5	1	1/5	3	**0,070**	0,403
Production process stability	9	1	3	5	1	9	**0,346**	n/a
Benchmark with industry best-practice	1	1/9	1/5	1/3	1/9	1	**0,032**	0,377
Inconsistency (C.R.) = 0,03								

Maintenance Cost							
	Amount of equipment	Maintenance probability	Maintenance time (per maintenance task)	Equipment variety	Maintainability of equipment	Weight	Sensitivity threshold
Amount of equipment	1	1	1	1/2	2	**0,175**	n/a
Maintenance probability	1	1	1	1/2	2	**0,175**	n/a
Maintenance time (per maintenance task)	1	1	1	1/2	2	**0,175**	n/a
Equipment variety	2	2	2	1	7	**0,397**	0,563
Maintainability of equipment	1/2	1/2	1/2	1/7	1	**0,079**	n/a
Inconsistency (C.R.) = 0,01							

Table 13: Pairwise comparison of subcriteria (own design)

Cost Management					
	Maintenance cost	**Transaction cost**	**Personnel demand**	**Weight**	**Sensitivity threshold**
Maintenance cost	1	5	1/2	**0,319**	0,522
Transaction cost	1/5	1	1/9	**0,066**	n/a
Personnel demand	2	9	1	**0,615**	0,398
Inconsistency (C.R.) = 0,00					

Risk Management						
	Safety of staff and environment	**Transparency of information**	**Dependence on partners**	**Financial risk of investment**	**Weight**	**Sensitivity threshold**
Safety of staff and environment	1	9	5	3	**0,581**	0,377
Transparency of information	1/9	1	1/3	1/5	**0,050**	n/a
Dependence on partners	1/5	3	1	1/3	**0,114**	0,357
Financial risk of investment	1/3	5	3	1	**0,255**	0,418
Inconsistency (C.R.) = 0,03						

Achieving sustainable competitive advantage						
	Asset Management	**Performance Management**	**Cost Management**	**Risk Management**	**Weight**	**Sensitivity threshold**
Asset Management	1	1	1	3	**0,300**	0,073
Performance Management	1	1	1	3	**0,300**	n/a
Cost Management	1	1	1	3	**0,300**	0,390
Risk Management	1/3	1/3	1/3	1	**0,100**	n/a
Inconsistency (C.R.) = 0,00						

Table 14: Pairwise comparison of subcriteria (cont'd) and criteria (own design)

Results			
	Option A	**Option B**	**Option C**
Achieving sustainable competitive advantage *Overall inconsistency = 0.02*	21,9%	28,3%	49,8%
Asset Management	9,8%	35,8%	54,3%
Performance Management	9,9%	30,3%	59,7%
Cost Management	55,7%	12,3%	32,0%
Risk Management	13,5%	37,3%	49,2%
Maintenance Cost	13,2%	19,0%	67,8%

Table 15: Results of the AHP model for selecting maintenance strategies (own design)

Results of interview with wind turbine owner

Asset Management

Equipment lifecycle cost (per year)				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/9	1/3	**0,077**
Option B	9	1	3	**0,692**
Option C	3	1/3	1	**0,231**
Inconsistency (C.R.) = 0,00				

Relevance of investment to capabilities				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/9	1	**0,091**
Option B	9	1	9	**0,818**
Option C	1	1/9	1	**0,091**
Inconsistency (C.R.) = 0,00				

Availability of spare parts and tools				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/3	**0,088**
Option B	7	1	3	**0,669**
Option C	3	1/3	1	**0,243**
Inconsistency (C.R.) = 0,01				

Inventory holdings of spare parts and tools				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1	5	**0,455**
Option B	1	1	5	**0,455**
Option C	1/5	1/5	1	**0,091**
Inconsistency (C.R.) = 0,00				

Bargaining power				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/4	1/9	**0,066**
Option B	4	1	1/4	**0,217**
Option C	9	4	1	**0,717**
Inconsistency (C.R.) = 0,04				

Performance Management

Quality of products				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1	1	**0,333**
Option B	1	1	1	**0,333**
Option C	1	1	1	**0,333**
Inconsistency (C.R.) = 0,00				

Production cycle time				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/9	1/4	**0,069**
Option B	9	1	3	**0,681**
Option C	4	1/3	1	**0,250**
Inconsistency (C.R.) = 0,01				

Flexibility to change strategy				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/3	1/9	**0,077**
Option B	3	1	1/3	**0,231**
Option C	9	3	1	**0,692**
Inconsistency (C.R.) = 0,00				

Responsiveness to maintenance demands				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/4	1/9	**0,063**
Option B	4	1	1/5	**0,194**
Option C	9	5	1	**0,743**
Inconsistency (C.R.) = 0,07				

Production process stability				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/9	1/9	**0,053**
Option B	9	1	1	**0,474**
Option C	9	1	1	**0,474**
Inconsistency (C.R.) = 0,00				

Benchmark with industry best-practice				
	Option A	**Option B**	**Option C**	**Rating**
Option A	1	1/7	1/3	**0,088**
Option B	7	1	3	**0,669**
Option C	3	1/3	1	**0,243**
Inconsistency (C.R.) = 0,01				

Table 16: Pairwise comparison of alternatives (own design)

Cost Management

Amount of equipment				
	Option A	Option B	Option C	Rating
Option A	1	1/9	1/3	**0,077**
Option B	9	1	3	**0,692**
Option C	3	1/3	1	**0,231**
Inconsistency (C.R.) = 0,00				

Maintenance probability				
	Option A	Option B	Option C	Rating
Option A	1	1/4	1/9	**0,069**
Option B	4	1	1/3	**0,250**
Option C	9	3	1	**0,681**
Inconsistency (C.R.) = 0,01				

Maintenance time (per maintenance task)				
	Option A	Option B	Option C	Rating
Option A	1	1/9	1/9	**0,053**
Option B	9	1	1	**0,474**
Option C	9	1	1	**0,474**
Inconsistency (C.R.) = 0,00				

Equipment variety				
	Option A	Option B	Option C	Rating
Option A	1	1	1/9	**0,091**
Option B	1	1	1/9	**0,091**
Option C	9	9	1	**0,818**
Inconsistency (C.R.) = 0,00				

Maintainability of equipment				
	Option A	Option B	Option C	Rating
Option A	1	1/5	1/9	**0,063**
Option B	5	1	1/3	**0,265**
Option C	9	3	1	**0,672**
Inconsistency (C.R.) = 0,03				

Transaction cost				
	Option A	Option B	Option C	Rating
Option A	1	4	9	**0,727**
Option B	1/4	1	3	**0,200**
Option C	1/9	1/3	1	**0,073**
Inconsistency (C.R.) = 0,01				

Personnel demand				
	Option A	Option B	Option C	Rating
Option A	1	1	5	**0,455**
Option B	1	1	5	**0,455**
Option C	1/5	1/5	1	**0,091**
Inconsistency (C.R.) = 0,00				

Risk Management

Safety of staff and environment				
	Option A	Option B	Option C	Rating
Option A	1	1/9	1/9	**0,053**
Option B	9	1	1	**0,474**
Option C	9	1	1	**0,474**
Inconsistency (C.R.) = 0,00				

Transparency of information				
	Option A	Option B	Option C	Rating
Option A	1	1	1/9	**0,091**
Option B	1	1	1/9	**0,091**
Option C	9	9	1	**0,818**
Inconsistency (C.R.) = 0,00				

Dependence on partners				
	Option A	Option B	Option C	Rating
Option A	1	9	3	**0,692**
Option B	1/9	1	1/3	**0,077**
Option C	1/3	3	1	**0,231**
Inconsistency (C.R.) = 0,00				

Financial risk of investment				
	Option A	Option B	Option C	Rating
Option A	1	1/9	1/3	**0,077**
Option B	9	1	3	**0,692**
Option C	3	1/3	1	**0,231**
Inconsistency (C.R.) = 0,00				

Table 17: Pairwise comparison of alternatives (cont'd) (own design)

Asset Management							
	Equipment lifecycle cost (per year)	**Relevance of investment to capabilities**	**Availability of spare parts and tools**	**Inventory holdings of spare parts and tools**	**Bargaining power**	**Weight**	**Sensitivity threshold**
Equipment lifecycle cost (per year)	1	7	1	3	7	**0,385**	n/a
Relevance of investment to capabilities	1/7	1	1/7	1/3	1	**0,052**	n/a
Availability of spare parts and tools	1	7	1	3	5	**0,363**	n/a
Inventory holdings of spare parts and tools	1/3	3	1/3	1	3	**0,143**	0,278
Bargaining power	1/7	1	1/5	1/3	1	**0,056**	0,471
Inconsistency (C.R.) = 0,01							

Performance Management								
	Quality of products	**Production cycle time**	**Responsiveness to maintenance demands**	**Flexibility to change strategy**	**Production process stability**	**Benchmark with industry best-practice**	**Weight**	**Sensitivity threshold**
Quality of products	1	1/9	1/9	1/3	1/9	1	**0,029**	n/a
Production cycle time	9	1	3	9	3	9	**0,458**	0,357
Responsiveness to maintenance demands	9	1/3	1	3	1	9	**0,208**	0,294
Flexibility to change strategy	3	1/9	1/3	1	1/3	3	**0,069**	0,187
Production process stability	9	1/3	1	3	1	9	**0,208**	n/a
Benchmark with industry best-practice	1	1/9	1/9	1/3	1/9	1	**0,029**	n/a
Inconsistency (C.R.) = 0,03								

Maintenance Cost							
	Amount of equipment	**Maintenance probability**	**Maintenance time (per maintenance task)**	**Equipment variety**	**Maintainability of equipment**	**Weight**	**Sensitivity threshold**
Amount of equipment	1	1/9	1/9	1/5	1/2	**0,032**	0,37
Maintenance probability	9	1	1	7	9	**0,416**	n/a
Maintenance time (per maintenance task)	9	1	1	7	9	**0,416**	n/a
Equipment variety	5	1/7	1/7	1	2	**0,089**	n/a
Maintainability of equipment	2	1/9	1/9	1/2	1	**0,048**	n/a
Inconsistency (C.R.) = 0,05							

Table 18: Pairwise comparison of subcriteria (own design)

Cost Management					
	Maintenance cost	Transaction cost	Personnel demand	Weight	Sensitivity threshold
Maintenance cost	1	9	9	**0,818**	0,494
Transaction cost	1/9	1	1	**0,091**	0,324
Personnel demand	1/9	1	1	**0,091**	0,367
	Inconsistency (C.R.) = 0,00				

Risk Management						
	Safety of staff and environment	Transparency of information	Dependence on partners	Financial risk of investment	Weight	Sensitivity threshold
Safety of staff and environment	1	9	9	7	**0,719**	n/a
Transparency of information	1/9	1	1	1/3	**0,063**	0,085
Dependence on partners	1/9	1	1	1/3	**0,063**	0,162
Financial risk of investment	1/7	3	3	1	**0,155**	0,124
	Inconsistency (C.R.) = 0,03					

Achieving sustainable competitive advantage						
	Asset Management	Performance Management	Cost Management	Risk Management	Weight	Sensitivity threshold
Asset Management	1	1/5	1/9	1/7	**0,042**	0,182
Performance Management	5	1	1/5	1/3	**0,135**	0,568
Cost Management	9	5	1	1	**0,454**	n/a
Risk Management	7	3	1	1	**0,369**	n/a
	Inconsistency (C.R.) = 0,05					

Table 19: Pairwise comparison of subcriteria (cont'd) and criteria (own design)

Results			
	Option A	**Option B**	**Option C**
Achieving sustainable competitive advantage *Overall inconsistency = 0.03*	11,9%	43,0%	45,1%
Asset Management	15,7%	61,7%	22,6%
Performance Management	7,8%	49,4%	42,7%
Cost Management	15,5%	36,5%	47,9%
Risk Management	8,7%	46,5%	44,7%
Maintenance Cost	6,2%	36,7%	57,1%

Table 20: Results of the AHP model for selecting maintenance strategies (own design)

Interview partners

The interview with the wind turbine service provider was conducted with:

Herr Thomas Jäniche
Leiter Service / Prokurist

Voith Industrial Services Wind GmbH
Straße am Zeltplatz 7
18230 Ostseebad Rerik, Germany

Thomas.Jaeniche@Voith.com
http://www.voithindustrialservices.de/wind

The interview with the wind turbine owner was conducted with:

Herr Dipl. oec. Ingo Lange
Gesellschafter

ECV Energy-Concept Verwaltungs-GmbH
Döhrener Str. 41
32469 Petershagen

Ingo.Lange@windenergieanlage.de

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Erklärung gemäß der Prüfungsordnung für die wirtschaftswissenschaftlichen Diplomstudiengänge sowie den Diplomstudiengang Kommunikationswissenschaft der Universität Hohenheim

Hiermit erkläre ich, dass ich die Diplomarbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Alle Stellen der Arbeit, die wörtlich oder sinngemäß aus Veröffentlichungen oder aus anderweitigen fremden Äußerungen entnommen wurden, sind als solche einzeln kenntlich gemacht.

Die Diplomarbeit habe ich noch nicht in einem anderen Studiengang als Prüfungsleistung verwendet.

Stuttgart-Hohenheim, den 10. Februar 2009

Unterschrift: ______________________________

(Stefan Gassner)