Professional MBA

Automotive Industry

Technology Valuation in an M&A Process in a Producing High-Tech Industry

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
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Linz, September 4th, 2015

I am deeply thankful to my family, my beloved wife Stephanie and my children Fabia-Marie and Xaver Josef for their love, support, and sacrifices.
I love you all dearly.

Affidavit

I, Roland Hintringer, hereby declare

1. that I am the sole author of the present Master's Thesis, "Technology Valuation in an M&A Process in a Producing High-Tech Industry", 98 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Linz, September 4th, 2015

Signature

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Abbreviations

M&A	Merger and acquisitions
NDA	Non-disclosure agreement
R&D	Research and development
PMI	Post-merger integration
DCF	Discounted cash flow
ADL Matrix	Arthur D. Little technology portfolio matrix
IP	Intellectual property
TLR	Technology readiness level
AFM	Axial flux machine
TFM	Transversal flux machine
PDM	Product data management
FEM	Finite element method
RPA	Rapid plant assessment
WIP	Work in progress
WACC	Weighted average cost of capital

1. Introduction

After years of holding back due to an instable economic outlook, merger and acquisition (M&A) transactions have significantly increased in the US in the years 2013 and 2014[1]. With a slight delay the same trend can be seen in Europe since 2014. Reasons for making M&A transactions more attractive include a growing consumer confidence, favorable credit markets, and limited prospects for an organic growth of normal business operations. Agile companies are always on the lookout for growth in order to find the right targets, while other, more conservative companies launched efficiency and cost cutting programs during the years of crisis. This has increased the cash on their balance sheets and put them into a comfortable situation. These cash positions need to be invested carefully in order to keep or extend a competitive advantage. With record low interest rates companies need to find the right opportunity to invest.[2] Shareholders reward risk-taking entrepreneurs and motivate chief executives to strike deals while interest rates are still low. According to a survey by KPMG[3], the primary reason (21%) for an M&A transaction is "Opportunistic" as a target becomes available. In case such an "opportunity" arises, it needs to be seized quickly. This is a very time critical process as a full due diligence process should not take longer than a few weeks. Hence, starting an analysis and setting up evaluation criteria only when such an opportunity arises, is much too late. A system or model for evaluation needs to be developed and has to be in place beforehand. Such models and methods are usually provided by consulting companies who have remarkable experience with due diligence processes and mature models for evaluating various domains of a company. For each domain, specific due diligence methods are available such as

- Financial Due Diligence
- Operational Due Diligence
- Legal Due Diligence
- Commercial Due Diligence
- Tax Due Diligence
- Technical Due Diligence

[1] Deloitte M&A trends report 2014 – A comprehensive look at the M&A market

[2] "What's a Company to Do With All That Cash," by Johanna Bennett, Barron's, Dec. 17, 2013.

[3] KPMG 2015 M&A Outlook Survey Report

1.1. Problem definition

The focus of the due diligence process still lies on commercial, financial, and tax issues. Technical due diligence focuses on the evaluation of the produced product and on machinery investment. Only a minor part of the due diligence process consists of evaluating the underlying technology of sold products and the potential of a technology to be used for other products or business cases. If a product has low technical complexity and requirements, this approach can be accepted. In case of a high-tech product, however, neglecting a holistic evaluation of a technology can result in an entirely wrong company value: The underlying technology of a product might be at the end of its lifecycle and an emerging substitution technology may give significant cost advantages. If the M&A target is not able to use this emerging technology in an adequate way, the value of taking over the company might be much lower than a usual commercial due diligence and company value analysis would show. There can be many reasons why a certain technology is not available, including legal issues such as insufficient property rights and simply a lack of knowledge and experience in using the technology. On the other hand, a company could use a technology which has much more potential than its currently sold products. This makes it possible to expand the company towards producing and selling other products and gaining significant synergies in production, research and development, quality assurance and many other domains. There is a considerable amount of literature in the M&A and due diligence sectors; however, reliable information and mature models concerning the worth of technology are very rare. In order to help closing this gap, this paper shows an approach to evaluate technologies in a way which supports management decisions in M&A processes.

1.2.Research questions

The following research questions shall be addressed:

- What are process steps in an M&A undertaking and how technology need to be taken into account?
- What are typical interfaces of technology evaluation to other domains in the due diligence phases of an M&A process?
- What are requirements for a technology evaluation in an M&A process?
- How are technology evaluation methods meeting the requirements in a technical due diligence of an M&A processes?
- How can those methods be applied and combined in a holistic technology evaluation model?
- What are criteria for a technology evaluation in an M&A process and how can they be evaluated in monetary values?

1.3.Research approach

Based on the research questions, the following approach is has been chosen. As a first step it shall be analyzed what the typical process steps in an M&A process are. Different domains of due diligences shall be introduced and it shall be indicated where technology is influencing. Interfaces and requirements to the technology evaluation out of the other due diligence domains shall be indicated and discussed.

Most common technology evaluation methods shall be introduced. A general indication shall be given about the possible use in an M&A process. Those methods shall be opposed to the requirement in a technical due diligence and rated about the fulfillment of these requirements. The best suitable methods shall be combined in a holistic model. As a target to the model which need to be developed, technology evaluation model shall indicate the premium or discount price, which needs to be taken into account for an offer. The model shall be based on the most important evaluation criteria for technology in an M&A process and shall allow to rate each criteria by a monetary value in order to oppose a potential gap with the costs that would occur to close this gap. Modell proposed in this work will be applied in a real M&A business

case. Conclusions from the application of the evaluation model, pros and cons shall be finally discussed and suggestions for future research work shall be made.

1.4. Structure of the work

The structure of this paper will firstly introduce and explain state of the art of M&A and due diligence processes (chapter 2), secondly explain methods for technology valuation (chapter 3), thirdly combine the methods to a holistic evaluation model (chapter 4), verify the model by applying it to a real technology evaluation case (chapter 5) and finally draw conclusions (chapter 6).

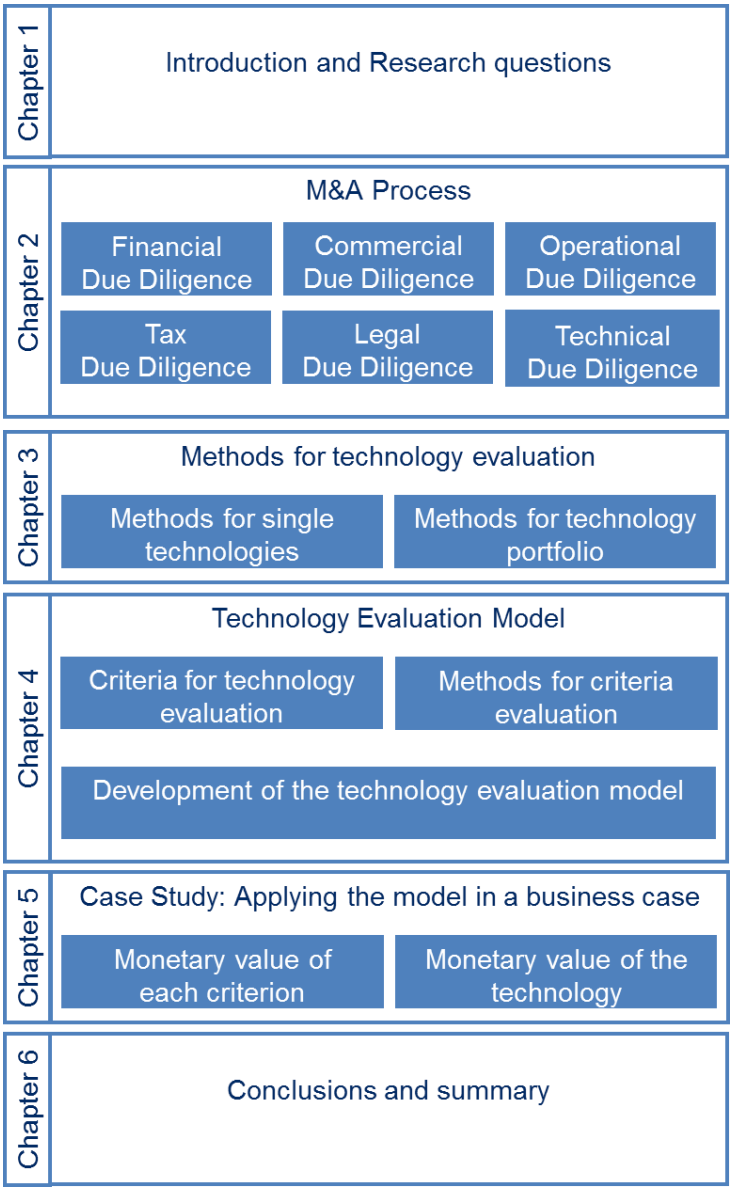

Figure 1: Scope of the master thesis

2. Due diligence in M&A processes

The term M&A in general refers to the transfer of an undertaking to a new owner. In particular, a merger is the uniting of two companies to a new one and an acquisition means that a company acquires another one by taking over a major amount of shares. Once an M&A deal is completed, the target company can either be integrated in the acquiring company or remain independent.

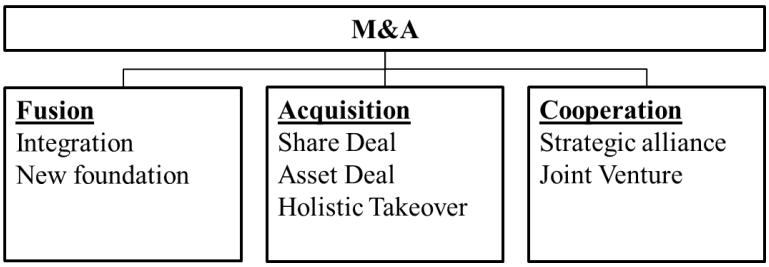

Figure 2: Types of M&A

2.1.Motives for M&A

The primary aim of M&A is to add shareholder value. This goal can be reached by various approaches; motivation for M&A can include the following items:

- efficiency gains,
- technology buy-ins,
- improved interest rates,
- unilateral effects,
- spreading the portfolio,
- disciplinary takeovers,
- economies of vertical integration,
- obtaining multimarket contact,
- economies of scale,
- synergy gains,
- rationalization,
- financial cost savings,
- economies of scope,
- diffusion of know-how,
- purchasing power,
- taxes,
- preemptive and defensive,
- raising entry barriers,
- strengthening the market power,
- risk spreading,
- diversification,
- free-cash flow,
- markets for corporate control and
- creating internal capital markets.

Looking back in history, several main motives can be observed: In the early 20th century, mergers were driven by forming monopolies or merging two monopolies to a

larger one. During the 1920s, the main motivation was the extension of the vertical integration by M&A along the value chain of a product. In the 1960s there was an M&A hype which caused by the diversification of large companies in order to minimize the risks. This was followed by the revers strategy, i.e. trying to concentrate on the core business during the 1980s. Since then, the main motive has been to meet the challenges of globalization.

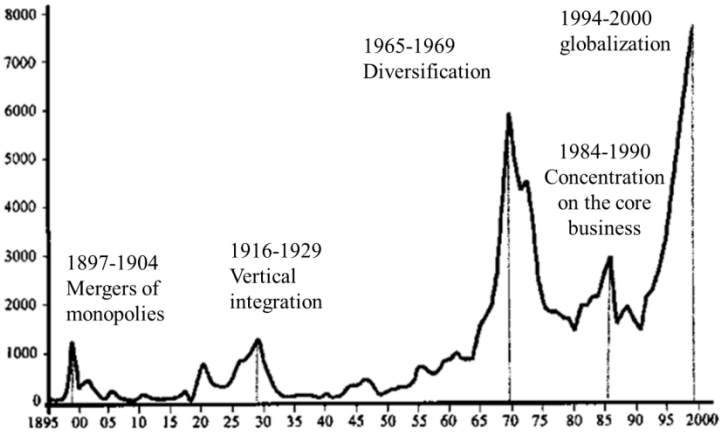

Figure 3: Motivation for M&A[4]

2.2.Proceedings of M&A

Proceedings of M&A projects are frequently described in literature. Many M&A advisory companies follow their internal processes which can differ from those of others. Nevertheless, the major phases in the M&A processes are usually very similar and will be described in this section.

An M&A process involves a wide range of activities including the buyer's and seller's point of view. This comprises, among other things, a careful check of the company and its business plan and the result of such an assessment is presented as a so-called due diligence report. Areas where due diligence projects are frequently encountered are finance, operations, technical, commercial, tax and legal. A numerous well-known consulting firms and the transaction departments of the major accounting firms and law firms are specializing in M&A. Usually larger M&A deals involves an M&A advisor and law firms on both sides. Another essential service which is part of M&A

[4] Gerhard Picot; Management of international Merger and Acquisitions, 1999

processes is the business valuation. In this business valuation, a range of the potential enterprise value is calculated based on rational models. This calculation is usually done by discounting future corporate profits using the discounted cash-flow method which is based on the company's business plan rated in the due diligence expertise.

Due diligence is, to some extent, the method which analyzes the required input data for a business valuation. An M&A process is concluded by the negotiation and drafting of a purchase agreement; the closing of the transaction is marked by the signing of the final purchase agreements and by actually transferring the company.

Typically, an M&A process is split into several phases: preparation, marketing, buyer due diligence, and contract negotiation.

Figure 4: Overview of an M&A process

2.3.Preparation

During the preparation phase, the buyer defines the general target profile of eligible companies. Parameters such as revenue, number of employees, and the target company's global footprint are defined. Based on these parameters a so-called search profile is compiled.

The seller side prepares a so-called teaser or executive summary with the most relevant company details, which usually includes a short description of the business and its products, the main markets, the location of the headquarter and other sites. In addition to this, the teaser lists basic facts about the company such as the annual turnover, the profit, the number of employees and the company's owner structure.

Acquisition Opportunity

Ref: 6554

Location: Immingham, UK

headford Strategic Growth

International Freight Forwarder based in the Immingham area

Independent shipping, forwarding, warehousing and Transportation Company.

Bids Invited

Key Business Features:

- Well established company after over 30 years of trading showing annual profits
- Debt free company
- Excellent location in the Immingham area, very busy location
- Excellent prospects for Growth
- Loyal staff and excellent client base ongoing
- Main Trade Routes
  - Short Sea – Europe & Scandinavia
  - Deep Sea – China, India & USA
- Company offers freight forwarding ships agency warehousing and distribution
- Ideal Bolt-on

Key Financials & Opportunities:

- Turnover: £2.7 Million
- Adjusted Net: £200K

Land & property:-

- 85,000 sq ft on freehold site of 5 acres
- 100,000 sq ft on long term lease

Client Base Made Up

Mode	Import (%)	Export (%)
Air	1	1
Sea	39	30
Road	10	19

In order that we may obtain our client's permission to release the Information Memorandum, please register your interest by completing the Non-Disclosure Agreement (including the Acquisition Profile) and return to:

Stuart Mounter (Mergers & Acquisitions - Senior Consultant)
stuart@headfordgroup.com
+44 (0)1454 275932

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Figure 5: Example of a teaser[5]

During the preparation phase the seller compiles a more detailed memorandum about the company, which is sometimes called the *deal book*. It contains detailed information which a potentially interested buyer has to reflect upon in order to decide whether to make an offer or not.

The deal book contains at least the following information:

- detailed owner structure,
- sales process,
- production technologies,
- growth potentials of the company,
- law issues,
- organizational structure including management team information,
- finance data (including at least a five-year history),
- detailed description of products,
- value added chain,
- intellectual property rights,
- statement about taxes,
- customer list and
- detailed information about the company's history.

This report is handed over after a potential buyer states his interest and a non-disclosure-agreement is signed.

[5] http://de.slideshare.net/ April 25, 2015; 12:32PM

2.4.Marketing phase

The seller needs to attract the interest of potential buyers. As a first information, the teaser will be distributed to potential buyers. Those who subsequently show interest will receive a more detailed memorandum. The more potential buyers respond, the higher a possible purchase price be. In the marketing phase, a first rough indication of a purchase price is requested from the interested parties.

The selling company prepares all data necessary for a due diligence by the buyer in a data room. This includes information on sales, and on operational, financial, tax, law and technical details of the products and the production; a verified report about the creditability of the data needs to be included as well. Today, data servers with secure internet connections are used, while in former times, physical documents were placed in a specific room for the assessors. In this data room, all documents and information was provided.

Before giving a potential buyer access to the data room, a non-disclosure-agreement has to be negotiated (NDA). This NDA is a contract which defines the treatment of confidential information that can be accessed in the data room and information shared during discussions and negotiations. In the NDA, the seller needs to be assured that no information will get into the hands of third parties without his approval. This is a very sensitive matter and builds the base for a trustful discussion and negotiation.

2.5.Due diligence

Due diligence is the procedure of analyzing a company with the aim of making a significant investment in this company or even of integrating the company into the buyer's own organization. The aim is to make sure that all relevant facts and all information about the investment target are available and that the preparation of the involved documents was performed diligently. Potential risks have to be indicated and a basis for the analysis of the company's value is given. Additionally, potential deal breakers have to be identified.

Beyond the hard facts of due diligence, additional information, which can have an influence on management decisions and business development in the future, is compiled. Gathering information about the principles and values of the seller and other

bidders can help during contract and price negotiations; other additional information can also help in the post-merger integration phase.

The first step of the due diligence phase is the negotiation of the NDA, in which the following details have to be agreed on:

- definition of confidential information,
- use of information only for the purpose of the M&A process,
- oral information must be covered,
- determination of employees who have access to confidential information,
- procedure in the case that information needs to be disclosed to a third party,
- duration of confidentiality and
- contractual penalty in case the agreement is breached.

After an NDA is signed, the involved parties meet for the first time. The seller party introduces the company to the buyer and gives a first overview of the business plan as well as of strengths and weaknesses of the company. This meeting is usually held by the top management of the buying company and the owner/major shareholder(s) of the selling company; the buying party's questions are discussed.

In case the selling party performed a vendor due diligence, the results are presented and handed over in form of a report. The buying party gets access to the data room.

A major part of the due diligence efforts is screening the data in the data room and valuing the company. As a due diligence phase usually needs to be completed within a few weeks, a professional and experienced team is needed to value the company based on a mature M&A process.

During the due diligence phase, the buyer can make site visits to analyze the situation in detail; the due diligence of international or global companies will focus primarily on the most important operation sites.

The due diligence phase involves an analysis of all areas which are relevant for evaluating the company, thus, the following types of due diligence are conducted:

- financial due diligence,
- commercial due diligence,
- operational due diligence,

- tax due diligence,
- legal due diligence and
- technical due diligence

2.5.1. Financial due diligence

During financial due diligence, the company's historical financial results and the future business plan are analyzed. This analysis will be done by investigating profit and loss statements, the balance sheet and cash-flow statements of the last three to five years. The main focus is trying to find patterns and identifying effects which underlie the company's business and performance. In combination with market data and a business trend analysis, this is supposed to give an indication of the company's future development. Areas of poor performance will be indicated.

A particular focus has to be put on organizational changes as they make it difficult to compare data of the past few years. The same is true for acquired or sold parts of the company. In addition to this, also non-recurring effects can influence the data and need to be separated.

The findings will be cross-checked with the company's business plan. The following focus areas are considered:

- determination of key performance indicators,
- cross check with industry benchmarks,
- plausibility of planning assumptions,
- analysis of capital expenditures,
- debt analysis,
- hidden reserves and
- financing structure.

2.5.2. Commercial due diligence

A commercial due diligence is performed in order to analyze the company's potential in terms of revenue and annual growth. The positioning of the company and its products within each market segment as well the timing of new products and product enhancements are analyzed. Market position and related strengths and weaknesses are considered and an estimation of the company's future market share is derived from all

these parameters. In addition to this, the potential for an expansion to other regions and industries has to be considered.

An analysis of the competition is performed. An important parameter is to understand the basis for competition such as technology, service, price, and distribution channels. In addition to this, the number of competitors and the relative market shares give an indication of the company's future potential. Depending on the industry and the business the company is situated in, it can be just a few competitors (oligopoly market) or many small companies. These details need to be reflected upon in the company's business plan.

Not only the company's performance is of interest, also the market's future potential and the overall industry is estimated in terms of growth and stability. It needs to be considered whether the company acts in a mature or in an emerging and strong growing market. Enlarging a company in a growing market is easier than trying to increase the relative market share in a saturated market.

The supply chain of the main products and all major business units has to be analyzed and an ABC analysis should be conducted. A potential risk could be that there are only a few suppliers serving the industry who can therefore dictate the prices. This could lower the company's profitability.

Additionally, the performance and stability of domestic and international distribution channels needs to be evaluated.

The identification of synergies with the buying company is essential. Synergies can be found in the supply chain, in production, sales, administration and other areas. They can justify a price premium that other bidders are not willing to pay and can give the decisive advantage in the bidding process.

2.5.1. Operational due diligence

An operational due diligence analyzes the cost side of a company. It focuses on the organizational structure's performance and on the processes within the organization. Areas such as purchasing, production, quality, maintenance, sales and marketing, and human resources are analyzed.

Purchasing concerns the supply of goods and services in the company. The higher the material share, the higher is the importance of purchasing for having an attractive offering in the market. An analysis of strategic purchasing processes concentrates on global and low cost sourcing as well as on the lead buyer concept. The operative purchasing analysis assesses the utilization of purchasing volumes, material groups, and supply chains.

The aim of production is the efficient manufacturing of goods. The production strategy has to follow the basis for competition on the market. Operation plants are evaluated in terms of cost optimization, productivity of machines and personnel. In addition to this, the degree of utilization of the plants is analyzed. Possibilities of increasing production for future expansion have to be considered. Investments in production facilities, which are necessary in order to meet the aim stated in the business plan, are considered.

Quality management ensures that customers' requirements can be fulfilled. Today, many national and international standards need to be met in this respect. Additionally, customers in business to business markets have to fulfill very specific requirements. Costs for defective goods which do not reach the mandatory quality are analyzed. If there are extremely high costs, the potential for improvement through a new management needs to be estimated.

The maintenance of the machines is checked and downtimes are analyzed.

In addition to all this, human resources are also part of the operational due diligence. The company's organizational structure is analyzed and key personnel in the management are identified. Losing personnel with essential know-how and with a good customer network can put the company in a difficult situation after it is taken over. The due diligence team needs to get a realistic judgment about whether or not part of the personnel will leave the company in the post-merger phase and in case a

risk exists, countermeasures have to be developed. Additionally, the management structure's efficiency is analyzed. Personnel costs are benchmarked with indicators in the same industry and management audits from the last years are reviewed. A special focus has to be put on the pension plans of the company. Over the past few years commitments were made for compensation during pension which can bring companies in difficult situations. It is recommended to perform a management review based on the processes of the buying company. This way, the management performances can be compared directly. In case the company's owner plays an important role in the management, a business a successor plan for his position needs to be made in case he leaves the company. During the human resource due-diligence, the cornerstones for the post-merger integration need to be defined.

2.5.2. Tax due diligence

A tax due diligence is performed to find risks in the taxation of the company. All local and federal taxes (for gross receipts, income, property, employment, sales, and other taxes) of the previous six years are analyzed. In case reports of independent external certified accountants are available, they need to be analyzed. In addition to this, the outcome of tax audits from the previous few years are checked for any major deviations. Based on the results, a risk assessment is conducted. It has to be made sure that the risks are covered in the balance sheet and sufficient provisions are made. In case a risk is identified and the provisions seem not to be sufficient, this risk will reduce the company's value and can be used as an important point in the negotiation strategy. During the tax due diligence a concept for an optimal future taxation is developed. Potential for an improvement of the taxation strategy in the buying company's organization can mean an advantage and justify a price premium. Depreciation and taxation of the acquisition and the financing of the sales price also have to be considered in the taxation concept.

2.5.3. Legal due diligence

A legal due diligence is performed in order to analyze the legal situation of the target company. Legal risks and opportunities in contracts with suppliers, customers, service providers and credit institutes are identified. The status of commercial property rights has to be understood and evaluated, operating permits of plants have to be checked, and risks of lawsuits and litigations need to be evaluated. Each of these legal issues can mean the loss of a company's livelihood. Any identified risks have to be considered in the contract wording of the buying agreement and especially warranty has to be excluded where possible. An important part of the legal due diligence is to find the best way for the legal transaction of the purchase. Various approaches such as a share deal and an asset deal have to be considered. The main framework and the contents of a purchasing agreement have to be determined.

2.5.4. Technical due diligence

Typical tasks of a technical due diligence are the analysis of the capacity and efficiency of the production and whether or not production can be expanded. In addition to this, the condition of the systems and machines are evaluated and it is assessed where automation concepts can improve the factories' output and improve efficiency and quality. In the course of the technical due diligence all major production sites are visited and evaluated. A very common way to perform an evaluation of production plants is a method called *Rapid Plant Assessment* (RPA) introduced by Eugene Goodson[6]. The RPA consists of two evaluation forms: One is a grid with eleven categories and the other one is a questionnaire consisting of 20 yes or no questions. Results from the site visit are transferred to score sheets after the visit. This is done to ensure that nothing is missed during the inspection, as the concept is based on optical information. For its evaluation, it is recommended that the evaluation team talks personally to factory employees and supervisors during the visit. The evaluation team should meet as soon as possible after the visit and enter their observations into the forms. An overview of the questions can be found in Figure 6.

[6] Read a Plant Fast; Harvard Business Review; May 2002; Page 105ff

Rated by:_____		Rapid Plant Assessment						Apr-15
Tour Date:_____		Table 1--Rating Sheet					Plant:_____	
	Ratings →	Poor	Below Average	Average	Above Average	Excellent	Best in Class	
No	Measure | Score →	1	3	5	7	9	11	Scores
1	Customer Satisfaction							
2	Safety, environment, cleanliness, & order							
3	Visual Management Deployment							
4	Scheduling system							
5	Product flow, space use & material movement means							
6	Inventory & WIP Levels							
7	People teamwork, skill level, & motivation							
8	Equipment & tooling state & maintenance							
9	Ability to Manage Complexity & Variability							
10	Supply Chain Integration							
11	Quality System Deployment							
	Totals							

Plant	Rapid Plant Assessment	Date	Apr.15
No	Table 2--Assessment Questionnaire		Yes/No
1	Are visitors welcomed and given information about plant layout, workforce, customers, and products?		
2	Are ratings for customer satisfaction and product quality displayed?		
3	Is the facility safe, clean, orderly, and well lit? Is the air quality good and noise levels low?		
4	Does a visual labeling system identify and locate inventory, tools, processes, and flow?		
5	Does everything have its own place, and is everything stored in its place?		
6	Are up-to-date operational goals and performance measures for those goals prominently posted?		
7	Are production materials brought to and stored at line side rather than in separate inventory storage areas?		
8	Are work instructions and product quality specifications visible at all work areas?		
9	Are updated charts on productivity, quality, safety, and problem solving visible for all teams?		
10	Can the current state of the operation be viewed from a central control room, on a status board, or on a CRT?		
11	Are production lines scheduled off a single pacing process with appropriate inventory levels at each stage?		
12	Is material moved only once as short a distance as possible and in appropriate containers?		
13	Is the plant laid out in continuous product flow lines rather than in "shops"?		
14	Are work teams trained, empowered, and involved in problem solving and ongoing improvements?		
15	Do employees appear committed to continuous improvement?		
16	Is a timetable posted for equipment preventive maintenance and continuous improvement of tools and processes?		
17	Is there an effective project management process, with cost and timing goals, for new product start-ups?		
18	Is a supplier certification process--with measures for quality, delivery, and cost performance--displayed?		
19	Have key product characteristics been identified and fail-safe methods used to forestall propagation of defects?		
20	Would you buy the products this operation produces?		
	Total number of Yeses		

Figure 6: Questionnaire of the Rapid Plant Assessment[7]

[7] Read a Plant Fast; Harvard Business Review; May 2002; Page 105ff

The described approach can only give a very rough indication of the technical capabilities of a company. Besides the evaluated topics, the value of a company can be influenced by many more factors such as access to raw material, design and trademark rights, production capabilities, and an innovative business model. In the area of industrial production the technological competence plays a major role and a company's innovation capabilities are the foundation for future success. In the past, this was true for Western production companies; today, strength in technology and innovation is the key success factor in emerging countries and in most major production and service industries.

It is thus rather surprising that technical due diligences are not the main focus of a due diligence process: It is not unusual that the technical due diligence is integrated as a subdomain of the operational due diligence and focuses merely on the performance of the production. As shown in figure 6, a survey about the use of various kinds of due diligences in Germany shows that only in 52% percent of M&A processes a technical due diligence is conducted.

Frequency of use by Type of Transaction / Size of the company by revenue / Type of Due Diligence	Akquisition			Joint Venture			Merger			∅
	smaller	equal	larger	smaller	equal	larger	smaller	equal	larger	
Financial	95,61	96,55	100,0	84,71	96,43	87,50	90,14	83,72	100,0	93,53
Tax	81,34	82,76	83,87	59,41	78,57	81,25	70,42	67,44	80,00	77,52
Management	67,07	55,17	77,42	60,59	64,29	53,13	57,75	53,49	93,33	65,19
Legal	82,55	89,66	87,10	75,88	82,14	78,13	77,46	81,40	80,00	81,50
Environmental	47,20	27,59	67,74	51,76	50,00	62,50	43,66	23,26	53,33	47,37
Insurance	51,92	24,14	45,16	42,35	57,14	46,88	43,66	23,26	60,00	48,65
Technical	52,69	48,28	51,61	60,59	50,00	53,13	39,44	25,58	73,33	52,18
Organisatorisch	58,73	48,28	51,61	55,29	53,57	53,13	54,93	48,84	86,67	57,44
Market	77,39	82,76	67,74	76,47	67,86	84,38	64,79	72,09	93,33	76,47

Figure 7: Frequency of the use of a technical due diligence[8]

In fact, neglecting an extended due diligence can lead to a wrong estimated value of the acquisition target and consequently to a wrong decision during the M&A acquisition process. This can, in the worst case, cause vital problems for the acquiring

[8] Kai-Uwe Marten, Anette G. Köhler: Due Diligence in Deutschland – Eine empirische Untersuchung

company. A model for an extensive technical due diligence including a detailed technology evaluation will be examined in the following chapters.

2.6.Final bid and contract negotiation

Figure 8: Overview of an M&A process with milestones

At the end of the due diligence phase, the potential buyers are requested to give a binding offer. As a first step, a stand-alone value of the company, which is based on an analysis of the financial facts and the information gathered in the due diligence process, is calculated. Various approaches for finding the stand-alone value can be used:

- discounted cash-flow (DCF),
- earnings-value method and
- multiple method.

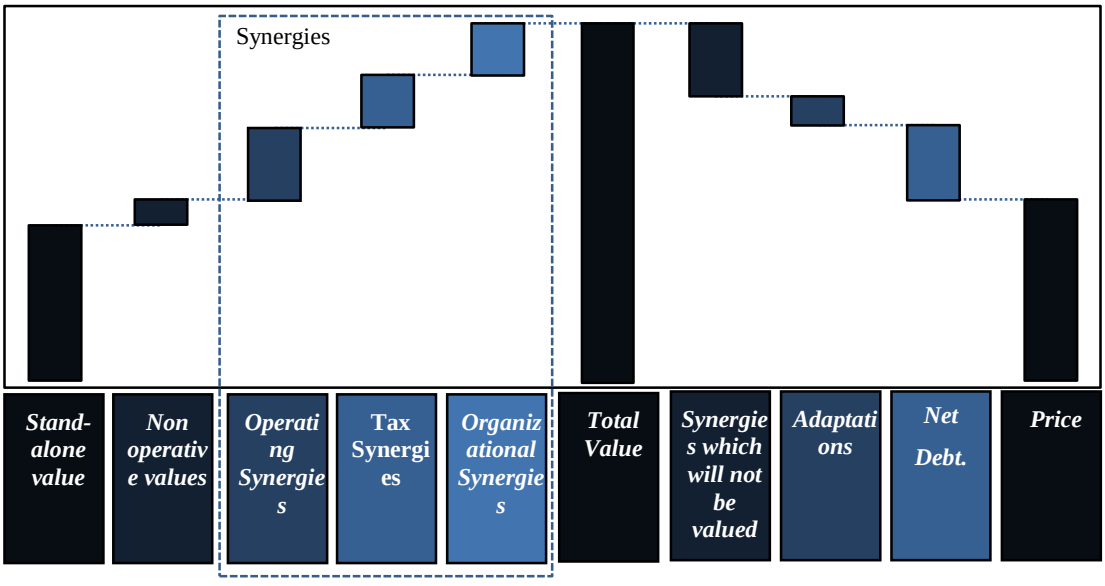

Figure 9: Purchase price setting

Based on the stand-alone value, synergies can upgrade the value of a company and negative impacts from the due diligences lower the value for the acquirer. The end of the M&A process is marked by the negotiation and drafting of a sale/purchase contract

agreement. The transaction is eventually closed by the signing of the final purchase agreements and the contracts' enforcement during the company's transfer.

2.7. Post-merger integration by the new owner

Integration as a result of a merger or an acquisition means that organizations or sub-units are combined with the objective that they result in a new, joint organization. It therefore initially comprises mainly the implementation of decisions; however, the actual merging of formerly independent organizations is often very complex and contains a high level of risk and uncertainty.

"When a firm is merged into another, its organizational structure may undergo far-reaching changes. New top management may be brought in. There may be changes and consolidations of physical plant; certain staff functions, such as accounting and industrial relations, may be consolidated into the parent organization. Thus, the management function after integration is quite certain to be different from the management organizational policy framework before"[9].

Particularly in industrial enterprises, special focus has to be put on the research and development of the organization as it has a high impact on the future competitiveness.[10] A failed post-merger integration of the research and development (R&D) organization could bring the entire company into a difficult situation. Especially in this phase it is essential to retain qualified key personnel. According to a study about the integration of R&D organizations in M&A processes by Christoph Grimme, the following selected recommendations should be taken into account[11]:

Inter-company project groups in R&D, the reciprocal exchange of personnel, the use of instruments for knowledge production and presentation, which may include knowledge databases, incentive systems for the exchange of information, and a communication policy to avoid or reduce the "not invented here" syndrome are highly

[9] Ansoff, H., Weston, F. (1962), Merger objectives and organization structure, in: Quarterly Review of Economics and Business 2 (1962), Nr. 3, page 49-58

[10] Brockhoff, K. (1987): Wettbewerbsfähigkeit und Innovation, in: Dichtl, E., Gerke, W., Kieser, A. (eds.): Innovation und Wettbewerbsfähigkeit, Wiesbaden, page 53-74.

[11] Christoph Grimme (2005): Post Merger Integration der Forschung und Entwicklung; Deutscher Universitäts-Verlag, page 310ff.

effective instruments to ensure the transfer of knowledge between the organizations and enable the targeted recombination of knowledge resources.

It is particularly important to rapidly work towards a harmonization of company cultures to make coordinating effects available and to possibly avoid culture shock. In addition to this, the participation of employees in the implementation of the new organization is one of the key factors. This can degrade the resistance in the R&D organization and generate willingness for change. Another key element is the standardization of the R&D management systems as long as they do not lead to insufficient administration.

The integration success in R&D will usually increase with an increasing degree of the product or market relationship of the two organizations. This needs to be taken into consideration during the due diligence phase.

System standardization, knowledge transfer, and overcoming personal constraints have a much higher relevance for success than the implementation of structural and process dimensions.

Especially in R&D, the focus has to be put on “soft factors” which motivate the employees to share knowledge and to support the project of integration. In addition to this, the establishment of a consistent system architecture is also essential. For these, full attention of the management is necessary.

3. Methods for technology valuation and the use in a technical due diligence:

Technology valuation refers to the assessment of a technology in the light of many different criteria in various decision-making situations. Different methods of technology assessment should be used for various decision-making situations. In this context it can be distinguished between qualitative and quantitative methods.
Methods to rate different criteria of the technology that a potential M&A target is using will be described in the present thesis. The pros and cons of a method when applying it in a technical due diligence will be assessed.
Some of the methods can be used to rate the technology of a potential M&A target in comparison to the technology of a competitor.

3.1. Pros and cons balance sheet

The method of a pros and cons balance sheet is the simplest method to compare different technologies. It collects the advantages and disadvantages and shows them as a list.

Procedure:

1. Definition of relevant criteria
2. Search for advantages and disadvantages for each technology and criteria
3. Creation of a pros and cons balance sheet

Use in a technical due diligence:

This method can be used for a very rough and fast comparison of technologies in the early stage of a DD. However, it is not suitable to make an investment decision of any kind. It can be used to exclude a technology that lags far behind compared to other technologies.

3.2. Checklists

Checklists can be a very helpful and pragmatic tool to collect relevant criteria of a decision.[12] They can be used to derive recommendations based on a qualitative survey.

[12] Wicher, H., Deubet, W.: Bewertung und Auswahl von Neuproduktideen. WiSu 20(3), page 171–176 (1991)

Depending on to which degree a technology fulfills the criteria of the questions in the checklists a ranking of technologies can be constructed. The benefit of a checklist is the flexible combination of criteria. Further it can be easily adopted and extended. Special attention needs to be paid to the questions and the number of questions addressing a certain criterion. An imbalance in the questions would lead to a overweighting of certain criteria and can therefore give a wrong picture of the technology under assessment.

Procedure:

1. Definition of criteria
2. Definition of questions
3. Setup of checklist

Use of method in a technical due diligence:

Based on the checklist, a ranking of technologies can be developed. The method can be used in the early phases of a due diligence. Based on the ranking, technologies can be sorted out. For any kind of investment decisions this method is not recommended as it is too facile.

3.3. Scoring model

The value benefit analysis is a method to evaluate multiple criteria of different strategic alternatives.[13] A number of qualitative criteria are rated by experts and can be compared with each other. It needs to be ensured that the different criteria are independent from each other. Each criterion is weighted. For practical reasons, the weightings shall add up to a total of 100. Each technology is rated by the fulfillment of each criterion. For rough assessments a rating of 1 to 3 is used. For more precise results, a scale of 1 to 5 or 1 to 10 is recommended.

[13] Burghardt, M.: Projektmanagement. Leitfaden für die Planung, Überwachung und Steuerung von Entwicklungsprojekten, 4th revised edition; Publics MCD Verlag, Erlangen (1997)

Procedure:

1. Definition of criteria
2. Definition of weightings
3. Rating of expert evaluation
4. Calculation of scores

Criterion	Weighting	Technology A		Technology B		Technology C	
		Rating	Score	Rating	Score	Rating	Score
Technical feasibility	15	2	30	5	75	2	30
Maturity level	5	4	20	3	15	3	15
Low risk	10	2	20	3	30	5	50
Technology mastery	10	3	30	4	40	1	10
Low investment costs	15	4	60	5	75	1	15
Low production costs	15	1	15	3	45	4	60
Low production complexity	10	1	10	1	10	3	30
Low risk of substitution technology	20	5	100	5	100	1	20
TOTAL			**285**		**390**		**230**

	Rating Levels				
Rating	--	-	o	+	++
Score	1	2	3	4	5

Use of method in a technical due diligence:

The scoring model can be primarily used as a structured procedure for an expert discussion about alternatives of different technologies. Further is gives a good documentation of the expert opinions and can be used as a reporting tool.

3.4. Cost-benefit analysis

The cost-benefit analysis compares the costs for realizing a technology alternative to the benefit a technology can create. For calculating the cost and benefit values, typical methods from investment analysis such as the net-present value method can be applied. It is important to ensure that all cost and benefit related items are considered including direct and indirect costs and benefits. Benefits can be for example direct advantages that can be transferred into monetary values, cost savings due to increased efficiency

of resource reduction as well as synergies with other technologies or organizations. Cost-benefit needs a strong foundation of underlying data and an experienced team.

Procedure:

1. Analysis and definition of cost and expense factors
2. Analysis and definition of benefits
3. Monetary estimation of costs and benefits
4. Calculation of the net benefit
5. List of non-monetary influence factors
6. Evaluation of the technology alternatives

Use of method in a technical due diligence:

The cost-benefit analysis is of great use if the facts to be analyzed can be easily described in monetary values. Such an example may be an investment in a machine that increases the throughput of a plant or a fuel saving technology in a car or a truck. In the latter case, the investment in the new technology can be compared to the fuel savings of the vehicles.

	Technology 1	Technology2
Investment in fuel saving technology:	1,000€	500€
Customer payback period:	5 years	5 years
Annual savings of fuel costs:	300€	50€
Net benefit:	500€	-250€
Non-monetary factor:	environmental friendliness	

The expected payback period has a major influence on the result. In case the customer would only accept a payback period of two years, both technologies would have an equal but negative net benefit. Thus, none of both technologies would be attractive to a customer.

3.5.McKinsey S-curve concept

The life phases of technology systems can be represented by an S-shaped curve. This fact is based on the systematic analysis of technology history[14]. Technologies come into existence and disappear later when a substitution technology has been developed and introduced successfully to the market.

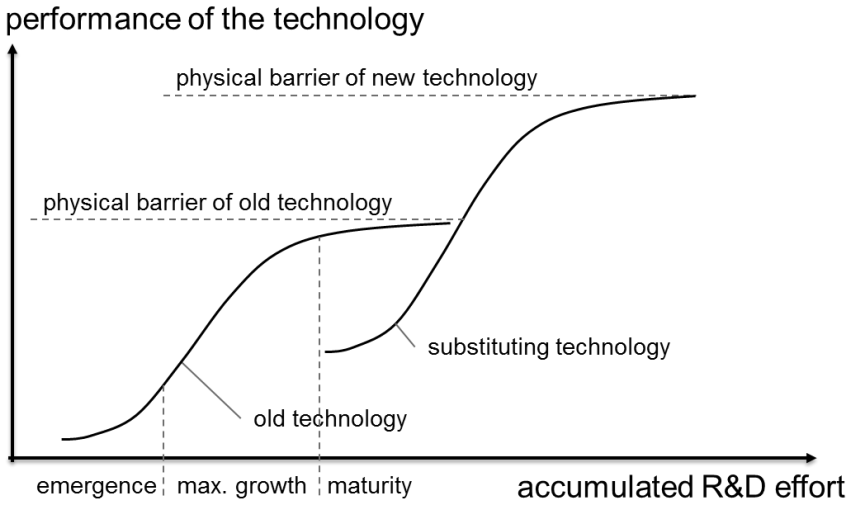

Figure 10: McKinsey S-Curve concept[15]

Use of method in a technical due diligence:

It is of significant importance to understand the lifecycles in the technology portfolio of the M&A target. The technical due diligence needs to investigate what potential lifetime the current technology has and if a substituting technology is already approaching. It can be used to predict the necessary R&D budget over the next years. In case a substitution technology is visible, the R&D budget can be shifted and expanded to the new technology at a certain time.

[14] Brockhoff K. Forschung und Entwicklung – Planung und Kontrolle R. Oldenbourg Verlag, Munich et al., 1999

[15] Krubasik, E.: Technologie - Strategische Waffe, in: Wirtschaftswoche, 25/1982, page 28-32.

3.6. Gartner hype cycle

The Gartner hype cycle is a model that describes how new technologies are emerging almost unnoticed, then there is a substantial public interest which decreases abruptly after first disappointments and reaches a realistic level with sustainable growth. Gartner assumes that such a behavior is a natural human reaction to new technologies.

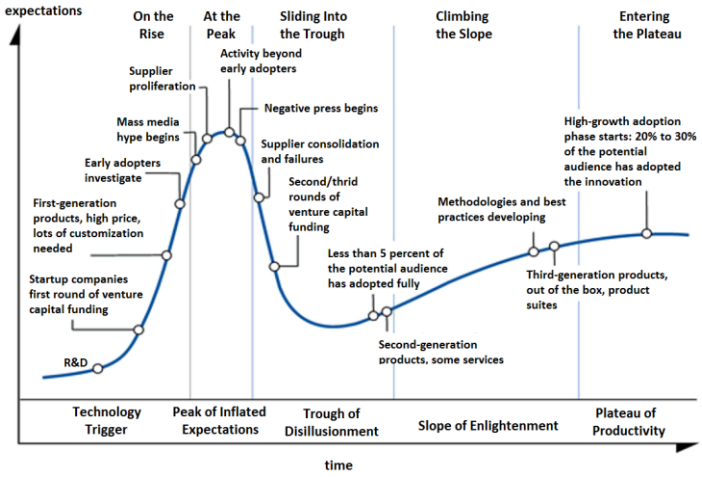

Figure 11: Gartner hype cycle [16]

Phase 1: Technology Trigger:

A scientific breakthrough, a promising product launch or a similar event ensures first press reports on the technology and triggers significant publicity. The technology then receives attention from outside of a narrow circle of specialists. Usually products are not commercially available and viability is unproven.

Phase 2: Peak of Inflated Expectations

The mainstream press starts writing about the new technology in a superficial manner. Some success stories lead to exaggerated expectations of what the technology is able to provide. Although there are a number of successful applications, the vast majority of projects fail and the crash begins.

Phase 3: Trough of Disillusionment

Because of unfulfilled expectations and the many failures, the technology is unpopular. For the press, the interest on technology wanes and reporting is stopped. Investments

[16] https://en.wikipedia.org/wiki/Hype_cycle; 16.06.2015, 13:52

continue at some companies which are able to improve their products to the satisfaction level of early adopters.

Phase 4: Slope of Enlightenment

Although the press coverage has faded, some companies work on the advancement of technology. A more realistic view on the cost/benefit ratio of the technology is available. New successful applications are introduced. The press starts to perceive this.

Phase 5: Plateau of Productivity

The practical performance of the technology can be demonstrated in a growing number of applications and will eventually be widely accepted. The final level of visibility and attention levels depends on whether the technology can be used only in niche markets or also in mass markets.

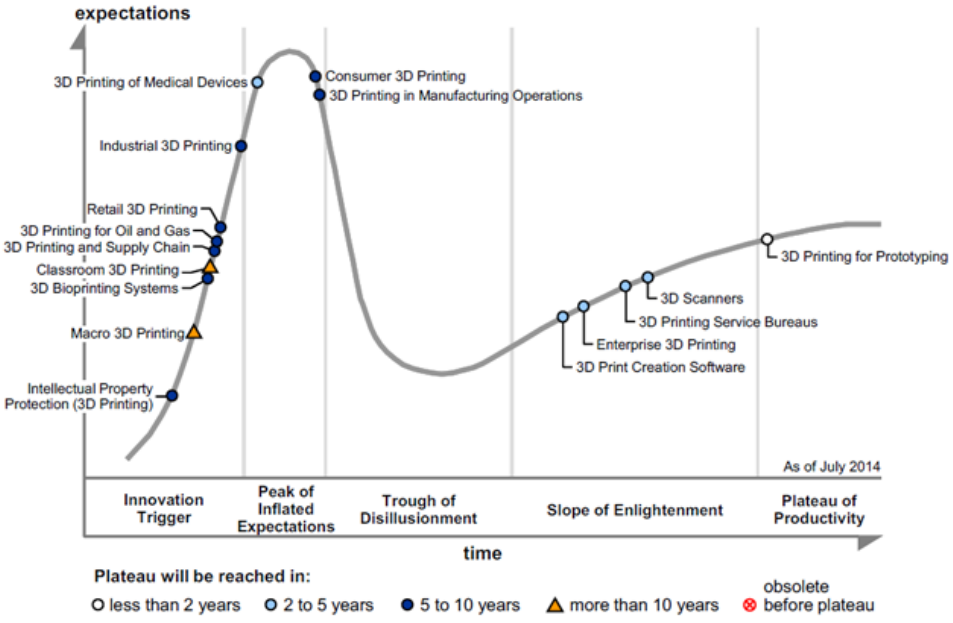

Figure 12: Gartner hype cycle for 3D printing[17]

Use of method in a technical due diligence:

Each technology in the portfolio shall be inserted into a Gartner hype cycle graph in order to have a realistic expectation of the technology. Also potential substitution technologies shall be shown. Good information on popular technologies is available at

[17] Gartner Says Consumer 3D Printing Is More Than Five Years Away http://www.gartner.com/newsroom/id/2825417; 16.06.2015, 13:52

consulting firms as shown in Figure 12. In the case of business to business products data are rarely available and need to be assessed by experts. This approach limits the risk of overestimating a technology during the peak of inflated expectations. Companies are usually strong in some phases of the Gartner cycle, but have difficulties to cope with technologies especially in the early phases as the market dynamics are very different in this phases. Depending on the buyers and the company's strength the value of a technology at the M&A target can be highest in different phases.

3.7. Technology readiness Levels

Technology readiness levels[18] indicate the maturity of a technology. Level one is a first indication of a technology principle and level nine indicates a fully developed technology already applied in series production.

TRL	Description
1	basic principles observed
2	technology concept formulated
3	experimental proof of concept
4	technology validated in lab
5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7	system prototype demonstration in operational environment
8	system complete and qualified
9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

[18] "Technology readiness levels (TRL)" (PDF). European Commission, G. Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)

Use of method in a technical due diligence:

Technology readiness levels shall be defined for each technology development project of a company. This gives a good indication of when new products will enter the market and if the development project portfolio is balanced or has a focus on early or late phases. In case the project portfolio has a focus on higher TRLs, this could indicate a lack of innovation performance in the organization. A concentration on early TRLs could indicate the risk of having a lack of new products in the next years and the need of high investments in R&D.

3.8. Technology portfolio by Arthur D. Little

The method of Arthur D. Little (ADL) to evaluate a technology portfolio takes into account that business and technology cycles are not fully conform.

An analysis of the technological and competitive positions of the strategic business areas as well as the position in the lifecycles of technologies and the respective industries is taken into account. The technologies are rated in terms of the dimensions of the portfolio, the technology lifecycle and the relative technology position.

To evaluate the dimension technology lifecycle technologies are divided into the phase's emergence, growth and maturity. This classification shows the remaining differentiation potential of technologies .The second dimension describes the relative technology position, the strengths and weaknesses of the company with respect to its R&D resources and its know-how position in relation to the competitors divided into the categories weak, favorable and strong. Strategy recommendations are distinguished between early and later technology development stages in the technology lifecycle. In the early stages, the technology dimension has increased priority as the company has more scope for action.

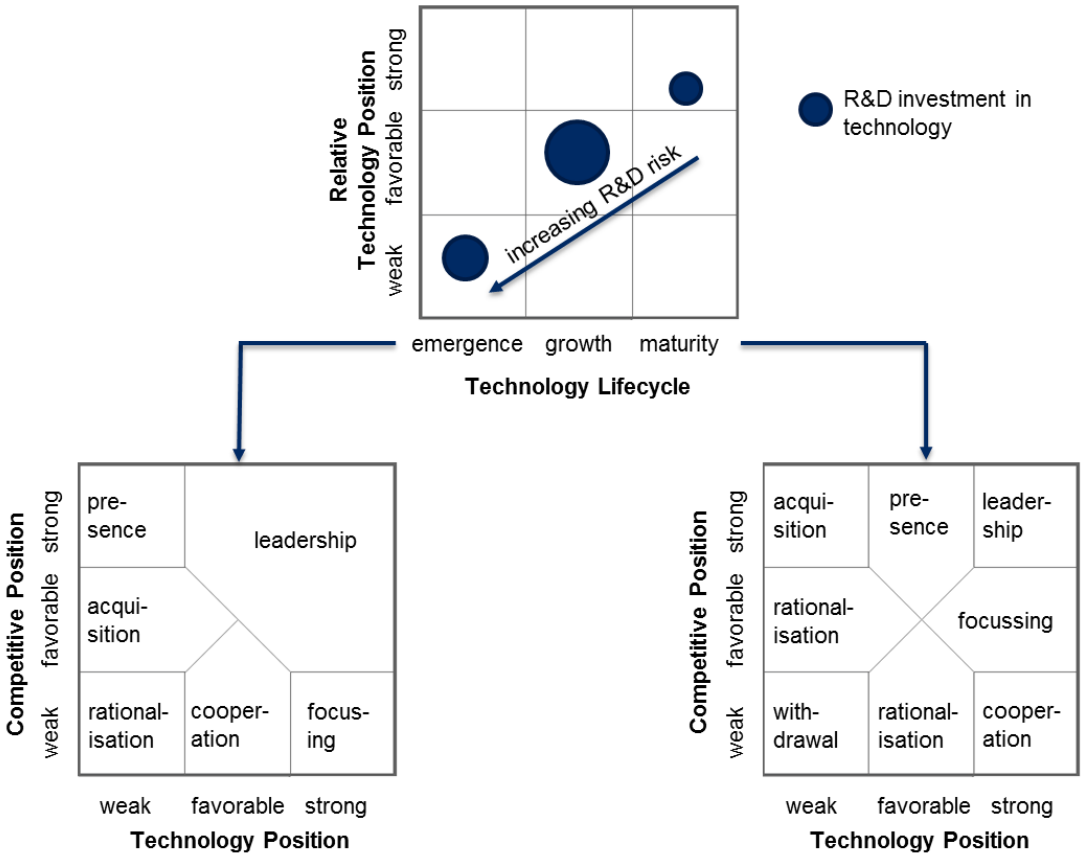

Figure 13: Technology portfolio by Arthur D. Little[19]

Use of method in a technical due diligence:

Each technology of an M&A target shall be listed in the ADL portfolio matrix. The strategies and recommended actions shall be analyzed and compared to the R&D organization of the M&A target. Further it shall be compared to the R&D strategy and strength of the buying company. An ideal fit would be if the buying company has a strength and experience in the field of actions from the ADL matrix and can maybe close gaps. If no synergies can be found or the technology portfolio is totally different to the buying company, an increased risk in R&D needs to be considered.

[19] Wolfrum, B.: Alternative Technologiestrategien. in: Zahn, E. (eds.): Handbuch des Technologie-Managements. Schäffer-Poeschel. Stuttgart. 1995

3.9. Technology portfolio by Pfeiffer

The approach considered by Pfeiffer[20] is based on the two dimensions technology attractiveness and resource strength. It assumes that in case of expanding emergence cycles and at the same time contracting market cycles an innovator can always achieve a significantly higher turnover than the imitator. Therefore it is recommended to invest early in relevant technologies and to follow a pioneering strategy.

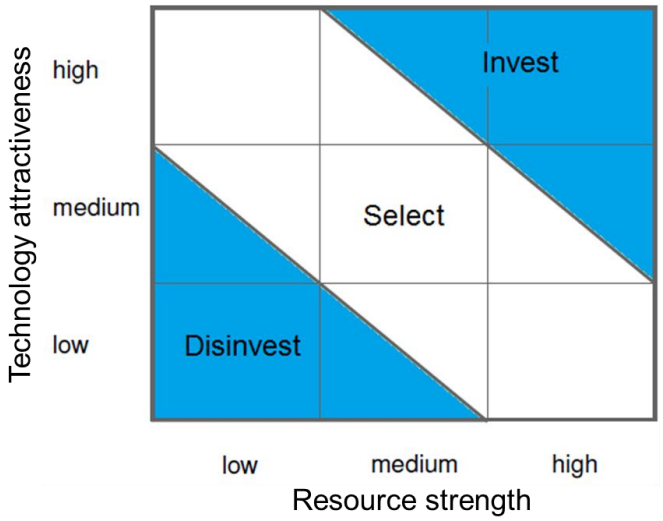

Figure 14: Technology portfolio by Pfeiffer

Influence factors of technology attractiveness:

- Technology potential
- Application range
- Compatibility

Influence factors of resource strength:

- Know-how
- Financial resources
- Agility and responsiveness

[20] Pfeifer, W.: Technologie-Portfolio zum Management strategischer Zukunftsgeschäftsfelder, 6th edition. Vandenhoeck und Ruprecht, Göttingen (1991)

The attractiveness of the technology is further based on three indicators:
Technology potential: To what extent does a technical advancement increase in performance and / or is cost reduction possible?
Application range: What is the number of possible applications of the technology?
Compatibility: What positive or negative effects can be expected in user and peripheral systems (barriers to innovation, driver)?
The resource strength indicates to what extend the M&A target is able to develop the technology further and to bring it to a success:
Know-how: What is the know-how level of the company compared to competitors?
Financial resources: What are the financial and investment resources to exploit the potential of a technology?
Agility and responsiveness: How fast can the company apply the new technology and benefit from it?
Use of method in a technical due diligence:
The approach of Pfeiffer needs to be used to define the R&D investment strategy. It needs to be ensured that sufficient financial and human resources are available or can be obtained. Information of the competitors needs to be gathered in order to ensure a successful technology leader and pioneering strategy. If the resources strength cannot be achieved, this could be a showstopper for a M&A.

3.10. Technology portfolio by Booz, Allen & Hamilton

In the portfolio approach of Booz, Allen & Hamilton[21] technology investments and corporate strategy are interrelated. The relevant technologies are listed for each business line and placed in the portfolio. The aim is to identify investment priorities based on the actual technological situation in the business segment.
An analysis of four steps is used. First, the technological situation is assessed. For this, the competitive landscape of the technology is analyzed. Second, the portfolio is developed based on the criteria “relative technology position” and “importance of

[21] Booz, Allen & Hamilton: The role of technology in the 1980s: will it depend on dollars or sense? – The result of a 1981 Booz-Allen survey. In: Booz, Allen & Hamilton. (eds.) Outlook, Nr. 5, S. 29–32 (1981)

technology". To estimate the relative position of a technology R&D spending, the number of patents and the capabilities of the R&D organization are rated. For "importance of technology", the added value, alteration rate and market attractiveness is used. As a third step, the consistency between technology and business strategy is analyzed. This is supposed to help to prevent discrepancies and to detect them early.

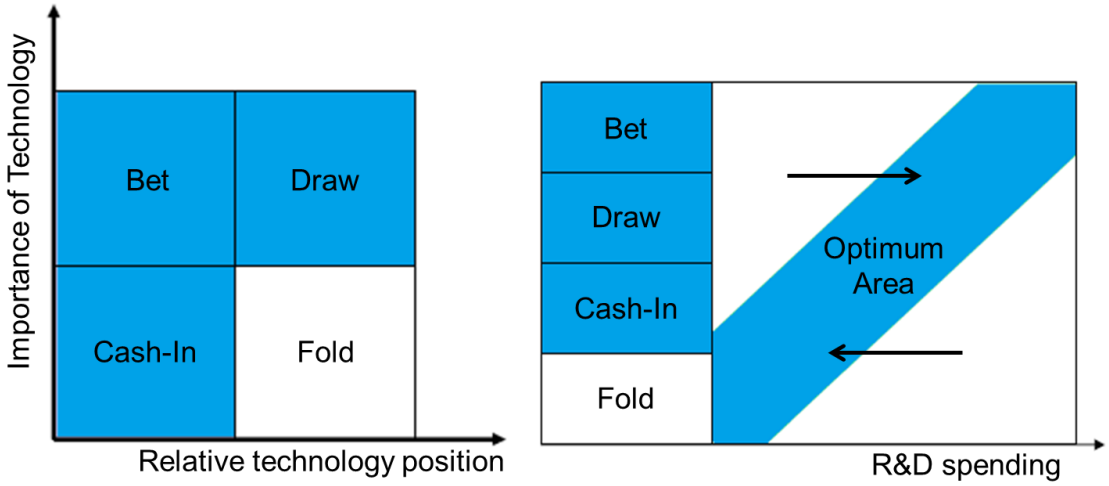

Figure 15: Technology portfolio by Booz, Allen & Hamilton

Influence factors for technology importance:

- Added value
- Alteration rate
- Market attractiveness

Influence factors for the relative technology position:

- R&D expenditure
- Number of patents
- Number of employees

As a last step, the recommended actions are derived from the model. Based on the importance of technology and the relative technology position "Bet", "Draw", "Cash-In" or "Fold" is recommended.

Use of method in a technical due diligence:

Technologies which have a good relative technology position and a high significance ("Bet") have a very high priority for a company since competitive advantages should be maintained or expanded. In case a technology is in the "Draw" field (technologies

with poor relative position but high importance) it is necessary to find out whether a position improvement can be achieved, or whether it is possibly better to invest in other technologies. Due to the low significance of technologies in the two fields "Fold" and "Cash-In", R&D expenses should be cut. Based on the rating of a technology and its positioning in the matrix the investment in R&D spending is recommended according Figure 15.

During the M&A process the product strategy is reviewed. The technology matrix by Booz, Allen & Hamilton can be used to derive strategic actions and analyses whether the R&D resource allocation is done optimally.

3.11. Portfolio matrix by McKinsey

The McKinsey technology portfolio matrix[22] is rating the technological potential of products and production processes in a quantitative way. The basis is the "S-curve concept" which describes the trend of a technology performance over time (see section 3.5.).

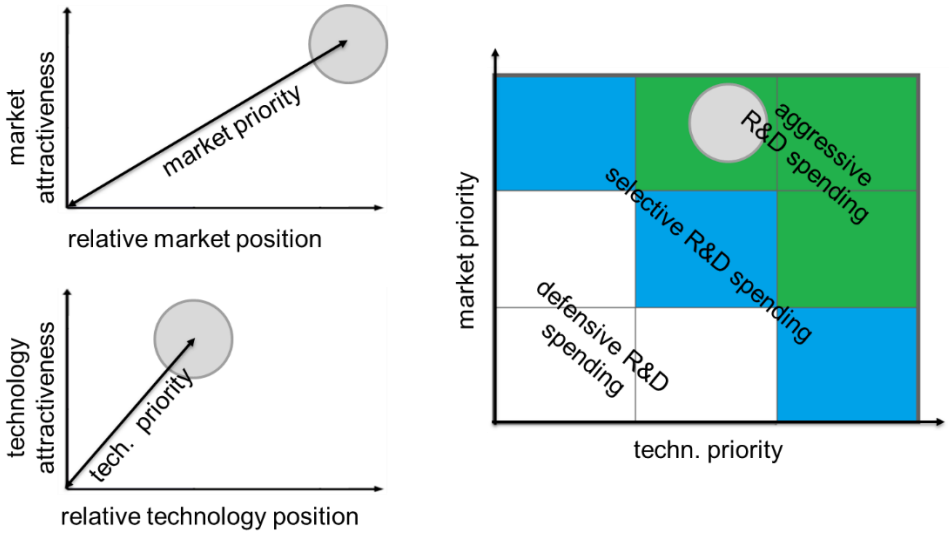

Figure 16: McKinsey portfolio matrix

The first side of the matrix shows the market priority. It considers the market attractiveness and the relative market position of a business unit. The other side of the matrix shows the technology priority which considers the technology attractiveness and the relative position of the technology used in the considered business unit. It shall

[22] Wolfrum, B.: Strategisches Technologiemanagement, 2nd edition, Gabler, Wiesbaden (1994)

take into account the technological potential in comparison to the competition as well as the potentially available resources for R&D. The business unit and its technology under evaluation need to be placed in the market priority chart as well as in the technology priority chart. The further to the upper right the technology is placed, the higher is its priority. The combination of the two priorities in the matrix defines the field for strategic actions. Based on this field, recommendations are given on how to apply R&D resources and spending.

Procedure:

1. Identify technologies
2. Rate the market and technology priorities
3. Combine priorities in the portfolio matrix
4. Derive R&D spending

Use of method in a technical due diligence:

The McKinsey Matrix is a useful tool in order to see how the R&D budget is spent optimally. It gives a good indication of how the R&D projects shall be prioritized and can be used as a basis for the R&D resource planning.

3.12. Machine hourly cost rate

In order to evaluate the production technology a machine cost analysis is conducted. It takes into account all costs related to a machine or a process step, divided by the number of hours a machine is used. All cost types including depreciation are considered. In order to evaluate the effective use of the machine, only the load hours of the machine are considered. The calculation does not consider idle times, maintenance or off time. The hourly cost rate of a machine allows a comparison of a machine use to a benchmark.

Procedure:

1. Evaluation of the total costs of a machine or process step
2. Evaluation of load hours per year
3. Calculation of the machine hourly cost rate
4. Benchmark the hourly cost rate

Use of method in a technical due diligence:

The method can be applied to get a good understanding of the level of technology and capability in production a company has. In case the technical due diligence is done for a company with a similar or the same technology as the buying company, the method can be used to compare the own hourly cost rate to the cost rate of the M&A target. The analysis shall be done for all machines and process steps to get a good understanding of the strengths and weaknesses in the production technology of the target.

3.13. Payback method

The payback method[23] is a very simple approach to analyze the payback period of an investment or a project based on the profits it creates. It gives the number of time periods which it takes for the positive cash flow to equal the amount of the initial investment.

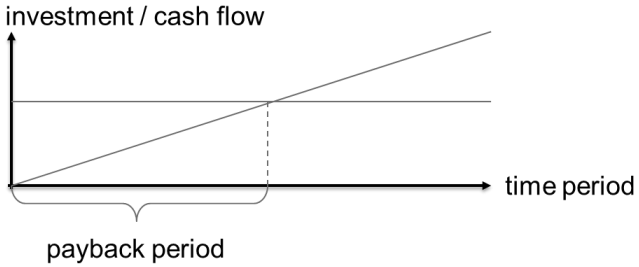

Figure 17: Payback method

For simplicity reasons average values are used. In order to get more precise results detailed costs and a detailed cash-flow calculation can be applied. Further the interest of the invested capital can be taken into account to increase precision. The payback method does not take into account the cost of capital. Thus, it does not show the true break-even year. A discounted payback calculation needs to be applied to consider the costs of capital. Still, it disregards the cash flows beyond the payback year which might lead to a poor choice.

Use of method in a technical due diligence:

[23] Joseph D. Andrew: Financial Management; Principles and Practice, Prentice Hall; 3rd edition (August 1, 2002); page 265

Taken investments into technology can be roughly evaluated whether they have paid off already. Forthcoming investments can be evaluated.

3.14. Discounted cash flow method

The discounted cash flow or net-present value method sums up the cash flow that a technology creates over its lifecycle[24]. It is based on the estimation of free cash flows from the technology and a discount rate to apply to the projected cash flows[25]. Simplified, the net-present value (NPV) specifies the present economic value (PV) of a technology minus the initial invest (I).

$$NPV = PV - I$$

A more precise net-present value takes into account the periodic cash flows (CF), the discount rates and the cost of capital with reference to the present. The cash flows are expected values calculated on the basis of objective indicators and subjective management estimations.

$$\sum_{t=1}^{T} \frac{CF_t}{(1 + WACC)^t}$$

As discount rate to discount the cash flows, the weighted average cost of capital[26] (WACC) is considered. They represent the minimum rate of return of a technology investment that is to be provided from the perspective of investors. The WACC can be calculated as a weighted average of capital cost of equity and debt. The debt costs are to be reduced with their tax advantage. A positive NPV indicates that the planned technology investment is expected to create an economic value. A negative NPV suggests that the present value of the technology is less than the amount invested. The investment would therefore be economically useful. In case of several technology alternatives, the alternative with the highest net-present value would be preferable.

[24] Razgaitis, R.: Valuation and Pricing of Technology-Based Intellectual Property. Wiley Verlag, Hoboken (2003)

[25] Brigham E.: Fundamentals of Financial Management; Birgham Houston; page 662

[26] Brigham E.: Fundamentals of Financial Management; Birgham Houston; page 307

3.15. Decision tree analysis

The decision tree method is based on the assumption that in the course of the technology lifecycle decisions must be made repeatedly. These decisions need to be consistent with the environment at the moment of the decision. Decisions are therefore made when they reveal information about the environment. Based on the financial option pricing theory, approaches were taken from five basic types of options which are available to the decision-makers[27].

Deferral option: the decision for or against an investment before the start of or a delay during the project.

Option to extent: the duration of the project may be extended by an additional payment

Option to expand: the project can be increased by additional investments

Option to contract: the project can be reduced by partial sale at a fixed price

Option to abandon: the project can be sold during the term at a fixed price

Switch option: alternating between two types of projects

The options are shown in a decision tree. For the phases and work packages it is useful to set the decision points along the innovation and technology development process[28]. For the decision tree different factors can be applied such as yes/no questions or quantity values such as cash flow. Each state node must be assigned a probability (p) of occurrence as shown in the following figure.

[27] Copeland, T., Antikarov, V.: Realoptionen. Das Handbuch für Finanz-Praktiker. Weinheim (2003)

[28] Herstatt, C.; Verworn, B.: Management der frühen Innovationsphasen – Grundlagen – Methoden – Ansätze; 2003, page 23

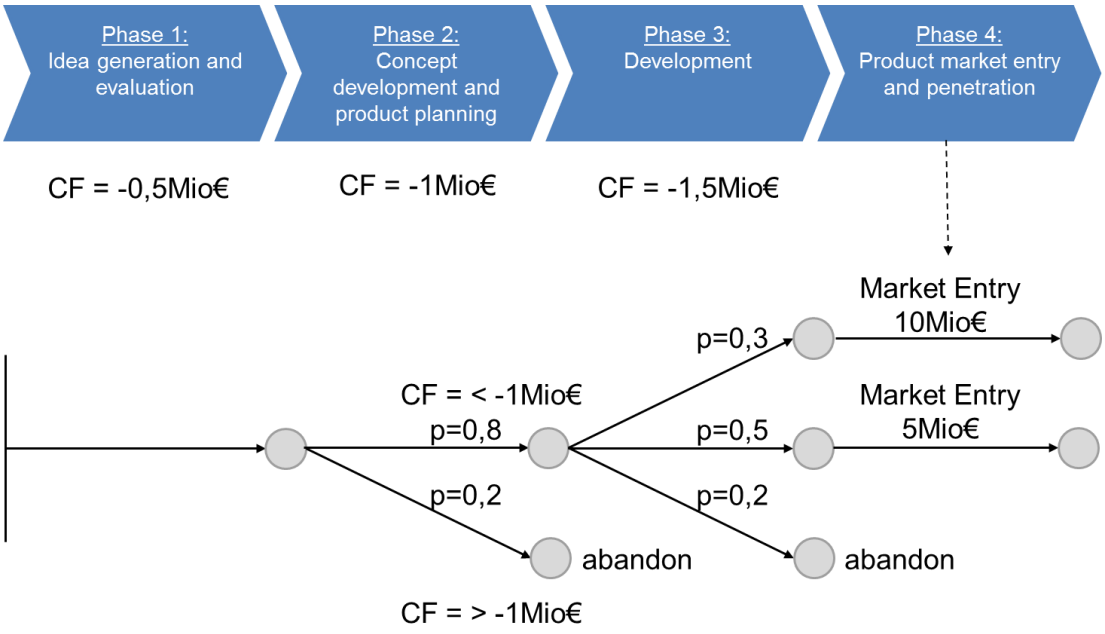

Figure 18: Stage-gate-based decision tree

Use of method in a technical due diligence:

During a technical due diligence, a decision tree model can be set up. Different scenarios in the technology development can be developed for the target company. It also gives important inputs to the risk evaluation and risk management.

3.16. Real options method

Development of technology has a risk of failing. It is hard to predict a detailed development plan and to stick with it. Many times the plan has to be adopted due to new insights which are explored during the development process. Thus project and business plans need to be flexible and subject to change. Real option models evaluates the flexibility of a technology, which allows the manager to adjust the strategy in the uncertain high-tech environment. Beyond the appeal for investment valuation, the real option method provides hidden values in technology investments.

In contrary to a discounted cash flow method, it assumes that managers will take flexible decisions over time and do not irrevocably stick with the status quo. The higher the uncertainty in the technology, the higher is the value of the ability of managerial flexibility.

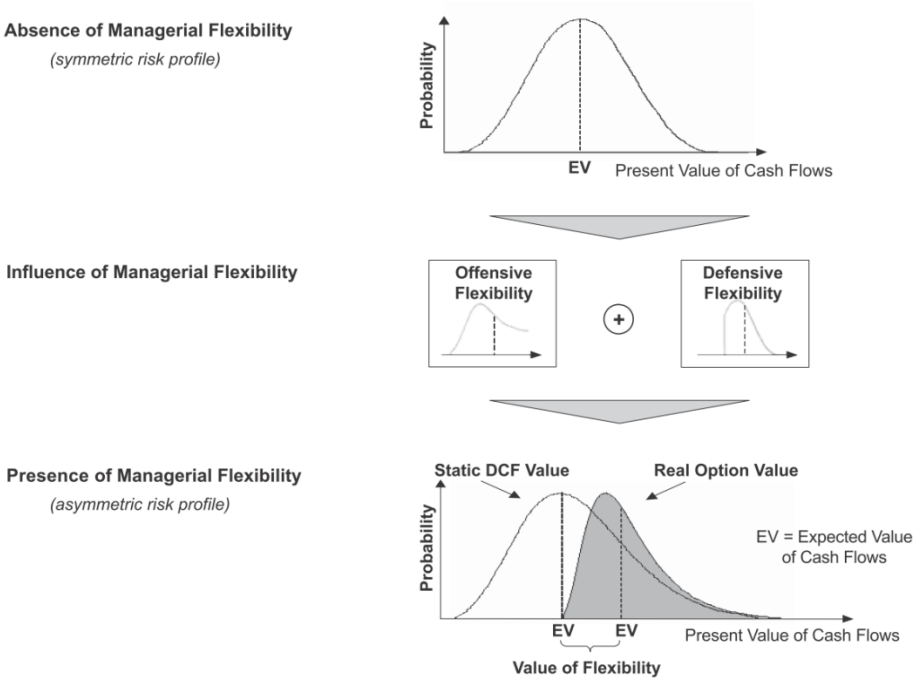

Figure 19: Value of managerial flexibility[29]

As the method is somehow more complicated than the usual methods used for technology evaluation it is recommended to use existing toolkits.

Procedure[30]:

1. Determine the key options for valuation
2. Calculate the discounted cash flow model
3. Map uncertainty in an event tree
4. Model managerial flexibility by adding decision notes
5. Calculate the real option value with a toolkit
6. Review and test results validity and stability

Use of method in a technical due diligence:

Technologies that are covered of under development at an M&A target can be used in various ways. Further, technologies can be applied in different industries, products or regions. This can create a high potential in the company of a certain technology. With the real option method this matter can be addressed and taken into account during the due diligence phase.

[29] Eichner T. et al. What is Technology Worth? The journal of investing; fall 2007; page 98

[30] Eichner T. et al. What is Technology Worth? The journal of investing; fall 2007; page 99

3.17. Performance indicators

Performance indicators allow to show the economic values of investments. A very common performance indicator is the return on investment (ROI) method. It calculates the profit of the necessary investment to realize a technology. The ROI is defined hereinafter by dividing the net profit by the total investment.

$$ROI_{(\%)} = \frac{gain\ from\ investment - cost\ of\ investment}{cost\ of\ investment} \times 100$$

It can be used both for the economic evaluation of entire companies or business units as well as of individual investments in a certain technology. In the assessment of technology investments it must be ensured that only the shares of profit dedicated to the technology and the dedicated invested capital are taken into account. When choosing between several alternatives, the one with the highest ROI is preferable.

Similar to the ROI, the "Return on Capital Employed" (ROCE) can be used to evaluate the economic value. In contrast to the ROI, ROCE takes into account the long-term employed capital.

During the last years a new performance indicator has become mainstream: the "Economic value added" (EVA). It takes into account the net operating profit after tax (NOPAT) and the weighted average cost of capital (WACC).

$$EVA = NOPAT - WACC$$

EVA takes into account that an investment which is earning exactly its cost of capital has the value of exactly its amount of investment. This means it measures how much an investment has added to shareholder's wealth by showing the value created in excess of the required return of the company's investors.

The internal rate of return (IRR) is an indicator that shows the advantages of a technology investment versus the expected return. It calculates the interest rate of when the net-present value is exactly zero.

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1 + IRR)^t} - I = 0$$

Use of method in a technical due diligence:

Performance indicators are part of a holistic accounting system. Depending on what performance indicators the buying company is used to, the same indicators shall be

used in the due diligence. This ensures that the performance indicators are well known and leads to a meaningful comparison with the M&A target in the decision process.

Performance indicators for technology:

Similar to KPIs in financial aspects performance indicators for technology and production are also widely used. Just a few shall be mentioned here to give an example.

Engine power density	$\frac{Engine\ power}{Engine\ weight}$	$\frac{kW}{kg}$
Transmission torque density	$\frac{transmission\ input\ torque}{transmission\ weight}$	$\frac{Nm}{kg}$
Pressing speed	$\frac{strokes}{time}$	$\frac{1}{min}$
Growth rate for a coating technology	$\frac{thickness\ of\ coating}{time}$	$\frac{mm}{h}$
Production tact time	$\frac{net\ time}{units\ produced}$	sec

3.18. Evaluation of IP protection

The technical due diligence aims to evaluate the value of the existing patents and patent portfolios. Additional value can be created in case the M&A target has a better patent strategy than the buying company.

The following dimensions need to be taken into account when valuating patents:

- Market and competitor information
- Research and development (technical risks, resources, investments, time)
- Production criteria (capacities, manufacturing costs)
- Fit criteria (synergies with other products, follower technologies)
- Legal issues (patent lifecycle, coverage, dependencies and regional factors)

one-dimensional evaluation	two-dimensional evaluation	three-dimensional evaluation
patentvaluation Gassmann/Bader	evaluation acc. to Ernst	evaluation acc. to Brockhoff
rating method Bader	evaluation acc. to Kucjartz	evaluation acc. to Faix
rating method Barney	evaluation acc. to Pfeifer et. Al.	evaluation acc. to Hofinger
rating method Breitzman / Narin	evaluation acc. to Poredda/Wildschütz	evaluation acc. to Schulze
rating method Ernst / Omland	comparison of exp. value	evaluation acc. to Wurzer

Figure 20: Overview on patent evaluation methods[31]

Many different methods are available to valuate patents in quantitative and qualitative ways. The more different approaches an evaluation method takes into account, the more dimensions it has. In Figure 20 a list of different methods grouped by the number of dimensions can be found. Since the due diligence is very time critical, a patent evaluation method for that particular use needs to be fast and efficient. As an example for the single patent evaluation, the method by Gassmann/Bader is introduced here as it is a very practical approach and can be performed with a reasonable effort within the due diligence phase as shown in Figure 21.

More comprehensive objective evaluation methods are provided by professional patent consulting firms. Objective criteria used have been derived from empiric indicators. In statistical studies the correlation of these criteria has been proved.

Use of method in a technical due diligence:

In case the patent situation is a critical and decisive factor for the M&A deal a professional patent consulting firm needs to be involved from the first day in the technical due diligence.

[31] Gassmann O.; Bader M.; Patentmanagement-Innovationen erfolgreich schützen; 3rd edition; Springer, 2011 page 69

Criteria	Score
Possibilities for bypassing and workarounds not possible 5..6 Possible with a huge effort 2..4 Easy to bypass 0..1	…
Attractiveness to use for competitors Very high 5..6 Average 2..4 Low 0..1	…
Possibility to evidence infringement by competitors Easily possible 5..6 Average 2..4 Not possible 0..1	…
Use of protected technology Very likely to use 5..6 Not decided yet 2..4 Not very likely 0..1	…
Related patent portfolio is too small 5..6 appropriate 2..4 too large 0..1	…
Other criteria Basis for a future technology or product … Support sales organization … Advantage in contract negotiations … Part of official standard … Others …	…
TOTAL	…

Figure 21: Patent evaluation according to Gassmann[32]

3.19. Direct competitor comparison

It is essential to have a clear picture about the competitiveness of technologies of a potential target firm. Thus, each technology should be assessed in comparison to the competitors. Performance indicators are defined for each technology which are compared to the competitors' indicators one by one.

[32] Gassmann O.; Bader M.; Patentmanagement-Innovationen erfolgreich schützen; 3rd edition; Springer, 2011; page 71

4. Applying the methods in a holistic technology evaluation model

During working on the present thesis, a model was set up to introduce a tool that fulfills the requirements for decision making in a technical due diligence of an M&A process. As a due diligence process is very time critical, a compromise between accuracy and effort and time consumption needs to be made. Further, the model described should give a better validity than the approaches used today as described in section 2.5.4.

4.1. Requirements of a technology evaluation model

The following requirements shall be fulfilled by a technology evaluation model:

- Low time consumption in applying the model
- Accuracy
- Flexibility to add assessment criteria
- Predicts the future potential of a technology
- Gives a monetary valuation of a technology
- Easy to understand and easy report of results
- Allows for good comparison between competitors
- Allows to assess technology strategy
- Allows to select/reject a technology
- Evaluates production and manufacturing criteria
- Evaluates the investment intensity of a technology
- Evaluates the technology portfolio of a target
- Evaluates the technology readiness of technologies

Figure 22 shows a suitability matrix of methods described in section 3 for the requirements in the list above. Based on this matrix the method for each criterion is selected.

Methods	pragmatic, low effort	Accuracy	Flexibility to add assessment criteria	Predict the future potential of a technology	Gives a monetary valuation of a technology	Easy to understand and easy report	Comparison between competitors	Assess technology strategy	Select / reject a technology	Evaluate production & manufacturing criteria	Evaluate investment criteria	Evaluate technology portfolio of a target	Technology Readiness of technologies
Pros and Cons Balance Sheet	●	◔	●	◑	○	●	●	◑	◔	○	●	◔	◔
Checklists	●	◔	●	◔	○	●	◕	◑	◕	●	●	◑	●
Scoring Model	●	◔	●	◔	○	◕	●	◑	◑	●	○	◑	●
Cost-Benefit Analysis	◕	◑	●	◑	◑	◕	◑	○	◔	◑	◑	○	○
McKinsey S-Curve Concept	◕	◔	◕	◕	○	◑	○	◔	◔	○	○	◑	◕
Gartner Hype Cycle	◕	◔	◕	◕	○	◑	○	◔	◔	○	○	◑	◕
Technology portfolio by Arthur D. Little	◑	◑	◔	◕	○	◔	◑	●	◕	○	○	●	○
Technology portfolio by Pfeiffer	◑	◑	◔	◕	○	◔	◑	●	◕	○	○	●	○
Technology portfolio by Booz, Allen & Hamil	◑	◑	◔	◕	○	◔	◑	●	◕	○	○	●	○
Portfolio Matrix by McKinsey	◑	◑	◔	◕	○	◔	◑	●	◕	○	○	●	○
Machine Hourly Cost Rate	◔	◕	◔	◑	◔	◕	●	○	○	●	●	○	○
Pay-back Method	◔	◕	◔	◕	◑	◕	●	○	◔	◑	●	○	○
Discounted Cash Flow Method	◔	●	◔	◕	●	◑	●	○	◑	◔	●	○	○
Decision Tree Analysis	○	◕	◑	◕	○	◔	○	◕	◕	○	○	◑	◔
Real options method	○	●	◑	●	●	○	●	○	◕	◔	●	○	○
Performance indicators	◔	◕	○	◔	○	◑	●	○	◑	◔	◕	○	○
Evaluation of IP Protection	◕	◑	●	◑	○	●	○	○	◔	○	○	◑	●

Figure 22: Suitability of methods

The value of a technology is influenced by many factors. Some of them are inherent in the technology but many criteria are to be seen in the context of the organization that uses the technology. The latter criteria are significant in an M&A process as they can give the decisive advantage for a buyer compared to potential co-bidders. Consequently, an evaluation model needs to have the flexibility to be easily adapted to additional requirements. Still the reporting scheme should be the same to make it easier for the management to understand it and compare it with other or former cases. The model should allow for combining different methods as flexibly as possible. This raises a significant issue as some methods give a qualitative rating while others give a quantitative rating. Thus, the model should be able to address both and make quantitative and qualitative methods somehow comparable. Figure 22 shows the strengths and weaknesses of different methods. In order to address the mentioned requirements a "scoring model" as described in section 3.3 shall be used for the framework of the evaluation model. The following main criteria can be used a generic basis for the evaluation of a technology.

- Technology (each technology is rated separately)
- Technology Portfolio
- R&D Organization
- R&D Processes
- Synergies with Buying Company
- Production
- Strategic Options

These criteria can be used as a core model that should fit the most requirements on technologies in a producing high-tech industry. Other criteria can be added in order to address special questions that are decisive for a special TDD case.

As different methods shall be used for each criterion, it is necessary to find a system that allows for have a direct comparison of the ratings and results from the different methods. Further, the outcome of the technology evaluation should give a clear indication of the value of the technology in context to increase or decrease the value of a company. This means the price premium or discount a buyer would take into account during the bidding and negotiation phase. Another requirement of the model

is to allow for a monetary valuation of a technology. Giving a monetary value for a technology has a high risk to take the number as fixed value and people tend to believe in it as given, which would be misleading. It certainly needs to be understood by the due diligence team that it is still a best guess approach. On the other hand, it helps during the rating process, especially in expert discussions, by being able to compare with investment and change management cases from the past. Moreover, its impact on the price of the company has to be calculated which will be done in monetary values.

4.2. Selecting the method for the evaluation model

Based on the evaluation of strengths and weaknesses of different methods according to Figure 22 a scoring model as described in section 3.3 is selected for the evaluation of the main criteria. It can be used with reasonable effort and allows for a very pragmatic approach. It has a high flexibility to address different criteria and compare them with each other. It can be easily understood and makes it possible to condense information for reporting. Also, a comparison between different technologies and companies or competitors can be drawn. The scoring model is widely used to evaluate production and manufacturing capabilities and is therefore a well-known and accepted tool in many organizations. The inaccuracy of a scoring model is countered by using more precise methods for each criterion. Further, it shall be extended to derive monetary values from the model. This extension makes it also possible to set up different scenarios for price negotiation. For example it is possible to include or take out assets such as licenses or tangible assets easily.

4.3. Explanation of the model

The model uses the company value from the financial analysis as a basis and gives an upgrade or downgrade of the value based on the technology ratings. To get the basic company value, a discounted cash flow method, as described in section 3.14., is used. Alternatively, other valuation methods can be used which might give a better indication of the company value in a highly dynamic market or for startups. As a second input value the “Maximum Technology Leverage” is estimated. It indicates the maximum impact a technology can have on the company value. It is defined as a

percentage of the financial analysis's result. The exemplary model shown in Figure 23 includes the main criteria as listed:

- Technology (each technology is rated separately)
- Technology portfolio
- R&D organization
- R&D processes
- Synergies with buying company
- Production

Weighting of main-criteria:

Each of these main criteria is given a weighting to estimate the impact on the technology value ("Weighting Main Criteria"). The weightings of main criteria shall sum up to 100%.

Weighting of sub-criteria:

Each main criterion has one or more sub-criteria. Each of these sub-criteria has a weighting that indicates the relevance and contribution to the main criteria. For the weighting of the sub-criteria, 100 percent shall be distributed across the sub-criteria within one main criterion.

Rating of sub-criteria:

On sub-criteria level the precise rating is done. For qualitative methods a rating shall be done by selecting between five levels of contribution to a technology (--/-/o/+/++). The reference for the rating is the average in the industry. The positive or negative deviation from this average shall be indicated in the rating process.

--	Criterion is significantly lower than industry average.
-	Criterion is lower than industry average.
o	Criterion is on industry average level.
+	Criterion is above industry average.
++	Criterion is significantly higher than industry average.

Contribution of sub-criteria to the total value:

The maximum impact on the company value of a sub-criterion is calculated by multiplying the maximum technology leverage, the weighting of the main criterion and the weighting of the sub-criterion.

$$Max.Value\ SubCriterion_{(\%)} = Max.Technology\ Leverage_{(\%)} \times Weight.Main\ Criterion_{(\%)} \times \text{Weight.SubCriterion}_{(\%)}$$

Depending on the chosen rating the factors below are used.

Rating	Factor
--	- 1
-	- 0.5
o	0
+	+ 0.5
++	+ 1

To get the impact of the criterion on the company value, the selected rating factor is multiplied by the maximum achievable value of a sub-criterion in percent.

$$Value\ SubCriterion_{(\%)} = Max.Value\ SubCriterion_{(\%)} \times Rating\ Factor$$

In order to get monetary values, the percentage value is multiplied by the company value from financial analysis.

$$Value\ SubCriterion_{(€)} = Value\ SubCriterion_{(\%)} \times Company\ Value\ from\ Financial\ Analysis_{(€)}$$

Use of monetary values in the model:

Monetary values which contribute directly to the technology value shall be inserted directly in the model and added up to the total value.

Calculating the value of a main criterion:

The values of sub-criteria are summed up to calculate the value of a main criterion.

Calculating the total technology value:

The technology value is calculated by summing up the values of main criteria plus the monetary values. It is shown by a percentage as well as by an absolute value.

Entity value:	+ 15.000.000 €									
Net debt:	+ 10.000.000 €									
Technology value:	+ 1.226.250 €	8,2%		Max. technology leverage:	50%					
Total equity value:	+ 6.226.250 €				+ 7.500.000 €					

Criteria	Weighting Main-Criterion	RATING					Weighting Sub-Criterion	Sub-Total %	Sub-Total €
Technology I	**20%**	--	-	o	+	++		**5,50%**	**+ 825.000 €**
Technology performance (technology leadership)						X	20%	2,00%	+ 300.000 €
Low Risk of substitution by other technologies					X		20%	1,00%	+ 150.000 €
IP rights					X		10%	0,50%	+ 75.000 €
Cost advantage			X				15%	-0,75%	- 112.500 €
Lifecycle						X	15%	1,50%	+ 225.000 €
Expert Assessment						X	15%	1,50%	+ 225.000 €
Dominant design available			X				5%	-0,25%	- 37.500 €
Technology II	**15%**	--	-	o	+	++		**-0,94%**	**- 140.625 €**
Technology performance (technology leadership)			X				20%	-0,75%	- 112.500 €
Low Risk of substitution by other technologies				X			20%	0,00%	+/- 0 €
IP rights		X					10%	-0,75%	- 112.500 €
Cost advantage				X			15%	0,00%	+/- 0 €
Lifecycle			X				15%	-0,56%	- 84.375 €
Expert Assessment						X	15%	1,13%	+ 168.750 €
Dominant design available				X			5%	0,00%	+/- 0 €
Technology Portfolio	**15%**	--	-	o	+	++		**1,69%**	**+ 253.125 €**
Lifecycle portfolio			X				30%	-1,13%	- 168.750 €
R&D risk portfolio					X		15%	0,56%	+ 84.375 €
R&D spending portfolio				X			25%	0,00%	+/- 0 €
Technology portfolio synergies						X	30%	2,25%	+ 337.500 €
R&D Organization	**10%**	--	-	o	+	++		**-1,13%**	**- 168.750 €**
R&D costs vs. turnover					X		20%	0,5%	+ 75.000 €
R&D personnel			X				15%	-0,4%	- 56.250 €
Theoretic technology know-how				X			5%	0,0%	+/- 0 €
Academic background (PhD, MSc, BSc)			X				5%	-0,1%	- 18.750 €
Cost per R&D employee		X					15%	-0,8%	- 112.500 €
Available test facilities		X					10%	-0,5%	- 75.000 €
Efficient use of facilities			X				5%	-0,1%	- 18.750 €
Use of external technology sourcing						X	15%	0,8%	+ 112.500 €
IT equipment		X					10%	-0,5%	- 75.000 €
R&D Processes	**10%**	--	-	o	+	++		**-1,63%**	**- 243.750 €**
Development efficiency			X				20%	-0,5%	- 75.000 €
Development process				X			15%	0,0%	+/- 0 €
PDM system				X			10%	0,0%	+/- 0 €
Project management		X					15%	-0,8%	- 112.500 €
R&D cost compliance				X			15%	0,0%	+/- 0 €
R&D time compliance			X				15%	-0,4%	- 56.250 €
Risk management				X			10%	0,0%	+/- 0 €
Synergies with buying company	**15%**	--	-	o	+	++		**-1,50%**	**- 225.000 €**
Research and development			X				40%	-1,5%	- 225.000 €
Production processes				X			60%	0,0%	+/- 0 €
Production	**15%**	--	-	o	+	++		**4,88%**	**+ 731.250 €**
Customer satisfaction						X	20%	1,5%	+ 225.000 €
Safety, environment, cleanliness, & order					X		5%	0,2%	+ 28.125 €
Visual management deployment					X		10%	0,4%	+ 56.250 €
Scheduling system						X	10%	0,8%	+ 112.500 €
Product flow, space use & material movement means						X	10%	0,8%	+ 112.500 €
Inventory & WIP Levels						X	10%	0,8%	+ 112.500 €
People teamwork, skill level, & motivation				X			5%	0,0%	+/- 0 €
Equipment & tooling state & maintenance			X				5%	-0,2%	- 28.125 €
Ability to manage complexity & variability				X			5%	0,0%	+/- 0 €
Supply chain integration				X			5%	0,0%	+/- 0 €
Quality system deployment					X		5%	0,2%	+ 28.125 €
Number of "Yes Questions"						X	5%	0,4%	+ 56.250 €
Process technology					X		5%	0,2%	+ 28.125 €
Monetary valuation								**1,3%**	**+ 195.000 €**
Real option values									+ 130.000 €
Licences									+ 60.000 €
Special equipment									+ 20.000 €
Investments needed									- 15.000 €

Figure 23: Exemplary evaluation model

4.4.Entity value from financial analysis

For estimation of the financial analysis, the discounted cash flow method as described in section 3.14 is used.

As a first step, the weighted average cost of capital based on the cost of equity and cost of debt are calculated by the following formulas[33]:

$$WACC = \frac{E}{E+D} \times r_e + \frac{D}{E+D} \times r_d \times (1-t)$$

$$r_e = r_{rf} + EMRP \times \beta_{relevered}$$

$$\beta_{relevered} = \beta_{unlevered} \times (1 + \frac{D}{E} \times (1-t))$$

$E \ldots market\ value\ of\ equity$

$D \ldots market\ value\ of\ debt$

$r_e \ldots cost\ of\ equity$

$r_d \ldots cost\ of\ debt$

$r_{rf} \ldots risk\ free\ rate$

$t \ldots corporate\ tax\ rate$

$EMRP \ldots Equity\ Market\ Risk\ Premium$

A second step calculates the present equity value based on the discounted cash flow.

$$EV = \sum_{t=1}^{T} FCF \times k$$

$$k = \frac{1}{(1+WACC_t)^t}$$

$k \ldots Discount\ Factor$

$FCF \ldots Free\ Cash\ Flow$

$t \ldots Period$

[33] KPMG – Equity Market Risk Premium –Research Summary (2 April 2015)

WACC Calculation	
Equity	50
Debt	10
Total	60
Cost of debt	6%
Tax rate	25%
Cost of debt after tax	4,5%
Risk free rate	2,0%
Equity market risk premium	3%
Beta	0,8
Debt to equity	20%
Beta relevered	0,76
Cost of equity	4,3%
WACC	4,3%

	2014	2015	2016	2017	2018	Terminal
Mio€	Ist	Budget	Plan	Plan	Plan	Value
EBIT		0,70	1,10	1,12	1,20	
Taxes	25%	-0,2	-0,3	-0,3	-0,3	
NOPAT		0,5	0,8	0,8	0,9	
Depreciation		0,3	0,2	0,3	0,4	
Working capital change		0,0	-0,6	-0,3	-0,5	
Invest		-0,5	-0,2	-0,3	-0,3	
Free cashflow [1]		0,33	0,23	0,54	0,52	0,52
Time period		0,5	1,5	2,5	3,5	3,5
WACC		4,3%	4,3%	4,3%	4,3%	4,3%
Discount factor		0,98	0,94	0,90	0,86	
Present value		0,32	0,21	0,49	0,44	13,54
Turnover	17,0	17,7	18,0	19,0	20,0	
Working capital	3,5	3,5	4,1	4,4	4,9	
Working capital change		0,0	-0,6	-0,3	-0,5	
Working capital (%)	20,6%	19,8%	22,8%	23,2%	24,4%	

Entity value	**15,00**
Net debt	10
Equity value	**5,00**

Figure 24: Calculation of entity value

The example shows an entity value of € 15.0 million. To derive the equity value, the net debt needs to be subtracted which gives an equity value of € 5.0 million.

4.5.Maximum technology leverage

The maximum technology leverage estimates the maximum impact a technology can have on the company value. It has a significant impact on the company value as it influences the technology value linearly. The maximum technology leverage can be entered by a relative number to the entity value deriving from the financial analysis. In case the market is mostly driven by technology, the technology value can overshoot the entity value by far. In that case, an absolute value can be put in the model. To find

the right value for the maximum technology leverage, a team of senior experts shall make an estimation.

	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Max. Tech. Leverage	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●

Figure 25: Match of methods for estimating the technology leverage

The following questionnaire should support the discussion:

- What price premium (in percent) would our customer pay if we could offer the best technical solutions in the market compared to the average?
- What discount would the customer ask for to buy the product if we would offer the weakest still acceptable technology level?

Defining the maximum technology leverage needs to be an iterative process. Assuming that with each single step in the technology evaluation process more precise information is available, the maximum technology leverage shall be assessed and adapted if necessary. If information about maximum and minimum acceptable prices is available, this could give a good indication as well.

4.6.Main criterion: Technology level

Certainly one of the most important and most challenging criteria for high-tech companies is the value of the technology used in the products and in the manufacturing processes. Depending on the industry, the weighting of the main criteria technology can be the highest by far. As a generic approach, the sub-criteria technology performance, risk of a substitution technology, IP rights, cost advantages, lifecycle, expert assessment and dominant design are addressed in the model. The table shows the suitability of methods for assessing each sub-criterion.

Methods	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Technology performance	●	●	◔	◕	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
Low Risk of substitution	○	●	○	○	●	◑	○	○	○	○	○	◑	○	○	○	○	●	○	●
IP Rights	○	●	○	●	○	○	○	○	○	○	○	○	◑	○	○	○	○	●	●
Cost advantage	◑	◔	◔	●	○	○	○	○	○	○	○	●	●	●	○	○	●	○	●
Lifecycle	○	○	○	○	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○
Expert Assessment	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Dominant Design	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●

Figure 26: Match of methods for estimating technology level

The performance of some technologies can be easily measured by performance indicators. Such indicators can be the growth rate, the lifetime, the power density or other indicators that give a clear indication.

4.7.Main criterion: Technology portfolio

Technologies in a company are usually available on different levels. To have a clear understanding of the overall picture, the whole technology portfolio needs to be understood and assessed. This is the basis for risk management and future investment plans.

Methods	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Lifecycle portfolio	○	○	○	○	●	●	●	○	○	○	○	○	○	○	○	○	○	○	○
R&D Risk portfolio	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○
R&D spending portfolio	○	○	○	○	○	○	○	○	●	○	●	○	○	○	○	○	○	○	○
Technology portfolio	○	○	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○

Figure 27: Match of methods for evaluating the technology portfolio

Specific methods are available to evaluate the sub-criteria of the technology portfolio. In order to get a good understanding in which phase technologies are in terms of lifecycle, each technology should be indicated in the McKinsey S-Curve and the Gartner Hype Cycle. Depending on the overall strategy of the company, a balanced lifecycle portfolio or a portfolio with a core area in an early or late phase in the cycles

can be favored. Alternatively, technology readiness levels can be assigned. For the risk assessment in the portfolio, the analysis matrix by Arthur D. Little shall be used. This method is also suitable to evaluate and redefine the allocation of a R&D budget. Recommendations for investment actions in the portfolio can also be derived from the Booz, Allen & Hamilton Matrix.

4.8.Main criterion: R&D organization

The performance of the R&D organization in high-tech companies is essential for the future performance and capability to develop new products and react to new customer demands. Sub-criteria such as R&D costs, R&D personnel, technology know-how, academic background, costs per employee, test facilities and their efficient use, external sourcing of technology and the status of the IT equipment are rated.

R&D Organization	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
R&D Costs vs. Turnover	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
R&D Personell	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Technology know-how	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Academic Background	○	●	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●
Cost per R&D employee	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	●	○	●
Available Test Facilities	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●
Efficient use of Facilities	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
Use of external sourcing	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
IT equipment	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Figure 28: Match of methods for evaluating the R&D organization

R&D costs are typically measured by a performance indicator. R&D personnel, technology know-how, academic background, test facilities and their efficient use and the IT equipment of a company can be assessed by setting up specific checklists for each of the sub-criteria. Whenever possible, performance indicators shall be applied as they allow for a better comparison with the buying company. In case information is available, the average academic background, costs per R&D employee and the test facilities shall be compared to the competitors. Good sources for such competitor information are annual reports of stock listed companies or company brochures and web presences.

4.9.Main criterion: R&D process

The industry places special demands on the development of a component or device. These include primarily that at the end of development work the device is as it was specified. A development process is a process that describes how to develop a technology or a product starting with the idea and the initial design via prototype to serial production. Development processes need to be as efficient as possible and shall be well-established in the organization. This effectiveness is of great importance because development costs less the more effective and faster it is. The target is to have a process that helps to keep costs and time to a minimum. This is achieved by standardizing development steps, or by designing process steps in a way that some tasks can be skipped and consequently the development time can be shortened.

R&D Processes	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Development Efficiency	○		●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Development Process	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
PDM System	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Project Management	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
R&D cost compliance	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
R&D time compliance	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○
Risk Management	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Figure 29: Match of methods for evaluating the R&D processes

To evaluate development efficiency a scoring model shall be used. For assessing the quality and efficiency of the processes in development, product data management (PDM), project management and risk management as well as a checklist should be applied. In order to rate the compliance of the deployed resources such as costs and time plan, performance indicators shall be applied.

4.10. Main criterion: synergies with buying company

Finding synergies with the buying company is key to the M&A deal. The bidding company with the highest synergies can accept the highest price premium and has a favorable position in negotiations. Synergies can be found in many areas. For the

technology valuation the synergies in research and development and in the production technology can realize the highest savings. Some synergies can also be monetized in the idea generation if this phase is cost-intensive as in the chemical industry.

Synergies with buying company	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Research and Developmer	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Production Processes	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Idea generation process	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Figure 30: Match of methods for evaluating synergies with the buying company

Synergies in R&D, production and idea generation can be assessed by checklists with tailored questionnaires. They can be introduced in the model by a +/- rating or by including an absolute number that increases or decreases the company value.

4.11. Main criterion: Production technology

In order to be able to create a competitive offering in a global market production companies in high-wage countries are forced to use the most efficient and effective technologies. Implementation of new production technologies is very time consuming and involves high investments. Critical criteria for the evaluation of production systems are the condition of machinery, the application of lean processes, the effectiveness of the quality system, the use of visual management, available measurement and control equipment in line and in the laboratories, the capability of the tool shop, order and cleanliness in the production facilities, safety at work, environmental care and the application of continuous improvement.

Production	Pros and Cons Balance Sheet	Checklists	Scoring Model	Cost-Benefit Analysis	McKinsey S-Curve Concept	Gartner Hype Cycle	Technology Readiness Level	Technology portfolio by Arthur D. Little	Technology portfolio by Pfeiffer	Technology portfolio by Booz, Allen & Hamilton	Portfolio Matrix by McKinsey	Machine Hourly Cost Rate	Pay-back Method	Discounted Cash Flow Method	Decision Tree Analysis	Real options method	Performance indicators	Evaluation of IP Protection	Direct Competitor comparison
Condition of machinery	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lean Proceses	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Quality System	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Visual management	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Measurement Equipment	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Capability of toolshop	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Order and cleanliness	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Safety at work	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Environmental care	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Continous improvement	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Figure 31: Match of methods for evaluating the production technology

Many systems are available for evaluating the production. Unfortunately, most of them are very complex and time consuming and therefore not suitable for a time critical due diligence process. Therefore, for most of the sub-criteria checklists shall be used. For the evaluation of lean processes and continuous improvement scoring models are available that shall be applied.

4.12. Monetary values

As the evaluation model is based on monetary values, it offers the possibility that criteria can be evaluated by monetary values directly. For example this could be an investment in special equipment that is not industry standard. On the other hand, also missing investments in machinery such as the urgent need of measurement or cleanliness machinery in order to reach the industry standard can be inserted in the model directly by the expected investment costs. License fees or fees for technology can be used in the model directly if they are paid or received by a lump sum. In case of a monthly or yearly payment agreement for licenses, the cash flow needs to be discounted by the interest rates in order to get the present values. A special case are real option values as explained in section 3.16. They can be calculated by computer-aided calculation methods and result in a monetary value that can be entered in the model. Monetary values directly contribute to the technology value.

5. Applying the model in a business case

In this chapter the evaluation model shall be applied in a business case. To start with, the business and the technologies used by the target company shall be explained. It shall be shown how the entity value is calculated and used as a basis of the technology evaluation. Each main- and sub criterion shall be evaluated and shown how to apply it in the model.

5.1. The business case: "EcoDrive"

The buying company "M.Tec" is developing and producing plastic parts and actuation systems for engines, transmissions and driveline systems for the automotive industry. Customers are the leading OE-suppliers for passenger cars and commercial vehicles worldwide. It generates a turnover of 370Mio€ and employees 2900 employees worldwide in 10 plants located in Germany, Romania, China, India and Brazil. Available are test equipment and laboratories for highest precision, safety, durability, and comfort.

The target company "EcoDrive" is focused on production, development and sale of highly efficient electric motors and alternators including the electric drive systems. "EcoDrive" customers are global producers of industrially used pumps, agricultural, construction and other machinery as well as original equipment producers of automotive and commercial vehicles and their suppliers. It focuses on nice segments with special requirements such as power density, lightweight or limited installation space. In order to fulfill these demanding requirements, the company has developed the technology of axial flux machines (AFM) and transversal flux machines (TFM) used in their products. The company is located in Michigan, USA and employees a total of 295 employees at one production location, creating a turnover of 30,9Mio€ in 2014.

5.1. Calculating the entity value

The entity value which is the basis of the technology evaluation model is calculated based on the DCF method described in section 3.14. The discounted cash flow calculation results in an entity value of 61,08Mio€ which is input in the technology evaluation model. An input as well is the net debt value of 10Mio€.

	2014	2015	2016	2017	2018	Terminal
Mio€	Ist	Budget	Plan	Plan	Plan	Value
EBIT		5,60	8,90	9,20	9,40	
EBIT (%)		14,9%	19,1%	17,3%	15,7%	
Taxes	25%	-1,4	-2,2	-2,3	-2,4	
NOPAT		4,2	6,7	6,9	7,1	
Depreciation		0,877	1,246	0,3	0,4	
Working capital change		-2,8	-3,1	-1,2	-1,5	
Invest		-1,4	-2,4	-3,4	-3,9	
Free cashflow [1]		0,88	2,42	2,60	2,05	2,05
Time period		0,5	1,5	2,5	3,5	3,5
WACC		4,3%	4,3%	4,3%	4,3%	4,3%
Discount factor		0,98	0,94	0,90	0,86	
Present value		0,86	2,27	2,34	1,77	53,84
Turnover	30,9	37,5	46,5	53,2	60,0	
Growth		21%	24%	14%	13%	
Working capital	9,3	12,1	15,2	16,4	17,9	
Working capital change		-2,8	-3,1	-1,2	-1,5	
Working capital (%)	30,1%	32,3%	32,7%	30,8%	29,8%	

Entity value	**61,08**
Net debt	10
Equity value	**51,08**

WACC Calculation	
Equity	50
Debt	10
Total	60
Cost of debt	6%
Tax rate	25%
Cost of debt after tax	4,5%
Risk free rate	2,0%
Equity market risk premium	3%
Beta	0,8
Debt to equity	20%
Beta relevered	0,76
Cost of equity	4,3%
WACC	4,3%

Figure 32: Calculation of entity value of "EcoDrive"

5.1.Maximum technology leverage

For finding the maximum technology leverage an expert round has been chosen. This M&A team consists of members from different departments. They have estimated the maximum impact of the technology to the company's value. Team members from R&D, advanced development, financing, controlling, purchasing and sales participated. The following questionnaire should support the discussion.

Question: What price premium (in percent) our customer would pay if we could offer the best technical solutions in the market compared to the average?

Team answer: The best technical solution would provide a motor with extremely high power density, providing high engine torque at broad speed range (from 0 – 20.000rpm) while having highest efficiencies. The technology is typically a permanently excited synchronous machine in a transversal flux technology. Having such an ideal solution, it would allow to use an electric powertrain without an additional gear box. This would save approximately 25% of the overall system (motor+inverter+transmission) costs. Consequently, the electric motor including electric drive could be 50% more expensive if it would fulfill these ideal requirement.

Question: What discount the customer would ask for to buy the product if we would offer the weakest, still acceptable technology level?

Team Answer: Low technology products are manifesting themselves by having a low power density, using much installation space. Typically electrically excited synchronous machines in radial flux design are used for low cost builds that are still acceptable solutions. In case a vehicle concept would allow a 25% larger installation space and a 50% lower power density than the system price would be around 75% of the price of an average industry solution.

Taking into account above statements the team decided to use a maximum technology leverage value of 30%. At a calculated equity value of 61,08Mio€ that would allow a maximum influence of technology of 18,3Mio€.

Control Question: What investment in developing the best in class technical solution would be necessary for a provider of an average technology?

Team answer: 18,3Mio€ seems reasonable to develop such a best in class technology.

During the discussion, the need for a more precise method for estimating the maximum technology impact was noted. Future research should address this point.

5.2. Definition of weightings

Weightings were distributed in the model by the M&A team. In the discussion, special focus was put on both technologies as a technology leader strategy is intended. Process, production and quality was weighted lower as it is assumed that can be supported by the buying company in the future. A list of values can be found in Figure 33.

Criteria	Weighting Main-Criterion	Weighting Sub-Criterion
Technology I: Axial Flux Machine	**20%**	
Technology performance (technology leadership)		20%
Low Risk of substitution by other technologies		20%
IP Rights		10%
Cost advantage		15%
Lifecycle		15%
Expert Assessment		15%
Dominant Design Available		5%
Technology II: Transversal Flux M	**20%**	
Technology performance (technology leadership)		20%
Low Risk of substitution by other technologies		20%
IP Rights		10%
Cost advantage		15%
Lifecycle		15%
Expert Assessment		15%
Dominant Design Available		5%
Technology Portfolio	**10%**	
Lifecycle portfolio		30%
R&D Risk portfolio		15%
R&D spending portfolio		25%
Technology portfolio		30%
R&D Organization	**10%**	
R&D Costs vs. Turnover		20%
R&D Personell		15%
Theoretic technology know-how		5%
Academic Background (PhD, MSc, BSc)		5%
Cost per R&D employee		15%
Available Test Facilities		10%
Efficient use of Facilities		5%
Use of external Technology Sourcing		15%
IT Equipment		10%

Criteria	Weighting Main-Criterion	Weighting Sub-Criterion
R&D Processes	**10%**	
Development Efficiency		20%
Development Process		15%
PDM System		10%
Project Management		15%
R&D cost compliance		15%
R&D time compliance		15%
Risk Management		10%
Synergies with buying company	**20%**	
Research and Development		40%
Production Processes		60%
Production	**10%**	
Condition of machinery		20%
Lean Proceses		15%
Quality System		10%
Visual management		10%
Availability and condition of measurement Equipment		10%
Capability of toolshop		10%
Order and cleanliness in Production		5%
Safety at work		5%

Figure 33: Weightings of "EcoDrive"

5.3. Technology evaluation

Technology performance is measured by selected KPIs for power density, electrical overload, mechanical overload, weight and maximum speed.

$$\text{Power density} = \frac{\text{Power (kW)}}{Weight\ (kg)} = \frac{40kW}{9kg} = 4{,}4$$

$$\text{Electrical overload} = \frac{max.Power(kW)}{Time(sec)} = \frac{60kW}{120sec} = 0{,}5$$

$$\text{Dynamic behaviour} = \frac{\text{Maximum speed change (rpm)}}{Time(sec)} = \frac{1000rpm}{1sec} = 1000$$

The KPIs have been compared to an average technology such as a radial flux permanent synchronous machine.

		EcoDrive axial flux	EcoDrive transversal flux	standard PSM
Power density	$\frac{\text{Power (kW)}}{Weight\ (kg)}$	4,4	5	1,9
Electrical overload	$\frac{max.Power(kW)}{Time(sec)}$	0,5	0,4	0,25
Dynamic behaviour	$\frac{\text{Maximum speed change (rpm)}}{Time(sec)}$	1000	1200	600
Maximum speed	rpm	15000	18000	10000

The technology performance of the TFM is best in class (++) while the AFM technology is still better than the industry standard (+).

The sub criteria “low risk of substitution” was evaluated by expert opinion. As the two technologies of axial and transversal flux are the moment the best known technology, the risk is rather low. The team rated with (++) in the model.

“EcoDrive” is owning 4 major patents – two for each technology. An analysis was performed according to section 3.18.

Criteria	Score
Possibilities for bypassing and workarounds not possible 5..6 Possible with a huge effort 2..4 Easy to bypass 0..1	4
Attractiveness to use for competitors Very high 5..6 Average 2..4 Low 0..1	2
Possibility to evidence infringement by competitors Easy possible 5..6 Average 2..4 Not possible 0..1	3
Use of protected technology Very likely to use 5..6 Not decided yet 2..4 Not very likely 0..1	5
Related patent portfolio is Too small 5..6 Appropriate 2..4 Too large	3
Other criteria Basis for a future technology or product +1 Support sales organization +1 Advantage in contract negotiations +1 Part of official standard 0 Others 0	3
TOTAL	20

Reaching 20 points at the IP protection analysis was considered as strong (+) by the M&A team.

Cost advantage is analyzed by a cost benefit analysis. Total costs for creating a certain power are compared to standard technology. From cost perspective, the axial flux technologies of "EcoDrive" are on par with widely used technology in the industry. The transversal flux technology still has slightly higher cost due to its complex electronic converter technology.

$$\text{Cost for Power} = \frac{Costs(€)}{\text{Power (kW)}} = \frac{7000€}{120kW} = 58{,}33\,\frac{€}{kW}$$

		EcoDrive Axial Flux	EcoDrive Transversal Flux	standard PSM
Costs per Power	$\frac{Costs(€)}{Power\ (kW)}$	58,33 €	69,17 €	66,60 €

The team is rating the cost advantage of the AFM with average (o). The TFM is even more expensive and rated with (-).

The buying company is looking for M&A targets that are providing technologies that are in the early phase of its technology cycle. The Gartner cycle is used to show the ideal target profile versus the technology provided by EcoDrive. Both technologies are in the preferred area in the Gartner cycle. Thus, a high rating is given.

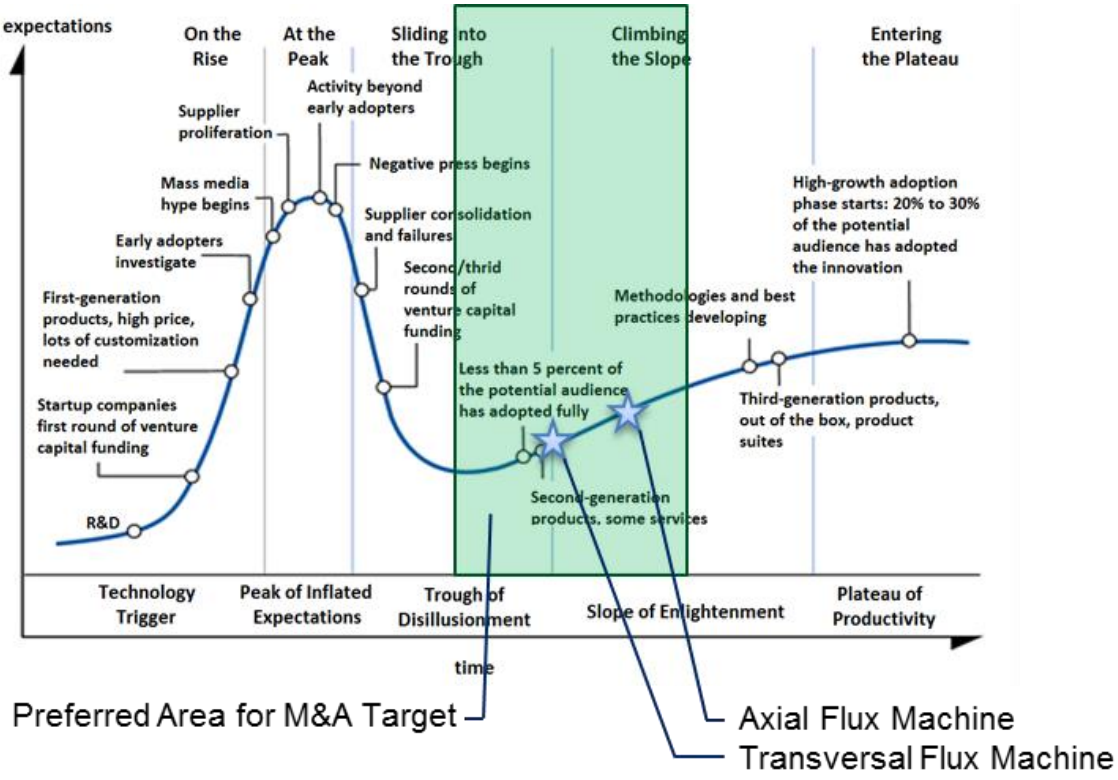

Figure 34: AFM and TFM in the Gartner hype cycle

A mature technology usually originates a dominant design which helps the customers to exchange suppliers. On the other hand it limits the risk for the supplier and makes and entry in another market with similar technology demands easier. In this business case, the top score is given if a dominant design is already available but can still be influenced by one supplier. For the "EcoDrives" technologies a dominant design is available. Although, some flexibility is still given. Thus, a top score (++) would be rated for the sub-criteria of dominant design. Considering the results for the axial flux

and transversal flux machine as described above it would lead to a value of the main criteria of 2,47Mio€ (+4,05%) for the Axial Flux Machine and 2,65Mio€ (+4,35%) for the transversal flux machine.

Criteria	Weighting main-criterion	RATING					Weighting sub-criterion	Sub-total %	Sub-total €
Technology I: Axial flux machine	**20%**	--	-	o	+	++		**4,05%**	**+ 2.473.828 €**
Technology performance (technology leadership)					X		25%	0,75%	+ 458.116 €
Low Risk of substitution by other technologies						X	25%	1,50%	+ 916.233 €
IP rights					X		10%	0,30%	+ 183.247 €
Cost advantage				X			15%	0,00%	+/- 0 €
Lifecycle						X	20%	1,20%	+ 732.986 €
Dominant design available						X	5%	0,30%	+ 183.247 €
Technology II: Transversal flux machine	**20%**	--	-	o	+	++		**4,35%**	**+ 2.657.075 €**
Technology performance (technology leadership)						X	25%	1,50%	+ 916.233 €
Low Risk of substitution by other technologies						X	25%	1,50%	+ 916.233 €
IP rights					X		10%	0,30%	+ 183.247 €
Cost advantage			X				15%	-0,45%	- 274.870 €
Lifecycle						X	20%	1,20%	+ 732.986 €
Dominant design available						X	5%	0,30%	+ 183.247 €

5.4.Evaluating the technology portfolio

The lifecycle of both technologies are still in the emergence phase as shown in the McKinsey S-Curve. Even though this has the advantage of less risk being substituted by an upcoming technology it is challenging for managing the technology portfolio.

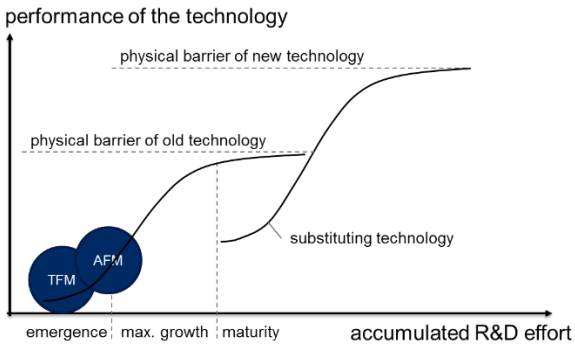

Figure 35: AFM and TFM in the McKinsey S-Curves

The risk in the portfolio is shown by applying the Arthur D. Little matrix. It indicates the significantly higher risk in the transversal flux machine technology. The ADL matrix recommends a clear leadership strategy for the AFM technology and a cooperation strategy for the TFM technology. A cooperation strategy could also be found by an additional merger or acquisition of competitors in the technology. Further it indicates the need for higher R&D investments for the TFM in order to achieve a leadership position with the TFM technology as well. Overall the risk portfolio is rated with attractive (+).

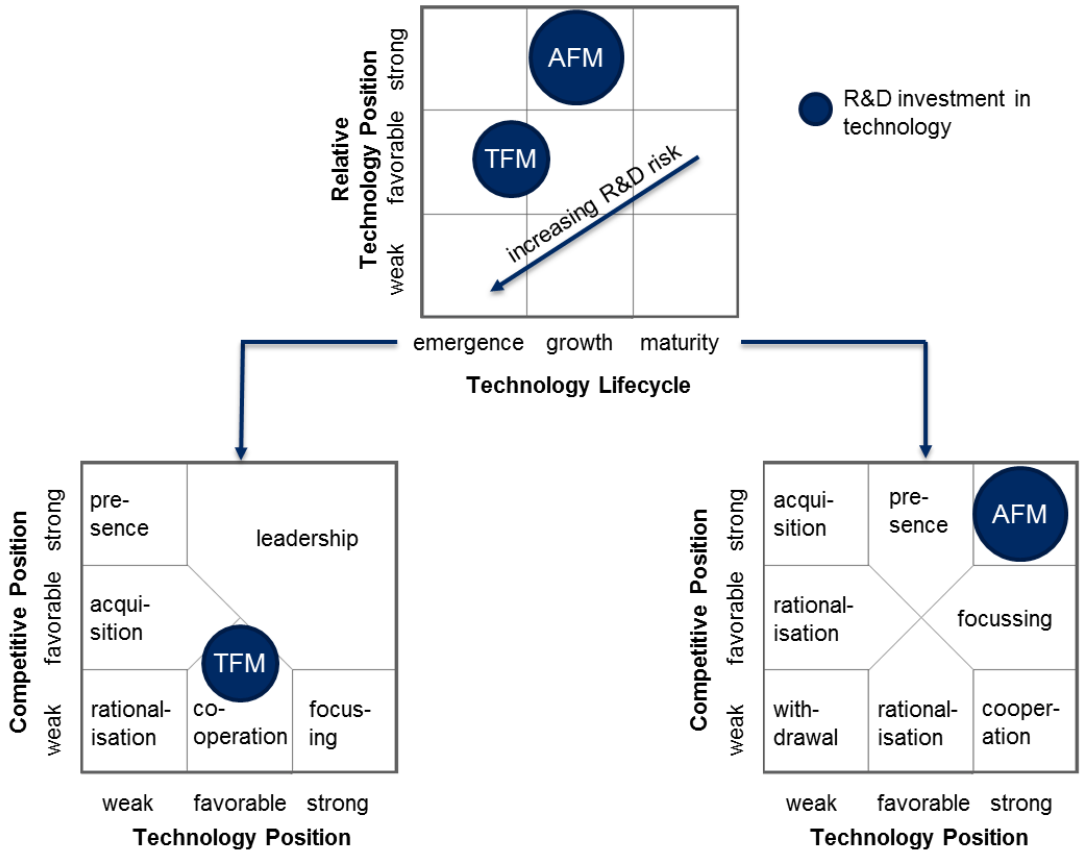

Figure 36: AFM and TFM in the Arthur D. Little matrix

In order to understand the R&D spending, the technology portfolio is analyzed by the method of Booz, Allen & Hamilton as well as by the method of Pfeiffer. The transversal flux machine (TFM) has a higher technology potential but the development is challenging and has significant risks. The axial flux machine has a slightly less technology potential and is therefore slightly less attractive. As the AFM technology has a higher maturity, also more resources have been allocated in the past.

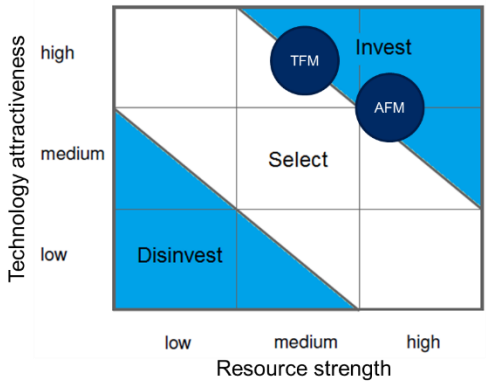

Figure 37: AFM and TFM in the Pfeiffer matrix

The AFM shows a higher resource strength in the Pfeiffer matrix. According to the Pfeiffer method, strong investment in both technologies is recommended.

Entering both technologies in the Booz, Allen & Hamilton matrix, it is recommended to invest even stronger in the TFM technology than in the AFM technology. Still, high R&D investment in both technology is recommended. Overall the R&D resource allocation is rated with average (0).

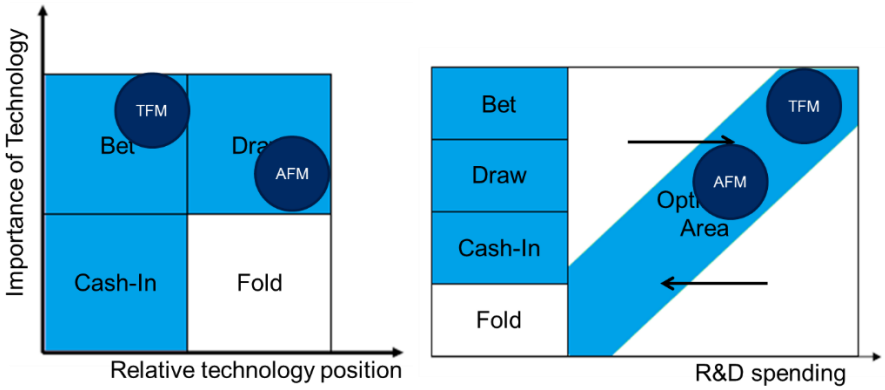

Figure 38: AFM and TFM in the Booz, Allen & Hamilton matrix

As a last sub-criterion in the technology portfolio, the fit and synergies between the single technologies shall be assessed. The AFM and TFM technology require very similar knowledge. Thus the technology portfolio synergies are rated as high (++).

The main criterion "Technology Portfolio" is increasing the companies value by 2,18% which corresponds with a total of 1.328Mio€.

Technology portfolio	**10%**	**--**	**-**	**o**	**+**	**++**		**2,18%**	**+ 1.328.537 €**
Lifecycle portfolio						X	30%	0,90%	+ 549.740 €
R&D risk portfolio					X		25%	0,38%	+ 229.058 €
R&D spending portfolio				X			15%	0,00%	+/- 0 €
Technology portfolio synergies						X	30%	0,90%	+ 549.740 €

5.5.Evaluating the R&D organization

R&D costs versus turnover are calculated by a simple KPI which is widely used in the industry.

$$R\&D(\%) = \frac{R\&D\ Costs(€)}{Turnover(€)} = \frac{0{,}69Mio€}{30{,}9Mio€} \times 100\% = 2{,}79\%$$

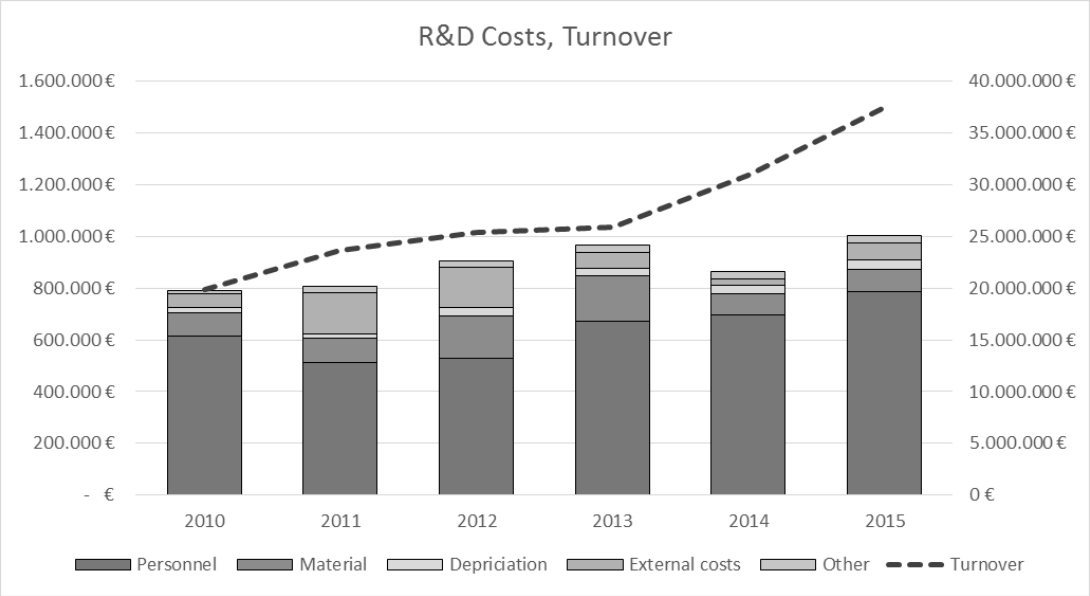

Figure 39: R&D costs

R&D investments in "EcoDrive" was kept at almost the same level (+9%) over the five last years. At the same time, turnover increased by 55%. This results in an extremely low R&D cost rate. Also in comparison with the automotive industry (4,1% in 2009)[34] the 2,79% of "EcoDrive" is by far too low and need to be increased. This gives a rating of (--) for the sub-criterion of "R&D costs versus turnover".

Available R&D personnel at "EcoDrive" is a compact team with highly skilled engineers. The team is too small for a significant growth. Thus the overall rating for R&D personnel of "attractive (+)" was given by the team.

The theoretic know how of the team is the backbone of the company "EcoDrive". It was rated by the team as excellent (++). This as well could be seen in the academic

[34] VDA: Allgemeine Situation der Automobilbranche; ACOD-Kongress 2011, 28. Februar 2011; Leipzig, page 20

background of the R&D teams. 33% of the R&D personnel own a PhD, 42% a master's, 8% a bachelor degree and 17% technicians. This is rated by the team as a very good mix (++). Cost per R&D employee is 14% lower compared to the buying company. This is a very good (++) rating also compared to the industry average.

"EcoDrive" performed most of the testing at external companies and universities. Only rudimentary test beds for function and durability are available. That gives a very low (--) rating for the sub criteria "Available Test Facilities".

The efficient use of the facility was rated as average (0). Further, it was analyzed that a total investment of 0,6Mio€ would be needed for a full test lab.

The use of external resources is on an average of 10% over the last 5 years. Most of it was used for external test facilities. Engineering services was rarely outsourced. The team rated the sub criterion "Use of external Technology Sourcing" with low (-).

The IT equipment including the infrastructure in the R&D organization was checked. Only a very basic IT equipment is available (--).

Overall the R&D organization is based on strong individual skills and a motivated team. R&D infrastructure needs to be improved significantly. This Results in an overall evaluation of -137.435€ (0,23%) decrease of the entity value. The needed investment in test equipment will be considered in the monetary values of the technology evaluation model.

R&D organization	10%	--	-	o	+	++		-0,23%	- 137.435 €
R&D costs vs. turnover		X					20%	-0,6%	- 366.493 €
R&D personnel						X	15%	0,5%	+ 274.870 €
Theoretic technology know-how						X	5%	0,2%	+ 91.623 €
Academic background (PhD, MSc, BSc)						X	5%	0,2%	+ 91.623 €
Cost per R&D employee						X	15%	0,5%	+ 274.870 €
Available test facilities		X					10%	-0,3%	- 183.247 €
Efficient use of facilities				X			5%	0,0%	+/- 0 €
Use of external technology sourcing			X				15%	-0,2%	- 137.435 €
IT equipment		X					10%	-0,3%	- 183.247 €

5.6.Evaluating the R&D processes

Although the overall development efficiency seem to be quite high, it was found that there are no processes available that guarantees a high quality and allows a decent project and risk management. Thus, it was decided by the team to only perform a rough evaluation by expert opinion for evaluation of the development efficiency, for development process, PDM System, project management, R&D cost compliance and risk management. The scoring method was used directly in the technology evaluation model.

R&D processes	10%	--	-	o	+	++		-1,80%	- 1.099.479 €
Development efficiency					X		20%	0,3%	+ 183.247 €
Development process		X					15%	-0,5%	- 274.870 €
PDM system				X			10%	0,0%	+/- 0 €
Project management		X					15%	-0,5%	- 274.870 €
R&D cost compliance		X					15%	-0,5%	- 274.870 €
R&D time compliance		X					15%	-0,5%	- 274.870 €
Risk management		X					10%	-0,3%	- 183.247 €

Overall, the low ratings in the R&D process leads to a significant decrease of the entity value of 1,1Mio€ (-1,8%).

5.7.Evaluating production

To assess the production a rapid plant assessment was performed during a site visit. The scoring method directly in the technology evaluation mode is used. Additionally a Yes/No questionnaire is used to do the ratings. For each sub-criteria an explanation is given which is derived from the rapid plant assessment[35] which can be found in Appendix 3. An average plant is achieving between 50 and 55 points. “EcoDrive” Michigan plant is reaching a score of 49. That is slightly below average. The analysis of the questionnaire shows only 6 “Yes” answers out of 20 possible. This is far below average as well. A low rating (--) is entered in the model. Finally, the technology evaluation model provides the possibility to rate extraordinary or outdated production technology. Machines at “EcoDrive” are older than 10 years in average and do not provide state of the art interfaces to be connected to an overall integrated production system. Therefore it does not meet state of the art and is rated (--).

[35] Read a Plant Fast; Harvard Business Review; May 2002; Page 105ff

Rapid Plant Assessment		
No	Table 2--Assessment Questionnaire	Yes/No
1	Are visitors welcomed and given information about plant layout, workforce, customers, and products?	Yes
2	Are ratings for customer satisfaction and product quality displayed?	No
3	Is the facility safe, clean, orderly, and well lit? Is the air quality good and noise levels low?	No
4	Does a visual labeling system identify and locate inventory, tools, processes, and flow?	Yes
5	Does everything have its own place, and is everything stored in its place?	Yes
6	Are up-to-date operational goals and performance measures for those goals prominently posted?	No
7	Are production materials brought to and stored at line side rather than in separate inventory storage areas?	No
8	Are work instructions and product quality specifications visible at all work areas?	No
9	Are updated charts on productivity, quality, safety, and problem solving visible for all teams?	Yes
10	Can the current state of the operation be viewed from a central control room, on a status board, or on a CRT?	Yes
11	Are production lines scheduled off a single pacing process with appropriate inventory levels at each stage?	No
12	Is material moved only once as short a distance as possible and in appropriate containers?	No
13	Is the plant laid out in continuous product flow lines rather than in "shops"?	No
14	Are work teams trained, empowered, and involved in problem solving and ongoing improvements?	No
15	Do employees appear committed to continuous improvement?	Yes
16	Is a timetable posted for equipment preventive maintenance and continuous improvement of tools and processes?	No
17	Is there an effective project management process, with cost and timing goals, for new product start-ups?	No
18	Is a supplier certification process--with measures for quality, delivery, and cost performance--displayed?	No
19	Have key product characteristics been identified and fail-safe methods used to forestall propagation of defects?	No
20	Would you buy the products this operation produces?	No
	Total number of Yeses	6

Figure 40: Yes/No questionnaire Rapid Plant Assessment (RPA)

Some the production equipment of “EcoDrive” is outdated and needs a refresh to meet requirements of large scale production. The team estimated a need for investment of about 1,5Mio€

Production	10%	--	-	o	+	++		-0,45%	- 274.870 €
Customer satisfaction				X			15%	0,0%	+/- 0 €
Safety, environment, cleanliness, & order					X		10%	0,2%	+ 91.623 €
Visual management deployment			X				5%	-0,1%	- 45.812 €
Scheduling system		X					5%	-0,2%	- 91.623 €
Product flow, space use & material movement means			X				5%	-0,1%	- 45.812 €
Inventory & WIP Levels				X			5%	0,0%	+/- 0 €
People teamwork, skill level, & motivation					X		5%	0,1%	+ 45.812 €
Equipment & tooling state & maintenance					X		5%	0,1%	+ 45.812 €
Ability to manage complexity & variability				X			5%	0,0%	+/- 0 €
Supply chain integration			X				5%	-0,1%	- 45.812 €
Quality system deployment			X				5%	-0,1%	- 45.812 €
Number of "Yes Questions"		X					20%	-0,6%	- 366.493 €
Process technology						X	10%	0,3%	+ 183.247 €

Overall, the production evaluation decreases the entity value by 0,64Mio€. The needed investment in production equipment will be considered in the monetary values of the technology evaluation model.

5.8.Evaluating synergies with buying company

On buyer side, very mature development organizations and processes are available. Product development is based systematically on requirements management to assure that products are developed from initial concept until series production according to the customer demand. The buyer has all the necessary skills from experienced project management systems, state of the art development tool boxes and a test center with a number of large function and durability test beds. Finite element method (FEM) analysis is used in the development process in an extended manner. Using FEM analysis, development effort and time can be reduced. At the same time the quality of the products can be increased. Those methods and processes could be transferred to the R&D organization of "EcoDrive". This gives a very high synergy potential between the two R&D organizations. The R&D synergy potential is therefore rated with very high (++).

Product synergies can be found in plastic parts. The buying company "M.Tec" can supply plastic parts to "EcoDrive" for its motors and inverters. That extends the value chain significantly and as well provides know how for lightweight design which is one of the key customer values. Thus it is rated with (++).

Production processes between the two companies are very different. Thus not too many process technologies can be transferred amongst the companies. A high potential for synergies is available by transferring lean management principles to "EcoDrive". This gives an overall rating of (+) for production synergies.

Overall the synergies sum up to 2,3Mio€ (+3,9%).

Synergies with buying company	20%	--	-	o	+	++		3,90%	+ 2.382.205 €
Product synergies						X	30%	1,8%	+ 1.099.479 €
Research and development						X	20%	1,2%	+ 732.986 €
Production processes					X		30%	0,9%	+ 549.740 €

5.9.Evaluating monetary values

During the assessment the following monetary values needed to be considered as direct monetary values. In the R&D evaluation it was found that test facility need to be updated. A total of 0,6Mio€ was estimated by the team. During production assessment it was obvious that a significant investment in large scale production needs to be taken.

This investment sums up to 1,5Mio€. This gives a total of 2,1Mio€ that needs to be deducted from the entity value.

Monetary valuation								-3,4%	- 2.100.000 €
Investment in test facilites									- 600.000 €
Investment in production facilites									- 1.500.000 €

5.10. Evaluation of the business case

The overall evaluation of the model shows a very strong technology impact increasing the entity value by 7,3Mio€. The R&D organization has excellent personnel with outstanding know how. These advantages are eaten up by the outdated equipment. Even worse is the application of processes. It can be seen that "EcoDrive" is on the limit with management capabilities. The weak R&D processes decreases the equity further by 1,1Mio€. The production system is slightly below average leading to a decrease of entity value of 0,27Mio€. Huge synergies can be found between for "EcoDrive" in the value chain, R&D and Production processes. The synergies adds a total of 2,38Mio€ (+3,9%) to the entity value. Finally, the needed investments of 2,1 Mio€ are deducted.

Entity Value:	+ 61.082.179 €									
Net Debt:	- 10.000.000 €							Technology Leverage:	30%	
Technology Value:	+ 5.229.861 €	8,6%							+ 18.324.654 €	
Total Equity Value:	+ 56.312.040 €									
Criteria	Weighting Main-Criterion	RATING					Weighting Sub-Criterion	Sub-Total %	Sub-Total €	
Technology I: Axial Flux Machine	20%	--	-	o	+	++		4,05%	+ 2.473.828 €	
Technology II: Transversal Flux Ma	20%	--	-	o	+	++		4,35%	+ 2.657.075 €	
Technology Portfolio	10%	--	-	o	+	++		2,18%	+ 1.328.537 €	
R&D Organization	10%	--	-	o	+	++		-0,23%	- 137.435 €	
R&D Processes	10%	--	-	o	+	++		-1,80%	- 1.099.479 €	
Production	10%	--	-	o	+	++		-0,45%	- 274.870 €	
Synergies with buying company	20%	--	-	o	+	++		3,90%	+ 2.382.205 €	
Monetary valuation								-3,4%	- 2.100.000 €	

Figure 41: Technology evaluation model of the business case

Overall the technology increases the entity value of "EcoDrive" by 5,23Mio€ which correspondents with 8,6% of the entity value. Considering the 10Mio€ of debt, the leverage would even 10,2%. Consequently, the technology gives a premium of 10,2% to the potential price of acquisition of the company "EcoDrive".

6. Summary and conclusions

This section will give an overview both on the work performed and its limitations, highlighting the most important conclusions.

6.1. Summary

The present work devised a conceptual model for evaluating technology in an M&A process in a producing high technology industry. Therefore the process of a typical M&A undertaking was analyzed diligently. Interfaces between technology and innovation processes and the typical domains of due diligence were explored and highlighted. Furthermore, the thesis explained state of the art technical due diligence and technology evaluation and its shortcomings.

Thereupon, the requirements for technology evaluation and main criteria were analyzed. Common methods for technology evaluation were introduced and evaluated by their strength and weaknesses. In a next step the present thesis analyzed all criteria in a technology evaluation rated the evaluation methods with respect to the suitability of evaluating the respective criterion. The best fitting methods were chosen and combined in a holistic evaluation model.

Then, the model was applied in a business case. It was worked out along a M&A undertaking. Since then the model has been used as a central tool for technology evaluation and is finally used to define the purchasing price in the negotiation phase of the M&A project. Conclusions and findings are discussed in each of the sections and the most important points are summarized in section 6.3.

6.2. Limitations

The evaluation model worked out in the present paper aims to be used in production-focused industries. Although the evaluation model's systematics can be used for service companies, such companies have different focuses and dynamics. Consequently, the selection of methods as well as the selection of criteria would be very different. It would be necessary to discuss whether these characteristics can be addressed with the model. The same is valid for fast emerging industries and technologies such as internet startups. However, this was not the scope of the present thesis.

6.3. Conclusions

During the analysis of M&A processes in section 2 of the present thesis the role and interfaces of a technical due diligence in an M&A process were analyzed. It emerged that M&A processes follow a quite standardized process. There is a lot of literature available and most of the consulting firms are following similar process steps. It could be seen that technology evaluation interfaces with most of the other domains in the due diligence process. This underlines the importance of having a solid and comprehensive technology evaluation as it influences most of the other due diligence domains as well.

Further, it was found that a reliable statement in a technical due diligence is a solid basis for post-merger-integration as investment strategies need to be derived from it.

Methods:

There are many methods available. It could be seen that most of the methods used in technology evaluation are basically suitable for M&A processes. However, some are too complex to finish within a few weeks' time which is a typical duration for an M&A process.

Furthermore, it showed that higher complexity does not always mean more precise results. Methods such as real option methods (as described in section 3.16) promise a very precise result but their numbers are not always very accurate. They are very complex and can only be performed by comprehensive and expensive computer programs.

During the business case it could be seen that mostly, simple and easy to use methods are used. These have the advantage to be more flexible and can be better understood when reporting results to the management.

Simple methods like "pros and cons balance sheets" and "scoring models" combined with good expert knowledge are preferred for quantitative questions. The model calculates a monetary value also for qualitative methods. During the business case it could be seen that having a monetary value helps a lot in estimating the contribution of a qualitative parameter or criterion, such as the "McKinsey S-Curve" method explained in section 3.5 or the Gartner Cycle method explained in section 3.6. Several

iterative loops had to be made comparing the resulting monetary values with experiences of the M&A team. It could be experienced that monetary evaluation helps to understand the impact of qualitative ratings.

Section 4.1 worked out the strength and weaknesses of each method. Several methods fulfill the requirements. The simpler a method is, the more often it can be used to analyze different criteria. Using simple methods for many analyses has the advantage of getting a good knowledge and experience in the M&A team. At the same time, however, accuracy is limited. It needs to be decided case by case which method to use. The matrix in figure 22 was frequently used during the case study after the team was introduction to each single method methods.

Fundamentally important was the choice of the method for the overall evaluation model. As explained in section 4.2 a scoring model was used. The scoring model turned out to be of great help as it combines great flexibility in integrating qualitative and quantitative methods and even gives the possibility to derive monetary values.

Portfolio analysis

Methods for portfolio analysis as introduced in sections 3.8 to 3.11 of the present work are of great use. They are an excellent support in expert discussions and help understanding and comparing technologies of an M&A target. They also support the risk analysis and help in reporting to the management as most of them use a graphic scheme. Further they can be used in setting up the R&D investment strategy for the M&A target in preparation of the post-merger-integration phase.

The decision tree analysis was not used as it takes too much time. However, the method is essential and recommended in the post-merger-integration phase. IP analysis is a huge task that needs professional support and is extremely time critical. Simple method shall be used in order not to increase complexity of the task so that the team can concentrate on the content.

Methods for comparison with competitors

During the model's application it could be seen that methods which compare the M&A target with its competitors (as described in section 3.19) are only useful if sufficient data and information are available. Generally, it could be seen that information about

stock-listed companies is available in annual reports. Nevertheless, even financial figures or technology information of annual reports can hardly be used. The reason for this is the reporting scheme of the companies which are mostly structured by markets. Also, companies usually try to make it difficult to get quantitative information of a single technology or product out of their reports. In order not to give competitors too much information, figures intentionally focus more on markets than on technologies or products.

Quantitative methods

Quantitative methods should be used when possible as they tend to be more precise. Especially for evaluation criteria which are cost-driven, a calculation based on real data is essential. They have the great advantage to allow an accurate comparison with the own company or due diligences performed in the past. A good data basis allows the set-up of performance indicators. They are great for comparing the target with the own company and with competitors given that sufficient data are available.

The evaluation model

Several turns and changes were made to finally get to the selected structure in the model. In total more the twenty variants were worked out, continuously adapted and improved during the research work. Quite early it became clear that a scoring model can provide the needed flexibility in the best way. The biggest challenge then was to bring this down to monetary values. This was especially challenging for qualitative methods. Figure 42 shows the structure of the model as explained in more detail in section 4.

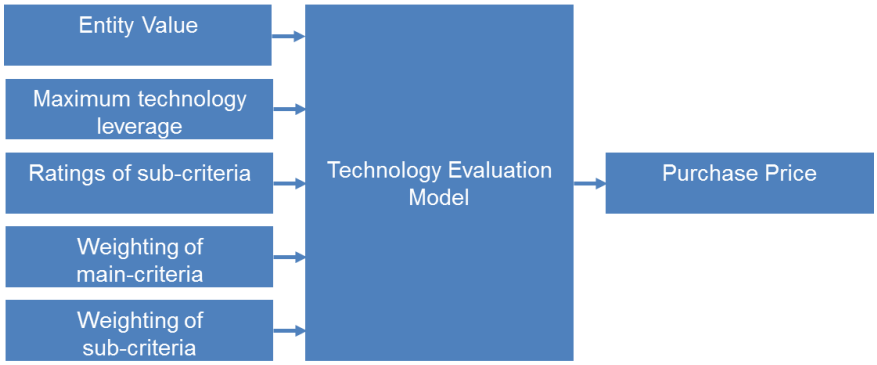

Figure 42: Overview of the technology evaluation model

To make the model easy to use, a five level rating was selected which turned out to be very useful. Especially useful was defining level three ("0") as the industry average helped in the evaluation process. With this reference it was easy to estimate whether it is above/below or significantly above/below the industry average. On the other hand, the five steps allowed a sufficient accuracy. As an example, in case the maximum technology leverage is 18 million euro, the weighting of the main-criterion "R&D processes" is 10% and the weighting of the sub-criterion "Development efficiency" is 20%, the accuracy between the rating steps is € 180.000. This was acceptable for the business case analyzed in the model.

Maximum technology leverage

As explained in section 4.5, the maximum technology leverage defines the maximum impact technology can have on the purchase price of the target. This is very critical as this parameter has a direct influence on the purchase price. It has to be chosen very diligently. Here as well an iterative approach had to be applied. As indicated in figure 25, only a few methods are suitable to select this critical factor. The suitable ones only allow a very rough evaluation. These circumstances have a high risk of miss-evaluating the technology value. In future work this issue needs to be analyzed further. Getting a more precise method here would be needed.

Weighting Criteria

Clustering the main criteria into several sub-criteria was an important step in the development of the model. It helps to improve the tangibility of the evaluation process and makes a comparison with expert experiences easier.

The model can be used either for entering weightings for main and sub-criteria as a percentage number or for entering a fix monetary value directly. In case a percentage number is used, it shall be done in several loops. After adding an additional main or sub-criterion all existing weightings need to be checked whether the value are reasonable in comparison to the new criterion. When required, the weightings need to be adapted. When using the model in the business case it could be seed that with each

loop the results get more and more precise. In case of different opinions in the team, it is recommended to use a pair-wise comparison[36] of the weighting factors.

Strength and weaknesses

The most important requirements for the model were that it had to be flexible to adapt and easy to use in a short time while also being easy to report. This could be fulfilled in an excellent way. However, the model's precision is limited by the precision of the use of methods. The more quantitative methods used in the model the better is the accuracy of the result. The more qualitative methods are used, the more important is the experience of the M&A team. These criteria are multiplied by the parameter of "maximum technology leverage" which is an estimated value as well. Getting all the results in monetary values is of great use for an experienced team as the values can be compared directly to experience by the M&A team.

The model provides a good structure and guidance for teamwork and can be used to inquire expert knowledge in a structured way. As could be experienced, apart from the openness of the M&A team and the ability to create team spirit with the target M&A team, this is one of the most important success factors.

[36] https://en.wikipedia.org/wiki/Pairwise_comparison; 19.08.2015 13:45

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8. Appendix 1: Technology evaluation model

Entity value:	+ 61.082.179 €									
Net debt:	- 10.000.000 €						Max. technology leverage:	30%		
Technology value:	+ 5.229.861 €					8,6%		+ 18.324.654 €		
Total equity value:	+ 56.312.040 €					10,2%				

Criteria	Weighting main-criterion	RATING					Weighting sub-criterion	Sub-total %	Sub-total €
		--	-	o	+	++			
Technology I: Axial flux machine	**20%**							**4,05%**	**+ 2.473.828 €**
Technology performance (technology leadership)					X		25%	0,75%	+ 458.116 €
Low Risk of substitution by other technologies						X	25%	1,50%	+ 916.233 €
IP rights					X		10%	0,30%	+ 183.247 €
Cost advantage				X			15%	0,00%	+/- 0 €
Lifecycle						X	20%	1,20%	+ 732.986 €
Dominant design available						X	5%	0,30%	+ 183.247 €
Technology II: Transversal flux	**20%**							**4,35%**	**+ 2.657.075 €**
Technology performance (technology leadership)						X	25%	1,50%	+ 916.233 €
Low Risk of substitution by other technologies						X	25%	1,50%	+ 916.233 €
IP rights					X		10%	0,30%	+ 183.247 €
Cost advantage			X				15%	-0,45%	- 274.870 €
Lifecycle						X	20%	1,20%	+ 732.986 €
Dominant design available						X	5%	0,30%	+ 183.247 €
Technology portfolio	**10%**							**2,18%**	**+ 1.328.537 €**
Lifecycle portfolio						X	30%	0,90%	+ 549.740 €
R&D risk portfolio					X		25%	0,38%	+ 229.058 €
R&D spending portfolio				X			15%	0,00%	+/- 0 €
Technology portfolio synergies						X	30%	0,90%	+ 549.740 €
R&D organization	**10%**							**-0,23%**	**- 137.435 €**
R&D costs vs. turnover		X					20%	-0,6%	- 366.493 €
R&D personnel						X	15%	0,5%	+ 274.870 €
Theoretic technology know-how						X	5%	0,2%	+ 91.623 €
Academic background (PhD, MSc, BSc)						X	5%	0,2%	+ 91.623 €
Cost per R&D employee						X	15%	0,5%	+ 274.870 €
Available test facilities		X					10%	-0,3%	- 183.247 €
Efficient use of facilities				X			5%	0,0%	+/- 0 €
Use of external technology sourcing			X				15%	-0,2%	- 137.435 €
IT equipment		X					10%	-0,3%	- 183.247 €
R&D processes	**10%**							**-1,80%**	**- 1.099.479 €**
Development efficiency					X		20%	0,3%	+ 183.247 €
Development process		X					15%	-0,5%	- 274.870 €
PDM system				X			10%	0,0%	+/- 0 €
Project management		X					15%	-0,5%	- 274.870 €
R&D cost compliance		X					15%	-0,5%	- 274.870 €
R&D time compliance		X					15%	-0,5%	- 274.870 €
Risk management		X					10%	-0,3%	- 183.247 €
Production	**10%**							**-0,45%**	**- 274.870 €**
Customer satisfaction				X			15%	0,0%	+/- 0 €
Safety, environment, cleanliness, & order					X		10%	0,2%	+ 91.623 €
Visual management deployment			X				5%	-0,1%	- 45.812 €
Scheduling system		X					5%	-0,2%	- 91.623 €
Product flow, space use & material movement means			X				5%	-0,1%	- 45.812 €
Inventory & WIP Levels				X			5%	0,0%	+/- 0 €
People teamwork, skill level, & motivation					X		5%	0,1%	+ 45.812 €
Equipment & tooling state & maintenance					X		5%	0,1%	+ 45.812 €
Ability to manage complexity & variability				X			5%	0,0%	+/- 0 €
Supply chain integration			X				5%	-0,1%	- 45.812 €
Quality system deployment			X				5%	-0,1%	- 45.812 €
Number of "Yes Questions"		X					20%	-0,6%	- 366.493 €
Process technology						X	10%	0,3%	+ 183.247 €
Synergies with buying company	**20%**							**3,90%**	**+ 2.382.205 €**
Product synergies						X	30%	1,8%	+ 1.099.479 €
Research and development						X	20%	1,2%	+ 732.986 €
Production processes					X		30%	0,9%	+ 549.740 €
Monetary valuation								**-3,4%**	**- 2.100.000 €**
Investment in test facilites									- 600.000 €
Investment in production facilites									- 1.500.000 €

9. Appendix 2: Questionnaire for R&D

Q: Please give an overview of the current R&D organizational structure:

- Existing competencies/disciplines
- R&D functions per location
- Headcount allocation
- Outsourced R&D services and resources

Q: How do you assess the success of your R&D efforts?

Please provide a list of key performance indicators (KPI) used by management in R&D.

Q: How many of the target's technologies are directly used in its products and applications?

Q: Please explain how the R&D process generally works, including approval concept and responsibilities. What are generally the timelines for new products and what track record is on that?

Q. How do you evaluate the future output in terms of patent numbers?

Q: How many patents is the target expected to apply for next year?

Q: Detailed overview of the current project pipeline with details on planned annual sales, production units and contribution margins

Q: What is your R&D strategy regarding the product development standards, e.g. modular design, platforms, and common parts?

10.Appendix 3: Rating instructions for rapid plant assessment

Customer Satisfaction	Customer ratings, quality certifications & ratings, warranty & product liability costs, employee knowledge of external and internal customer requirements, visitor materials & welcome, market share, rate of new product introduction & acceptance
Safety, environment, cleanliness, & order	Safety & environment record, place for everything & everything in its place, cleanliness of operations--exterior & interior, floors, equipment, spills, leaks, noise, lighting, paint, dust, air quality, employee dress, restroom conditions, desks & workbench order & cleanliness, degree of "spiffing" for visitors (negative), inventory order, material flow order & cleanliness, color & other coding for safety & order
Visual Management Deployment	Operations mission & performance objectives visible; visibility of labeling & coding of product lines, inventory, equipment, & tooling; color coding & differentiation ; visibility of customer identification & ratings; visibility of charts tracking operation's & teams' safety, quality, & productivity, control room showing status of total operation, customer order & order fulfillment visibility, Kanban deployment, inventory count can be made visually, machines & tool labeling--costs, preventive maintenance visibility, product displays, audit results visible
Scheduling system	Degree of scheduling to customer order, order process efficiency, product line scheduling at single point, scheduling buckets (each order, hourly, daily, weekly, or monthly), supplier scheduling & delivery, replenishment versus order fulfillment, computer scheduling versus kanban, pull versus push systems, flow time efficiencies, backroom costs of scheduling, MRP costs, data entry costs
Product & material flows; space use	Product line versus shop layout, rolling carts pulled by tractors or by hand or conveyers versus forklifts, travel distances between processes, material movement responsibility--process owned or separate material staff, container size (forklift

	requirement?), containers designed for parts families, single versus multiple docks to minimize material travel, space utilization, goals for space use reduction
Inventory & WIP Levels	WIP levels at each process, WIP in transit in plant, separate stores versus line side storage, number of inventory storage areas, finished product levels, total inventory to sales ratio, process cycle time to flow time ratios, countability of inventory, WIP movemend triggered by computer, material department or next process, theoretical versus actual flow times
People teamwork, skill level, & motivation	Team problem solving capability & history, employee willingness to talk about customers, products, & company; uniformity of dress; communications & recognition environment; sales per employee; team meeting areas & performance charts; training investments, educational support, benefit package & costs, unionization activity, workforce-management relationship, community support, company-supported activities (picnics, open houses, sports teams, local involvement, employee knowledge of & support of customers & business, work instructions standards
Equipment & tooling state & maintenance	Preventive maintenance system, setup change times, integrated go-no go quality checks, machine performance data availability, knowledge & utilization of bottleneck processes, process control capability, total asset utilization, operator routine maintenance, maintenance staff & teams, MRO replenishment efficiency, tool & fixture orderliness, cleanliness, & storage location, equipment improvement policy, equipment technology strategy
Ability to Manage Complexity & Variability	Use of common parts, processes, & procedures prototype process, paper transactions required on floor, keyboard entries versus bar coding, backroom paperwork & computer transactions costs, matching of data collected with data needed, simplicity & clarity of operations layout, indirect to direct labor

	ratio, support staff to total workforce ratio, overhead cost ratios, commonality of tooling & fixturing, commonality of equipment & tools, commonality of support software & applications programs across the operation & among sister plants, equipment efficiencies, ability to handle variable demand, ability to eliminate controllable variations, ability to smooth demand, ability to handle supply chain, number of suppliers
Supply Chain Integration	Number of suppliers, supplier release system--from inventory levels or customer order, supplier certification, sourcing policies--short-term or long-term, supplier quality ratings, delivery, & productivity objectives & history, new product development responsibility, responsibility for kitting parts, C-stock replenishment efficiency, supplier material scrap & rework, supplier cost-saving ideas implemented, supplier knowledge of lean
Quality System Deployment	Quality certification, quality process & measurement at each process & for each product, scrap & rework, problem solving process, product & customer quality data, quality ratings, new product startup process, continuous improvement environment, degree of focus on customer satisfaction , implementation of best practices, degree operational strategies are linked to corporate strategy, total quality system well-developed & deployed