Professional Supply Management 2

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Capital Equipment Purchasing

Optimizing the Total Cost of CapEx Sourcing

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Professional Supply Management

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Series Preface

The trend towards globalisation and increasing labour division, as well as the rapid development of information and communication technology, has led to worldwide value creation networks connected by material, informational and financial capital flows. Owing to their complexity and cross-border natures, these global supply chains issue a challenge to the involved agents.

Supply chain management aims to plan and steer efficient value creation networks while taking economic, ecologic and social aspects (keyword: sustainability) into account. A successful procurement function (advanced purchasing) encompasses the entire management of all processes that provide a firm with all its required goods from external sources. Realising a competitive advantage for the firm is an initial goal of supply chain management. By linking procurement and supply chain management, cross-company improvements can be achieved and permanently established.

Procurement as part of supply chain management is a central management task—in many firms it is embedded at the top management level. For these reasons, procurement and supply chain managers no longer focus on pure cost reductions; instead, they are trying to create a differentiation benefit for their firms and value creation networks. Issues such as risk management, funding, sustainability within supply chains and product innovation continue to grow in importance because of new challenges, for example changing political parameters, oligopolies in supplier markets and scarce resources.

Despite procurement's major practical relevance, these challenges do not seem to have been acknowledged sufficiently from an academic perspective. The connection between procurement and supply chain management has also not yet been fully researched. The series "Advanced Purchasing & Supply Chain Management" aims to contribute to closing this gap. This goes hand in hand with generating applicable value for science and practice. In parallel, the publications appearing in these series will be published in the English series "Professional Supply Management".

Reaching this ambition has been supported by the "Kerkhoff Competence Center of Supply Chain Management" (KCC), which is a joint excellence platform of Kerkhoff Consulting and the Logistics Institute of the University of St. Gallen. The KCC's goal is to create an intersection point between science and practice by analysing the trends and challenges in purchasing, procurement and supply chain management as well as deriving recommendations for practical actions. In addition, practical knowledge advancement in procurement and supply chain management is being strived for.

The contributions in the series "Advanced Purchasing & Supply Chain Management" cover current topics such as innovation and excellence in the management of value creation networks and link theoretical concepts to practical application. The authors are researchers from the University of St. Gallen, scholars from other leading international research institutes who focus on procurement and supply chain management, Kerkhoff Consulting advisors and other experts in the field. Research and practice have been linked tightly by bringing together such contrasting author teams.

After the economic and financial crisis 2008/2009, many firms are again striving for growth. Even though crisis-related cost reduction programs are still in effect, purchasing departments are refocusing on securing availability. Additional emphasis should be placed on replacement and extension investments and their cost management, especially when purchasing capital equipment.

The first volume of this series is based on a situation of increased capital demand combined with the reluctant granting of credit by banks. It introduces ways out of the "working capital trap" by looking at strengthening internal financing capability from a practical firm and supply chain perspective. In addition, concrete guidance is offered for purchasing and supply chain managers on how to improve the financial competitiveness of their own firms and their value creation partners. Other planned topics of this series are "Performance Measurement in Procurement", "Evaluation and Differentiation of Supply Chains", "Cost Structure Analysis in Purchasing" as well as "Procurement of Upkeep and Maintenance Services".

This book is the second volume of the series. It focuses on the challenges of capital equipment purchasing and offers instruments and methods for all participants. The depicted process of capital equipment purchasing also helps structure the complex procurement process and allows the positioning of instruments and methods within it. With this, the book contributes towards the professionalisation of the so far insufficiently noted success factor of procurement management.

As the publishers of this series, we wish the readers distinct interest, as well as numerous suggestions and inspiration on how to master the challenges of capital equipment purchasing. We are convinced that the depicted procurement process and the presented instruments and methods offer a valuable contribution.

Düsseldorf, Germany
and
St. Gallen, Switzerland
June 2011

Gerd Kerkhoff
Erik Hofmann
Wolfgang Stölzle

Foreword

The procurement of office materials is generally a procedure of low complexity. Low value, a short lifetime, a simple function and a correspondingly vast quantity of suppliers help simplify the buying process. The procurement of office materials is usually seen as an unproblematic process creating additional work and, therefore, it is left to the purchasing department. The procurement of production materials is also a relatively simple procedure. Required parts are clearly specified and order quantities, as well as ordering times, are exactly calculated by IT systems. It only becomes critical when material or parts are missing, delivered too late or of bad quality.

The procurement of capital equipment is, however, much more complex. Often big investments are made for facilities with a long life expectancy. These technically complex and highly interlinked units are usually only provided by selected specialist suppliers. Most companies only focus on the technical aspects, and procurement is often neglected as a project participant, even though its expertise could prove as helpful. The procurement process is planned, steered and finally executed by a person who is responsible for the budget, and procurement is insufficiently integrated.

In 2009, industry in Germany invested more than €46 billion and counting. While in 2002 more than 18.3% of national output (GDP) was invested, the EU commission estimates that after a decrease in 2009 that share will rise to 18.7% in 2011 and to more than 19% in 2012. However, this high GDP share is not reflected in the growing importance of capital equipment procurement in German companies. In the course of capital equipment procurement, long-term decisions are made, which require an exact analysis of life cycle costs as well as a sustainable concept for maintenance, upkeep and servicing. Conversely, during the selection of products and suppliers, direct and indirect business functions such as production or development are in charge instead of skilled procurement personnel. This fact allows us to understand why, during the distribution of capital and asset goods, the importance of life cycle costs are played down and bold product attributes, such as new, simple or powerful, are accentuated. The large financial efforts as well as the long estimated service lives of capital equipment shows how important the buying and selection process actually is.

Being a combination of a commercial viewpoint and project management, capital equipment purchasing represents a special case of purchasing. The selection of a supplier also always affects other costs, such as initialising costs (e.g. construction costs) and follow-up costs (e.g. upkeep). These particular challenges highlight the importance of capital equipment purchasing and of why it requires highly qualified personnel.

Because of its major practical relevance, the authors herein present several methods and instruments that fulfil the requirements of lasting benefits resulting from a capital goods purchase. The following elaboration adds a higher professional level to the entire discipline of purchasing capital equipment.

Kerkhoff Consulting GmbH, Germany
June 2011

Oliver Kreienbrink
Partner

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Chapter 1
Introduction to Capital Equipment Purchasing

1.1 Capital Equipment as Procurement Objects

Capital equipment is characterised by both high non-recurrent acquisition costs and high running operating costs. It is thus mostly amortised over several years and subject to numerous influencing factors, such as changes in demand. Moreover, capital equipment is vital for maintaining a company's operative capabilities and securing its future competitiveness.

Compared with production materials and consumables, capital equipment has a relatively long useful life and high running costs. Whether new production facilities, vehicle fleet extensions or similar non-recurrent acquisitions, they all present major financial burdens for a company as opposed to goods procured on a regular basis.[1] If a company is unable to provide its own funds to finance the investment through equity capital, it will face the challenge of obtaining the necessary capital from elsewhere. In addition to the actual costs of the capital equipment, the company accordingly must shoulder the long-term financing costs, which must be taken into account in procurement planning. Over the entire period of the investment, numerous risks must be carefully considered and the related costs compared with the anticipated capital return.[2]

Owing to the international financial and economic crisis, national economies partly were in very serious difficulties in the course of 2008 and 2009 and the repercussions have not yet been overcome. Companies throttled their production, and the capital equipment industry suffered especially significant order declines and losses as a result of the slump in the global economy.[3] Expenditures for the procurement of capital equipment are meaningful indicators of a macroeconomic situation. If they are stable or rising, capacities will be increased and machinery modernised. If the economic situation is uncertain, such investments are made only up to a point or under specific circumstances, and the budget for investments will generally be pared back. In 2009, companies were additionally confronted with liquidity bottlenecks

[1] Cf. Schierenbeck (2003, p. 321).

[2] Cf. Eilenberger (2003, p. 133).

[3] Cf. Hofmann et al. (2011, p. 1 et seq.).

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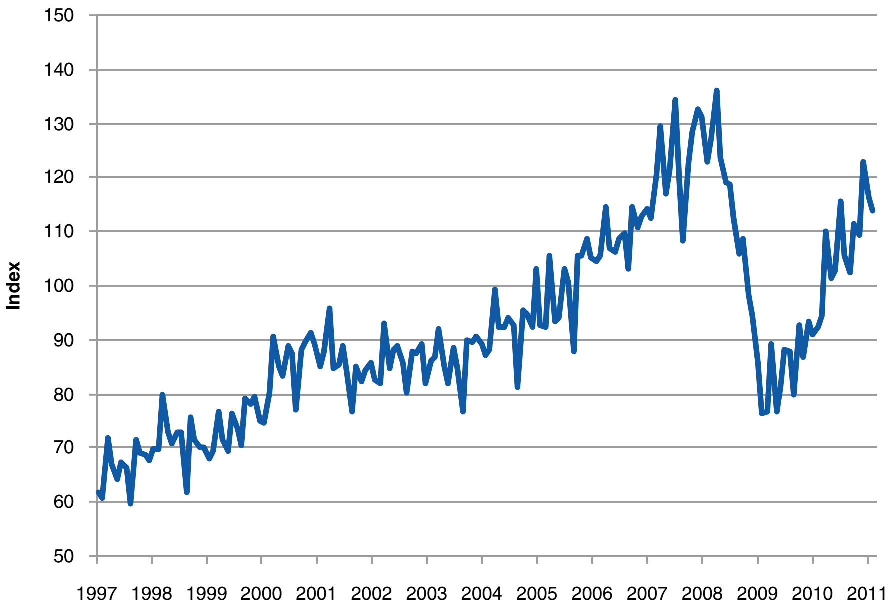

Fig. 1.1 Development of incoming orders for capital equipment in Germany (index values, 2005 = 100). (Cf. Deutsche Bundesbank 2011)

because of the lack of orders. Along with this, purchase volumes were reduced and costly investments delayed or even abandoned.

After the positive macroeconomic market development, the business community's reservations about capital-intensive investments during the financial and economic crisis inevitably resulted in a huge pent-up demand for capital equipment after the lowest point in the economy had passed. Between January 2010 and January 2011, incoming orders for capital equipment increased in Germany by 21 index points (from 93–114 index points). Figure 1.1 shows the development in incoming orders for capital equipment within Germany from 1997–2011.[4] This diagram reflects the steep decline in orders in 2008/2009 and also shows that previously there had been a largely steady positive development in incoming orders. Because of the economic recovery from 2010 onwards, the capital equipment industry is able to retake a positive view of the future.[5]

1.2 Relevance of Capital Equipment Purchasing

The increase in the scientific literature on the subject of industrial and capital equipment results from the high ratings these markets have in practice.[6] Companies regularly face major challenges in the procurement of capital equipment characterised

[4] Section 2.4 presents an overview of the industrial sectors included in this calculation.

[5] Cf. Deutsche Bundesbank (2011).

[6] Cf. Backhaus and Voeth (2007, p. 3 et seq.).

not only by high costs and long-term tied-up capital but also by highly technical features. It takes decision-makers to proceed with farsightedness and to act across functions. In this context, not only the acquisition costs of capital equipment must be taken into account but also the total life cycle costs, including services in the form of maintenance and repair. Technical function areas within a company—in particular, product development as well as manufacturing and production—are faced with the need for capital equipment, thus requiring collaboration with their purchase departments. However, the necessary cooperation of the corporate areas involved may result in lost time because of coordination talks and general conflicts of interest between special technical and commercial areas or departments. For major investment projects where state institutions are partly involved with public funding, not only are cost/benefit considerations concerned, but compliance management is also a subject area of vital importance. Transparency in an investment's individual components is not the only focus in this respect. Special attention is also paid to the process leading up to the selection of a supplier or service provider in order to show investors or stakeholders that funds are used as optimally as possible.

Ideally, purchase departments are responsible for controlling the costs of and scheduling capital equipment purchasing so that due date and budget objectives can be ensured. But although investments are decisive for a company's future success, what is frequently lacking is any holistic consideration of the capital equipment purchasing process.

In line with the major importance for future corporate success and the implications of a decision to purchase capital equipment, the process from decision to investment all the way to its implementation and commissioning requires particular attention and systematic procedures. In this context, the purchasing department should provide for a smooth capital equipment purchasing process. Owing to protracted planning and decision-making processes where capital equipment is concerned, purchasing departments must meet the high requirements for smooth interface management. In this respect, the integration of corporate divisions involved in the procurement process needs to be ensured. For predefined purchasing and contract award objectives, a realisation model should assign the pertinent resources for a successful implementation. Procedural as well as organisational aspects must be taken into account here.

The more complex the components of an investment decision, the greater the number of internally involved people and special departments of the company as well as the number of external interfaces. This increasing number of people participating in the decision-making process also increases, at the same time, the coordination expenditures required among players. A major challenge in this respect is bringing together the interests of individual specialised areas. While technically oriented departments focus on high quality, the fastest remedy for failures and the highest possible development level, these interests might partly run counter to the intentions of the purchasing department.[7] Aside from any given technical conflicts of interest, it is important—for capital equipment purchasing—to penetrate the

[7] Cf. Arnolds et al. (2010, p. 425).

Fig. 1.2 Overview of the contents of the present publication on capital equipment purchasing

complexity of interdependencies of decisions. The decision for a specific manufacturer of machines thus might entail that any further supplier selection is restricted because the initial decision has been fixed by contractual components.

Our publication presents the fundamentals and challenges of capital equipment purchasing and, with a practical example of the procurement of a wind turbine, illustrates the relevant aspects and steps of capital equipment purchasing. First, we characterise capital equipment (Chap. 2) and capital equipment purchasing (Chap. 3). Chapter 4 then presents the challenges and solutions in the procurement of capital equipment. The process of capital equipment purchasing is presented in Chapter 5. Following that, instruments and methods are presented in terms of the players involved (Chap. 6) and the properties of capital equipment (Chap. 7). In conclusion, a summary and outlook follows (Chap. 8). Figure 1.2 shows the contents of this publication on capital equipment purchasing.

Chapter 2
Characterisation of Capital Equipment

2.1 Overview of the Main Procurement Object Groups

To be able to classify capital equipment, we first present an overview of the goods to be procured in enterprises. According to Large (2009), five so-called main procurement object groups can be distinguished (Fig. 2.1):

- Production materials directly enter the goods to be produced and, depending on the degree of the manufacturing progress, they can be subdivided into raw materials, semi-finished and finished products. Another classification characteristic of production materials is their specificity. The following types of specificity can be distinguished:
- Buyer-specific production materials are individually developed and produced for the products of a buyer (e.g. drawing parts).
- Supplier-specific production materials can only be obtained from a specific supplier in a specified form, namely the buyer knows certain technical specifications but does not know any product information beyond this (e.g. catalogue parts).
- Relations-specific production materials are specified jointly by a buyer and a supplier and generally they can only be produced by this supplier (e.g. machine tools).
- Unspecific production materials are parts manufactured according to industry standards by a large number of suppliers and procured by a large number of buyers (e.g. standard screws).
- Consumables are necessary for carrying out value-added processes but do not enter the product to be produced. Examples of consumables are production resources, repair and maintenance materials, tangible energy carriers and other consumables, such as cleaning and office materials.
- Capital equipment as the focus of our publication can be defined as the tangible assets of a company's fixed assets.[1] It can also be classified based on the degree of production relevance.

[1] Cf. Large (2009, p. 12). Section 2.2 provides a detailed discussion of this term.

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Main Procurement Object Groups	Structuring Main Procurement Object Groups				Explanation
Production material	Unspecific production material	Supplier-specific production material	Buyer-specific production material	Relations-specific production material	Enter into the goods to be produced (raw materials, semi-finished products, and finished products)
Consumables	Production resources	Repair and maintenance material	Tangible energy carriers	Other consumables	Necessary for carrying out the value added processes but do not enter into the product (e.g. coolants and lubricants)
Capital equipment	Production-specific capital equipment	Not production-specific capital equipment			Tangible assets of fixed assets
Services	Production-specific services	Not production-specific services			Service is provided by a person and cannot be stored; production and consumption take place simultaneously
Trade goods					Goods which are procured and resold without any processing steps having been performed

Fig. 2.1 Overview of the main procurement object groups. (Cf. Large 2009, p. 8)

- Services are provided by a natural or legal entity to meet a demand (e.g. project engineering services). They can be structured according to the degree of production relevance (e.g. maintenance/repair, logistics, facilities).
- Trade goods are procured and resold without any processing steps having been performed (e.g. tools for a machine).[2]

Capital equipment thus presents one of the five main procurement object groups and, accordingly, has a prominent place within the goods to be procured by enterprises.

2.2 Definition of Capital Equipment

Although the term capital equipment is widespread in theory and practice, no standard definition is available. A few relevant definitions are provided below to illustrate this situation:

[2] Cf. Large (2009, p. 8 et seq.); Töpfer (2007, p. 725 et seq.).

- Engelhardt and Günter (1981): "Capital equipment presents services which are provided by organisations (non-consumers) to either produce—with their application (use or consumption)—other goods to meet third-party demand or resell them, unchanged, to other organisations which will provide this service."[3]
- Backhaus (1982): "Capital equipment presents services which are procured by organisations to provide other services not comprising the distribution to end consumers."[4]
- Gabler Wirtschafts-Lexikon (2011):[5]
  - In a broader sense: "Services which are procured by non-consumers directly or indirectly for the provision of services to meet third-party demands (private and public enterprises) or, respectively, for collectively meeting own demands (public authorities). Procurement is generally connected with organisational buying/selling interactions."
  - "Also narrower sense of the term, e.g. capital equipment as commercial durables (plants, machinery)."
- Large (2009): Capital equipment presents the tangible assets of fixed assets; thus the tangible items which are to permanently serve the business process.[6]
- Goede (2003): "Goods with a long useful life (e.g. machinery, factories, raw materials), which are not required in and of themselves but which are necessary for the manufacture of consumer goods and other capital equipment. They are not consumed in one accounting period and generally are depreciated over a number of years (also called: equipment goods, industrial goods, investment goods, producer goods)."[7]
- Steiner (2004): "Durable means of production are called capital equipment. During its useful life, it gives off a flow of different usages (e.g. plant equipment). In contrast, non-durable means of production are converted or depleted (e.g. raw materials, auxiliaries, and resources or consumables). For consumer goods as well, the distinction can be made between durable (commodity goods) and non-durable (consumption goods), usually statistically classified according to their life of either more than one year or less than one year."[8]
- Swan et al. (2002): "Capital goods are assets used to support business operations. Examples include production lines for manufacturing, testing equipment used by a construction company. Capital goods are typically high-cost, infrequent purchases that require good up-front decision-making to minimize long-term costs."[9]

[3] Engelhardt/Günter (1981, p. 24).

[4] Backhaus (1982, p. 3).

[5] Gabler Wirtschafts-Lexikon (2011).

[6] Cf. Large (2009, p. 12).

[7] Goede (2003, p. 1579 et seq.).

[8] Steiner (2004, p. 337).

[9] Swan et al. (2002, p. 795).

- Leenders et al. (2006): "Capital assets are long-term assets that are not bought or sold in the regular course of business, have an ongoing effect on the organisation's operations, have an expected use of more than one year, involve large sums of money, and generally are depreciated. Assets may be tangible or intangible."[10]

Owing to the great variety of different applications of the term, a definition is presented at this point that will be used as the basis for further statements in this publication. According to the authors, capital equipment presents tangible and intangible goods that are procured by organisations and that present the technical prerequisites for the production of goods and services. Characteristic of capital equipment is the permanence of use with the possible inclusion of services of provision, maintenance and repair; also characteristic is the high value of an individual object compared with the material used. This definition comprises, for example, plants, buildings, real estate property and patents but excludes special tools used only once, training courses or solar systems procured by private actors.

2.3 Classification of Capital Equipment

At this point, we introduce our own classification so that the multitude of capital equipment definitions can be classified. Capital equipment should be classified along the following dimensions:

- Production-related—not production-related: Is capital equipment directly used for the production of other goods or is it not tied directly into the production process?
- Simple—complex: Does the capital equipment concern individual parts or an entire plant or machine?
- Standardised—individual: Is the same capital equipment manufactured and/or procured repeatedly or is it explicitly developed and produced or purchased for a specific customer?
- Tangible—intangible: Can the capital equipment be physically/legally presented or is it of an intangible character?

Table 2.1 presents this classification on the basis of the dimensions shown and provides examples for every class. In the case of intangible goods, the difference between simple and complex components is inapplicable since they generally have no components.

[10] Leenders et al. (2006, p. 423).

Table 2.1 Classification of capital equipment with examples provided

		Standardised		Individual	
		Tangible	**Intangible**	**Tangible**	**Intangible**
Production-related	**Simple (individual part)**	Electric motor for a CNC machine	Standard software for production planning	Special tool for production	Individual software for production planning
	Complex (complete plant or machine)	CNC machine		Individual production plant	
Not production-related	**Simple (individual part)**	Truck engine; desk	Standard software for distribution/sales	Art object	Individual software for distribution/sales
	Complex (component)	Truck, PC, printer		Multi-storey parking garage, engine test stand	

2.4 Macroeconomic Importance of Capital Equipment

The capital equipment industry is of immense importance worldwide. Yet, because of these divergent definitions by the appropriate industrial sectors, the indicated values considerably differ in parts. According to a study by Datamonitor, the current worldwide volume of the capital equipment industry comes to about € 474 billion.[11] However, this only includes the manufacture of machines and electrical systems. By contrast, the *Statistische Bundesamt* (German Federal Bureau of Statistics) indicates for Germany alone sales by capital equipment producers of about € 550 billion in 2010.[12] That is equivalent to approx. 13% of the total production value in Germany.[13] Germany's capital equipment industry is highly export-oriented; thus, export sales amount to approx. 56% of total sales.[14] Moreover, with a workforce of about 2,195,000 people working in about 7,500 businesses, the capital equipment industry is of considerable importance for the labour market in Germany.[15]

The mentioned calculations by the *Statistische Bundesamt* include the following industrial sectors:[16]

- Manufacture of steam boilers (without central heating furnaces)
- Manufacture of data processing equipment and peripheral devices
- Manufacture of devices and equipment in telecommunications
- Manufacture of measuring, control, navigational and similar instruments and devices; manufacture of clocks and watches

[11] Cf. Datamonitor (2010, p. 9).

[12] Cf. Statistisches Bundesamt (2011a).

[13] Cf. Statistisches Bundesamt (2011b).

[14] Cf. Statistisches Bundesamt (2011a).

[15] Cf. Statistisches Bundesamt (2011a).

[16] Cf. European Union (2007, p. 3).

- Manufacture of radiation and electrical therapy equipment and medical electrical equipment
- Engineering
- Manufacture of motor vehicles and motor vehicle parts
- Shipbuilding and boat building
- Rail vehicle construction
- Aircraft and spacecraft industry
- Manufacture of military combat vehicles
- Manufacture of weapons and ammunition
- Manufacture of medical and dental apparatuses and materials
- Repair and installation of machinery and equipment

The great diversity of these industrial sectors shows that capital equipment purchasing is concerned with a broad range of products.

Chapter 3
Characterisation of Capital Equipment Purchasing

Capital equipment purchasing includes all processes for supplying a company with capital equipment from sources external to the company. These processes comprise strategic and operative planning and reach from demand assessment to disinvestment with the inclusion of maintenance and repair. The objective of the activities within the scope of capital equipment purchasing is to ensure competitiveness and contribute to a sustained increase in corporate value.

To be differentiated from the above is the term ‘project purchasing’, which is often used synonymously in practice. A distinction should here be made between project purchasing as a form of organisation and procurement within the scope of a project. In project purchasing as a form of organisation, “all materials required for a special project are procured by the team or buyer responsible for the project.”[1] Procurement within the scope of a project refers to the supply function regarding an assignment limited in time and substance. This may include the procurement of capital equipment or other main procurement groups, such as consulting or facility services.

The term ‘capital equipment purchasing’ emphasises the operative character of the activities connected with the supply functions and thus refers to the mere processing of outside purchasing. By contrast, capital equipment purchasing additionally includes the corresponding planning, monitoring and control processes.[2] Since, however, corporate practice usually talks about capital equipment purchasing, both terms are used synonymously in the following.

Capital equipment purchasing as such can be typified as presented in Table 3.1. First, the typology can be used for structuring capital equipment purchasing within the enterprise. The purchasing organisations may be public authorities or enterprises; however, the following only concerns procurement by enterprises. Capital equipment can be procured irrespective of the procurement of other capital equipment (individual transaction) or by taking other capital equipment into account (composite transaction). One example of a composite transaction is the procurement of an aircraft by an airline with an existing fleet. If the existing fleet only

[1] Hildebrandt (2010, p. 59).

[2] Cf. Mohr (2009, p. 26 et seq.).

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Table 3.1 Typology of capital equipment purchasing

<table>
<tr><td>Purchasing Organisation</td><td colspan="3">Public authorities</td><td colspan="3">Enterprises</td></tr>
<tr><td>Degree of Dependency</td><td colspan="3">Individual transaction</td><td colspan="3">Composite transaction</td></tr>
<tr><td>Procurement Region and Degree of Internationalisation</td><td colspan="2">National</td><td colspan="2">Continental</td><td colspan="2">International</td></tr>
<tr><td>Internal Organisation</td><td colspan="3">Unipersonal</td><td colspan="3">Multipersonal (buying centre)</td></tr>
<tr><td>External Integration</td><td colspan="3">Involvement of other organisations</td><td colspan="3">No other organisations involved</td></tr>
<tr><td>Award Procedure</td><td colspan="3">In the form of invitations to tender</td><td colspan="3">No invitation to tender</td></tr>
<tr><td>Degree of Personalisation</td><td colspan="3">Personal contact</td><td colspan="3">Anonymous</td></tr>
<tr><td>Time Restrictions</td><td colspan="3">Urgent</td><td colspan="3">Non-critical</td></tr>
<tr><td>Financial Volume of Investment in relation to Annual Investment Volume</td><td colspan="2">< 5%</td><td colspan="2">5% –30%</td><td colspan="2">> 30%</td></tr>
<tr><td>Leasing</td><td colspan="3">Yes</td><td colspan="3">No</td></tr>
<tr><td>Performance Contracting</td><td colspan="3">Yes</td><td colspan="3">No</td></tr>
<tr><td>Objective of Investment in Terms of a Company's Production of Goods and Services</td><td colspan="2">New investment</td><td colspan="2">Substitute investment</td><td colspan="2">Expansion investment</td></tr>
<tr><td>Purchasing Class</td><td colspan="2">Initial purchase</td><td colspan="2">Modified repeat purchase</td><td colspan="2">Unmodified repeat purchase</td></tr>
</table>

includes aircraft from a single manufacturer, this situation will have major effects on the maintenance costs of decision alternatives. The procurement region can be subdivided into national (e.g. Germany), continental (e.g. Europe) or international. Depending on the procurement region, different legal aspects must be taken into account, for example. Since specialised capital equipment is frequently offered by only a few manufacturers, the procuring company has to consider international purchasing.

In terms of the organisations involved, internal and external players can be distinguished. At procuring companies, capital equipment purchasing may be effected by one person (unipersonal) or by a so-called buying centre (multipersonal). A buying centre includes all the members of an organisation involved in the procurement process of a product or service. Differentiated within the buying centre are the roles of user, influencer, decision-maker, buyer and information selector.[3] Although capital equipment purchasing is also possible without tying in other external players, additional organisations are typically involved, especially where the procurement of complex capital equipment is concerned. Moreover, the procurement process may then involve pertinent authorities, financial institutions, consultants, planning offices, various suppliers and foreign trade organisations (Fig. 3.1).

The award procedure may be effected either with or without an invitation to tender, namely the written enquiry about the terms and conditions of potential suppliers. The degree of personalisation ranges all the way from personal contact with the supplier to complete anonymity. The more complex the capital equipment to be

[3] Cf. Webster/Wind (1972, p. 14).

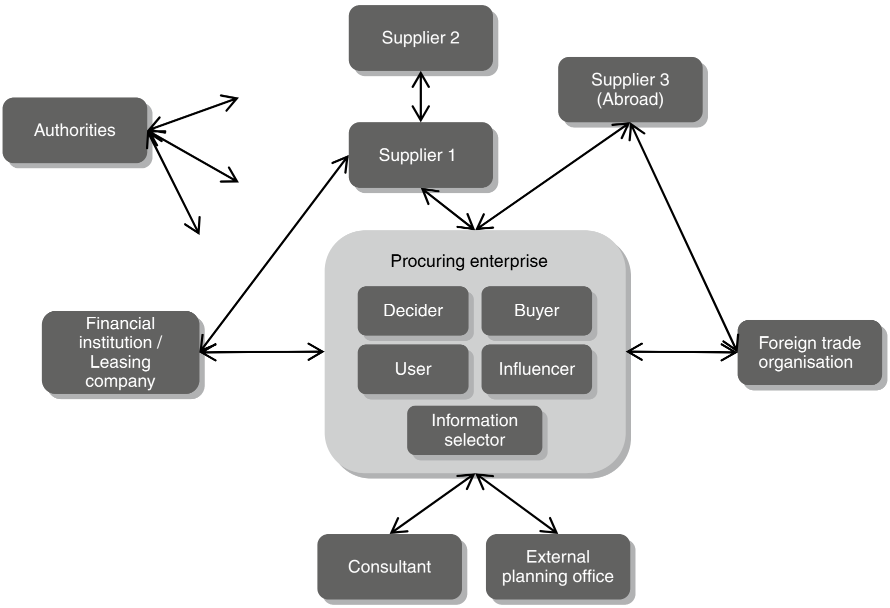

Fig. 3.1 Players involved in capital equipment purchasing. (Cf. Webster/Wind 1972, p. 78 et seq.)

procured, the more important the personal contact. Other distinguishing features are not only the time limit (urgent or non-critical) but also the percentage of the financial investment volume relative to the annual investment volume. The higher this percentage, the more important it will be for the company to carry out the procurement process in a structured manner.

Another important differentiating feature with regard to the contract is the question of whether leasing or performance contracting[4] will be applied. Moreover, different objectives may be pursued with capital equipment with regard to the company's production of goods and services. New investments create new capacities of operative capabilities, substitute investments are used to maintain operative capabilities and expansion investments increase operative capabilities. Finally, capital equipment purchasing differentiates between initial purchases, modified repeat purchases and unmodified repeat purchases (Table 3.2).

Figure 3.2 shows the special features of capital equipment purchasing compared with the other main procurement object groups. These properties are classified according to the dimensions of players, products and procurement process. Since there are major differences even within the individual main procurement object groups, the indicated performance criteria are merely a trend. Thus, for example, in individual cases even consumables or trade goods might require high financial input. However, this is typically characteristic of production materials, services

[4] Performance contracting in the context of capital equipment purchasing is discussed in detail in Sect. 7.4.

Table 3.2 Characterisation of the different purchasing classes of capital equipment. (Cf. Arnolds et al. 2010, p. 426)

Characterisation Criteria			
Purchasing Classes	*Novelty of Problem*	*Information Requirement*	*Attention to Alternatives*
Initial Purchase	High	High	Important
Modified Repeat Purchase	Medium	Limited	Limited
Unmodified Repeat Purchase	Low	Low	Minor

	Characteristic	Production Material	Production Resources	Services	Trade Goods	Capital Equipment
Players	Several organisations are often involved in the procurement process	✓	✗	✗	✗	✓
	Members of the organisation frequently form a group (buying center)	✓	✗	✓	✗	✓
	Frequently international relations	✓	✗	✗	✓	✓
	Personal selling is of major importance	✓	✗	✓	✓	✓
	No regular procurement	✗	✗	✓	✗	✓
Product	Highly technical in nature	✓	✓	✗	✓	✓
	Provide the technical prerequisite for rendering operational performance	✗	✗	✗	✗	✓
	Services play an important part	✗	✗	✓	✗	✓
	Long useful life	✗	✗	✗	✗	✓
	Purchase price usually amounts to about 30% to 50% of the life cycle costs	✗	✗	✗	✗	✓
	Frequently high financial stakes	✓	✗	✓	✗	✓
Procurement Process	Frequently awarding in form of invitations to tender	✓	✗	✓	✓	✓
	Long-term business relations play an important part	✗	✗	✓	✗	✓
	Frequently long procurement period	✗	✗	✗	✗	✓
	Frequently contingent decisions	✓	✗	✓	✗	✓
Number of Matches		8	1	8	4	15

✓ right
✗ wrong

Fig. 3.2 Special features of capital equipment purchasing compared with the other main procurement object groups

and capital equipment. Capital equipment purchasing mostly refers to the procurement of production materials and services. Yet, there are still great differences even here—such as with regard to the long useful life and the small percentage of the purchase price with capital equipment. This means that capital equipment purchasing partly focuses on other subject matters compared with the other main procurement object groups.

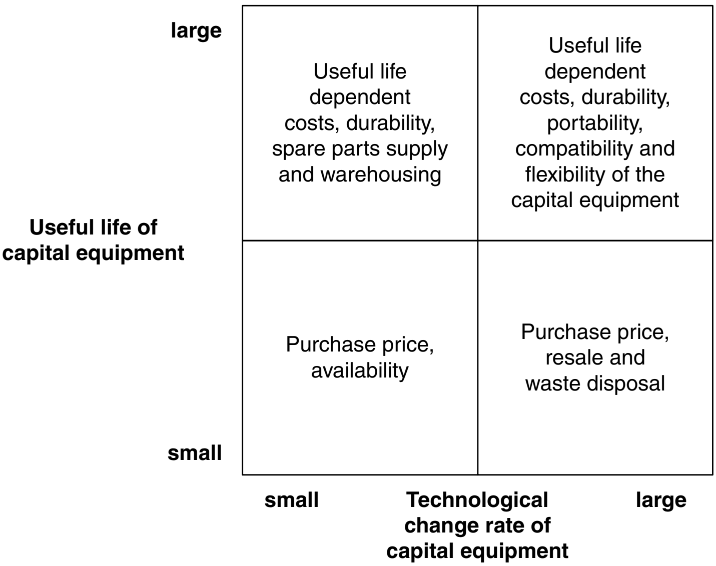

Fig. 3.3 Challenges of the procurement organisation within the scope of capital equipment purchasing. (Cf. Weber 2000, p. 5)

The challenges for the procurement organisation also differ within capital equipment purchasing. Thus, the focus is on different aspects depending on the useful life and the technology change rate of the capital equipment. Figure 3.3 shows, for example, some challenges of the individual matrix fields. While for a short useful life, the purchase price is more likely to be taken into account, a longer useful life should increasingly take into account the useful life-dependent costs. If the technology of the capital equipment changes only slightly, the spare parts supply will be an important subject, for example. Finally, in case of a high technology change rate, the high flexibility of the capital equipment should be taken into account.

Chapter 4
Typical Challenges and Possible Solutions in the Procurement of Capital Equipment

Numerous challenges exist within the scope of capital equipment purchasing. Below, we specify the major challenges and approaches to possible solutions. The following chapters then present in detail the solutions.

Since new technologies are continuously being developed and launched, industrial buyers must have up-to-date information about current developments. In this context and because of the increasing cost pressure, requirements on purchasing departments are steadily rising. On one hand, quality standards must be met, while costs must be saved, on the other hand. The procurement of capital equipment must take into account not only the purchase price but also the direct follow-up costs (e.g. maintenance, repair, etc.) and indirect follow-up costs (productivity, labour costs, etc.). The information overload on the part of capital equipment manufacturers with regard to their products often results in insufficient market transparency, aggravating the framework conditions of a request for quotation. Moreover, conflicts of interest may result from the divergent objectives of different corporate divisions. In capital equipment purchasing, the production department, for example, is focused on applications (e.g. large number of additional functions), whereas the purchasing department is primarily oriented on low cost prices. This results, among other things, in time lost because of protracted, internal coordination processes, especially if targets as well as the decision authority had been ambiguously defined prior to the procurement process. Furthermore, challenges in the procurement of capital equipment result in terms of legal aspects, such as the non-applicability of the *Allgemeine Einkaufsbedingungen* (General Conditions of Purchase) because of the individuality aspect of capital equipment.

The special characteristics of capital equipment purchasing as already presented in Chap. 2 in comparison with other main procurement object groups bring about other challenges requiring special solutions. These challenges and solutions are briefly presented below based on the dimensions of procurement process, players and products (Fig. 4.1).

Owing to high complexity and diversity, the process of capital equipment purchasing presents various challenges for enterprises. Such challenges result from the different characteristics of the procurement process, such as the long procurement period, frequent awarding in the form of tenders and long-term business relations.

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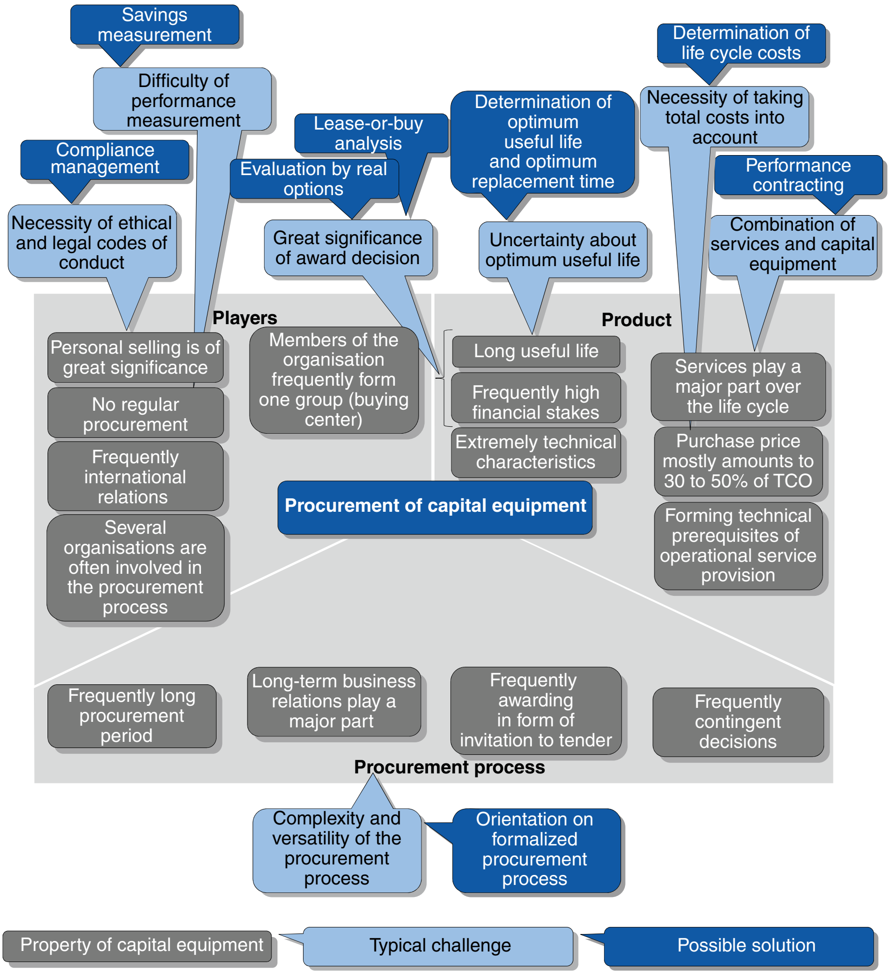

Fig. 4.1 Typical challenges and possible solutions within the scope of capital equipment purchasing

To be able to provide, nonetheless, a structured procedure, the procurement of capital equipment should have a formalised procurement process (Chap. 5).

- The players involved are faced with numerous ethical and legal codes of conduct. Owing to the great number of personal interfaces and the high degree of internationalisation of capital equipment purchasing, this subject is of particular relevance in this context. This special challenge, for example, can be successfully handled by means of compliance management (Sect. 6.1).
- Since capital equipment is often procured at irregular intervals and accordingly no comparison with historical prices is possible, it is difficult to measure the monetary procurement success. This challenge should be met using savings measurement methods (Sect. 6.2).

- Since the purchase price for capital equipment frequently amounts to only 30–50% of total life cycle costs, any possible follow-up costs of capital equipment purchasing should be especially taken into account. This may be done in the course of ascertaining life cycle costs or the total cost of ownership (Sect. 7.1).
- Because of the long physical life of capital equipment, the question moreover presents itself as to how long the economically sensible useful life of capital equipment actually is. In answer to this question, various methods can be used to calculate the optimum useful life and optimum replacement time (Sect. 7.2).
- The long useful life in combination with usually high financial stakes results in a major tie-up of capital. Furthermore, any decisions made within the scope of capital equipment purchasing have far-reaching consequences in terms of time. The great importance of the award decision can be met, for example, by an evaluation of real options (Sect. 7.3).
- Owing to the increasing combination of capital equipment and services, the latter play an important part in capital equipment purchasing. Performance contracting (Sect. 7.4) provides one possibility for developing a performance package of capital equipment and services.

Chapter 5
Process for the Procurement of Capital Equipment

Although capital equipment is frequently individualised, the process for the procurement of these goods is similar in many cases. Since many players are often involved and far-reaching decisions need to be made, the procurement process is generally characterised by a relatively long duration with numerous different phases. The process for the procurement of capital equipment may take months or even years in some instances. Furthermore, procurement frequently requires contingent decisions to be made. That means the decision for a concrete procurement object depends on previous capital equipment purchases, which will influence future decisions. For instance, capital equipment purchasing should take into account any possible synergy effects with existing plants in terms of maintenance. The procurement process presented in the following aims to provide a suitable framework for managing these challenges (Fig. 5.1).

The procurement process can be roughly subdivided into a preparatory phase (Sect. 5.1), an agreement phase (Sect. 5.2) and an execution phase (Sect. 5.3). The preparatory phase extends from ascertaining the needs to the final negotiations with potential suppliers. The agreement phase comprises the process steps from the award decision up to the control and release of the capital equipment. However, this does not conclude the process of capital equipment purchasing. The concluding execution phase comprises the steps from the organisation of start-up and test operations all the way to divestment. These processes are accompanied by the cross-sectional activities of interdependence management, evaluation and project management (Sect. 5.4) that run parallel. These cross-sectional activities are used not only for implementing the holistic claim of the procurement process but also for recursivity if individual phases must be run through repeatedly. In the case of a successor or expansion investment for already procured capital equipment, the process will begin anew. The procurement process should be carried out not only for the components of a capital equipment—if the investment can be broken down into partial investments—but also for total investments.

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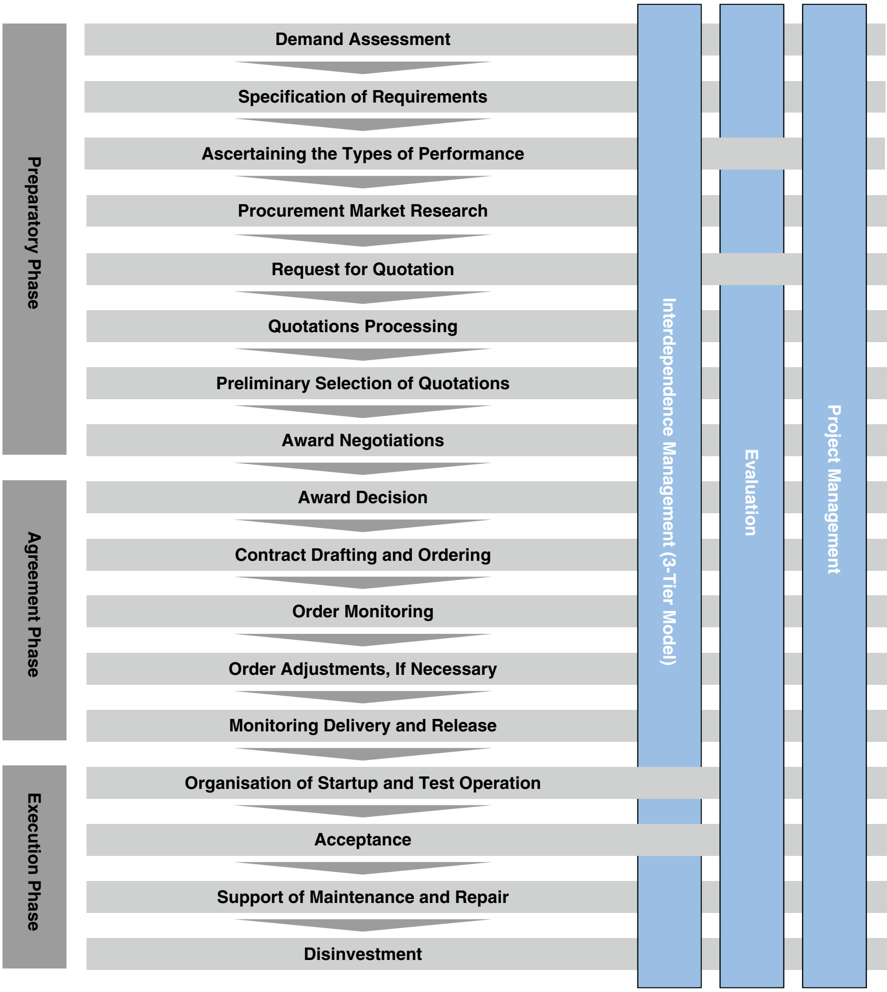


Fig. 5.1 Process for the procurement of capital equipment

5.1 Preparatory Phase

The first step in any procurement process is *demand assessment*. This step clarifies which procurement objects should be procured and in what amounts, at what times and how often. Also to be clarified are the costs these procurement objects will cause.[1] The impulse for the procurement of capital equipment presenting an irregular or non-recurrent demand generally comes from the specialised department concerned. That department should first state the function that should be provided

[1] Cf. Kreuzpointner/Reißer (2006, p. 19).

by the capital equipment to be procured. Then, purchasing should clarify together with the specialised department what types of capital equipment are suitable or available in this case. Forecast procurement planning is required for capital equipment that is regularly procured.

The next step refers to the *specification of requirements* to be recorded in general specifications (also called technical specifications). The contents and scope of the general specifications depend on the importance, risk and value of the capital equipment to be procured. It is relevant to record as definitely as possible the requirements for the capital equipment. Not only the buyer but also the user and the decision-maker should be involved in this process. A special difficulty in capital equipment purchasing is that the requirements in this step are often imprecisely determined. These must frequently be ascertained in an iterative process via a request for quotation. In any event, however, the requirements established should be categorised by necessity ("must have" and "nice to have") and weighted accordingly. This facilitates the award decision described in detail below.

After the requirements have been specified, market research aims to clarify which types of performances can meet these requirements (*ascertaining the types of performances*). This step aims to analyse what types of capital equipment are possible for the specified assignment. For example, the task of the intra-operational transport of production materials will bring about completely different solutions, such as trailer trucks, electric overhead conveyors or automated guided vehicle systems. Furthermore, we examine in this section whether different financing alternatives are possible for the relevant capital equipment, such as rental, leasing or performance contracting (Sect. 7.4).

Within the scope of *procurement market research*, the basic structure of a procurement market should be ascertained as well as the development of certain market values over time. Furthermore, information should be gathered about the product to be procured, potential suppliers and concrete market prices. To gain a comprehensive picture of a procurement market, many different sources of information must be included in the research. Possible sources of information for procurement market research include:[2]

- Trade fairs and exhibitions
- Contacts with sellers
- Internal sources
- Supplier publications, e.g. supplier catalogues and price lists
- Other publications, e.g. trade journals, statistics, trade registers and trade directories
- Supplier visits
- Exchange of experience with other companies

After potential suppliers have been found, the process of the *request for quotation* should be set in motion for the capital equipment to be procured. This process step is alternatively called request for quote, invitation to tender, enquiry or request

[2] Cf. Arnolds et al. (2010, p. 51 et seq.).

for quotation. The necessary enquiry documents generally comprise, for a written enquiry, an enquiry cover letter, a specification of the capital equipment (if available including technical drawings), technical specifications and information on the expected date of delivery and surrender. The number of quotations obtained here depends on the value of the goods to be procured.[3]

Quotations received should be subsequently checked for their legal validity and factual completeness (so-called *quotation processing*). If necessary information is missing, it should be requested from the supplier. Quotations must furthermore be subject to a technical and commercial check. If there are not enough quotations to choose from after formal criteria have been checked, further inquiries to alternative suppliers could be made.

If, after a formal check of the quotations, there are still too many quotations left to be able to conduct well-targeted expedient negotiations with all suppliers, a *preliminary selection of the quotations* must be made. Basically, the same criteria should be used as for the subsequent award decision. However, especially in capital equipment purchasing, quotations from long-standing business partners should not be sorted out prematurely since these suppliers tend to be more prepared to rework their quotations. For other quotations, it is also recommended to introduce into the decision an assessment of the negotiation potential to be realised.

If, based on the investment volume and possible cost or performance potentials, the negotiation of one or several quotations is considered sensible, this may be carried out in a personal meeting or via video conference or phone. It needs to be checked within the scope of the *award negotiations* whether the agreements are correctly understood on all sides and whether all differences have been cleared up. The award negotiations should not be considered as a competition between supplier and buyer but rather as an interaction from which both parties should emerge as "winners". Nonetheless, both parties are interested in skilfully using their negotiating positions, which result, for example, from the seller's monopoly position or the buyer's market power. Essential for successful award negotiations is a good preparation of the negotiation organisation and its procedure.

5.2 Agreement Phase

The *award decision* is an important step in the process of capital equipment purchasing since it paves the way for the project's success. In the selection of alternatives, support for decisions is provided by investment assessment methods that take into account life cycle costs (Sect. 7.1), the real options approach (Sect. 7.3) and an evaluation based on the scoring model (Sect. 5.4.2). The award decision can be made as soon as a negotiation result has come about that is satisfactory for the parties involved in terms of various criteria, such as price, quality agreements and due dates.

[3] Cf. Büsch (2007, p. 174 et seq.).

After the decision has been made, *contract drafting and* ordering follow. Purchase contracts are used for the procurement of standardised capital equipment and contracts for work are used with regard to individualised capital equipment. The contents of a contract include technical specifications, due dates and maturities as well as other clauses, such as terms and termination possibilities, liability clauses, especially for late supply and defects, and the jurisdictional venue clause. The final contract version should be clearly understandable and free from legal sophistry. When contract drafting has been concluded, the ordering process can be initiated. A contract comes about if an order is given on the basis of a quotation, certified by an order confirmation or executed by implied acceptance.[4]

If there is a long period of time before the capital equipment will be delivered, it is recommended to check the order progress at regular intervals (*order monitoring and control*). In case of deviations versus the original plan, corresponding countermeasures should be introduced immediately and the delay should be communicated to the internal parties involved.

Individualised capital equipment frequently entails subsequent changes in the scope of performance. Order adjustments may result from changed requests by the procuring enterprise, or they may result because of technical or commercial adjustments on the supplier's side. In addition, orders may be adjusted because of changing external framework conditions. In such situations, the written contract is of great importance since there will always be the question of who has to pay for the changes and how possible time delays should be handled. It is the objective within the scope of the claim management to amicably clarify unforeseeable events in the procurement process in terms of their commercial consequences.

After the capital equipment has been delivered, it must be checked whether the performance scopes specified in the contract have been complied with (*monitoring delivery and release*). If that is the case, release is provided for test operation.

5.3 Execution Phase

The execution phase is the last phase in a procurement process. Following the agreement phase, the *organisation of start-up as well as the test operation* should be set in motion.[5] The capital equipment should be carefully checked to detect any possible defects.[6] The test operation checks reliability and detects security defects. Additionally, it is recommended to have employees instructed in the operation of the capital equipment.

Within the scope of *acceptance*, an acceptance report is frequently used—especially in case of a contract for work (Sect. 6.1)—based on which complete and defect-free performance is confirmed in writing. A significant part of the contract

[4] Cf. Kreuzpointner/Reißer (2006, p. 108 et seq.).

[5] Cf. Terwiesch/Bohn (1998).

[6] Cf. Kreuzpointner/Reißer (2006, p. 146).

performance ends with acceptance, namely when the stipulated compensation is due and payable and when the warranty period begins. If defects in the capital equipment are not indicated on the acceptance form, the ordering party has to provide proof of any subsequently detected defects and major costs could thus be incurred for the enterprise.[7]

To guarantee the permanent availability of capital equipment, *the support of maintenance and repair* should be emphasised. Maintenance is steadily increasing in importance because of the complexity of procurement objects, the combination and integration of several plants and the cost pressures on enterprises. Various maintenance strategies can be used not only internally but also by external companies. Moreover, new service concepts are constantly being developed, such as performance contracting solutions (Sect. 7.4).[8]

Divestment is the decommissioning of capital equipment (often in combination with a sale) without making any substitute investment. The divestment of capital equipment makes room for new things and frees up capital to flow, for example, into expansion and substitute investments. Divestment thus is a form of internal financing and secures the company's technological progress. The optimum replacement time as well as the optimum useful life can be determined by various methods, such as the net present value method (Sect. 7.2).[9]

5.4 Connecting Cross-Sectional Activities

The sequential processes of capital equipment purchasing are accompanied by the connecting cross-sectional activities of interdependence management (Sect. 5.4.1), evaluation (Sect. 5.4.2) and project management (Sect. 5.4.3). These parallel processes take place separately in most investment purchasing steps and they are used for the orientation and support of the overall process.

5.4.1 Interdependence Management

Within the scope of interdependence management, a three-tier model helps ascertain and present the types of performances and the suppliers of capital equipment to be procured, as well as their reciprocal influences and any connections between them.

Tier 1, relating to the type of performance of the capital equipment, is used for initially rendering more concrete and then clustering all relevant procurement services according to type. Here a firm differentiates between applicable materials,

[7] Cf. Kreuzpointner/Reißer (2006, p. 146).

[8] Cf. Voigt (2008, p. 508 et seq.).

[9] Cf. Voigt (2008, p. 475 et seq.).

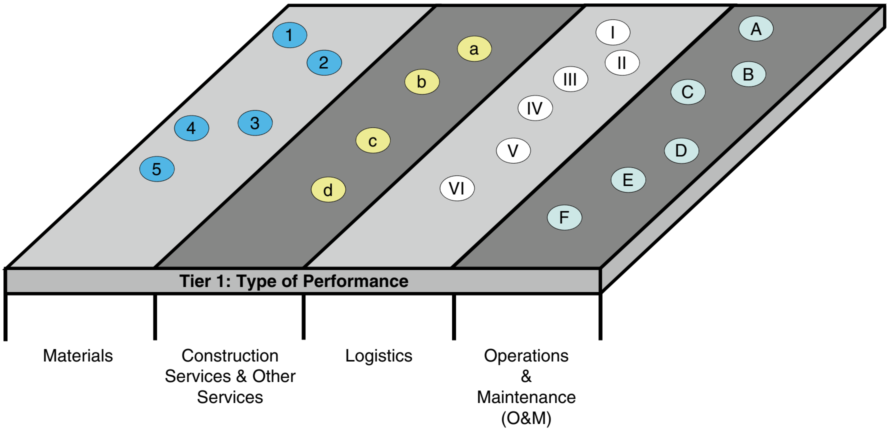


Fig. 5.2 Clustering diagram of the type of performance for capital equipment (tier 1)

construction services and other services possibly to be incurred, attendant logistics and the area of “Operations & Maintenance” (Fig. 5.2). Logistics here relates to any service or performance for the transportation and storage of capital equipment. “Operations & Maintenance” comprises any service or performance for the operation, maintenance and repair of capital equipment. In this tier, precise specifications of the capital equipment can be included, such as determining the material and material requirements, the pertinent dimensions and quality requirements, the weight and the determination of technical standards and tolerance limits for technical specifications. This step in the analysis is necessary because of the highly differentiated procedures in the procurement of the pertinent services or performances. On one hand, the classification according to the types of performances shows, in a first step, which are required to make the investment. On the other hand, the complexity of an investment project is already evident here and this justifies a systematic procedure.

This allocation to types of performances allows a first rough subdivision of the relevant performance areas of capital equipment. Behind every type of performance, however, there is a separate procurement market with specific market structures. To account for this fact, tier 2 in Fig. 5.3 shows that every type of performance is assigned one or several suppliers, thus allowing an assessment of procurement market structures.

In tier 2, a pool of suppliers should be gathered via extensive procurement market and supplier research. Any existing suppliers and their portfolios as well as empirical values within the company should also be used for this approach. Targeted clustering should be carried out together with all the relevant people involved in capital equipment purchasing in order to ensure a common state of knowledge and the highest possible transparency within the procurement process. Transparency will be increased by allocating suppliers to types of performances. It thus becomes clear which degree of attention the pertinent types of performances require. A large

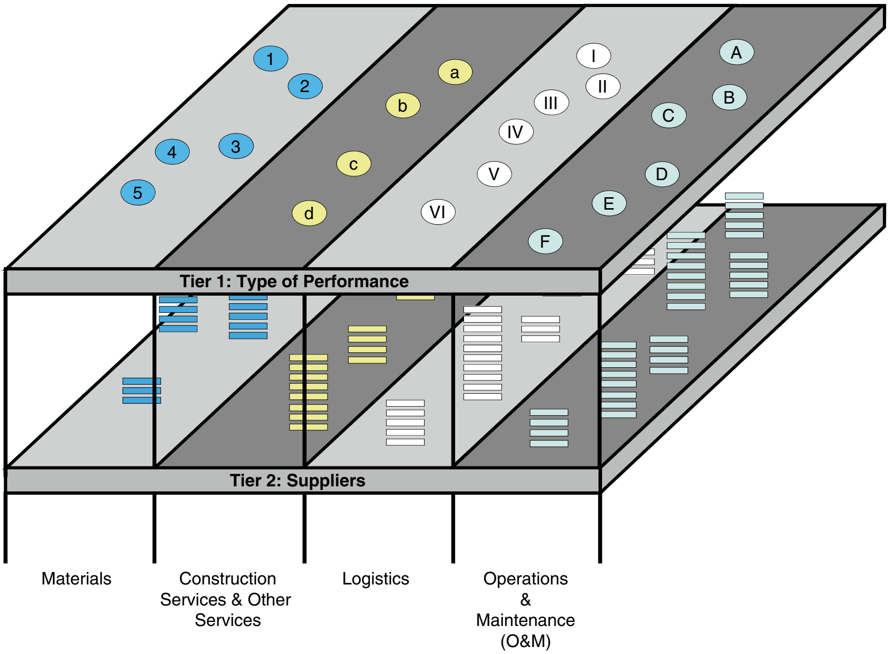


Fig. 5.3 Clustering diagram of suppliers for capital equipment (tier 2)

number of suppliers is generally considered an indicator of strong competition so that the development of competition requires fewer expenditures. By contrast, types of performances opposite only one singular supplier or a few suppliers are a sign of higher attention being required in the procurement process because of the limited powers of negotiation.

Tier 3 presents the interdependencies of performances to be procured—keeping in mind the supplier situation (Fig. 5.4).

As discussed, the selection of specific materials and material combinations possibly results in dependencies that are relevant for further decision-making. Owing to possible coordination rounds with the people involved in the process, concrete procurement strategies should be elaborated based on corresponding combination potentials and their realisation. These strategies often include contingent decisions. If a decision is made, for example, for material 1, two different procurement strategies result when scenarios are being considered. These strategies should be weighed against each other. For example, procurement strategy 1 falls back on material 1 and includes construction service b, logistics III and the operations & maintenance of characteristics B. By contrast, procurement strategy 2 also purchases material 1; however, it is here additionally supplemented with material 2, and construction service c is thus used, as well as logistics VI and the operations & maintenance of category E. Similarly, certificates, patents or other legal framework conditions may be reasons for a material's subsequent processing steps being tied to specific

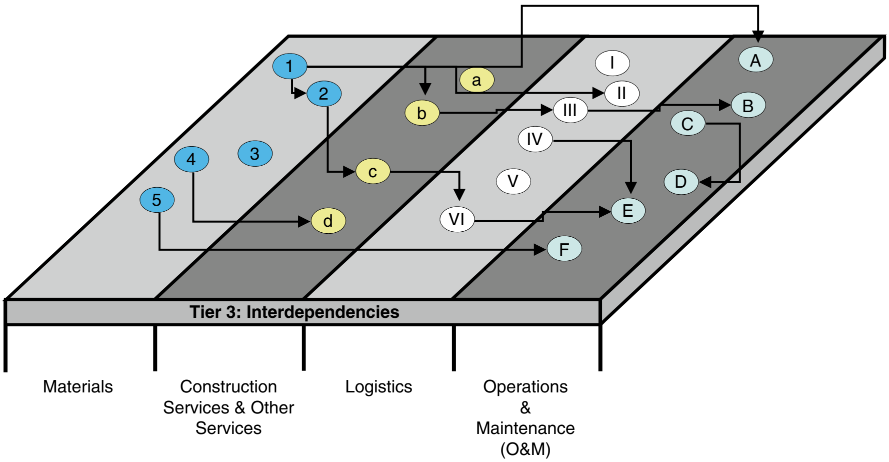


Fig. 5.4 Diagram of interdependencies of the types of performances for capital equipment (tier 3)

individual suppliers. Also conceivable is a dependency in terms of the logistics connected with the procurement of the selected material. The selection of a material or a material group might entail a risk that—because of the size of a material—there will only be a small group of potential logistics providers able to transport such goods. Moreover, the selection of the logistics provider might have already been specified by the supplying manufacturer or dealer, making it impossible to separate logistics from the actual service or performance.

Establishing interdependencies in materials, services, logistics and operations & maintenance restricts the freedom of the investment decision. Potential combinations and their viability are the focus of consideration when developing procurement strategies for capital equipment. Figure 5.5 provides a summary of the three-tier model of capital equipment purchasing.

Examining interdependencies is not only limited to the areas presented in this three-tier model. Rather, almost all process steps in capital equipment purchasing must reanalyse the ascertained dependencies between type of performance and supplier to take into account any influences on contingent decisions.

5.4.2 Evaluation

As the three-tier model only presents the interdependencies of the individual procurement strategies, it is necessary for the evaluation to quantitatively and qualitatively assess, in another step, the identified and/or adopted procurement strategies. In an exemplary manner, Fig. 5.6 shows procurement strategies 1 and 2 and their quantitative characteristics.

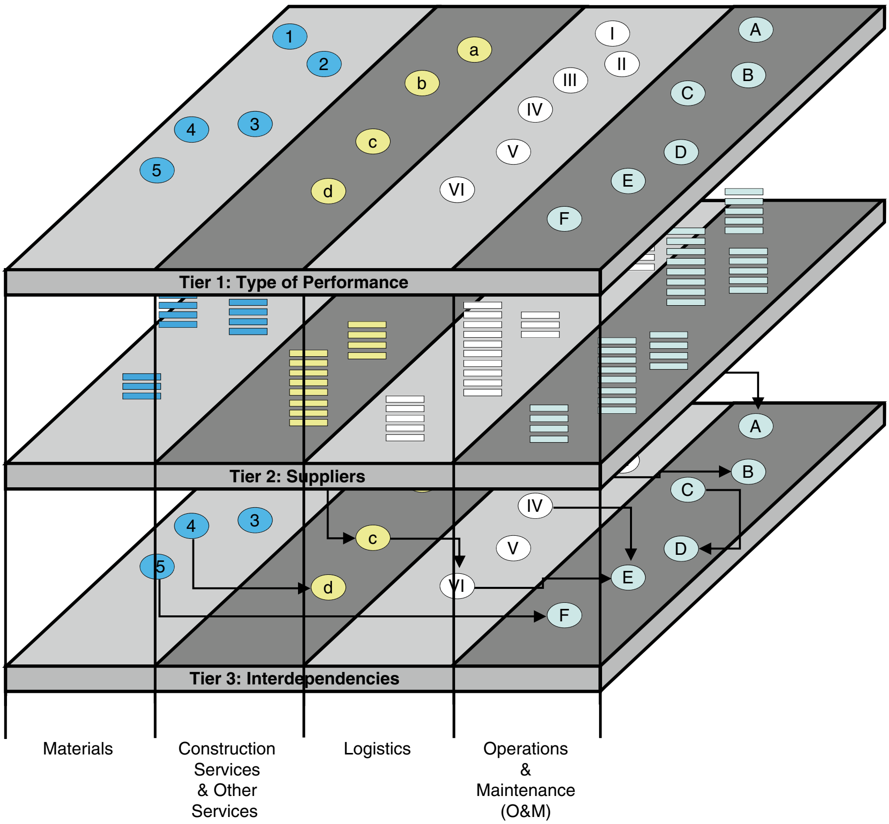


Fig. 5.5 Diagram of the three-tier model of capital equipment purchasing for the presentation of interdependencies

In a quantitative evaluation, revenues and expenditures over the total useful life of the capital equipment are listed for alternative procurement strategies, taking into account comparable assumptions. In this manner, net present value[10] can be calculated and a decision about a preferred strategy can be made from a monetary/ quantitative viewpoint. Other methods for a quantitative evaluation are the cost and profit comparison method, pre-investment analysis or average ROI method, payoff method, method of the internal rate of return or the annuity method.[11]

Figure 5.7 shows a qualitative evaluation for procurement strategies 1 and 2. These procurement strategies are evaluated based on a cost/benefit analysis[12]

[10] The net present value of an investment is the sum of in and out payments discounted to the beginning of the investment, such payments having been caused by this investment. Cf. Lee/Lee (2006, p. 189).

[11] Cf. Bittler et al. (1972, p. 65).

[12] The cost/benefit analysis analyses several complex alternatives and it aims to order the decision-maker's preferences with regard to a multidimensional target system. Cf. Götze et al. (2008, p. 175).

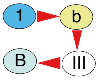
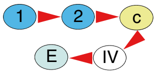
		Useful Life				Sum Total	Net Present Value
Procurement Strategy 1 	**Expenditures (€ million)**	-20 m €	-20 m €	-100 m €	-70 m €	**-210 m €**	x_1
	Revenues (€ million)	0 €	0 €	+70 m €	+400 m €	**470 m €**	
Procurement Strategy 2 	**Expenditures (€ million)**	-100 m €	-10 m €	-90 m €	-20 m €	**-200 m €**	x_2
	Revenues (€ million)	0 €	0 €	+70 m €	+400 m €	**470 m €**	

Fig. 5.6 A monetary/quantitative comparison of procurement strategies for capital equipment

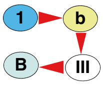
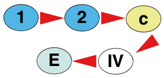
Evaluation Criteria	Environmental Aspects	Tied-up Resources	Interface Synergies	.....	Value
Weighting	**20%**	**40%**	**40%**		
Procurement Strategy 1 	**+4**	**+6**	**+8**		**6.4**
Procurement Strategy 2 	**-2**	**+9**	**+3**		**4.4**

Fig. 5.7 A qualitative comparison of procurement strategies for capital equipment

for the evaluation criteria of environmental aspects, tied-up resources and interface synergies. This evaluation can be alternatively provided by means of the "analytic hierarchy process".[13] The number and depth of detail of the analysis of individual evaluation criteria, as well as the appropriate weighting, should be adjusted both individually and to the corresponding capital equipment. In the example shown, procurement strategy 1 has a higher value and thus wins the qualitative comparison.

[13] Cf. Saaty (1990, p. 9 et seq.).

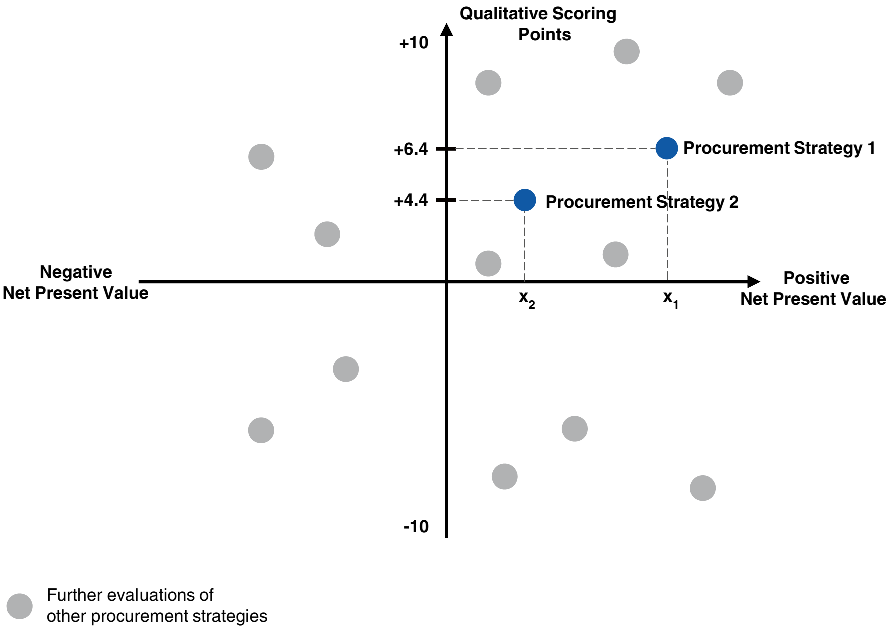


Fig. 5.8 Exemplary scoring model for capital equipment purchasing

To ensure the comparability of different procurement strategies for capital equipment and to arrive at a well-founded decision, a scoring model is frequently further required, which can provide both quantitative and qualitative factors for an evaluation (Fig. 5.8).

Complex investment decisions can be visualised two-dimensionally for decision-making. Since procurement strategy 1 has both a higher net present value and more scoring points, it should be preferred over procurement strategy 2. If a procurement strategy only shows an advantage in one of the two dimensions, it is a matter of weighing up the qualitative benefit (scoring points) and the monetary/quantitative evaluation (net present value). This evaluation can be carried out by re-weighting the two dimensions.

An evaluation is relevant for virtually all project steps in capital equipment purchasing since a decision must always be made in terms of choosing among several alternatives. From step to step in the process, the degree of the maturity of the evaluation increases ever more because of the availability of increasingly more concrete data and information. For example, procurement market research aims to determine which regions are included in research procedures; in order monitoring and control, the question is which processes and due dates should be monitored qualitatively and quantitatively and which key figures or ratios should be used for this. In addition, particularly important is an evaluation of the purchasing process, namely measuring the success of capital equipment purchasing (Sect. 6.2).

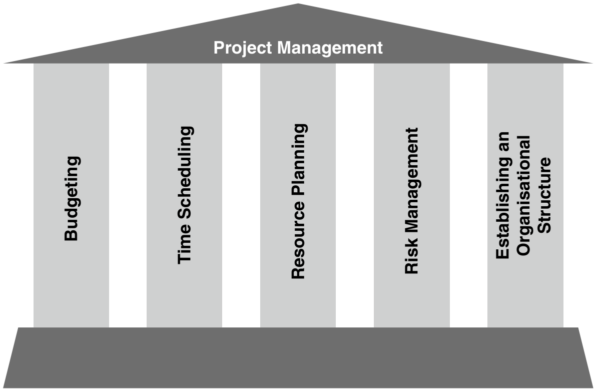


Fig. 5.9 Functions of project management within the scope of capital equipment purchasing

5.4.3 Project Management

Across all project steps, the procurement of capital equipment requires effective and efficient project management, which includes an adequate procurement organisation. This comprises all planning, monitoring and control activities connected with capital equipment purchasing. In this respect, essential functions are budgeting, time scheduling, resource planning and risk management, as well as establishing a suitable organisational structure, including incentives and decision-making channels (Fig. 5.9).

Budgeting within the scope of project management especially focuses on the setup and control of a finance plan for capital equipment purchasing. This is usually based on a prior investment analysis. After the capital spending requisition according to specific release limits has been approved by the responsible players, expenditures may be spent. Cost control subsequently aims to detect possible cost deviations by means of a nominal/actual comparison and introduces measures for counteraction, if necessary. These countermeasures may include, for example, adjustments in performance specifications or efficiency-improving activities.

Moreover, project management uses uncompromising time scheduling. Project scheduling reflects the time needed for individual phases and considers the lead times of the different steps. Taking into account the supplier's structure, a detailed view of the individual procurement volumes in the respective phases enables a determination of the necessary lead times for the types of performances to be considered. For example, the procurement time of an individually manufactured machine significantly deviates from the procurement time of a machine without any degree of individualisation. To develop the time scheduling presented in Fig. 5.10 for the implementation of a procurement strategy, the described tiered model should be transferred into a suitable time schedule. In this respect, compliance with the individual phases is subject to permanent control and monitoring.

The point in resource planning is to link the competing cost, time and substantive objectives as optimally as possible and control them in an iterative process. The types of resources are subdivided into personnel resources, physical means and

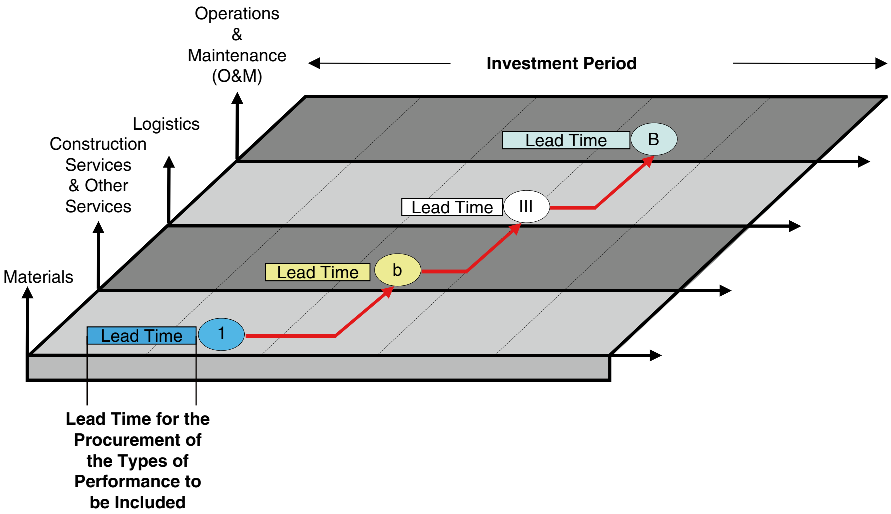


Fig. 5.10 Time schedule of a procurement strategy within the scope of capital equipment purchasing

financial means. Personnel resources relate to the spatial and temporal availability of adequately qualified employees. For example, industrial buyers familiar with the procurement of capital equipment should have the corresponding technical knowledge in order to understand the responsible technical personnel. Physical means include, for example, the premises required for project execution; also, the means of information and communications, as well as plants and machinery. In this respect, it should be clarified who has access to the available physical means and to what extent. Financial means should be planned in close coordination with budgeting.

Risk management comprises all measures for an evaluation and the improvement of the risk situation of a capital equipment purchasing project. The risk of an event is principally defined here as the product of the probability of onset and amount of damage. Within the scope of the risk management process, the relevant risks are first identified and assessed. The planning process for the measures subsequently decides how every assessed risk should be handled. The strategies underlying the measures can be subdivided as follows:[14]

- Causal risk strategies:
  - Risk avoidance: Complete elimination of the risk, e.g. by avoiding capital equipment suppliers from crisis-ridden countries.
  - Risk reduction: Reducing the risk by lowering the probability of the onset or extent of damage, e.g. using effective project management for capital equipment purchasing.
  - Risk spreading: Reducing the risk by exploiting the correlation properties between individual risks, e.g. by multiple sourcing.

[14] Cf. Becker/Rieke (2005, p. 275).

- Effect-specific risk strategies:
  - Risk shifting: Transfer of risks to contract partners and insurance companies, e.g. by stipulating contract penalties in case of due date default on the supplier's part for important assemblies or components of the capital equipment.
  - Risk carrying: Deliberately accepting the losses and profits connected with the risk, e.g. procurement from favourable but risk-prone capital equipment manufacturers.

In addition to the described functions, project management for capital equipment purchasing still has further functions to perform, such as the preparation of a project contract, project communications and change management. After the completion of all activities, final control must also be provided and the project documented; the dissolution of project structures is required as well. In practice and with regard to its concept, capital equipment purchasing is, in many cases, not organisationally separate from the procurement of other goods. Moreover, capital equipment purchasing is frequently decentralised in its organisation, namely major decisions are made by those responsible on location. Finally, it is thus especially important to create incentive systems in capital equipment purchasing that involve all participating players and that are oriented on the overall welfare of the enterprise. Accordingly, incentive systems should be addressed, as far as possible, not only to the purchasing staff but also to the staff in technical departments, and the total costs of the pertinent capital equipment should also be taken into account in this respect.

Chapter 6
Instruments and Methods of Capital Equipment Purchasing in Terms of the Players Involved

6.1 Compliance Management in Capital Equipment Purchasing

6.1.1 Introduction to Compliance Management

While capital equipment purchasing mostly takes only economic cost/benefit aspects into account, people frequently fail to realise that compliance and compliance management are relevant for the observation of statutory and internal regulations in capital equipment purchasing. Yet, the subject of compliance is of particular importance in terms of legal uncertainties because of non-recurrent investments, protracted planning and decision-making processes, as well as multi-organisational interface management systems.[1]

Compliance generally stands for the observation of laws, regulatory standards and voluntarily imposed regulations.[2] Overriding objectives in this respect are the minimisation of any kind of economic risks, as well as a guarantee of the consistency of the law to avoid liability risks and any damage to reputations.[3]

In addition to safeguarding against risks concerning external stakeholders, the objectives of comprehensive compliance management extend to internal corporate and/or organisational processes. Specifications regarding processes and regulations for procedures result in the organisation's efficiency being increased within the scope of compliance management. In this respect, project-related compliance management in capital equipment purchasing must be integrated into the enterprise's overriding strategic objectives and its organisational structure.[4] The concept and design of compliance management generally comprises three steps:

[1] Cf. Arnolds et al. (2010, p. 429).

[2] Cf. Schneider (2003, p. 646).

[3] Cf. Fissenewert (2010, p. 64 et seq.).

[4] Cf. Bürkle (2005, p. 565).

E. Hofmann et al., *Capital Equipment Purchasing,* Professional Supply Management 2,
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- It is first necessary to identify and analyse potential risks to derive a corresponding strategy for risk avoidance or minimisation for the entire enterprise and the pertinent investment project.
- In a next step, a compliance guideline should be prepared that comprises not only behavioural guidelines but also regulations on contract management, supplier codices[5] and training for employees.[6]
- In a third step, it is indispensable to establish an internal control system to measure and ensure not only compliance with the specified requirements and guidelines but also the success of the compliance management process. To this end, monitoring should be implemented along the entire procurement process based on reports, supplier audits and corresponding key figures and ratios.[7]

6.1.2 Fitting Compliance Management into the Capital Equipment Purchasing Process

Compliance management is applied not only before but also during the entire procurement process. It can thus be interpreted as a control element that helps determine—prior to the beginning of a project—the legal and organisational framework conditions of the normative reporting system that will be valid over the entire project. Moreover, the basis of effective compliance management is both the documentation of the entire procurement process and the continuous monitoring of compliance with regulations and provisions along the process (Fig. 6.1).[8] For that reason, it is necessary that structured compliance management in capital equipment purchasing accompanies the entire procurement process—all the way from demand assessment to divestment.

6.1.3 Interdependencies with Other Aspects of Capital Equipment Purchasing

The following section presents the interdependencies of compliance management with three aspects of capital equipment purchasing based on wind turbine procurement.

[5] A supplier codex is a generally valid standard regarding sustainable economic management for all suppliers of goods and services.

[6] Fissenewert (2010, p. 63 et seq.).

[7] Cf. Rodewald and Unger (2006, p. 113 et seq.).

[8] Cf. Hauschka (2008, p. 7).

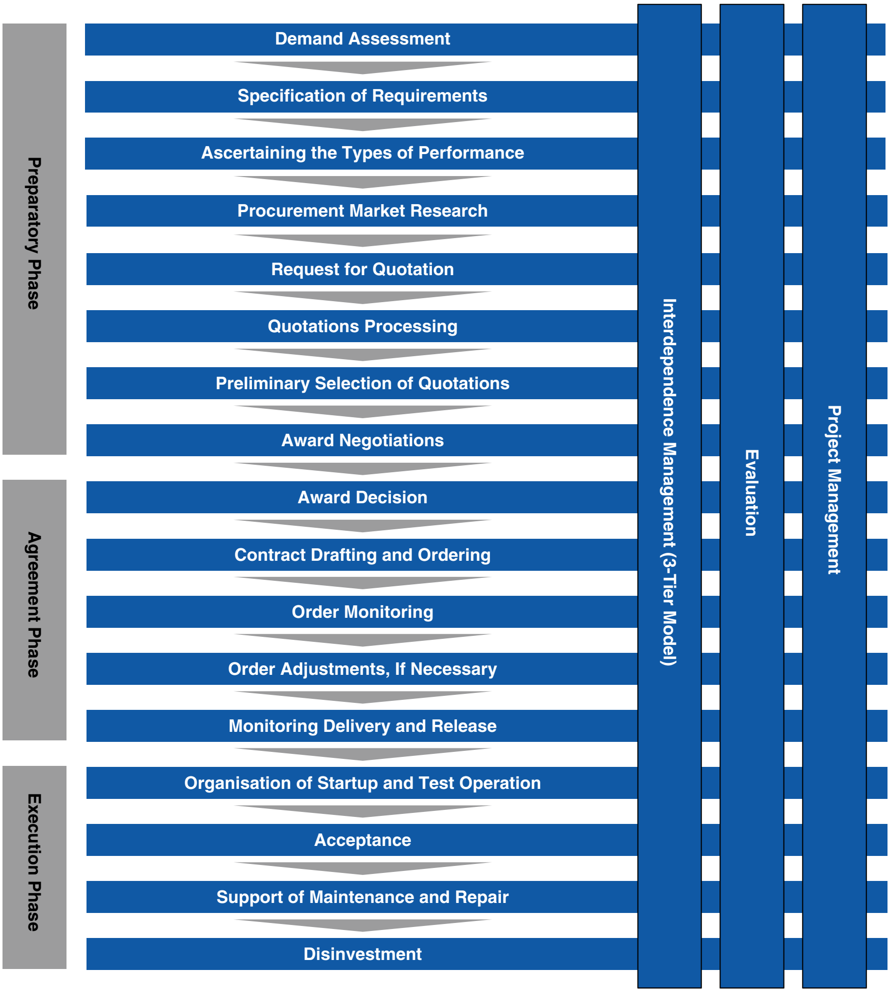

Fig. 6.1 Fitting compliance management into the capital equipment purchasing process

6.1.3.1 Compliance with the Legal Aspects of Contract Award and Contract Drafting

In terms of the procurement and construction of wind turbines, two legal pitfalls should be especially considered to ensure that all legal provisions are complied with. First, it is often difficult to differentiate between contracts for work and contracts of service because, frequently, both legal bases are effective. Second, for pertinent invitations to tender, legal aspects of the contract award should be taken into account when certain threshold values are exceeded. Moreover, it should be ensured that contracts concluded in this context present themselves as safe and advantageous for life.

In terms of contract drafting, it must always be kept in mind that—because of the non-assignability of capital equipment purchasing—the contracting parties' rights and obligations are usually laid down in individual contracts, which is why *Allgemeine Einkaufsbedingungen* (General Conditions of Purchase) are rarely used in these cases. With regard to the law on contracts for work, there are essential differences compared with the law on purchase contracts—with the immediate examination and notification of defects being substituted by acceptance. There are also longer periods of limitation, as well as a general reworking in the case of faults or the lack of promised properties. To be especially taken into account is the differentiation between the law on contracts for work and the law on contracts of service since—for capital equipment such as wind turbines—both legal bases are often valid for components of the plants and their subsequent maintenance. In this respect, the law on contracts for work is predominantly seen only as the legal basis for plant procurement.[9] However, it is supplemented in most cases by special statutory regulations, such as the *Vergabe- und Vertragsordnung für Bauleistungen* (VOB—German Standard Building Contract Terms). Moreover, for wind turbine procurement, operating companies often avail themselves of services provided by suppliers, such as maintenance and repair work. Consequently, the supplier's role is not limited to the mere procurement of required materials and the construction of plants or installations. This also includes extraordinary repairs and controls that are carried out after commissioning. In such cases, the law on contracts of service (§§ 611 et seq. *Bürgerliches Gesetzbuch* (BGB—German Civil Code) should additionally be taken into account in Germany. In the case of maintenance/repair contracts, the strict delimitation of both indicated legal bases can cause considerable difficulties.

Legal restrictions are established by the *Gesetz gegen Wettbewerbsbeschränkungen* (GWB—Law against Restraint of Competition). According to § 98 No. 4 GWB, such ordering parties are included in the area of the application of the law on contract award whose positions as ordering parties do not result from their affiliations with public authorities but from their activities performed in a specific sector. These are private companies, which are, however, treated as public sector institutions since they either are close to the state or operate in legally protected competition. According to § 98 No. 4 GWB, this category includes enterprises that operate in the area of drinking water or energy supply, in public transportation or in the telecommunications sector.

Wind turbine operating companies are so-called sector principals for which the new *Sektorenverordnung* (SektVO—Sectoral Ordinance) is decisive for the award of contracts if certain threshold values are reached (§ 2 *Vergabeverordnung VgV*—Awarding Ordinance).[10] For construction orders, this threshold value is € 4,845,000. SektVO is applicable because, in most cases, the wind turbine award volume is much higher than is the indicated amount. Three types of award procedures generally exist according to SektVO:

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[9] §§ 631 et seq.BGB.

[10] For the sectoral area, SektVO replaces VgV.

- The *open procedure,* which invites an unlimited group of companies to submit tenders.
- The *non-open procedure,* which invites only a limited group of companies to submit tenders.
- The *negotiation procedure,* which is the only procedure to allow negotiations with companies.

As far as possible, the procedure of public tender invitations should always be used; and only in cases where this is not possible, there may be limited tender invitations. Only if this type of tender invitation is also unfeasible, there may be discretionary awarding (§ 101 GWB).

In terms of contents, tender invitations must be in accordance with the general principles of the law on contract award according to § 97 GWB. These include the competition principle, the transparency requirement and the prohibition of discrimination. They also take into account the interests of small and medium-sized companies, the awarding to expert, efficient and reliable companies and the principle of the most economic tender possible, as well as subjective bidder rights (being entitled to compliance with provisions about the award procedure). In individual contractual regulations, the ordering party may orient itself on the VOB (Part A). This is, however, neither a legal ordinance nor a law, but it may be taken over as *Allgemeine Geschäftsbedingung* (AGB—General Commercial Terms and Conditions). Yet, since the VOB usually does not regulate contractual components precisely enough, enterprises awarding the contract often define and lay down additional contractual components, as explained at the beginning of this chapter.

As a result of the regulation of VOB for exceeding threshold values, the majority of wind turbine contracts must also comply with the exact form of the description of performances and technical requirements as well as the obligations for notification according to SektVO. In some cases, companies also inform—in addition to the expected performances—about the pertinent weighting in the valuation of the tendered performances from the company's viewpoint. However, this procedure entails the risk that participants in the tender invitation will limit their tenders to an attractive price/performance ratio exclusively for the highest valued components and less interesting partial aspects of the tender are, from the suppliers' viewpoints, not adequately taken into account. Based on the published weighting, the contract must then be awarded nonetheless to the supplier with the best offer, according to the evaluation criteria that, in the final analysis, are not necessarily in accordance with the most economical overall tender. Figure 6.2 shows the legal framework of compliance management.

6.1.3.2 Compliance-Conforming Evaluation of Tenders and Award Selection

A compliance-conforming evaluation of the tenders received is closely connected with the award decisions for public institutions or enterprises for which the same legal regulations apply. As objective criteria on the legal side, the *Allgemeine*

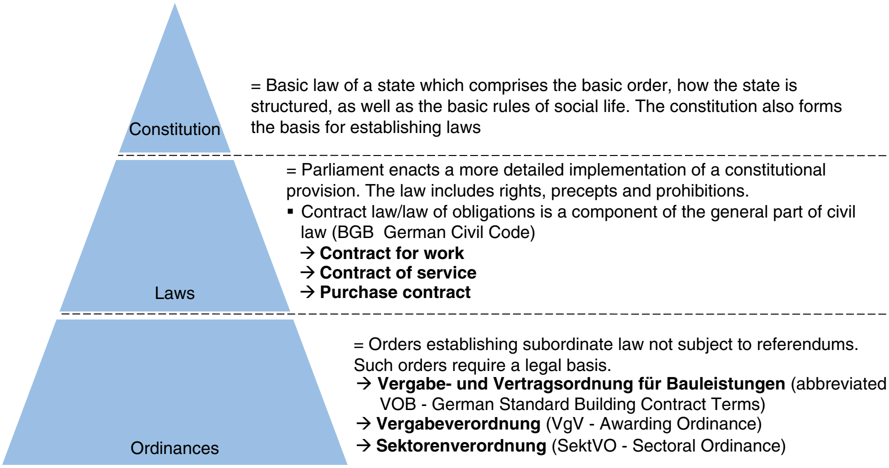

Fig. 6.2 Legal framework of compliance management

Grundsätze des Vergaberechts (§ 97 GWB V) (General Principles of the Law on Contract Award) have already been mentioned; it is imperative that these are taken into account for tender invitations and for awarding.

Furthermore, in addition to the statutory criteria, the enterprise must also provide a qualitatively and quantitatively well-founded evaluation of the tenders. This comprises not only a design evaluation but also an evaluation of the suppliers.

Examples of compliance-conforming criteria in terms of the design evaluation include:

- Total costs of capital equipment
- Operating period of prototypes
- Use of materials
- Corrosion protection
- Logistics concept
- Spare parts management
- Maintenance and repair concept

Examples of compliance-conforming criteria in the evaluation of suppliers include:

- References and experiences with special topographical conditions and technical implementability
- Qualification for the complete delivery of the installation
- Available capacities for the delivery of the complete order and possible follow-up orders
- Expansions of the investment

The focus when considering the legal aspects of a contract award is on the process for the invitation to tender, an objective evaluation of the quality offered by suppliers and criteria for the ultimate decision. Moreover, the objective of tender evaluations should be to better assess and compare monetary performance by decision-makers and also assess and compare purchasing, especially to provide a basis for the adequate project control of capital equipment purchasing. Difficulties in the objective evaluation of tenders received may result from different factors. Generally, opportunistic behaviour by those authorised to make decisions or by other influential groups may greatly affect the objectivity of tender evaluations since such people frequently pursue personal interests instead of making decisions for the company's benefit. One example is the influence of technicians and engineers who generally have a leading edge in knowing about the technical installation compared with the people in purchasing. Especially with technically sophisticated investments, such as wind turbines, those responsible in purchasing should have a certain level of expert knowledge. This will make it possible to critically evaluate qualitatively as well as money-wise any recommendations and decisions made by the technical staff. It is thus easier to prove any possible influence in terms of bribery or arrangements upon order placement.

Irrespective of opportunistic behaviour, a multitude of other influencing factors may complicate any evaluation of the costs incurred, especially follow-up costs. With regard to wind turbines, this will include, for example, location-specific environmental effects (e.g. corrosion due to salty air in maritime areas), transport costs regarding the construction of installations or long replacement periods—all of which permit only the limited comparability of historical prices with current market prices. One of these factors is the restrictions and dependencies to be taken into account in the decision for or against a component and/or a service from a specific supplier. In particular, the follow-up costs connected with a decision should be objectively identified and evaluated in the selection and award of projects. Such follow-up costs are incurred by components which—perhaps because of a previous decision—can be procured only from a limited number of suppliers; they also result from the expected maintenance and repair expenditures.

The example of a wind turbine can illustrate very well the dependencies and restrictions because of decisions concerning individual components. In almost all cases, the entire installation is obtained from a single supplier. Thus, for example, the decision for a special drive determines virtually all subsequent decisions and costs—from the foundation for the installation all the way to the rotor blade. In addition, the costs for maintenance and other services are determined, which are incurred after the actual procurement date.[11]

Documented and transparent regulations for the evaluation of tenders and selection process as well as the determination of calculation methods of the savings assessment are thus indispensable, and they should be specified prior to the beginning of the project within the course of compliance management. Moreover, the purchasing department should be closely involved from the beginning of the project and through all steps in the process. That is the only way to counteract early any opportunistic behaviour by buyers or others entitled to make decisions in the selection

[11] In Sect. 7.1, these additionally incurred follow-up costs are considered in detail.

process; and it's the only way of objectively evaluating and controlling the actual purchasing and negotiating performance.

6.1.3.3 Organisational Structure and Communication within the Scope of Document Management

The importance of the documentation of specified rules and standards can be illustrated by the examples of compliance with legal regulations, supplier selection and award decisions as well as the objective assessment of savings. Aside from the enforcement and upholding of necessary standards through clear organisational and communication structures, it is relevant for compliance management to record and document all processes, decisions and decision-making criteria in partial projects.[12] A document management system (DMS) is essential in case of the inclusion and interaction of several organisations.[13]

When a single company carries out an investment project, the information and communication systems and channels through the organisational structure and the operative business are already known and established. But the definition of information and communication systems is especially necessary when major investment projects are considered where several organisations are involved. When two or more parties participate in an investment, different communication and information systems will also meet in this cooperation scenario. The specification and written manifestation of these systems and communication channels take into account the objective of risk minimisation in capital equipment purchasing.

The construction of wind turbines generally requires that not only several investors but also service providers are involved in all partial projects and these all need to be informed about any decisions. For that reason, relevant processes directly concerned with or affected by capital equipment purchasing should be listed in an overview at the beginning of the project for transparency purposes. Based on structured partial processes, the implementation of compliance management within the overall process includes the requirement of both an internal and an external code of rules, as well as the definition of an internal and external information system or communication concept, respectively. In this respect, a DMS allows the continuous adjustment of data because the organisations involved have permanent access to up-to-date documents.

These circumstances are explained below by way of the example of the construction of a transformer substation including a helipad in the course of building a wind farm. Since the helipad is not offered by the supplier that in this case builds the actual transformer substation, both companies must be constantly informed about any decisions and technical changes in the project, for example if the technical structures of the transformer substation have to be adjusted because of the installation of a helipad. By means of a DMS and clearly defined process and communica-

[12] Cf. Hinrichs (2003, p. 3).

[13] Cf. Staab (2002, p. 194).

tion structures, both parties have permanent access to the latest plans. Coordination efforts and expenditures can thus be reduced.

Another advantage of such compliance-conforming project documentation through a DMS is secure electronic filing since any changes in documents can thus be traced completely at any time. Compliance management requirements are thus complied with not only in structural and organisational terms but also from a legal point of view.

6.1.4 Conclusions Regarding Compliance Management

This section showed the manifold risks in capital equipment purchasing using as an example of the procurement of wind turbines and made it clear that compliance management is indispensable for capital equipment purchasing. Legal liability risks are minimised, and the effective control of all capital equipment purchasing is rendered possible by defining the control parameters and structures prior to the beginning of the investment. These should also accompany the project in its individual process steps from demand assessment all the way to divestment.

To implement a compliance-conforming reporting system that also takes into account the overriding strategic objectives of the overall project, a balanced scorecard[14] can be used to break down the requirements of the different partial processes for capital equipment purchasing. Moreover, it should be examined whether any professional support of the compliance function by consulting would be useful.

6.2 Savings Measurement in Capital Equipment Purchasing

6.2.1 Introduction to Savings Measurement

The complexity of procurement markets is increasing steadily because of the trend of globalisation, increasing cost pressures, lower depth of added-value and new technologies and reduced product life cycles. Because of these factors, the strategic importance of purchasing and its influence on the corporate result is also continuously increasing. This calls for an efficient procurement controlling system and thus continuous performance measurement since the effective control of procurement, a continuous improvement process and the safeguarding of positive purchasing results will only be possible with functioning procurement controlling.[15]

[14] Cf. Wagner and Kaufmann (2004, p. 269).

[15] Cf. Reinisch (2008, p. 609).

The problems of performance measurements in procurement and purchasing result from deviating definitions of purchasing performance, the exact definition of purchasing objectives and strategies and a detailed measurement with regard to the typical corporate scope of functions of the procurement area. It is accordingly indispensable that the performance concept is individually designed for the enterprise, and qualitative as well as quantitative elements are combined within the scope of procurement controlling. This ensures a multidimensional target control in purchasing.[16]

Traditional performance measurement methods are often criticised since they are oriented on the past and are more designed for the short-term, which can provide inadequate incentives and result in inefficient behaviour in the long run. Furthermore, they are rarely holistic in orientation and frequently are insufficiently coordinated. Therefore, methods have been developed to take into account both financial and non-financial aspects. This has resulted, *inter alia*, in the development of the balanced scorecard,[17] which measures, documents and controls the activities of a company in terms of vision and strategy. Another method is the performance pyramid[18]. Here, the strategic orientation of a company and its units is rendered measurable by using financial and non-financial key figures and ratios at the same time. In recent years, performance measurement research has been extended to functional approaches, such as marketing, research and development, purchasing and supply chain management.[19]

Compared with other main procurement groups, capital equipment purchasing has numerous special features that may bring about difficulties in performance measurement. Problems may also result from the technical characteristics of the capital equipment, which require a decision that not only takes costs into account but also incorporates output and consumption figures, repair-specific construction and spare parts supply. Since the purchase price for capital equipment usually amounts to only 30–50% of total life cycle costs, possible follow-up costs must be taken into account in performance measurement. Moreover, contingent decisions and their complexity frequently increase the difficulties in performance measurement. The fact that capital equipment is not procured at regular intervals sometimes means that old and new prices can only be compared up to a point.[20]

With regard to the other subjects dealt with in this book, there are interdependencies of savings measurement regarding capital equipment in terms of performance contracting, among others (Sect. 7.4). Performance contracting solutions look at the entire life cycle with the inclusion of specialised service providers, thus rendering more difficult any comparison of the offers and of the purchasing performance as well. Moreover, these acquisitions are non-recurrent or rarely made. For the major-

[16] Cf. Reinisch (2008, p. 610).

[17] Cf. Stölzle et al. (2001, p. 73 et seq.); Kaplan and Norton (1992, p. 71); Brewer and Speh (2000, p. 75 et seq.).

[18] Cf. Lynch and Cross (1995, p. 63 et seq.).

[19] Cf. Hartmann et al. (2007, p. 130 et seq.).

[20] Cf. Arnolds et al. (2010, p. 425 et seq.).

ity, long-term framework agreements exist, which allow the development and use of synergies. However, this is actually difficult to record in financial variables. Owing to numerous variations of operator models, *inter alia* with regard to risk assumption, the scope of performance and flexibility, any comparability is additionally restricted and any recording in monetary data is rendered difficult.[21]

From a theoretical point of view, savings measurement should be carried out upon the conclusion of the divestment since only at that point in time will information be available about all payments connected with the capital equipment. However, this is hardly expedient from a practical viewpoint since capital equipment is generally operated for many years and the control function of savings measurement is lost thereby. It is accordingly desirable to perform savings measurement after acceptance when the costs incurred in connection with the purchase of the installation at least are known. Then, corresponding assumptions can be made about the follow-up costs not yet known at that time. From among the cross-sectional activities, savings measurement primarily concerns project management since it may have consequences on the budget of follow-up investments (Fig. 6.3).

The necessary resources and capabilities for a successful performance measurement system are subdivided into five groups: people, processes, data, software and hardware. People include those responsible for the performance measurement system, employees responsible for the organisation and support of the performance measurement system, data providers and users. Major processes within the scope of performance measurement are the definition of indicators, the organisation of data management and data utilisation (Sect. 6.1). A performance measurement system requires all performance-relevant data, the target values of indicators (nominal values), performance results and metadata to describe the indicators. In addition, software is required for the database from which data will be extracted, transformed and loaded as is presentation and communications software. Important hardware includes PCs, a server and communications infrastructure in good working order.[22]

6.2.2 Fitting Savings Measurement into Performance Measurement

Performance measurement is defined as the "development and application of mostly several quantifiable measures of various dimensions (e.g. costs, time, quality, innovativeness, customer satisfaction) […] which are used for evaluating the efficacy and efficiency of performance and performance potentials of very different objects in the company (organisational units of various sizes, personnel, processes)."[23]

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[21] Cf. Wünsche (2007, p. 309 et seq.).

[22] Cf. Küng and Wettstein (2001, p. 1 et seq.).

[23] Gleich (1997, p. 115).

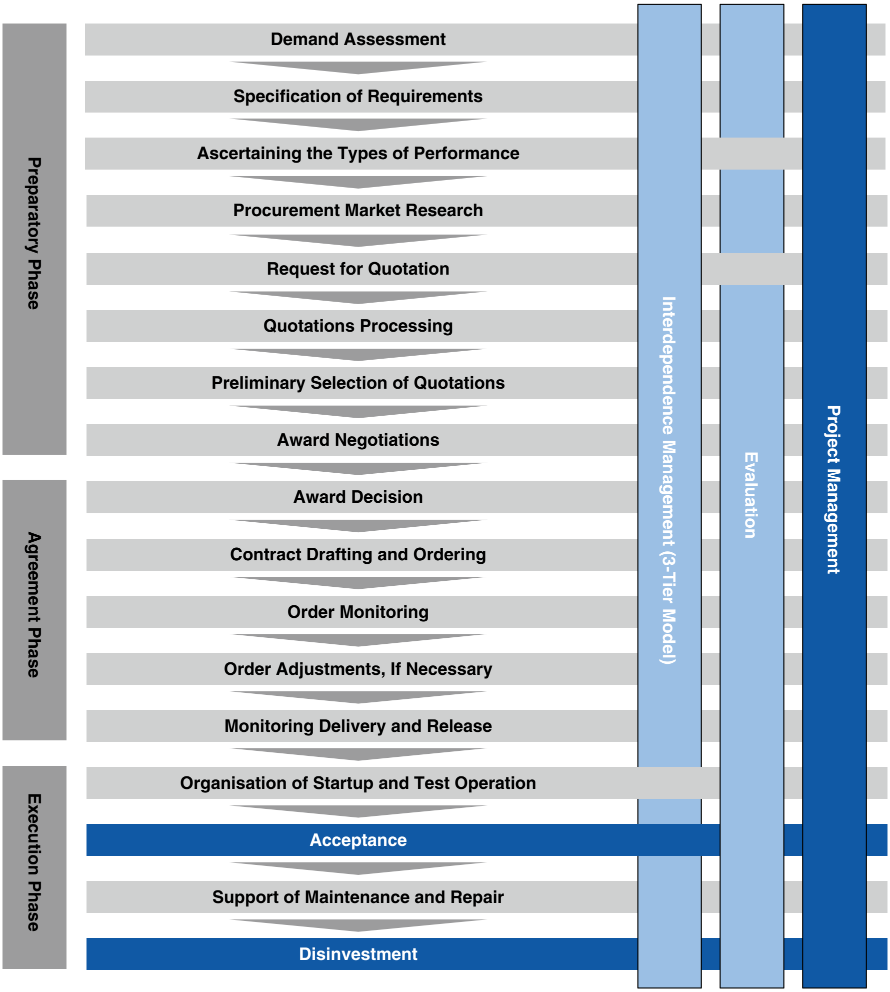

Fig. 6.3 Fitting savings measurement into the capital equipment purchasing process

Performance measurement systems present a further development of the traditional ratio systems. Because management has become increasingly more dissatisfied with existing systems, newer methods have been developed to increasingly emphasise the holistic concept and future orientation.[24] Compared with performance measurement systems, traditional ratio systems are especially monetary in design and thus oriented on the past. They are flexible only to a limited extent since only a single system covers both internal and external interests. It should be checked primarily to what extent the financial objectives have been reached. A vertical reporting structure exists, namely information is exchanged according to the corpo-

[24] Cf. Entchelmeier (2008, p. 38).

rate hierarchy. Traditional ratio systems are highly fragmented, which means that costs, output and quality are considered separately. The focus is on cost reduction. By contrast, performance measurement systems are addressed to the customer and thus future-oriented. They are also highly flexible. Since the degree of the implementation of a strategy is reviewed, impulses are provided for future improvements in processes. Moreover, there is both a vertical and a horizontal reporting structure, namely according to the hierarchy and within the pertinent corporate level. Performance incentives in performance measurement systems are team- or group-specific.[25]

Complexity is increasing in procurement. In addition, there is a growing need to holistically measure and control the value contribution of the corporate function. This requires a combination of general performance measurement systems and approaches from purchasing and from procurement management in a combined "supply performance measurement" system.[26]

Supply performance measurement is understood as "the conversion of efficiency and efficacy of supply management in financial and non-financial objectives and measures across all performance levels, with the integration of control information referring to the future as well as the past."[27] According to this, it has three major core characteristics:[28]

- Key figures should be oriented on the procurement strategy.
- Key figures are multidimensional to ensure the integrated coverage of the production of goods and services.
- Supply performance measurement systems are introduced on all performance levels of procurement management, such as at the buyer level, product group level and central purchasing and supplier level.

Investments have long been made in the development and utilisation of procedures to estimate performances, develop strategies and enable performance-specific compensation. Since procurement management in the enterprise is increasingly more transparent and strategically important, there has been a rising demand for methods reflecting this new function. Buyers must regularly relate the contribution of procurement to the company's strategic objectives. This in turn leads to a demand for reliable methods reflecting this strategic contribution. Savings measurement is a method in accordance with the criteria of multidimensionality, strategic orientation and conceptional design across performance levels.[29]

Savings measurement is allocated to the cost-based methods of supply performance measurement. Two basic types can be distinguished regarding the monetary performance of procurement with key figures in saving:[30]

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[25] Cf. Lynch and Cross (1995, p. 38).

[26] Cf. Entchelmeier (2008, p. 54).

[27] Entchelmeier (2008, p. 54).

[28] Cf. Entchelmeier (2008, p. 186 et seq.).

[29] Cf. Carter and Monczka (2005, p. 8).

[30] Cf. Entchelmeier (2008, p. 106).

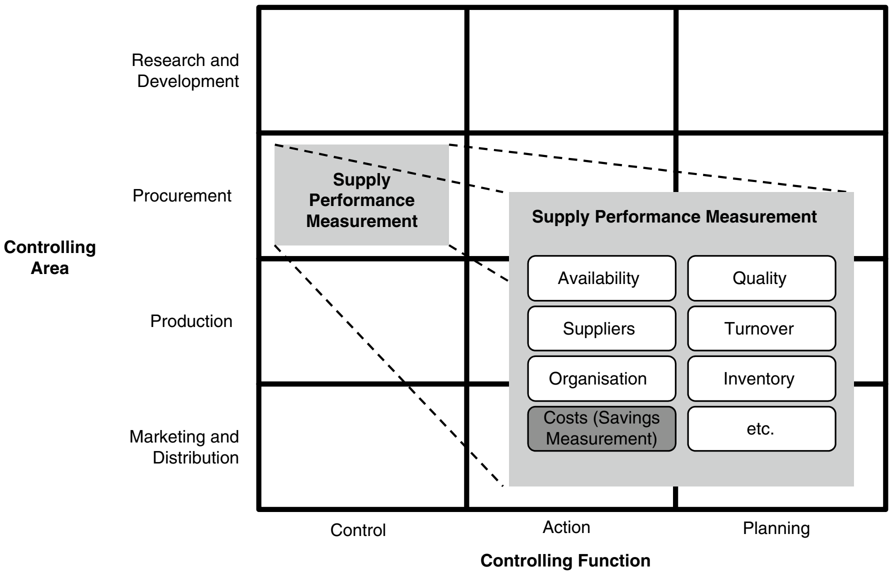


Fig. 6.4 Fitting savings measurement into controlling

- "Success" measures the performance of procurement generated by direct activities.
- "Result" also includes—in addition to success—all external effects, for example market price fluctuations. This shows the effect of the activities by the procurement market on corporate performance.

Figure 6.4 fits savings measurement into controlling. Within the scope of controlling, performance measurement is used to monitor the relevant control information. Supply performance measurement refers, in turn, to monitoring the procurement function in the company. Control information within the supply performance measurement comprises availability, quality, costs and so on. We now talk about savings measurement when cost-related variables are the focus in supply performance measurement.

Savings are principally divided into hard savings and soft savings. Hard savings are money-wise recordable savings that directly affect profits, for example price reductions or reduced personnel and transactions costs such as transport costs. By contrast, soft savings rather relate to qualitative criteria and these have only an indirect effect on profits. Thus, the purchase of higher-quality materials can result in reduced reworking being required.[31] Numerous methods are available to measure hard savings; however, there is no generally recognised method to record and control key figures in capital equipment purchasing.[32]

[31] Cf. Reuter and Hartmann (2008, p. 49); Nollet et al. (2008, p. 125).

[32] Cf. Entchelmeier (2008, p. 77).

Owing to the high technical complexity and accordingly necessary know-how of the workforce, capital equipment suppliers are characterised by a fixed permanent staff of skilled workers and relatively rigid production capacities so that uniform employment is aimed at. Capital equipment markets are thus highly sensitive to business activities and economic cycles. Accordingly, a business upswing may bring about delays in delivery periods and price increases. By contrast, economic lows result in price concessions. This makes it difficult to provide a performance measurement of capital equipment purchasing. Additionally, the evaluation of capital equipment purchasing is aggravated by the technical complexity. Manufacturers offer, moreover, numerous services to be procured including the planning, installing and commissioning of the goods. To aggravate the situation, the price policy often varies greatly on the suppliers' side. For instance, capital equipment is frequently offered at a favourable purchase price, while spare parts and maintenance work are charged at margins in the three-digit percentage range. Sufficiently high market transparency can only be ensured through intensive preparations, visiting special trade fairs and external consulting. For capital equipment, follow-up costs incurred in the course of procurement—such as planning, utilisation and maintenance costs—must be especially taken into account. In addition, strategies should be developed to ensure high plant availability.[33] In this respect, output-oriented performance contracting solutions suggest themselves (Sect. 7.4).

Savings measurement is of special importance for capital equipment purchasing since the share of the purchase price in the total costs of the procurement process is relatively small; instead, a complex and protracted selection process takes place, which must also consider information gathering, price policy and follow-up costs—aside from the purchase price of the installation.[34]

6.2.3 Methods for Savings Measurement in Capital Equipment Purchasing

The following section presents practical methods for savings measurement. Each of these methods has its challenges and special application possibilities, which are each explained with reference to capital equipment purchasing.

- Method of period-to-period comparison
  Reference value of the method of period-to-period comparison is the "historical price". That is the last quoted purchase price of a procurement object that had been realised in the prior period or in a previously specified period of time of several prior periods. This method determines the difference between the historical and current purchase price. In this case, no measurement of new purchases is possible since in that case no previous year comparisons can be made and

[33] Cf. Arnolds et al. (2010, p. 427 et seq.).

[34] Cf. Entchelmeier (2008, p. 106 et seq.).

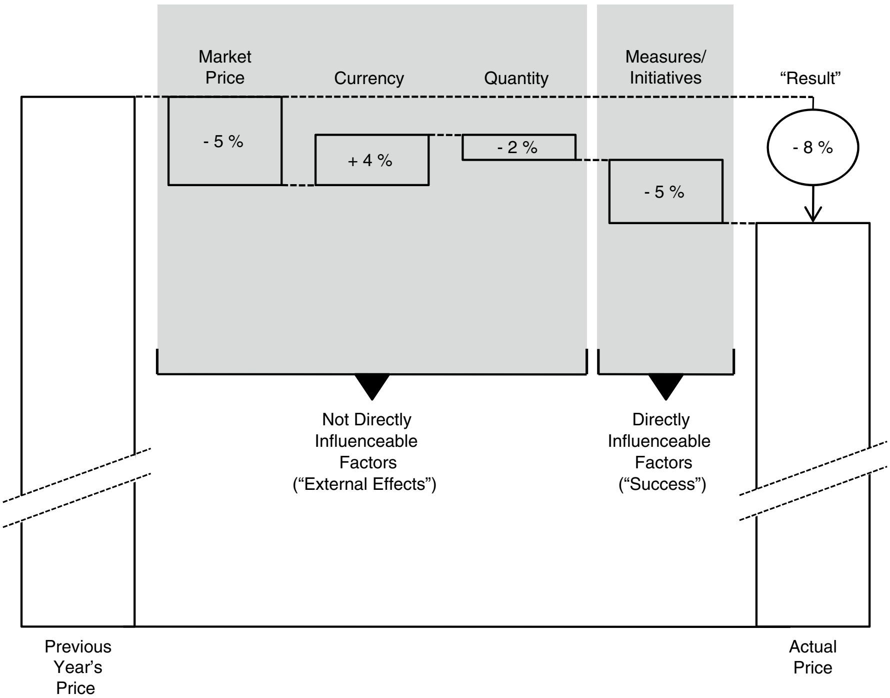


Fig. 6.5 Influences in the calculation of savings according to the period-to-period comparison method. (Entchelmeier 2008, p. 79)

thus no historical price should be ascertained either. Moreover, in the method of period-to-period comparison, performance calculation is also subject to external effects resulting from currency effects, market price changes or volume changes (Fig. 6.5). These positive or negative effects over which the buyer has no direct influence may distort the result of the period-to-period comparison method in capital equipment purchasing.[35]

In capital equipment purchasing, difficulties arise, in many cases, within the scope of performance measurement using the period-to-period comparison method because there often is no historical price. Accordingly, the method can only be used to a limited extent, but it is possible for capital equipment that is regularly procured and for which a historical price is available—as is the case, say, for company cars regularly procured.

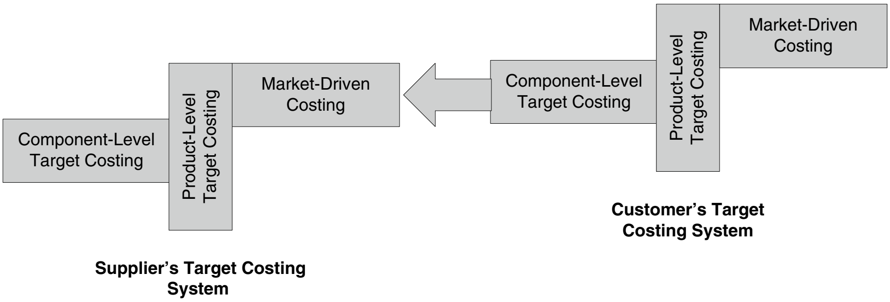
In practice, numerous tactics of buyers exist to be able to ascertain a result that is favourable for them according to the period-to-period comparison method. For new parts, it is possible, for example, to initially list expensive suppliers and select a high-priced supplier. In the following years, suppliers are selected that are slightly more economical compared with the previous year to fake a positive

[35] Cf. Entchelmeier (2008, p. 78 et seq.); Arnolds et al. (2010, p. 363).

purchasing performance in the annual comparison.[36] To counteract such opportunistic behaviour, the enterprise should implement a compliance management system (Sect. 6.1).

- Price quotation method
  The price quotation method uses—as a reference price—offers already obtained that have been technically and commercially examined.[37] To calculate the reference price, the mean value of the three best quotations is often established in practice. If there are only three or fewer quotations, the reference price is specified by the best quotation. But the quotation subsequently realised can even be used as the reference price. Since the price quotation method establishes a new reference base, external effects have no influence. Historical prices are not necessary for this method, which allows the measurement of new and repeat purchases.[38] However, this method also bears the risk of manipulability so that the buyer's own performance is better presented. To improve the calculated purchase result, expensive suppliers can deliberately be included in the quotation process so that the average price is higher and greater savings can accordingly be shown. Moreover, it should be noted that the first quotation of suppliers is often made by reserving a margin for negotiations. Accordingly, savings are often shown to be too high.[39]
  Challenges in the price quotation method occur with regard to savings measurement in capital equipment purchasing because it is generally very difficult to technically compare quotations or because there is only one supplier. Nonetheless, the application of this method is possible when comparable capital equipment is offered by several suppliers.
- Target costing method
  For the target costing method, the price for a product is determined by ascertaining what it may cost to be successful with the end customer. Costs for the end product can be broken down into the costs of goods and services that are necessary for the manufacture of the end product (Fig. 6.6). The reference price thus is the target price ascertained from the sales market side. Savings by the purchasing department are calculated as the difference between the target price and the negotiated procurement price.[40]
  Care must be taken with the target costing method that—aside from the cost target—the quality requirements of the procurement object are not neglected. To be able to comply with the quality requirements, the validity of the developed target price should be ensured. This can also be achieved by involving the buyer in establishing the target price so that the buyer may intervene if the price cannot be obtained with the required quality. This usually results in higher expenditures so that the target price development should be limited to strategic procurement

[36] Cf. Emiliani et al. (2005, p. 152).
[37] Cf. Rüdrich et al. (2004, p. 82).
[38] Cf. Arnolds et al. (2010, p. 363 et seq.); Entchelmeier (2008, p. 79).
[39] Cf. Entchelmeier (2008, p. 78 ff); Smeltzer and Manship (2003, p. 29).
[40] Cf. Entchelmeier (2008, p. 80); Ewert and Ernst (1999, p. 23).



Market-Level Target Costing	Market analyses to determine the required scope of functions and the price to be realized.
Product-Level Target Costing	Product development with specification of target costs.
Component-Level Target Costing	Benefit of every component from customer's point of view is compared with the corresponding costs.

Fig. 6.6 Method for ascertaining target costing. (Following Cooper and Slagmulder 1999, p. 204)

objects. Another difficulty in the application of this method in practice is the determination of the cost percentage of the individual goods and services in the end product. Value analysis[41] can be used to solve this problem. The target costing method is often used in the starting phase of a new development. But it can also be used for repeat purchases.[42]
Expenditures are relatively high when using the target costing method in capital equipment purchasing. Moreover, the share of capital equipment costs in the end product cannot be precisely determined. In capital equipment purchasing, the target costing method can accordingly be used only if this percentage can be exactly determined.

- Market price index method
The market price index method compares the realised purchase price based on price indices. Internal price indices are provided based on the price catalogues of different suppliers ("catalogue approach"). External price indices are made available by independent state or private information providers, such as the *Statistische Bundesamt* (German Federal Bureau of Statistics). These usually exist for standardised goods and services, such as steel (Fig. 6.7).[43]
The advantage of the market price index method is that the development of the purchase price is evaluated in relation to the development of the market index. If, for example, prices increase less than the market index, an improvement in the

[41] Cf. Miller (1955, p. 123 et seq.).
[42] Cf. Smeltzer and Manship (2003, p. 30); Entchelmeier (2008, p. 78 et seq.).
[43] Cf. Entchelmeier (2008, p. 82); Smeltzer and Manship (2003, p. 29 et seq.).

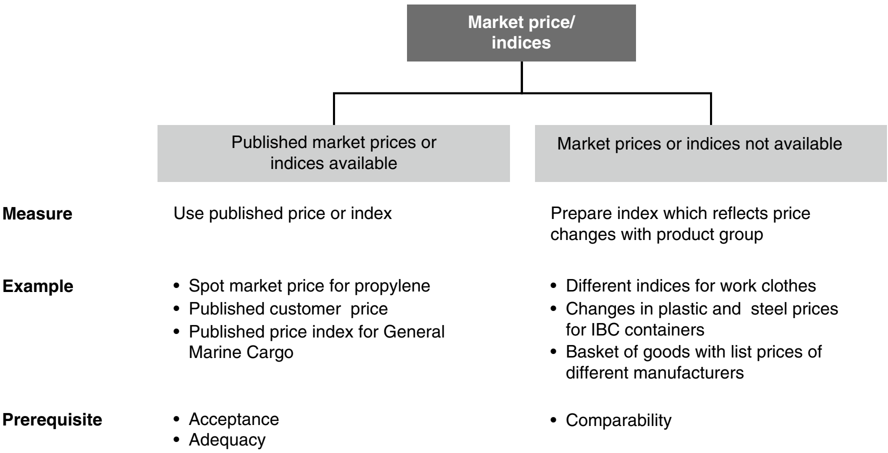


Fig. 6.7 Determination of market prices and indices. (Following Buchholz 2002, p. 374)

purchase performance would be shown. Moreover, this method allows the measurement of new and repeat purchases and eliminates the influences of external effects by establishing a new reference base. The problem with the method is that market price indices only exist for selected purchase goods, such as raw materials. In addition, it may be relatively complex to generate and process the indices.[44]
The challenge with capital equipment purchasing is that, as a rule, there are no market indices for capital equipment. Accordingly, the application of this method is generally not considered for capital equipment but much rather the market price adjustment method presented below is preferred.

- Market price adjustment method
  The market price adjustment method is a combination of the period-to-period comparison method and the market price index method. The reference price is determined by adjusting the historical price of the development of the market price indices of the underlying raw material components for the procurement object. External effects, such as fluctuations in market prices and currencies, are partly eliminated by the adjustment of market prices. However, for new purchases, no savings measurement is possible using the market price adjustment method. Moreover, the reference price calculation is complex.[45]
  Frequently, no historical price and no market price index are available for capital equipment, thus rendering any performance measurement difficult. Accordingly, the market price adjustment method should be used merely for capital equipment with prices very much depending on the market price index as well as for capital equipment that is regularly procured. One example of this might be the regular procurement of rotor blades for a wind turbine.

[44] Cf. Buchholz (2002, p. 374); Entchelmeier (2008, p. 82 et seq.).

[45] Cf. Entchelmeier (2008, p. 78 et seq.).

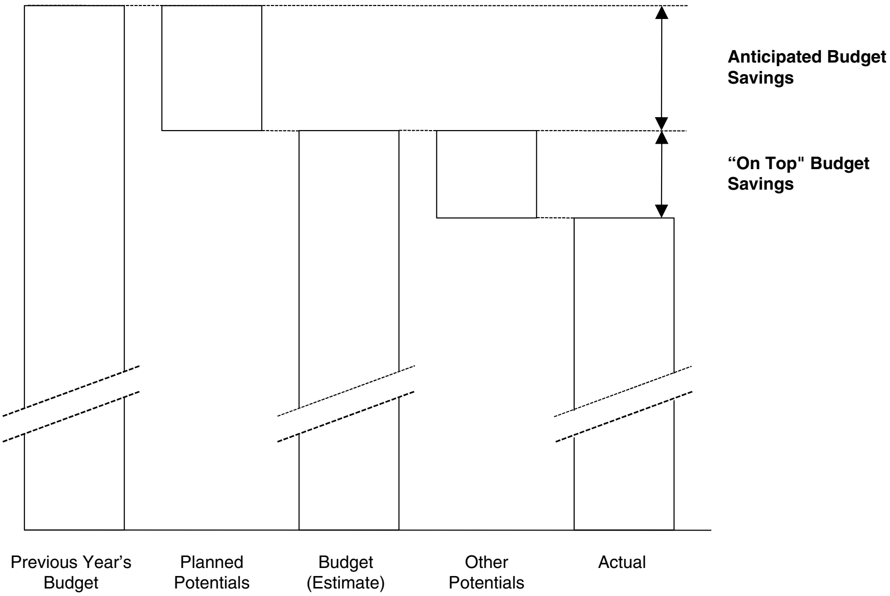


Fig. 6.8 Exemplary presentation of budget savings. (Entchelmeier 2008, p. 84)

- Budget method
  For this method, the planned prices and planned volumes of the procurement objects are ascertained based on the previous year's budget, and the targeted budget is determined by taking the planned measures into account. Figure 6.8 illustrates the two types of savings in the budget method. Anticipated budget savings are savings from potentials that had already been taken into account in the budget within the scope of the planning process, and they are calculated as follows:

$$\textit{Anticipated budget savings} = \textit{reference price} - \textit{budgeted price}$$

"On-top" budget savings include savings that could be realised in excess of planned savings during the reporting period.[46] "On-top" budget savings are calculated as shown:

$$\textit{“On-top” budget savings} = \textit{budgeted price} - \textit{actual price}$$

The reference price is such planned price for a specific procurement object that would have to be used in budgeting if purchasing had not anticipated any savings potentials for this procurement object. As a rule, the results of traditional methods for measuring savings are used here as reference prices. By contrast, the budgeted price already includes anticipated savings for the specific procurement object. The actual price is the price actually realised.

[46] Cf. Quitt et al. (2010, p. 67 et seq.).

To be able to apply the budget method as a savings method for capital equipment, it is thus necessary that capital equipment purchasing is included in budgeting within the scope of purchase planning and that detailed volume planning is provided at a procurement object level. Purchasing must furthermore be able to determine suitable reference prices for the individual purchase classes, namely new purchase, modified purchase and identical repeat purchase. Since, in determining reference prices, the budget method refers to traditional methods for measuring savings, it is basically assumed that purchasing can generally determine at least one suitable reference price for every purchase class.
Within the scope of purchase planning and the accompanying budgeting, because the budget method already shows savings potentials, it can be principally verified whether they had also actually been realised by purchasing. Moreover, any unplanned savings can be shown, which could be realised during the year in excess of the planned savings—providing a holistic, future-oriented performance assessment of purchasing.[47]

- Analytic value approach
  For the analytic value approach, capital equipment is broken down into its components, and the individual parts are assessed using various reference variables. Reference prices are ascertained based on historical prices or, if they are not available, via budget prices or budget prices minus anticipated savings. In terms of historical prices, two adjustment possibilities exist. If market indices are available and reasonable in their application for the component to be procured, historical prices will be adjusted by the development of these indices. A security extra is included in the calculation if there is little comparability of the component procured in the past. Finally, total savings are ascertained and the percentages of the used reference prices are shown.
  This method can be used in a great many cases since different reference prices are combined. However, it is extremely complex to use. The method is frequently applied in plant engineering.

In practice, numerous other methods are used for savings measurement in capital equipment purchasing. Three of these methods are presented below.

- The reference variable of the *market comparison method* is an average catalogue price. Challenges for the performance measurement of capital equipment purchasing accordingly result because prices for capital equipment are rarely listed in catalogues. It is, however, possible to use the market comparison with capital equipment, which is listed in catalogues.
- The *method of cost avoidance* ascertains the procurement performance by means of actual costs plus avoided costs. Avoided costs can be obtained by one part being purchased at a lower price than its average price. It is not important in this respect whether the new price is higher than the price until then.[48] Cost avoidance can result, for example, if the supplier announces a price increase which

[47] Cf. Quitt et al. (2010, p. 76 et seq.).
[48] Cf. Carter and Monczka (1978, p. 28).

purchasing can fend off, however.[49] It should be noted that it is difficult to ascertain avoided costs. Accordingly, the method of cost avoidance can only be used with capital equipment whose avoided costs can be ascertained.

- The reference variable of the *total cost method* is the total cost of procurement plus running costs, for example for maintenance ("total cost of ownership"). This method can be combined with other savings measurement methods; however, any of the problems that exist with the pertinent method will still occur. It is recommended to use this method with capital equipment whose running costs make up a major part of total costs.

As shown, performance measurement in capital equipment purchasing can be effected using various methods. Table 6.1 presents a summary of the presented methods and their characteristics and special features in terms of performance measurement in capital equipment purchasing.

6.2.4 Process of Savings Measurement in Capital Equipment Purchasing

The ideal process of savings measurement in capital equipment purchasing comprises several steps (Fig. 6.9). At the beginning, the procurement object to be measured is defined. Subsequently, the environmental conditions relevant for the selection of the method for savings measurement can be ascertained. This may include the characteristics of the procurement processes, capital equipment, strategies of the procurement organisation, corporate strategy and existing know-how. Taking into account the suitability of the key figure (communications and control function, monitoring and surveillance function, etc.) and the expenditure for ascertaining the key figure, the most suitable method is selected and applied in the next step. Measures are subsequently derived from savings measurement (e.g. budget adjustments, integrating results into incentive systems, etc.) and the result of performance measurement is communicated. This communication can be effected using a savings guideline.[50]

Enterprises have different methods for measuring and communicating successful purchasing performance. However, there is no joint "language" within the enterprise with regard to key purchasing figures, so distrust might result concerning the presented performance figures of purchasing. To counteract such distrust, it is recommended to develop and establish a savings guideline.

A few key points should be taken into account in formulating a savings guideline. For instance, terms and methods should be first put down in writing to ensure conclusiveness and understanding. In addition to the reference variables used, ex-

[49] Cf. Sievers (2010, p. 31).

[50] Cf. Reuter and Hartmann (2008, p. 48 et seq.).

Table 6.1 Challenges and application areas of the method of savings measurement in capital equipment purchasing

Method	Reference variable	Challenges in capital equipment purchasing	Possible application in capital equipment purchasing
Period-to-period comparison method	Historical price (price of prior period or last quoted price)	Often no historical price is available	Capital equipment that is regularly procured and for which a historical price exists
Price quotation method	Average of the n-best commercially and technically reviewed quotations	Frequently, it is technically difficult to compare the quotations, or there is only one supplier	Technically comparable capital equipment that is offered by several suppliers
Target costing method	Target costs (target price)	High expenditure in execution	Percentage of costs of the capital equipment in the end product can be determined exactly
Market price index method	Market price index	Frequently no market price index available for capital equipment	Capital equipment whose price depends very much on the market price index
Market price adjustment method	Historical price adjusted by the development of the market price indices of the basic raw materials	Frequently no historical price available and no market price index for capital equipment	Capital equipment whose price depends very much on the market price index and which is regularly procured
Budget method	Budget (estimate) = planned price × planned volume	Budget determination is made independent of actual costs	Sufficient wealth of experience available with prices for capital equipment
Analytic value approach	Historical prices and budget prices	Use of the method is connected with high expenditures	Capital equipment that can be broken down into components for which either historical prices or empirical values are available
Market comparison method	Average catalogue price	Prices for capital equipment are rarely listed in catalogues	Capital equipment listed in catalogues
Cost avoidance method	Actual costs plus avoided costs	Ascertainment of avoided costs of capital equipment is difficult	Ascertainment of avoided costs of capital equipment is possible
Total cost method	Total costs of procurement plus running costs (e.g. maintenance)	Problem continues to remain regarding the savings measurement with the capital equipment purchase price	High percentage of running costs of capital equipment

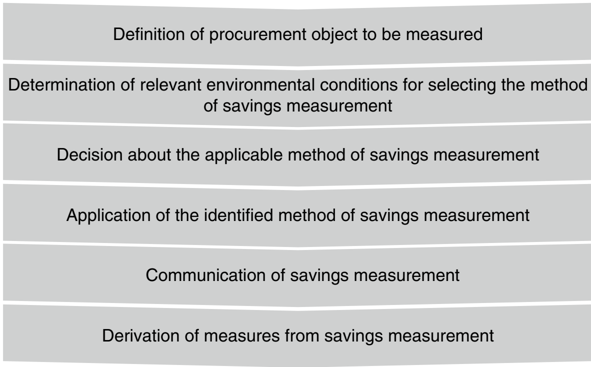


Fig. 6.9 Schematic process of savings measurement in capital equipment purchasing

pectations on purchasing must also be formulated. It should also be documented in writing which performance data are used for savings measurement and how they should be ascertained. For example, straight cost reductions can be used for evaluation and monitoring or, additionally, the processes from which such cost reductions result. By including many players in the savings measurement process, the acceptance of the method can be increased as can the understanding of key figures and ratios. This, however, bears the risk of protracted decision-making. Furthermore, it is advantageous for acceptance to use simple and easy to understand key figures and ratios. Non-buyers should be helped to understand the processes by providing them with clear graphic presentations. The savings guideline should show, at the beginning, the targeted hard savings and focus on the essential. Of major importance is, moreover, the target group-specific selection, processing and communication of the collected information relevant for the performance measurement of purchasing.[51] Using this guideline allows a target-specific application of the savings measurement process and a consistent use of the information obtained.

6.2.5 *Case Study: Savings Measurement in the Procurement of a Wind Turbine*

In the following section, the process of savings measurement in capital equipment purchasing is illustrated based on the purchase of a wind turbine. In a first step, the wind turbine is defined including maintenance and repair services. It should be noted here which location-specific characteristic features result, including the costs of special corrosion protection for offshore installations or measures against icing such as rotor blade heating. Any special requirements for heavy transport and truck crane services with regard to the installation of the wind turbine should also be recognised. An analysis will follow of the relevant environmental conditions.

[51] Cf. Reuter and Hartmann (2008, p. 48 et seq.).

	Purchase Price	Running Costs for Planned Useful Life	Total Cost	Techn. Review	Mean Value of Total Cost of 5 Lowest-Priced Tenders Being Technically Okay	Cost of the Selected Tender	Savings
Tender A	1,600,000 €	850,000 €	2,450,000 €	o.k.			
Tender B	1,150,000 €	560,000 €	1,710,000 €	o.k.		1,710,000 €	**134,000 €**
Tender C	2,000,000 €	720,000 €	2,720,000 €	o.k.			
Tender D	1,100,000 €	770,000 €	1,870,000 €	not o.k.			
Tender E	1,000,000 €	800,000 €	1,800,000 €	o.k.	1,844,000 €		
Tender F	1,100,000 €	780,000 €	1,880,000 €	not o.k.			
Tender G	1,500,000 €	740,000 €	2,240,000 €	o.k.			
Tender H	1,200,000 €	760,000 €	1,960,000 €	o.k.			
Tender I	1,200,000 €	810,000 €	2,010,000 €	o.k.			

Fig. 6.10 Determination of the average quotation for the calculation of the price quotation method using the example of a wind turbine. (Following Rüdrich et al. 2004 p. 83; Entchelmeier 2008, p. 67)

In the case of the wind turbine, it should be noted that neither catalogue prices nor market price indices exist. Wind turbines are long-term investments that are continuously being further developed. Accordingly, price comparisons are unrealistic and historical prices are unsuitable. Additionally, it is difficult to compare installations because of the different types of equipment and different service offers, especially in terms of maintenance and repair services. For the performance measurement of the procurement of a wind turbine, the price quotation method takes into account life cycle costs, as the measurement of new and repeat purchases is here made possible. Historical prices are unnecessary and external effects are left out. The example shown in Fig. 6.10 presents the savings determined from the mean value of the total costs of the five best quotations subjected beforehand to a quality check. After having used the price quotation method for performance measurement, it is recommended to communicate the savings measurement to the departments involved and to the corporate management level to increase confidence in the method used.

6.2.6 Conclusions Regarding Savings Measurement

In structurally and economically difficult times, and also because of the general information overload, process optimisation and acceleration aspects are gaining increasing importance since they have considerable efficiency-increasing potentials. To be able to improve processes, they must be measured beforehand, however. Procurement has a multitude of methods and instruments for performance measurement. On one hand, there are traditional approaches; on the other hand, there are more sophisticated methods, such as the balanced scorecard and performance measurement systems. Performance measurement systems should be company-specifically adjusted and should follow closely the strategic orientation. They provide the different recipients in the company with inherently consistent and coordinated information. Measures for the improvement of the company are derived from there.[52] Savings measurement as a cost-based method of supply performance measurement is of particular relevance in the procurement of capital equipment because of special conditions in this area. The characteristics of capital equipment purchasing include a strong technical orientation, complexity and the lack of comparability because of potential follow-up costs. Savings measurement presents a special challenge in capital equipment purchasing because of suppliers' varying pricing policies and insufficient market transparency, as well as the low percentage of the purchase price in total costs.[53]

The duties of management concerning savings measurement in capital equipment purchasing include, *inter alia*, defining objectives, determining performance measuring variables, and giving employees feedback in terms of their performances. There can be no focus without a specified objective and clearly defined methods for measuring success or performance. That condition would result, in turn, in inconsistent decisions. By contrast, too many measures can cause confusion and fluctuating performances by buyers. Management accordingly must take care that all employees are informed about the corporate and departmental objectives and also that the methods of performance measurement are known.

If savings measurement in capital equipment purchasing is implemented as a method of performance measurement, all employees involved should be informed about the method and its application and consequences. Great importance is attached to the communication of the method and the provision of concise information as well as to the determination of contact partners for support and for clearing up any uncertainties. This transparency promotes the smooth and successful implementation of savings measurement. Moreover, savings measurement can be used, after successful implementation, as an instrument for the target-specific control of procurement activities for capital equipment. By means of the information gained from performance measurement, decision-makers are not only provided with an overview of the operative capabilities of purchasing. Specific measures can also be taken to improve procurement performance. Additionally, because of the cost transparency provided by savings measurement, buyers are able to provide a target-specific alignment of their purchasing activities.

Generating a target focus will show employees the direction in which their decisions should be aligned and which performance is expected of them. Thus, employees obtain conclusive and understandable feedback about their performances. The knowledge thus gained will enable them to work specifically on their personal abilities and accordingly expand their contributions in successful procurement and corporate performances. This transparency contributes, moreover, to greater workforce and staff satisfaction.

[52] Cf. Hertel et al. (2005, p. 356 et seq.).

[53] Cf. Arnolds et al. (2010, p. 425 et seq.).

However, for holistic corporate steering and control, savings measurement should not be used exclusively. Instead, several performance measurement systems should be integratively combined. Measuring the performances and results of savings measurement could be integrated with the key figures and ratios on process costs, process period and process quality of the process-oriented supply performance measurement as a key figure in a supply balanced scorecard.[54] Alternatively, the procurement value-added can be taken into consideration as the value-oriented top key figure in purchasing.[55]

[54] Cf. Entchelmeier (2008, p. 106 et seq.).

[55] Cf. Hofmann et al. (2011, p. 91 et seq.).

Chapter 7
Instruments and Methods of Capital Equipment Purchasing in Terms of the Characteristics of Procurement Objects

7.1 Life Cycle Costing (LCC) and Total Cost of Ownership (TCO) Approaches in Capital Equipment Purchasing

7.1.1 Introduction to the LCC and TCO Approaches

Owing to the long planning periods and useful lives of capital equipment and the multitude of costs not only directly connected with capital equipment, it is difficult to record the costs incurred by such projects. They often come to bear only at much later points in time or even before the actual procurement of the object in the life cycle of an investment object. Moreover, recording them can hardly be managed with absolute precision.

The following section presents two methods for recording the total costs connected with the procurement of capital equipment. It concerns the systematic approaches of LCC and TCO. Both are used as instruments for calculating the costs of a product or of a (partial) plant or installation over its entire life; yet, the terms should not be used as synonyms.

In the narrowest sense, LCC is also considered as a well-founded "cost accounting" investment analysis.[1] Like TCO, it also includes all costs incurred at later points in time than the actual procurement date.[2] However, the degree of details of the TCO perspective goes beyond that of the LCC perspective as explained here. For LCC, all acquisition costs are taken into account plus the pertinent use costs. Figure 7.1 presents a typical LCC system.

Acquisition costs are incurred in the planning, realisation and introduction stages. Use and follow-up costs will be incurred after these stages. The end of an LCC system is the stage of liquidation, which includes dismantling and sale or retrofitting costs (divestment). Capital equipment generally incurs high use and follow-up costs because of the long service life of such goods and the accompanying use of

[1] Cf. Herrmann (2010, p. 135).

[2] Cf. Woodward (1997, p. 343).

E. Hofmann et al., *Capital Equipment Purchasing,* Professional Supply Management 2,
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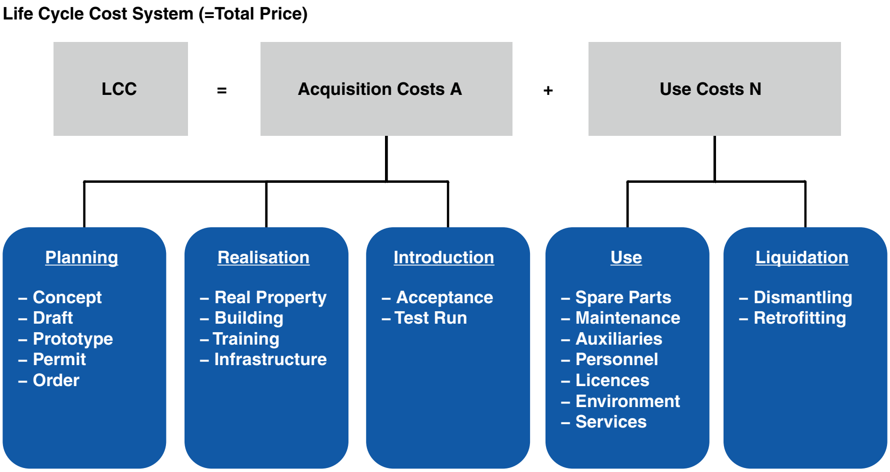

Fig. 7.1 LCC system in the context of capital equipment purchasing. (Own presentation following Arnolds et al. 2010, p. 428)

numerous services. This aspect includes spare parts, auxiliaries, licenses and other personnel costs.[3] Further examples of follow-up costs can be technical documentations, conversion and expansion possibilities, space requirements and services by the supplier for installation and test runs. However, in terms of services rendered, only maintenance work is mostly taken into account. In particular, this does not consider any cross-company costs such as those taken into consideration in supply chain management. In any event, it does not reach far enough. The inclusion of all use costs should be taken into account in the decision-making process within the scope of capital equipment purchasing.

The TCO approach provides a more far-reaching perspective of the possible costs and procurement alternatives of an investment purchase since—in addition to the costs included in the LCC approach—other cost pools incurred for the supplier are additionally considered. This includes costs for tools, energy and personnel, as well as interest and costs of production logistics.

The TCO approach thus allows the cross-company identification and analysis of the costs of a value-added process or of a product provision process. It is the objective of this approach to identify the best possible provision alternative or sourcing strategy from a total cost point of view and implement it from this holistic perspective.

Since it is important to present complex procurement decisions transparently (especially in monetary terms), the TCO approach is considered as a structured approach for understanding the total costs in connection with the purchase and use of an object.[4] A reliable decision basis can thus be established. Ellram defines TCO

[3] Cf. Bünting (2009, p. 42).

[4] Cf. Noske (2007, p. 317).

as: “a philosophy for really understanding all relevant supply chain related costs of doing business with a particular supplier for a particular good/service”.[5] The approach accordingly includes all the costs that a company incurs in the procurement and subsequent use of a specific product or service by a specific supplier over the entire life of the product or service (ownership).[6] In this context, Ellram aims at the cost prices plus the costs of supplier management and supplier-specific handling costs. In this respect, the costs of supplier management include supplier selection, qualification and certification, as well as the relationships with suppliers, which are connected with costs. Usually, transaction costs incurred are included here. The central point of departure of the TCO approach based on Ellram’s transaction cost model comprises the systematic recording and evaluation of cost factors connected with a transaction.[7] The TCO approach thus is an adequate instrument to support transaction cost analysis in the procurement area. Based on the life cycle costs with the focus on types of performances, the TCO perspective operationalises the costs of interaction with suppliers and thus takes a corresponding view of the market. Behind every type of performance, there is a procurement market with its own market structures, which is taken into account by the TCO perspective.

In the TCO calculation, three approaches are distinguished:[8]

- Monetary approaches based on direct costs: Only direct costs are taken into account.
- Monetary approaches with calculation formulas: Formulas are developed for the determination of costs.
- Value-based approaches: Value-oriented TCO models combine monetary quantities with other performance data that are difficult to monetise. Qualitative factors are here weighted by a factor.

Table 7.1 shows the advantages and disadvantages of these models.

This chapter clearly differentiates between TCO and LCC, as defined in scientific work; however, such strict differentiation is not absolutely required in practice nor for the facts and circumstances dealt with in the other chapters. Thus, these two terms are from now on used synonymously for the sake of simplicity.[9]

Within the scope of a procurement project, both these approaches can provide a transparency of the costs incurred at the time of the actual acquisition and at later points in time. They will thus provide a company with better planning and transparency with regard to the costs incurred. Cost dependencies and interdependencies can be shown using the instruments in the procurement process. Additionally, the sensitivity of costs incurred will be increased by a multipersonal procedure taking into account the available instruments.

[5] Cf. Ellram (2002, p. 661).

[6] Cf. Ellram (1993, p. 52 et seq.).

[7] Cf. Ellram and Siferd (1998, p. 58).

[8] Cf. Ellram (1995, p. 12 et seq.).

[9] Cf. Bünting (2009, p. 39).

Table 7.1 Advantages and disadvantages of TCO models. (Cf. Ellram 1995, p. 14)

Model	Advantages	Disadvantages
Monetary approaches on the basis of direct costs	• Consideration of relevant factors • High flexibility • High adaptability	• Relatively time-consuming • Unsuitable for repeat purchases • Uneconomical for capital equipment of low value
Monetary approaches with calculation formulas	• Not very time-consuming after the introduction of the model • Suitable for repeat purchases	• Introduction of the model is time-consuming • Formulas must be regularly reviewed • Low flexibility
Value-based approaches	• Applicable for non-monetis-able costs • Simple application with repeat purchases	• Introduction of the model is time-consuming • Weightings are not objective

7.1.2 Fitting the LCC System and the TCO Approach into the Process for Capital Equipment Purchasing

As described in the preceding section, LCC and TCO not only provide a look at the totality of all required resources and costs incurred but also evaluate the complete course of the project. Accordingly, LCC and TCO are applicable in the entire cross-sectional activity "Evaluation" (Fig. 7.2). However, LCC and TCO are of special importance for the preselection of quotations and award decision. Owing to the integration along the entire process, TCO and LCC can also be used as a basis for subsequent cost controlling and thus as a management tool from the beginning to the end of the procurement project.[10]

7.1.3 Relevance of LCC and TCO Analysis Methods in the Overall Process

Depending on the type of capital equipment, certain costs may have a significant influence, while others have only a minor influence on total costs. For example, concerning capital equipment purchasing in the nuclear industry, environmental protection aspects and issues of disposal costs are eminently important; in other investments, energy might be a considerable cost driver. In addition to the price of capital equipment, evaluation criteria must be derived specifically for industrial sectors to enable the most exact and comprehensive total cost consideration, particularly related to the individual capital equipment.

[10] Cf. Schweiger (2008, p. 26).

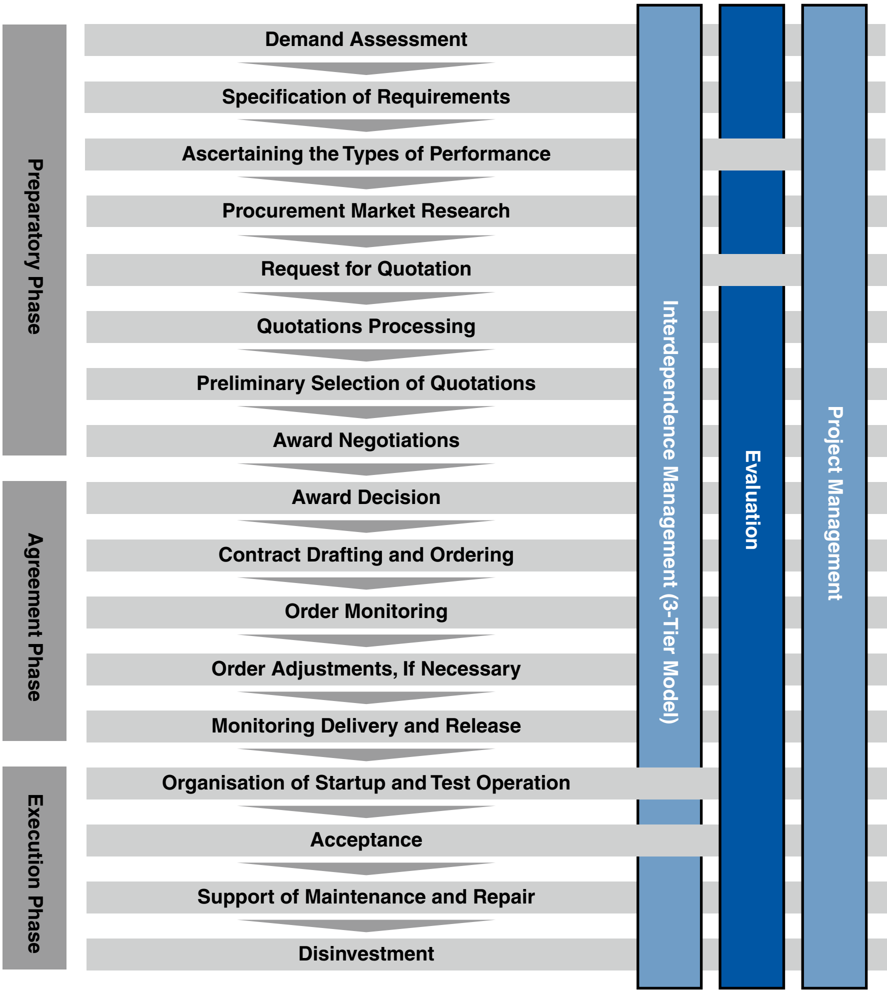

Fig. 7.2 Fitting the LCC system and the TCO approach into the process for capital equipment purchasing

For example, a close look at the procurement process of wind turbines shows that, during the planning stage, there will be the first cost pools—with the development and implementation of possible test facilities, prototypes or services for expertises (e.g. safety of installations or potential environmental impairments). During the realisation stage, aside from costs for general construction services, additional expenditures should be expected for logistic services. As soon as the installations are set up and can be commissioned, the acceptance inspection by the ordering party will follow, as well as the test run. Should any defects arise during this stage and should any reworking be required, it must be clarified who has to bear the costs—the contractor or the customer. It remains to be clarified in the individual case, however, whether lost profits or costs incurred from delayed commissioning should be taken over. With the ultimate utilisation of the installations, costs are especially incurred for spare parts, maintenance and other services over the total operational life of the installation, which, from the beginning, are also to be taken into account for the total costs of the procurement project. Liquidation is considered the final project stage, which is connected with corresponding costs for dismantling.

This example shows clearly that only a total approach taking total costs over the life cycle into account will guarantee an objective evaluation of the purchasing situation. This is the only possible way to ensure the effective control of costs as well as strategic decision-making for the best possible provision alternative and sourcing strategy for capital equipment purchasing.

7.1.4 Case Study: Calculation of LCC and TCO Using the Example of a Wind Turbine

The following case shows how LCC and/or TCO costs are calculated, using the example of the procurement of a wind turbine. We should first distinguish between investment costs and operating plus dismantling costs. Dismantling costs include the costs of disassembly, waste disposal and returning the property to its original condition. Since operating and dismantling costs are incurred in the course of the installation's useful life, cash values must be determined in this case. In the calculation example, a planned useful life of 20 years and a 7% interest rate was used as the basis. This calculation can be performed for several investment alternatives and furthermore expanded by the proceeds to be expected (Fig. 7.3).

7.1.5 Conclusions Regarding the LCC and TCO Approaches

The application of the described approaches enables an enterprise to develop increased planning and transparency with regard to the costs incurred on capital equipment purchasing. Cost dependencies and interdependencies can be shown using the described evaluation instruments in the procurement process.

Yet, the difficulties of both the LCC and the TCO approach should be taken into account and reconciled accordingly. Thus, for example, high complexities limit the acceptance of both methods, especially in capital equipment purchasing, which frequently extends over a long period of time and includes contingent decisions.[11] Moreover, follow-up costs normally cannot be forecast 100% and often remain hidden even though they amount to a multiple of the price of acquisition.[12] Owing to

[11] Cf. Reap et al. (2008, p. 295).

[12] Cf. Wübbenhorst (1986, p. 88).

Fig. 7.3 Calculation of TCO using the example of a wind turbine

Price of installation	1,300,000 €
Planning	40,500 €
Development	31,500 €
Foundation	99,000 €
Power grid connection	162,000 €
Other costs	117,000 €
Total incidental costs of investment	450,000 €
Maintenance and repair	25,935 €
Insurance	12,968 €
Purchased electricity	4,988 €
Real estate costs	17,955 €
Tax	20,948 €
Total operating costs per year	99,750 €
Costs of dismantling the installation	87,500 €
Cash value of total operating and dismantling costs	1,079,365 €
Total costs of investment	1,750,000 €
Cash value of total cost of ownership	**2,829,365 €**

the lack of historical values, only inadequate assumptions can frequently be made in the case of capital equipment and their special requirements in procurement. The reason for this is the lack of meaningful data rendering the recording of total costs difficult and requiring high transparency and conclusiveness in data processing. However, estimates and extrapolations can provide approximate values and contribute their share to a total cost perspective. Moreover, no standard approach exists for either of the two methods, which is why costs should be determined object- and/or project-specifically, and it is imperative that a structured procedure is used.

Both a successful TCO and LCC perspective can only be approached in cross-functional teams. Accordingly, capital equipment purchasing should be carried out by a multipersonal team, possibly with a buying centre structure.

7.2 Optimum Useful Life and Replacement Time of Capital Equipment

7.2.1 Introduction to Optimum Useful Life and Replacement Time

Capital equipment is generally procured at long time intervals, often connected with high financial stakes and has a long useful life. Enterprises thus tie up relatively large amounts of capital in fixed assets. Furthermore, the procurement of adequate capital equipment can significantly contribute to the success of an enterprise. For example, capital equipment often has a direct influence on the production costs of an enterprise.[13] A decisive role in capital equipment purchasing is the question of the eco-

[13] Cf. Dobler et al. (1990, p. 322 et seq.).

nomically optimum useful life and economically optimum replacement time. In this context, economically optimum means choosing the useful life of the capital equipment as that point in time where payment surpluses reach their maximum levels.

The useful life of capital equipment cannot be individually specified in each case; instead, it is frequently predetermined and influenced by various factors. For example, legal reasons—such as expired licenses—can clearly terminate the use of capital equipment and render superfluous any calculations beyond that time. The physical life of an installation or plant ends if it can no longer fulfil its function—because of wear and tear, for example. Such wear and tear could, moreover, result in a sudden total failure or in a slow reduction of technical operative capabilities. Capital equipment's gradually decreasing operative capabilities are presented below. Its physical life can generally be considerably to be prolonged through maintenance and repair work;[14] however, costs of maintenance and repair will continue to increase ever more.

The following section considers a case of slowly decreasing operative capabilities. It is assumed that the physical life can be increased by maintenance and repair work. Running costs for maintenance and repair work increase over the course of time and, as of a certain point in time, their cumulated sum often exceeds many times the costs of the capital equipment for acquisition, installation and commissioning. Thus, the sum of all these payments should be considered primarily to be payments corresponding with the life cycle costs of the capital equipment. Owing to higher costs for repair and maintenance, increasing technical obsolescence and expected changes in the application area, the possible physical life is usually higher than is the economically optimum useful life.[15] In turn, the economically optimum useful life is influenced by two opposite effects. The advantage of a long useful life is in the distribution of acquisition costs over an increasing number of periods. It is detrimental, however, that with the useful life installation, maintenance and repair costs usually increase over-proportionately.[16] Downtime costs also increase with an increasing useful life. An exemplary course of these payment flows is presented in Fig. 7.4. Current outpayments represent maintenance and repair costs, which generally increase with an increasing useful life. Current inpayments represent the flows of funds attributable to the capital equipment. Finally, cost-accounting depreciations represent the distributed acquisition costs.

The data necessary for the calculations of optimum useful life and optimum replacement time are based on LCC analyses (Sect. 7.2). As presented in Fig. 7.4, current outpayments and inpayments as well as acquisition investments are required for this calculation. Furthermore, required are the residual value which may be positive or negative, as well as the company's internal rate of return. In many companies, the internal rate of return is determined by the type of financing or the risk profile, which is mostly determined by corporate management or by the financial division. Since the need for capital equipment and its specifications is frequently applied for by a company's operative output units (e.g. the production department

[14] Cf. Götze (2006, p. 235).

[15] Cf. Götze (2006, p. 235).

[16] Cf. Poggensee (2009, p. 255).

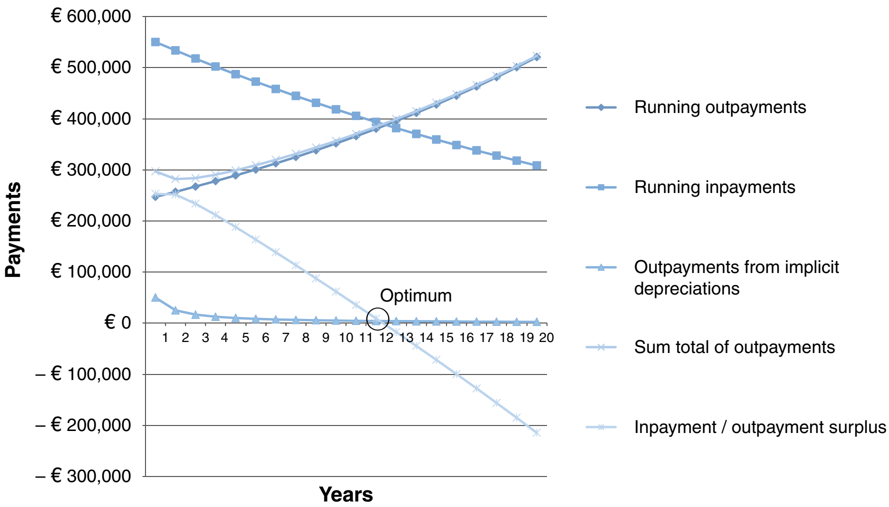

Fig. 7.4 Exemplary course of payment flows for procured capital equipment in its life cycle. (Cf. Poggensee 2009, p. 255 et seq.)

of an industrial business) and because the necessary data are administered by the company's controlling department while purchasing is responsible for the procurement process, it is relevant that all players involved are networked for a determination of the capital equipment's optimum useful life.

The methods presented in this section can also be used for performance contracting decisions (Sect. 7.4). For example, the optimum useful life of capital equipment can first be determined and, on that basis, a lease-or-buy analysis can then be carried out for the period ascertained.

The analysis of determining the optimum useful life and the optimum replacement time of capital equipment is substantially performed at the beginning and the end of the procurement process (Fig. 7.5). The process steps in between are partly influenced by the results of the analysis. For example, to provide a feasibility analysis of the quotations obtained, it is necessary to know the optimum useful life. This optimum useful life is determined within the scope of the specification of requirements and—based on the findings obtained—budget planning and quotation requests can be carried out. By contrast, the optimum replacement time should be ascertained at regular intervals during the operating stage of the capital equipment as well as when new information relevant for the payment flow comes to light. But even cross-sectional activities are affected by this solution. Thus, the determination of optimum useful life and optimum replacement time presents an evaluation between a current and a follow-up investment. Interdependence management and project management must also be taken into account for this issue. For example, with regard to the decision on a later investment, interdependencies should be examined in terms of other capital equipment being used. Since this analysis is a major component in time scheduling and has far-reaching effects on the budget, project management will also play a major part.

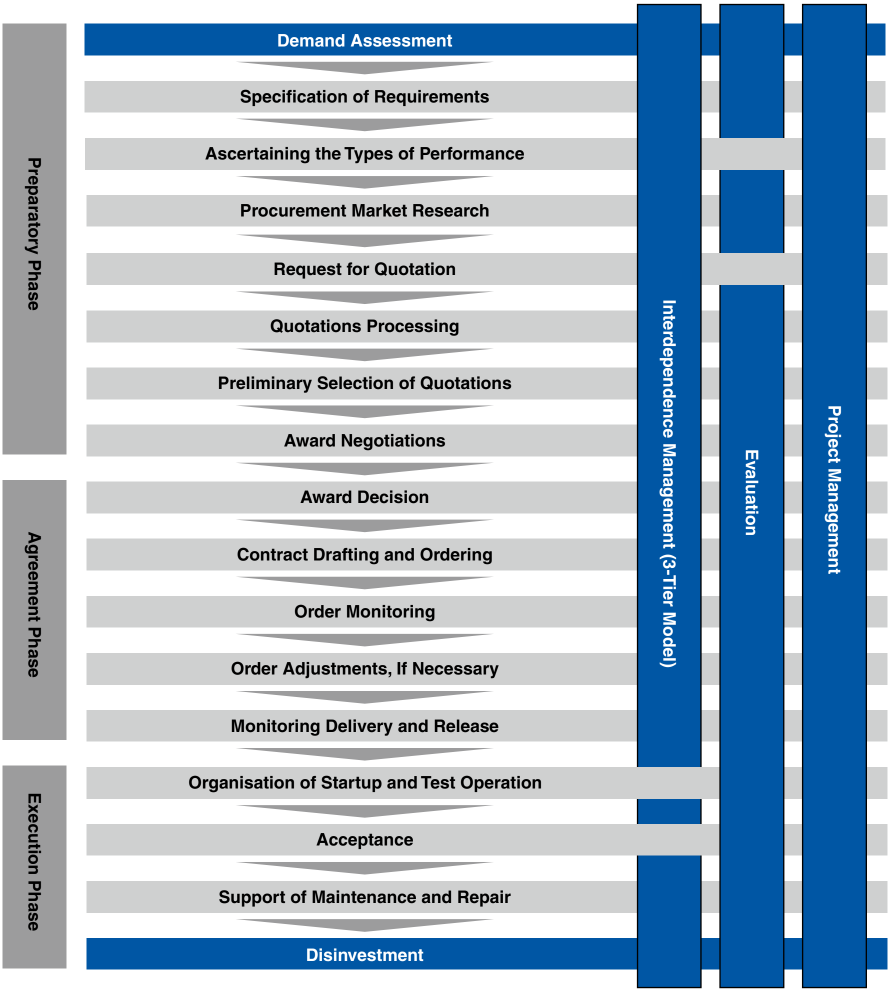

Fig. 7.5 Fitting the determination of optimum useful life and optimum replacement time into the procurement process of capital equipment

Based on the point in time of the calculation, life cycle analysis distinguishes between the calculation of useful life and that of replacement time. The optimum useful life of capital equipment is determined *ex ante*, namely before the time of the investment.[17] Since it cannot be assumed that the calculation bases for the useful life calculation will actually come about as such and since, furthermore, capital equipment is available that continues to be improved with technical progress, planned

[17] This is also necessary since a given useful life is assumed, for example, for the assessment of the advantageousness of various investments.

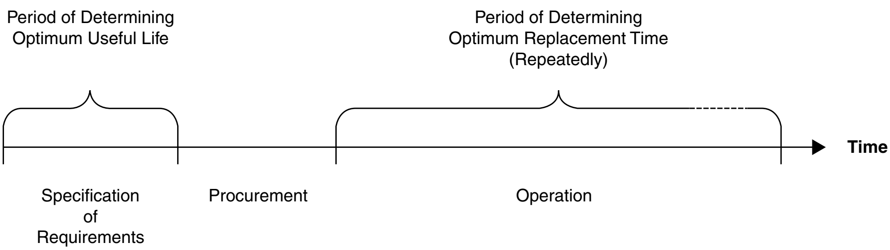

Fig. 7.6 Determination of optimum useful life and optimum replacement time over the course of time

the remaining useful life should be regularly reviewed *ex post* and adjusted using a replacement time calculation (Fig. 7.6).

As presented in Fig. 7.7, the models for the determination of the economically optimum useful life and the economically optimum replacement time can be categorised.

In the following sections, the useful life calculation without any successor objects will be explained (Sect. 7.2.2.1) followed by the useful life calculation and replacement time calculation with infinitely many identical successor objects (Sect. 7.2.3). Moreover, the case of replacement time determination with only one successor object will be presented (Sect. 7.2.2.2). The useful life calculation without any successor objects as well as the replacement time determination with only one successor object are especially suitable for the introduction to this chapter because they are mathematically easy to understand and can be implemented in practice without major expenditures. This model is used, for example, if the goods produced with the capital equipment are no longer to be produced after the end of its useful life. For many companies, the purchase of a production plant is considered to be a

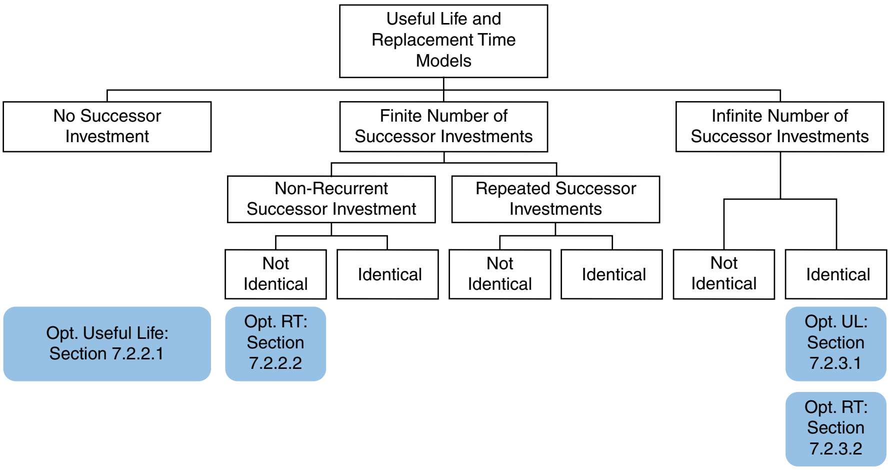

Fig. 7.7 Type and number of follow-up investments in useful life and replacement time models. (Cf. Götze 2006, p. 238)

non-recurrent major investment. By contrast, the continuous renewal of the company's own fleet would present an infinitely repeated identical investment. The calculations of useful life and replacement time are differentiated by the point in time of the calculation. Useful life is rendered concrete *ex ante*, namely before the time of investment.[18] Since it cannot be assumed that the calculation bases will actually happen as predicted and since capital equipment is available that is improved because of technical progress, the useful life calculation must frequently be reviewed and adjusted *ex post*. This can be carried out using a replacement time calculation.

In the following sections, the calculation of net present value is frequently necessary. The net present value results from the cash value, namely the value that all future inpayments and outpayments attributable to the investment project have at the present time. The net present value is calculated as follows:[19]

$$KW_k = -I_0 + \sum_{t=1}^{n} NE_t \cdot (1+i)^{-t} + R_k(1+i)^{-k}$$

with

KW_k	Net present value at a useful life of k periods
I_0	Acquisition outpayment
NE_t	Payment surplus at time t calculated from the difference between inpayments and outpayments
R_k	Inpayment from liquidation proceeds or residual value after a useful life of k periods
i	Interest rate

Based on the example of a one-megawatt wind turbine, the following sections will present the determination of the optimum useful life and the optimum replacement time of capital equipment. Acquisition costs I_0 of the wind turbine should be € 1,000,000, and an imputed interest rate $i=10\%$ is assumed. Based on the data, the optimum useful life and the optimum replacement time of a non-recurrent investment will first be presented.

7.2.2 Optimum Useful Life and Replacement Time of a Non-Recurrent Investment

7.2.2.1 Useful Life of a Non-Recurrent Investment without Any Successor Objects

Using the net present value model for the optimum useful life of a non-recurrent investment, the following rule applies: the optimum useful life is that in which the net present value of the investment object reaches its maximum.

[18] This is also necessary since a given useful life is assumed for the assessment of the advantageousness of various investments.

[19] Cf. Hansen et al. (2009, p. 719).

t / k	Current Inpayments E_t	Current Outpayment A_t	Residual Value R_k	Payment Surplus NE_t	Dis-count Factor Abf_t	Discounted Payment Surplus	Discounted Residual Value	Cumulated Discounted Payment Surplus	Net Present Value KW_k
1	550,000.00 €	247,000.00 €	900,000.00 €	303,000.00 €	0.91	275,454.55 €	818,181.82 €	275,454.55 €	93,636.36 €
2	550,000.00 €	256,880.00 €	814,500.00 €	293,120.00 €	0.83	242,247.93 €	673,140.50 €	517,702.48 €	190,842.98 €
3	550,000.00 €	267,155.20 €	741,195.00 €	282,844.80 €	0.75	212,505.48 €	556,870.77 €	730,207.96 €	287,078.74 €
4	550,000.00 €	277,871.41 €	678,193.43 €	272,158.59 €	0.68	185,887.98 €	463,215.23 €	916,095.94 €	379,311.18 €
5	550,000.00 €	288,955.06 €	623,937.95 €	261,044.94 €	0.62	162,088.37 €	387,416.38 €	1,078,184.31 €	465,600.69 €
6	550,000.00 €	300,513.27 €	577,142.60 €	249,486.73 €	0.56	140,828.76 €	325,781.95 €	1,219,013.07 €	544,795.02 €
7	550,000.00 €	312,533.80 €	536,742.62 €	237,466.20 €	0.51	121,857.71 €	275,433.83 €	1,340,870.78 €	616,304.61 €
8	550,000.00 €	325,035.15 €	501,854.35 €	224,964.85 €	0.47	104,947.76 €	234,118.76 €	1,445,818.54 €	679,937.30 €
9	550,000.00 €	338,036.56 €	471,743.09 €	211,963.44 €	0.42	89,893.19 €	200,065.12 €	1,535,711.73 €	735,776.85 €
10	550,000.00 €	351,558.02 €	445,797.22 €	198,441.98 €	0.39	76,507.97 €	171,874.13 €	1,612,219.71 €	784,093.83 €
11	550,000.00 €	365,620.34 €	423,507.36 €	184,379.66 €	0.35	64,623.95 €	148,436.75 €	1,676,843.65 €	825,280.40 €
12	550,000.00 €	380,245.15 €	404,449.53 €	169,754.85 €	0.32	54,089.13 €	128,870.08 €	1,730,932.78 €	859,802.86 €
13	550,000.00 €	395,454.96 €	388,271.55 €	154,545.04 €	0.29	44,766.19 €	112,468.44 €	1,775,698.97 €	888,167.41 €
14	550,000.00 €	411,273.16 €	374,682.04 €	138,726.84 €	0.26	36,531.11 €	98,665.49 €	1,812,230.09 €	910,895.58 €
15	550,000.00 €	427,724.08 €	363,441.58 €	122,275.92 €	0.24	29,271.88 €	87,005.03 €	1,841,501.97 €	928,506.99 €
16	550,000.00 €	444,833.05 €	354,355.54 €	105,166.95 €	0.22	22,887.39 €	77,118.09 €	1,864,389.36 €	941,507.45 €
17	550,000.00 €	462,626.37 €	347,268.43 €	87,373.63 €	0.20	17,286.41 €	68,705.21 €	1,881,675.77 €	950,380.98 €
18	550,000.00 €	481,131.42 €	342,059.41 €	68,868.58 €	0.18	12,386.62 €	61,522.39 €	1,894,062.39 €	955,584.78 €
19	550,000.00 €	500,376.68 €	338,638.81 €	49,623.32 €	0.16	8,113.81 €	55,370.15 €	1,902,176.20 €	957,546.35 €
20	550,000.00 €	520,391.75 €	336,945.62 €	29,608.25 €	0.15	4,401.08 €	50,084.82 €	1,906,577.28 €	956,662.10 €

Fig. 7.8 Calculation of the optimum useful life of a non-recurrent investment without any successor objects

What follows is a calculation of the optimum useful life of the exemplary wind turbine (Fig. 7.8). Current inpayments E_t *and* outpayments A_t as well as the residual value R_k in the grey highlighted fields have already been determined in the life cycle costs calculation of the capital equipment and are thus given here. The calculation is provided according to the following steps:

- Payment surpluses NE_t of every year are calculated from inpayments and outpayments.
- Subsequently, the annual discount factor is calculated at $Abf_t = (1 + i)^{-t}$.
- Payment surplus and residual value are multiplied by the discount factor to discount them to the current point in time.
- For every useful life k, the cumulated payment surplus is calculated up to that point in time at $\sum_{t=1}^{k} Abf_t \cdot NE_t$.
- Finally, the net present value of capital equipment is calculated from the sum of the discounted residual value and the cumulated discounted payment surpluses of the corresponding year, reduced by the initial outpayment.

Since the net present value reaches its maximum of € 957,546.35 after 19 years, this period of time is equivalent to the optimum useful life.

7.2.2.2 Replacement Time upon Non-Recurrent Replacement by a New Object

The wind turbine calculated in the section before had been acquired and it is in operation. In that example, no successor investment had been planned. In the fol-

New Installation									
Year t / k	Inpayments E_t	Outpayments A_t	Residual Value R_k	Payment Surplus NE_t	Discount Factor Abf_t	Discounted Payment Surplus	Cumulated Discounted Payment Surplus	Discounted Residual Value	Net Present Value KW_k
1	555,500.00 €	247,000.00 €	900,000.00 €	308,500.00 €	0.91	280,454.55 €	280,454.55 €	818,181.82 €	98,636.36 €
2	555,500.00 €	256,880.00 €	814,500.00 €	298,620.00 €	0.83	246,793.39 €	527,247.93 €	673,140.50 €	200,388.43 €
3	555,500.00 €	267,155.20 €	741,195.00 €	288,344.80 €	0.75	216,637.72 €	743,885.65 €	556,870.77 €	300,756.42 €
4	555,500.00 €	277,841.41 €	678,193.43 €	277,658.59 €	0.68	189,644.55 €	933,530.20 €	463,215.23 €	396,745.44 €
5	555,500.00 €	288,955.06 €	623,937.95 €	266,544.94 €	0.62	165,503.43 €	1,099,033.64 €	387,416.38 €	486,450.02 €
6	555,500.00 €	300,513.27 €	577,142.60 €	254,986.73 €	0.56	143,933.36 €	1,242,967.00 €	325,781.95 €	568,748.96 €
7	555,500.00 €	312,533.80 €	536,742.62 €	242,966.20 €	0.51	124,680.08 €	1,367,647.08 €	275,433.83 €	643,080.91 €
8	555,500.00 €	325,035.15 €	501,854.35 €	230,464.85 €	0.47	107,513.55 €	1,475,160.63 €	234,118.76 €	709,279.39 €
9	555,500.00 €	338,036.56 €	471,743.09 €	217,463.44 €	0.42	92,225.73 €	1,567,386.36 €	200,065.12 €	767,451.48 €
10	555,500.00 €	351,558.02 €	445,797.22 €	203,941.98 €	0.39	78,628.46 €	1,646,014.83 €	171,874.13 €	817,888.95 €
11	555,500.00 €	365,620.34 €	423,507.36 €	189,879.66 €	0.35	66,551.66 €	1,712,566.49 €	148,436.75 €	861,003.24 €
12	555,500.00 €	380,245.15 €	404,449.53 €	175,254.85 €	0.32	55,841.60 €	1,768,408.08 €	128,870.08 €	897,278.17 €
13	555,500.00 €	395,454.96 €	388,271.55 €	160,045.04 €	0.29	46,359.35 €	1,814,767.43 €	112,468.44 €	927,235.87 €
14	555,500.00 €	411,273.16 €	374,682.04 €	144,226.84 €	0.26	37,979.44 €	1,852,746.87 €	98,665.49 €	951,412.36 €
15	555,500.00 €	427,724.08 €	363,441.58 €	127,775.92 €	0.24	30,588.54 €	1,883,335.41 €	87,005.03 €	970,340.43 €
16	555,500.00 €	444,833.05 €	354,355.54 €	110,666.95 €	0.22	24,084.35 €	1,907,419.76 €	77,118.09 €	984,537.85 €
17	555,500.00 €	462,626.37 €	347,268.43 €	92,873.63 €	0.20	18,374.55 €	1,925,794.31 €	68,705.21 €	994,499.52 €
18	555,500.00 €	481,131.42 €	342,059.41 €	74,368.58 €	0.18	13,375.84 €	1,939,170.16 €	61,522.39 €	1,000,692.55 €
19	555,500.00 €	500,376.68 €	338,638.81 €	55,123.32 €	0.16	9,013.10 €	1,948,183.26 €	55,370.15 €	1,003,553.41 €
20	555,500.00 €	520,391.75 €	336,945.62 €	35,108.25 €	0.15	5,218.62 €	1,953,401.88 €	50,084.82 €	1,003,486.70 €

Fig. 7.9 Calculation of the optimum useful life of the new installation for determining the replacement time of a non-recurrent replacement

lowing example, it is assumed that in the second year of operation—thus before the expiration of its useful life—a wind turbine with improved efficiency comes onto the market that generates a higher output with an unchanged input. The purchasing staff members trained in innovations-oriented procurement management realise this and they calculate that the new installation is an improvement on the existing one. It should now be determined at what point in time the operating installation will be most economically replaced by a new wind turbine.[20]

The calculation is based on running inpayments and outpayments, as well as the liquidation proceeds R_k for a useful life of k periods. First, the optimum useful life and net present value of the new wind turbine are calculated. The procedure is here identical to the calculation of the useful life of a non-recurrent investment without any successor objects in Sect. 7.2.2.1.

For the new wind turbine, a useful life of 19 years is also optimal, with a net present value at the present point in time of € 1,003,553.41 (Fig. 7.9).

The net present values of the operating installation are already known. The optimum replacement time is now calculated by adding all the possible useful lives of the old installation and the optimum net present value of the new installation discounted to that point in time, thus $KW_g = KW_k^{alt} + Abf_k \cdot KW_{opt}^{neu}$. The total net present value KW_g should be then maximised.

The optimum net present value occurs in year 10 (Fig. 7.10). Since the old wind turbine is already in its second operating year, it will continue to be operated—according to this calculation—for another eight years and replaced after its 10th operating year.

[20] Cf. Obermeier and Gasper (2008, p. 99 et seq.).

Year t / k	Old Install.	New Installation			Net Present Value of Both Installations KW_g
	Net Present Value KW_k old	Maximum Net Present Value KW_k	Discount Factor Abf_t	Discounted Maximum Net Present Value	
1	93,636.36 €	1,003,553.41 €	0.91	912,321.28	1,005,957.65 €
2	190,842.98 €	1,003,553.41 €	0.83	829,382.98	1,020,225.96 €
3	287,078.74 €	1,003,553.41 €	0.75	753,984.53	1,041,063.27 €
4	379,311.18 €	1,003,553.41 €	0.68	685,440.48	1,064,751.66 €
5	465,600.69 €	1,003,553.41 €	0.62	623,127.71	1,088,728.40 €
6	544,795.02 €	1,003,553.41 €	0.56	566,479.74	1,111,274.76 €
7	616,304.61 €	1,003,553.41 €	0.51	514,981.58	1,131,286.19 €
8	679,937.30 €	1,003,553.41 €	0.47	468,165.07	1,148,102.37 €
9	735,776.85 €	1,003,553.41 €	0.42	425,604.61	1,161,381.47 €
10	784,093.83 €	1,003,553.41 €	0.38	383,044.15	1,167,137.98 €
11	825,280.40 €	1,003,553.41 €	0.34	340,483.69	1,165,764.09 €
12	859,802.86 €	1,003,553.41 €	0.30	297,923.23	1,157,726.09 €
13	888,167.41 €	1,003,553.41 €	0.25	255,362.77	1,143,530.18 €
14	910,895.58 €	1,003,553.41 €	0.21	212,802.31	1,123,697.89 €
15	928,506.99 €	1,003,553.41 €	0.17	170,241.84	1,098,748.84 €
16	941,507.45 €	1,003,553.41 €	0.13	127,681.38	1,069,188.84 €
17	950,380.98 €	1,003,553.41 €	0.08	85,120.92	1,035,501.90 €
18	955,584.78 €	1,003,553.41 €	0.04	42,560.46	998,145.24 €
19	957,546.35 €	1,003,553.41 €	0.00	0.00	957,546.35 €
20	956,662.10 €	1,003,553.41 €	-0.04	-42,560.46	914,101.63 €

Fig. 7.10 Calculation of the optimum replacement time with a non-recurrent replacement

7.2.3 Optimum Useful Life and Replacement Time of Recurrent Investment Chains

7.2.3.1 Useful Life in Investment Chains

Follow-up investments are necessary if the calculated optimum useful life of a wind turbine is shorter than is the time span for which such an installation is required. As shown in Fig. 7.7, these follow-up investments can be identical or not identical, as well as finite and infinite. Since several investments follow each other without overlappings and interruptions, they can be visualised as one net present value-identical[21] investment chain. The rather unrealistic assumption of infinity under practical viewpoints does not present any problem insofar as payments in the distant future remain

[21] Net present value-identical means that each object has the same acquisition outpayment, the same length of useful life and the same net present value. It also means that the successor object starts operation precisely when the predecessor model is liquidated. Cf. Poggensee (2009, p. 256).

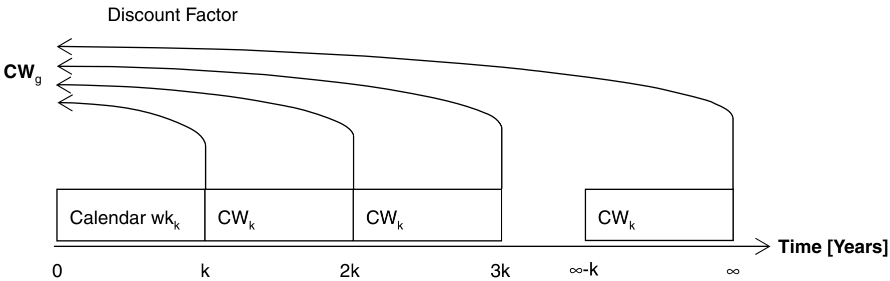

Fig. 7.11 Total net present value with infinitely repeated net present value-identical investment chains. (Cf. Poggensee 2009, p. 271)

virtually unconsidered because of the discount effect.[22] However, this assumption is a mathematical simplification of the problem that can be used if it is unknown at the time of planning how long the product produced with the capital equipment is supposed to be produced.[23] The assumption of identical follow-up investments results from a lack of information about the future. It is, accordingly, assumed that the new installations are procured under the same terms and conditions.[24]

The total net present value of this investment chain is co-determined by the length of the individual objects in the chain. The net present values of the individual objects are discounted to the current point in time and subsequently added.[25] As shown in Fig. 7.11, an infinite investment chain can be graphically presented—with a useful life k and a net present value KW_k for every object.

KW_g is calculated by discounting and by the subsequent addition of the individual objects in the chain to the current point in time. The total net present value can be presented as follows with the total formula:[26]

Total net present value of the series:

$$KW_g = KW_k \cdot \frac{1 - \left[\frac{1}{(1+i)^k}\right]^\infty}{1 - \frac{1}{(1+i)^k}}$$

The fraction in brackets can be neglected because the exponent renders it infinitesimally small. The calculation is thus cancelled out as follows:

$$KW_g = KW_k \cdot \frac{1}{1 - \frac{1}{(1+i)^k}}$$

22 Cf. Bellman (1955, p. 133).

23 Cf. Wünsche (2009, p. 99).

24 Cf. Wünsche (2009, p. 99).

25 Mathematically, this is equivalent to a geometric series.

26 Cf. Poggensee (2009, p. 272).

After increasing the fraction by the accumulation factor multiplied by the interest rate and factoring out the interest rate to the denominator of the fraction, the following results:

$$KW_g = \frac{KW_k}{i} \cdot \frac{i \cdot (1+i)^k}{(1+i)^k - 1} = \frac{KW_k}{i} \cdot KWF_i^k = \frac{DJ\ddot{U}}{i}$$

with

$$KWF_i^k = \frac{i \cdot (1+i)^k}{(1+i)^k - 1} \quad \text{Capital recovery factor}^{27}$$

$DJ\ddot{U} = KWF_i^k \cdot KW_k$ Average annual surplus or annuity

The total net present value KW_g thus results from the division of the average annual surplus *DJÜ* by the internal rate of return *i*. The total net present value of the investment chain can be optimised by determining the *DJÜ* for every possible length of the useful life *k*.

Figure 7.12 shows one example of calculating the optimum useful life in infinitely repeated investment chains. Since the calculation is carried out for the same wind turbine as that in Fig. 7.8, the net present values KW_k are identical and not recalculated here. To determine the optimum useful life, the procedure is as follows:

- First, the capital recovery factor is calculated: $KWF_i^k = \frac{i \cdot (1+i)^k}{(1+i)^k - 1}$.
- To obtain the average annual surplus, the net present value is multiplied by the capital recovery factor.
- Finally, the total net present value KW_g results with $KW_g = \frac{DJ\ddot{U}}{i}$.

In the present example, the maximum total net present value of KW_g=€ 1,227,606.90 and thus the optimum useful life is nine years (Fig. 7.12).

It should be noted that the optimum useful life in the calculation without a successor object was 19 years. The optimum useful life of nine years—compared with 19 years for a non-recurrent investment—should be explained such that, while the net present value of an individual object actually increases further after nine years, the marginal yield and thus the *average annual surplus* [*DJÜ*] diminishes. For a non-recurrent investment, it is advisable to continue the investment until the net present value reaches its maximum. By contrast, for an investment chain, it is desirable from a financial viewpoint to provide the follow-up investment upon reaching the maximum average annual surplus to realise interest gains in all subsequent investments.

[27] The capital recovery factor—also called the annuity factor—distributes a value of the current point in time to *k* periods, taking into account interest and compound interest.

Year k	Net Present Value KW_k	Capital Recovery Factor KWF_{ik}	DJÜ	KW_g
1	93,636.36 €	1.10	103,000.00 €	1,030,000.00 €
2	190,842.98 €	0.58	109,961.90 €	1,099,619.05 €
3	287,078.74 €	0.40	115,438.61 €	1,154,386.10 €
4	379,311.18 €	0.32	119,661.60 €	1,196,616.02 €
5	465,600.69 €	0.26	122,824.29 €	1,228,242.89 €
6	544,795.02 €	0.23	125,088.96 €	1,250,889.58 €
7	616,304.61 €	0.21	126,592.36 €	1,265,923.57 €
8	679,937.30 €	0.19	127,450.18 €	1,274,501.79 €
9	735,776.85 €	0.17	127,760.69 €	1,277,606.90 €
10	784,093.83 €	0.16	127,607.66 €	1,276,076.61 €
11	825,280.40 €	0.15	127,062.76 €	1,270,627.63 €
12	859,802.86 €	0.15	126,187.52 €	1,261,875.19 €
13	888,167.41 €	0.14	125,034.90 €	1,250,348.97 €
14	910,895.58 €	0.14	123,650.63 €	1,236,506.35 €
15	928,506.99 €	0.13	122,074.32 €	1,220,743.21 €
16	941,507.45 €	0.13	120,340.30 €	1,203,403.01 €
17	950,380.98 €	0.12	118,478.42 €	1,184,784.22 €
18	955,584.78 €	0.12	116,514.66 €	1,165,146.65 €
19	957,546.35 €	0.12	114,471.67 €	1,144,716.67 €
20	956,662.10 €	0.12	112,369.17 €	1,123,691.71 €

Fig. 7.12 Calculation of optimum useful life in infinite identical investment chains

7.2.3.2 Replacement Time with Investment Chains

The investment chain calculated in Sect. 7.2.3.1 is used as the basis in the following example. The currently operated wind turbine was acquired two years ago. Now, a more efficient type of installation with a higher average annual surplus comes onto the market. A wind turbine of the new type should be purchased at the latest for the next replacement time of the ongoing chain. However, it might be economically more advantageous to replace the existing installation, namely prior to the expiration of its calculated useful life.

When calculating the replacement time in such infinite investment chains, there is a differentiation between the cases of either an annual replacement possibility or a replacement over more than one year. In the following section, we focus on the calculation of the annual replacement possibility. Annual replacement time means that the replacement of the old by the new investment chain is possible in every period (here: one year). More than one year means that a replacement is not possible in every period for different reasons.

The replacement time is determined by comparing the extension period of the old object with the average annual surplus of the new object.[28] Thus, we consider the old object in terms of limits.[29] Marginal surpluses are calculated from the sum total of the additional payment surpluses NE_k of the year under consideration, reduced by the residual value loss:

$$G\ddot{U}_k = NE_k - (R_{k-1} - R_k) + i \cdot R_{k-1}$$

To determine the optimum replacement time, the marginal surplus of the old installation is compared with the average annual surplus of the new wind turbine. The old installation is replaced at the earliest possible point in time in which the marginal surplus of the old installation is smaller than or equal to the average annual surplus of the new wind turbine ($G\ddot{U}_{k,alt} \leq DJ\ddot{U}_{neu}$) or in which the useful life of the old installation expires. Figure 7.13 presents the calculation of the marginal surpluses of the last installation of the old investment chain.

It is known from Sect. 7.2.3.1 that the optimum useful life of a wind turbine in this investment chain is nine years. Thus, following this line of thought, a new investment should be made after the ninth period at the latest. The newly available wind turbine is the same as that in Fig. 7.10; thus, the net present values KW_k are also identical and these will not be calculated here again.

The maximum average annual surplus thus is € 133,260.69 and this results in an optimum useful life of nine years for the wind turbine (Fig. 7.14). The marginal surpluses of the old installation are compared with this average annual surplus. Since the currently operated installation was acquired two years ago, the marginal surplus of the third year is taken into account, which is € 128,089.80. Since the *marginal surplus* of the old wind turbine (€ 128,089.80) is lower than is the *average annual surplus* of the new installation (€ 133,260.69), it is desirable to replace the old installation with the new installation after the current year.

7.2.4 Conclusions Regarding Optimum Useful Life and Replacement Time

Various recommendations can be provided for the successful determination of the optimum useful life and the replacement time. The purchasing staff—as contacts towards the outside—should be particularly trained to find innovative novelties on the market so that replacement time calculations can be set in motion. Data on the existing installation should also be continuously recorded and updated to directly access such data when needed. Since the data on the potential, new capital equipment are usually incomplete and difficult to determine, the enterprise should build up further competences to be able to estimate these impact factors as efficiently

[28] Cf. Poggensee (2009, p. 280).

[29] Since we assume that a year's inpayments and outpayments will fall due at the end of the corresponding year, the year is the marginal period of time to be considered.

Current Installation			
Year t / k	Payment Surplus NE_t	Residual Value R_k	Marginal Surplus $GÜ_k$
1	303,000.00 €	900,000.00 €	103,000.00 €
2	293,120.00 €	814,500.00 €	117,620.00 €
3	282,844.80 €	741,195.00 €	128,089.80 €
4	272,158.59 €	678,193.43 €	135,037.52 €
5	261,044.94 €	623,937.95 €	138,970.12 €
6	249,486.73 €	577,142.60 €	140,297.59 €
7	237,466.20 €	536,742.62 €	139,351.96 €
8	224,964.85 €	501,854.35 €	136,402.32 €
9	211,963.44 €	471,743.09 €	131,666.75 €
10	198,441.98 €	445,797.22 €	125,321.80 €
11	184,379.66 €	423,507.36 €	117,510.08 €
12	169,754.85 €	404,449.53 €	108,346.28 €
13	154,545.04 €	388,271.55 €	97,922.11 €
14	138,726.84 €	374,682.04 €	86,310.18 €
15	122,275.92 €	363,441.58 €	73,567.25 €
16	105,166.95 €	354,355.54 €	59,736.76 €
17	87,373.63 €	347,268.43 €	44,850.97 €
18	68,868.58 €	342,059.41 €	28,932.71 €
19	49,623.32 €	338,638.81 €	11,996.79 €
20	29,608.25 €	336,945.62 €	-5,948.82 €

Fig. 7.13 Calculation of the marginal surplus of the last installation of the investment chain running out

and reliably as possible. Additionally, corresponding channels and work specifications must be available to provide the corresponding information to the company's involved players.

7.3 Real Options Approach for the Evaluation of Investment Alternatives

7.3.1 Introduction to the Real Options Approach

Decisions to be made within the scope of capital equipment purchasing have the objective, *inter alia*, of maximising the value of the capital employed. Since the

New Investment Chain					
Year t / k	Payment Surplus NE_t	Residual Value R_k	Net Present Value KW_k	Capital Recovery Factor KWF_i^k	Average Annual Surplus $DJÜ=KW_k{}^* KWF_i^k$
1	308,500.00 €	900,000.00 €	98,636.36 €	1.10	108,500.00 €
2	298,620.00 €	814,500.00 €	200,388.43 €	0.58	115,461.90 €
3	288,344.80 €	741,195.00 €	300,756.42 €	0.40	120,938.61 €
4	277,658.59 €	678,193.43 €	396,745.44 €	0.32	125,161.60 €
5	266,544.94 €	623,937.95 €	486,450.02 €	0.26	128,324.29 €
6	254,986.73 €	577,142.60 €	568,748.96 €	0.23	130,588.96 €
7	242,966.20 €	536,742.62 €	643,080.91 €	0.21	132,092.36 €
8	230,464.85 €	501,854.35 €	709,279.39 €	0.19	132,950.18 €
9	217,463.44 €	471,743.09 €	767,451.48 €	0.17	133,260.69 €
10	203,941.98 €	445,797.22 €	817,888.95 €	0.16	130,728.97 €
11	189,879.66 €	423,507.36 €	861,003.24 €	0.15	125,735.39 €
12	175,254.85 €	404,449.53 €	897,278.17 €	0.13	118,647.19 €
13	160,045.04 €	388,271.55 €	927,235.87 €	0.12	109,809.41 €
14	144,226.84 €	374,682.04 €	951,412.36 €	0.10	99,539.75 €
15	127,775.92 €	363,441.58 €	970,340.43 €	0.09	88,126.00 €
16	110,666.95 €	354,355.54 €	984,537.85 €	0.08	75,825.35 €
17	92,873.63 €	347,268.43 €	994,499.52 €	0.06	62,865.01 €
18	74,368.58 €	342,059.41 €	1,000,692.55 €	0.05	49,443.45 €
19	55,123.32 €	338,638.81 €	1,003,553.41 €	0.04	35,732.28 €
20	35,108.25 €	336,945.62 €	1,003,486.70 €	0.02	21,878.29 €

Fig. 7.14 Calculation of the average annual surplus of the new investment chain

available capital is limited, only the economically best investments with a positive value contribution can be realised. Many companies use methods such as the net present value method or the internal rate of return method[30] to make decisions on capital equipment purchasing. However, these methods have the prerequisite that the payment flows connected with the investment decision are already known at the decision-making time and that the interest rate employed remains constant over the entire life of the capital equipment.[31] In practice, however, these prerequisites are generally not fulfilled. Furthermore, these approaches do not take into account that the interest rate employed should be adjusted over the course of time to the risk of

[30] Cf. Lee and Lee (2006, p. 152 et seq.).

[31] Cf. Schulmerich (2010, p. 23).

the investment and that management also has certain decision flexibilities during the term of capital equipment. For example, capital equipment might be enlarged or prematurely sold. Owing to these decision possibilities, the cash flow structure will change as will the interest rate to be used, which is, however, not considered by the net present value method and the internal rate of return method. The real options approach, by contrast, is in theory closely related to finance options and it takes into account the uncertainty of the investment and flexibility of management. According to Hilpisch, a real option designates the right "…to implement (to end) a project—having an uncertain value S in the passage of time—over a period of time (or at a specific point in time) against payment (receipt) of a fixed amount K."[32]

In the process of capital equipment purchasing, the real options approach can principally take place at every step where an uncertain evaluation must be made. This might be the case, for example, in demand assessment (uncertainty about future sales), the preselection of quotations, award decision (uncertainty about the actual payment flows of the capital equipment) or divestment (uncertainty about expected repair costs). In addition, interdependencies must always be taken into account in terms of other capital equipment, suppliers and offered services. At every step, project management should also be involved in the real options approach (Fig. 7.15).

If used correctly, the real options approach can be useful in other aspects of capital equipment purchasing. In a lease-or-buy analysis, for example, the option of prematurely decommissioning an investment object can influence the leasing decision. If leasing conditions are calculated using the real options approach, the flexibility of the leasing agreement can be additionally taken into account for example. Real options also influence the determinations of useful life and replacement time. If the useful life of an installation is calculated as a real option, flexibility may delay the acquisition of the successor object by one year, influencing the calculation and thus the optimum useful life. The real options approach also aims to determine at what point it will pay to no longer use specific capital equipment but keep it serviced for later use; accordingly, in the calculation of life cycle costs, shutdown and recommissioning costs should be analysed as should the costs for the maintenance of the capital equipment not in operation.

In accordance with its multitude of possible applications, the real options approach is mathematically complex. Since real options are mostly calculated using financial mathematics tools, such as the binomial model[33] or the Black–Scholes formula[34], corresponding expertise in this field must exist within the company. However, since the real options approach is based on uncertainty, know-how in financial

[32] Hilpisch (2006, p. 32).

[33] With the binomial model, the price of the basic value is observed for successive periods. It is assumed that, in every short period, only two movements are possible, namely either by a fixed value up or down. Cf. Lee and Lee (2006, p. 34).

[34] The Black–Scholes formula is a method for evaluating call options. The formula uses the price of the basic value, the exercise price, the risk-free interest rate, the lifetime of the option and the standard deviation of the price of the underlying security. Cf. Lee and Lee (2006, p. 35).

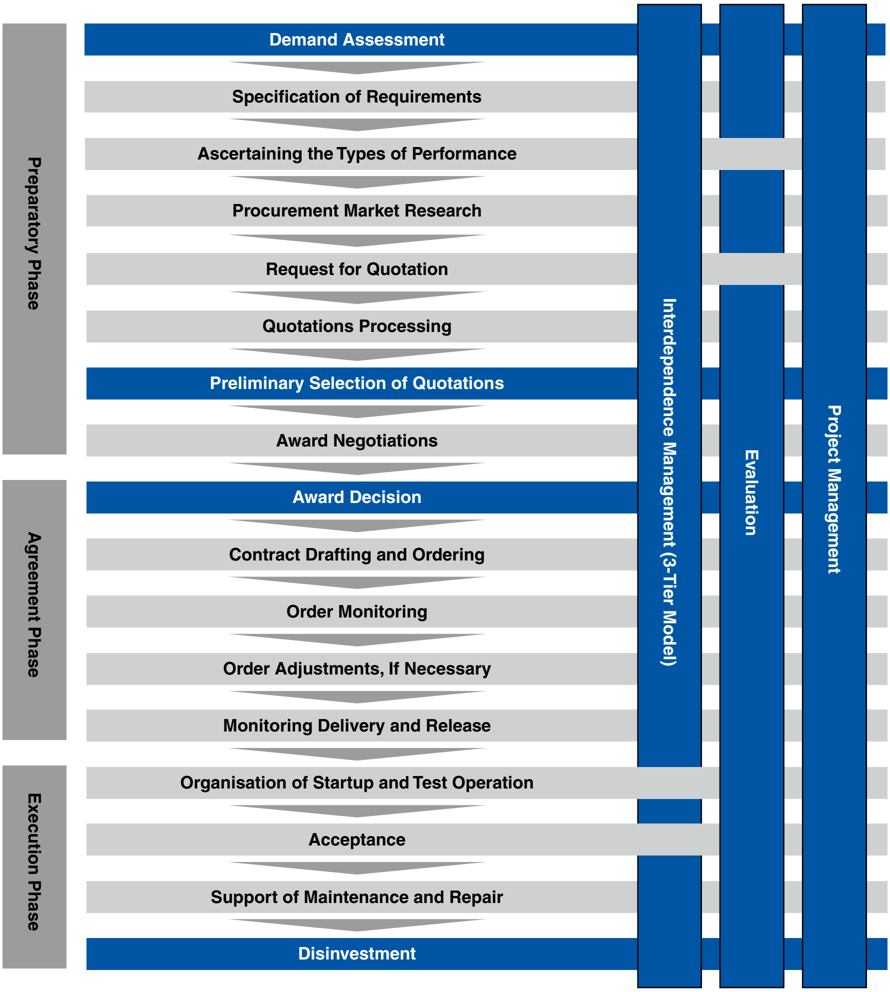

Fig. 7.15 Fitting the application of the real options approach into the overall capital equipment purchasing process

mathematics is required as well as empirical knowledge about the required data and the assessment of corresponding probabilities.

The application of the real options approach is not required for every investment decision. Investment opportunities exist that are so clearly value generating or value destructing that traditional methods provide sufficient information and more complex real options arrive at the same result. Furthermore, the real options approach should only be used for investments in which the gained benefit exceeds the additional implementation and calculation expenditure. Amram and Kulatilaka show in which situations a real options approach is particularly useful:[35]

- When several investment opportunities exist.
- When uncertainties influencing the cash flows of the capital equipment are so high that it may be sensible to wait for further information.
- When the value of the investment is based more on the chance of future growth than on generated cash flows.
- When the uncertainties influencing the cash flows of capital equipment are so high that the decision flexibility creates additional value. Only the real options approach can correctly evaluate investments in flexibility.
- When, over the course of the lifetime of the capital equipment, there are new decisions and fundamental strategy changes.

Real options can be differentiated by their type of afforded flexibility. Virtually all real options available in practice can be subdivided into four basic types according to Hilpisch:[36]

- Growth options provide management the flexibility to react to positive internal and external factors. One example of a growth option is the possibility of expanding production capacity.
- Timing options allow for the postponement of decisions to wait for new developments or for a better point in time. One example of this is the option of postponing the purchase of an installation to a later date.
- Shrinkage options afford decision-makers the flexibility to react to negative factors. The option of prematurely breaking off a leasing agreement is a typical shrinkage option.
- Complex real options are a combination of the time or contents of several real options from other categories. Thus, for example, the exercise of the option to extend the operating period of an installation is directly mutually dependent upon the timing option for the purchase of a replacement installation.

Finally, while financial options frequently present "bets" by outsiders on the stock value of a company and cannot change the value of the company concerned, any wrong decision with real options definitely affects the resources and thus the value of a company.[37] If, for example, a company buys capital equipment too late, value will be lost, which is subsequently reflected in the company value. Furthermore, financial options should be traded passively only. The decision-making possibility is limited to the selection of options and the underlying stock. By contrast, real options can also be actively controlled since those responsible can directly influence the value drivers.[38] The last possibility should also be employed when using the real options approach in capital equipment purchasing.

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[35] Cf. Amram and Kulatilaka (1999, p. 24).

[36] Cf. Hilpisch (2006, p. 65 et seq.).

[37] Cf. Howell et al. (2001, p. 7).

[38] Cf. Hilpisch (2006, p. 189).

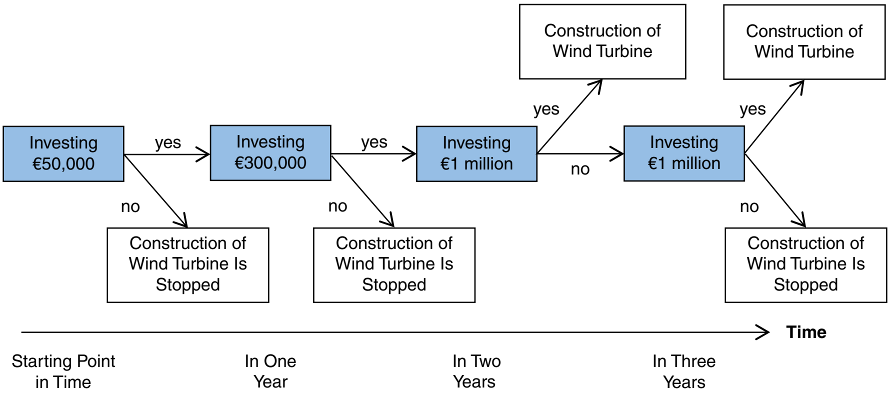

Fig. 7.16 Exemplary decision tree for the possible installation of a wind turbine or termination of the procurement project

7.3.2 Mode of the Operation of the Binomial Model for the Calculation of Real Options

In the following section, the mode of operation of the binomial model[39] is explained based on a company's decision to install a wind turbine. In the long-term, such an investment decision is of great importance for the company and its value, and it is influenced by many uncertainties as well as decision-making possibilities. In the present case study, it is assumed that the costs of the applications and preparations for the installation of the wind turbine amount to € 50,000 at the start. After one year, another € 300,000 must be invested to complete the planning of the wind turbine. Subsequently, the company will have two years to decide whether € 1 million should actually be invested in its installation. The option for the installation of a wind turbine is a complex real option. The costs of € 50,000 provide the possibility of investing € 300,000 in one year. The investment of € 300,000, in turn, creates the chance of investing € 1 million. This final investment can be made in the second or third year. Thus, the option of postponing the investment by one year is a timing option. The decisions to be made in the example are highlighted in Fig. 7.16.

The binomial model is applied in a two-tier process to evaluate this investment project. First, the possible conditions of the investment values are calculated. In the following example, the term investment value designates the sum of the cash values of all payment surpluses, namely the value generated by the wind turbine in the course of its operation without taking the investment costs into account. Starting from these investment values, we calculate back in steps considering the necessary decisions. In this manner, the value of the option for the installation of the wind turbine—and thus the optimum decision—can be determined in every condition.

[39] Modified example taken from Copeland and Tufano (2004, p. 93 et seq.).

7.3.2.1 First Step: Modelling the Binomial Tree of the Investment Object Over the Course of Time

Based on the value of the wind turbine at the current point in time, possible investment values are modelled as an event tree. First, the investment value is fictitiously determined for the current point in time (assumption: the wind turbine already exists at the starting point). This calculation can be made using traditional evaluation methods, such as the net present value method. Subsequently, the possible course of the investment value of the wind turbine is estimated over the course of time. In the binomial model, only a movement either up or down is possible in every period[40], and it is here assumed that a downward movement with a subsequent upward movement results in the same investment value as an upward movement with a subsequent downward movement; accordingly, a fixed calculation factor is assumed for the upward and downward movements. If it is assumed that the possible value of the wind turbine has a logarithmically normal distribution[41], the calculation factor for the value change can be calculated for the upward movement b_{auf} as:

$$b_{auf} = e^{\sigma * \sqrt{t}}$$

Here, e is the base of the natural logarithm, σ the standard deviation and t the past time in years. So that a downward with a subsequent upward movement results in the same investment value as an upward and a subsequent downward movement, the calculation factor for downward movements b_{ab} is the inverse value of the factor for upward movements:

$$b_{ab} = \frac{1}{e^{\sigma * \sqrt{t}}}$$

If the investment values of the wind turbine do not have a logarithmically normal distribution, the formulas here presented do not apply.

In the present example, the wind turbine would have a value of € 1 million if it were to exist at the present point in time. The standard deviation σ of the investment value is assumed to be 0.3. With this standard deviation, the factor for the upward movement is approx. 1.35 and for the downward movement approx. 0.74. The wind turbine's investment values realised with these calculation factors are presented in Fig. 7.17.[42]

[40] The limitation to only one possible movement per time interval does not present any true limitation. If we let the length of time intervals go towards zero, the attainable conditions increase towards infinity.

[41] A variable has a logarithmically normal distribution if the logarithm of the variable has a normal distribution. Cf. Lee and Lee (2006, p. 170).

[42] It is assumed in this example that the value of the wind turbine depends on a single key value. It is easy to determine the volatility of this price difference in the past. A sensitivity analysis can then determine to what extent this key value influences the wind turbine. The volatility of the wind turbine's value can thereby be subsequently determined. Cf. Copeland and Tufano (2004, p. 94).

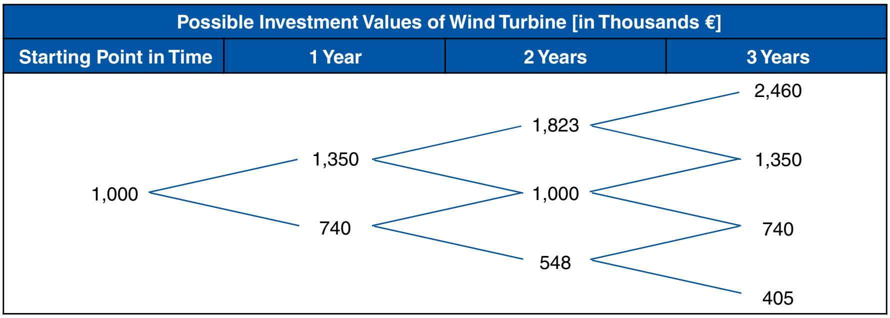

Fig. 7.17 Exemplary event tree of the wind turbine investment values over the course of time

Therefore, the wind turbine value is influenced by relatively high uncertainties. Furthermore, management has some decision-making possibilities to evaluate the options for the wind turbine's installation in terms of planning and the time of investment. This will be carried out in a second step.

7.3.2.2 Second Step: Determining the Value of the Option and the Optimum Decisions

Options can be evaluated with the so-called replication argument. The replication argument is based on the application of the unit price under the assumption that two different investment opportunities have the same outpayments in any environmental condition, are perfect substitutes and, therefore, have exactly the same values.[43] To determine the value of the real options, the present example will prepare a portfolio of the wind turbine and a risk-free security that has exactly the same outpayments as does the wind turbine as a real option.

In calculating the value of the option on the wind turbine, we start on the right side of the event tree, namely at the end of the third period (Fig. 7.18). If the last investment is not made—i.e. the project is stopped—the periodic option value is zero. Otherwise, in the third year, the periodic option value is the difference between the investment value of the wind turbine and the actual costs of the wind turbine's installation. In the case of a triple upward movement—thus, if the wind turbine value is € 2,460,000 at the end of the third year—the periodic value of the option is € 2,460,000 reduced by the last investment of € 1,000,000, namely € 1,460,000. Since this is a significant increase in corporate value, the investment should be made. If, however, the value of the wind turbine is only € 740,000 or € 405,000, there will be no investment and the option value is zero.

From the end of the tree, we will periodically work forward to the start. In the second year, the decision-making possibilities are "exercise option", namely build the wind turbine, and "keep option alive", namely postpone the decision. In each

[43] Cf. Copeland and Antikarov (2001, p. 89).

Possible Option Values [in Thousand €]			
Starting Point in Time	**1 Year**	**2 Years**	**3 Years**
			2,460 - 1,000 = 1,460 invest 1,000
			1,350 - 1,000 = 350 invest 1,000
			740 < 1,000 do not invest
			405 < 1,000 do not invest

Fig. 7.18 Exemplary option values and optimum decisions in the third year

status, the decision results in a higher value increase for the company. If the value of the wind turbine is € 1,823,000 at the end of the second period, the value generated by exercising the option in this period will be the investment value of the wind turbine (€ 1,823,000) reduced by the final investment of € 1 million, namely € 823,000. If the decision is postponed, the company still has the option of building the wind turbine in the third year. To determine the value of this option, the replication portfolio is calculated, which consists of shares in the wind turbine as well as a risk-free security with an interest rate of $i=8\%$ and which has, in both possible statuses of the third year, the same outpayments as does the option. For this condition, the continued option has two possible outpayments: € 1,460,000 or € 350,000. This means that a certain share m in the wind turbine, reduced by a certain quantity b of the risk-free € 1,000 securities, also results in these outpayments, depending on whether the investment value of the wind turbine reaches the condition € 2,460,000 or € 1,350,000. Both possible conditions can be presented by the following equations:

$$2{,}460 \cdot m - (1 + 0.08) \cdot b = 1{,}460$$

$$1{,}350 \cdot m - (1 + 0.08) \cdot b = 350$$

Since these are two equations with two unknowns, namely binomial equations, the values for the unknowns can be easily and unambiguously determined using a linear equation system. The results of this linear equation system are $m=1$ and $b=926$. The value of the replication portfolio in the second period and thus the value of the option is accordingly calculated as:

$$1 \cdot 1{,}823 - 926 \cdot 1 = 897$$

Since this value is higher than is the option value upon exercising it, the option will be continued. The same calculation is performed for all three conditions.

Possible Option Values [in Thousand €]			
Starting Point in Time	1 Year	2 Years	3 Years
			2,460 - 1,000 = 1,460 invest 1000
		897 > 823 = (1,823-1,000) wait	
			1,350 - 1,000 = 350 invest 1000
		181 > 0 = (1,000 - 1,000) wait	
			740 < 1,000 do not invest
		0 > -452 = (548 - 1,000) do not invest	
			405 < 1,000 do not invest

Fig. 7.19 Exemplary option values and optimum decisions in the second year

Figure 7.19 presents the option values for the option kept alive and for the exercised option; the calculation of the option value upon exercising is shown in parentheses.

To obtain the option values for the first year and the current point in time, the procedure is the same as it was in the second year. In the second period, € 300,000 is invested if the option for the installation of the wind turbine is worth this investment. If the option does not amortise this price, no investment will be made and the project will be abandoned. In the case of an upward movement in the first year, the value of the replication portfolio is € 537,000. Since this option value is significantly higher than is the required investment, the investment of € 300,000 is worthwhile. In the case of a downward movement, the value of the replication portfolio (€ 93,000) is significantly lower than is the required € 300,000. In this case, investment should be waived. Based on the option values € 237,000 and € 0 in the first year, the replication portfolio is € 122,000 for the current point in time. Thus, the investment of € 50,000 at the current point in time should be made. Figure 7.20 presents the option values and the pertinent decisions for the corresponding condition of the investment value.

Since the option is worth € 122,000 in the first period and the initial investment of € 50,000 thus generates value, the initial investment is made. In the first year, we invest when we are in the upper condition (upward movement); there will be no investment if the investment value is in the lower condition (downward movement). In this case, the project is stopped, and the lowest conditions in the second and third years can no longer be reached. If the investment value increases in the first year and subsequently drops for two years, the investments of € 50,000 and € 300,000 are made, but the wind turbine will not be built and thus the planning costs of € 350,000 should be written off as “lost capital”.

Possible Option Values [in Thousand €]			
Starting Point in Time	1 Year	2 Years	3 Years
			2,460 - 1,000 = 1,460 invest 1,000
		897 > 823 = (1,823-1,000) wait	
	537 - 300 = 237 invest 300		1,350 - 1,000 = 350 invest 1,000
122 > 50 invest 50		181 > 0 = (1,000 - 1,000) wait	
	93 < 300 do not invest		740 < 1,000 do not invest
		0 > -452 = (548 - 1,000) do not invest	
			405 < 1,000 do not invest

Fig. 7.20 Complete overview of the option values and optimum decisions

7.3.3 Conclusions Regarding the Real Options Approach

As the example shows, the real options approach cannot reduce or avoid uncertainties but it can be used to evaluate them financially and make them usable. Owing to the complex calculation process, the real options approach should only be used for the procurement of capital equipment connected with high amounts of capital employed and correspondingly high risks. Although the method is not very widespread in practice, if correctly applied, it offers great potential for the evaluation of investment projects. According to Howell et al., the following typical errors in applying the real options approach occur in practice:[44]

- Use of real options in situations when they are not appropriate, e.g. if the uncertainties assumed are not accidental.
- Use of an inadequate real options model.
- Application of wrong values.
- Faulty calculation and evaluation of the models.

These typical sources of error show clearly that major importance is attached to the analysis of the decision situation and the selection of the real options model in capital equipment purchasing. In addition to know-how in financial mathematics, the calculation requires empirical knowledge of the data and onset probabilities.

[44] Cf. Howell et al. (2001, p. 193).

7.4 Performance Contracting within the Scope of Capital Equipment Purchasing

7.4.1 Introduction to Performance Contracting

From a buyer's point of view, performance contracting is the acquisition of a complete problem solution in the form of a performance bundle of materials and services based on a technical infrastructure solution. Not only the product alone is provided in this case, but also the related services, and it is paid by a performance-specific user fee.[45] Performance is frequently oriented on the life cycle. Two forms can be distinguished:[46]

- The manufacturer guarantees an agreed availability of the capital equipment (performance sale).
- The manufacturer operates the capital equipment on its own and obtains a result-specific compensation for it (results sale).

In recent years, the concept of performance contracting has steadily gained in importance in the course of the increasing inter-organisational division of labour. But as the business model by James Watt (1736–1819) shows, this is certainly not a new idea:[47]

We let you have a steam engine cost-free. We will install it and take over the customer service for five years. We guarantee that you will pay less for the engine's coal than you currently spend to feed the horses doing the same work. And all we are asking is that you give us one third of the money you will save.

Figure 7.21 shows the development stages of the procurement of capital equipment with obligatory services in the context of performance contracting. The core idea of the approach is to assign value-added processes to a third supplier. This supplier has both the appropriate technologies and the capabilities in its special field (e.g. a steam engine) and generates advantages of size by bundling orders (e.g. central purchasing of coal). The supplier can also fall back on a know-how edge in industrial management. Figure 7.22 shows a few current examples of performance contracting offers.

The following section provides a more detailed explanation of the examples in Fig. 7.22:

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[45] Cf. Kleikamp (2002, p. 21 et seq.).

[46] Cf. Kleikamp (2002, p. 21 et seq.).

[47] There is no reference for this quotation. The formerly world-renowned company Boulton and Watt formed by the businessman Matthew Boulton and the engineer James Watt was based on the business model of operating their own developments of steam engines and usually asking to be paid one-third of the energy savings versus the previously installed, less effective steam engines. Cf. Muirhead (1858, p. 296).

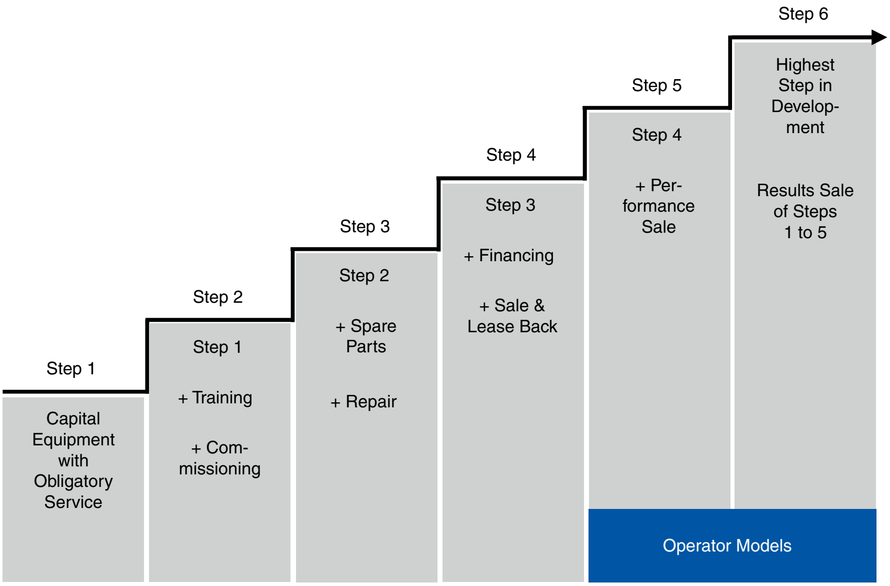

Fig. 7.21 Ideal development stages in performance contracting. (Freiling 2002, p. 218; Freiling et al. 2004, p. 74.)

	Perfomance Sale	Results Sale
Consumer Good	• Car Manufacturer (e.g. Daimler Fleet Management) • Copier Manufacturer (e.g. Xerox Enterprise Print Services)	• Truck Manufacturer (e.g. Mercedes Benz –CharterWay Rent and Drive) • Machine Building and Plant Engineering Company (e.g. Hochtief)
Consumable	• Chemicals Manufacturer (e.g. SAFECHEM) • Plastics Manufacturer (e.g. SABIC)	• Coatings Manufacturer (e.g. BASF Coatings) • Pesticides Manufacturer (e.g. Syngenta)

Fig. 7.22 Examples of performance contracting offers. (Cf. Kleikamp 2002, p. 66)

- Performance sale of a consumer good:
  - Daimler Fleet Management offers multi-brand fleet management services including service leasing, driver support, claims management and online reporting. According to a modular concept, companies can choose between standardised product packages and customised services.[48] As DaimlerChrysler Fleet Management guarantees the availability of trucks, this is the performance sale of a consumer good.

[48] Cf. Daimler Fleet Management GmbH (2011).

  - Within the scope of leasing agreements, the copier manufacturer Xerox also offers full-service solutions. This means companies pay for the equipment depending on actual use.[49]

- Performance sale of a consumable:
  - In addition to the sale of solvents, SAFECHEM offers additional service elements, such as storage, the waste disposal of used goods, solvent handling and consulting and analysis services. The price is calculated per quantity of solvents sold.[50] This business model accordingly presents the performance sale of a consumable.
  - The Saudi-Arabian chemicals and metals group SABIC leases high-quality and recyclable standard plastics to its customers. Aside from the actual products, SABIC also provides consulting services and waste disposal.[51]

- Results sale of a consumer good:
  - Mercedes Benz CharterWay Rent and Drive is one example of the results sale of consumer goods, namely the vehicles are operated by Mercedes Benz, which is then paid depending on results. In addition to the vehicle, the enterprise also provides the driver as well as event, project and management services.[52]
  - Another example of the service results sale of consumer goods is the water supply in a Brazilian vacation region by a consortium led by Hochtief. After setting up the installation, the consortium manage the drinking water supply as well as wastewater disposal for 25 years.[53]

- Results sale of a consumable:
  - Results sale is also provided for consumables. Examples of this include the cooperation concepts by BASF Coatings. A billing model can here be agreed upon where the car manufacturer no longer pays for the volume of coatings supplied but for the perfectly coated car body.[54]
  - The pesticides manufacturer Syngenta also offers results sale for consumables. Syngenta provides the pesticide application and accepts the risk of any diseases and pest infestations of the corresponding agricultural fields.[55]

Figure 7.23 presents an overview of the criteria of performance contracting addressed with the performance-specific order award in the manufacturing industry. The performance-specific order award explores issues and considerations based on which various activities in terms of machinery or equipment are awarded to a performance provider. Such a provider may be independent or it may be the machinery

[49] Cf. Xerox (2011).

[50] Cf. The Dow Chemical Company (2011).

[51] Cf. Kleikamp (2002, p. 68).

[52] Cf. Mercedes Benz (2011).

[53] Cf. Kleikamp (2002, p. 67 et seq.).

[54] Cf. BASF Coatings (2011).

[55] Cf. Kleikamp (2002, p. 68 et seq.).

Criteria of Performance Contracting	Options		
Givens of the performance provider	Independent performance provider	Machine or equipment manufacturer	
Ownership right during the contract term	Leasing company	Special Purpose Vehicle	
Ownership right after the contract term	Leasing company	Special Purpose Vehicle	
Responsibility for the maintenance personnel	Performance provider		
Responsibility for the operating personnel	Customer	Perfomance provider	
Compensation model	Compensation based on the availability of the installation	Compensation based on the performance of the installation (output)	Compensation based on the customer's economic results
Place of business operation	Customer-internal	Fence-to-fence	Performance provider-internal
Exclusivity of business operation	Individual customer	Several customers	

Fig. 7.23 Performance-specific order award of performance contracting in the manufacturing industry. (Hypko et al. 2010, p. 637)

or equipment manufacturer itself. Within the scope of the order award, ownership rights during and after the contract term should be clarified. The performance provider is responsible for the management of maintenance activities and thus also for the maintenance personnel. The operating personnel can be controlled by the customer as well as by the performance provider. The order award can take different compensation models into account. Flat rate amounts for the installation (pay-for-equipment) nowadays are no longer perceived as a compensation model within the scope of performance-specific order awards.[56] In practice, compensation is provided based on the technical availability of the installation (pay-on-availability), per created performance unit (pay-per-unit or pay-on-production) or the customer's economic results, such as cost savings. Performance or service may be rendered at the customer, at the manufacturer or fence-to-fence, namely external to the customer but in its immediate vicinity. In addition, the customer may be the only customer of the performance provider or one customer of many.

7.4.2 Fitting Performance Contracting into the Process of Capital Equipment Purchasing

Performance contracting concerns the process steps from the request for quotation to the award decision, as well as the support of maintenance and repair (Fig. 7.24). Following the request for quotation and careful review and analysis, all performance contracting offers should be compared with each other and with offers for purchasing or leasing capital equipment. Based on this comparison, a preliminary selection of the offers should be made in terms of specified criteria. In subsequent award negotiations, the distribution of risks will play an especially major part, aside from costs and services. Among others things, the distribution of liability risks should be

[56] Cf. Decker and Paesler (2004, p. 1).

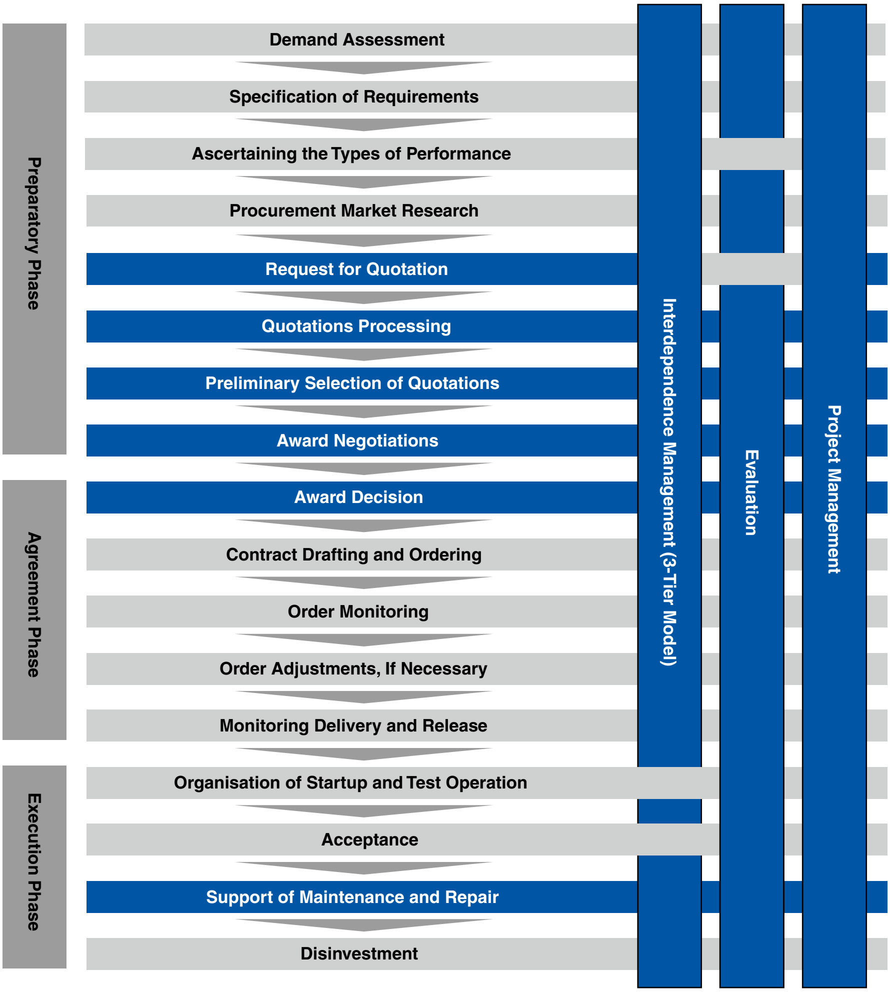

Fig. 7.24 Fitting the performance contracting concept into the total capital equipment purchasing process

clarified, for example for quality deficiencies. Also to be clarified is the distribution of financing risks, which may be caused by the unexpectedly fast obsolescence of capital equipment. Finally, the award decision is made after all required information is available and has been evaluated. Aside from these process steps, cross-sectional activities are also involved. As with traditional procurement methods, project management also has a support function in performance contracting over the entire procurement process. An evaluation is relevant especially for the preliminary selection of the offers and the award decision. Interdependence management should also be taken into account in performance contracting. For example, quotation analysis aims to examine the interdependencies between the services and costs offered by the performance contracting supplier as well as their effects on existing processes.

Table 7.2 Chances and risks of performance contracting in capital equipment purchasing

Chances	Risks
Improvement of competitiveness, e.g. by concentration on core competences (top objective)	Know-how loss of purchasing company to competitors
Improvement in working capital by off-balance sheet financing[a]	Dependence on supplier since existing knowledge may be lost regarding the setup and operation of the installation
Realisation of synergies by having the manufacturing company or a specialised operator operate the installation	Risk of possible quality losses because of the loss of monitoring and control
Use of scaling effects and increasing the efficiency of operational management by having the supplier operate the installation	Faulty assessments of (consequential) risks of performance contracting, e.g. loss of direct customer contacts
Access to new technologies through the know-how by the supplier	Risk of contract extension under worse conditions or risk of supplier's insolvency
Creating a more favourable risk structure by shifting the risks to the supplier, e.g. operating risks	Problems in the start-up and integration of the employees of the performance contracting supplier
Optimisation of the capacity utilisation of the buying company by better detecting any process improvements by the supplier	No direct and fast access to performance contracting supplier in the case of quality problems in the operating stage
Potential to lower operating costs by optimising the installation and saving production costs	Underestimating the costs of restructuring, especially of process adjustments and unambiguous specifications of interfaces
Potential to increase quality through additional know-how by the supplier	Risk of internal resistance because of fear of personnel transfer to supplier
Increasing flexibility because of access to external personnel and installation capacities	Mushrooming costs of contract design and for enforcing contract claims in the case of disputes

[a] With off-balance sheet financing, assets and debts are outsourced to special purpose vehicles so that they are not mentioned in the balance sheet. Cf. Mills and Newberry (2005, p. 252).

7.4.3 Chances and Risks of Performance Contracting in Capital Equipment Purchasing

In many sectors of the industry, performance contracting is already used in practice. However, the implementation of performance contracting concepts not only bears chances but also risks for the companies involved (Table 7.2). Suppliers and buyers should take the following aspects of performance contracting into account to ensure successful implementation.

Performance contracting improves the competitiveness of the buying company in different ways. On one hand, similar to the leasing concept, off-balance sheet financing improves the working capital situation[57]; on the other hand, synergies are

[57] On the subject of ascertaining and strengthening internal financing, see Hofmann et al. (2011).

realised from the supplier's operation of the machinery and plants. As the above-mentioned examples show (Fig. 7.22), these synergies may be because of the realisation of scaling effects or more efficient operating management. When the supplier operates its own installations, it is able to see process improvements and, accordingly, it can optimise its installations.[58] This generally results in lower production costs and thus lower procurement prices for the buyer. A win–win situation results for both actors if savings are fairly divided. Furthermore, there is not only the potential to reduce capital costs but also additionally obtain access to technologies that could not have been financed in the form of a classical investment because of budget restrictions.[59] In addition, up-to-date, sophisticated and efficient installations can be used without any time delay and long-term financial plan, which was previously not realisable because of the limitations of funds.[60] But even for perfected capital equipment, outsourcing in the form of performance contracting may be sensible, especially if a more cost-effective operation can be ensured. Again similar to leasing, there is also the benefit of converting fixed costs to variable costs.

From a procurement point of view, performance contracting can provide a more advantageous risk structure. Market and sales risks can be shifted to the supplier; these risks result from the lower demand for the manufactured products and, consequently, they have a direct effect on the profitability of the investment and on the residual value of the installation. The sourcing risk is also frequently transferred to the supplier—this is the procurement of raw materials and advance deliveries required for production. Moreover, the supplier bears the operating risks depending on the contract design. This includes the wrong assessments of costs and process periods or the risk of lower capacity utilisation if a buyer defaults when an installation is used by several customers, or if market demand decreases. Additionally, the responsibility for liability risks can be shifted in the case of long-term warranty cases and quality complaints. Technical risks can also be turned over to the provider, for example any unexpectedly fast obsolescence of the technology, changed customer requirements that result in new investments and environmental damage.

However, it should be assumed that the supplier knows these risks and includes them appropriately in calculating the remuneration. The aim is a relationship of trust and fairness with the provider preventing any mutual exploitation of opportunistic behaviour and informational asymmetries. The player who can control the risks most adequately should, therefore, accept them as well. For that reason, it may be sensible for the procuring company to take over at least partially the market and sales risks, for example in the form of sales guarantees.

The objective of performance contracting is an increase of the output (e.g. the availability) at the same or lower costs. Performance contracting is sensible, especially if the capital equipment has low specificity, namely it has not been especially designed for a single application. In that case, the provider can use the goods during the contract term for other customers to achieve scaling effects. Especially from the buyer's point of view, capacity utilisation can be optimised. Furthermore, low

[58] Cf. Lay (2007, p. 151).

[59] Cf. Lay (2007, p. 158).

[60] Cf. Mast (2004, p. 20 et seq.).

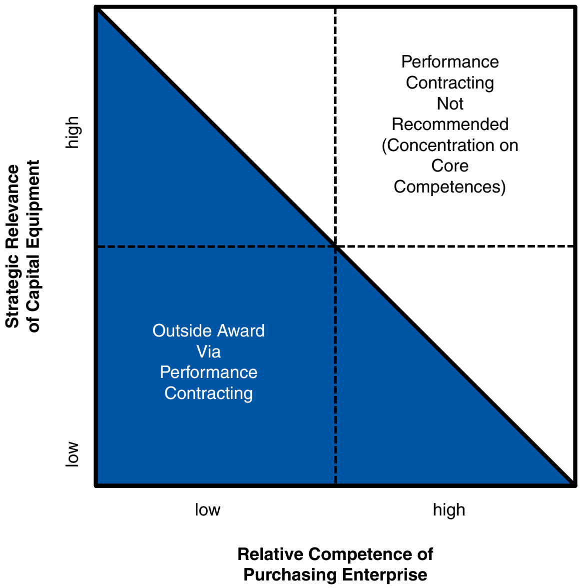

Fig. 7.25 Connection between strategic relevance and relative competence in the context of performance contracting. (Wildemann 2008, p. 193)

specificity is a prerequisite for further use after the end of the contract so that the installation or the goods can be modernised with reasonable expenditures and adjusted to the needs of other customers.

Yet, there are not only chances resulting from performance contracting but risks as well. For instance, there is the risk of increasing dependence since competences are shifted to the provider. From a procurement point of view, performance contracting does not make sense, especially when production processes count among a company's core competences (Fig. 7.25). In the case of a termination of business relations, the recovery of these competences would require unreasonably great efforts. Accordingly, performance contracting should only be taken into account if the provider has higher competences in the special field or if the core competence will be attributed a lower strategic importance in the future.[61] Core competences here comprise not only operating and development competences but also resources and skills with regard to quality standards and cost efficiency.

7.4.4 Financing Models in Performance Contracting

For the provider, a conversion of the business model from the classical sale of capital equipment to performance contracting entails a change in revenue structure. While revenues are directly available after a sale, they extend in the performance contracting business over the entire contract term, which is ideally equivalent to

[61] Cf. Lay (2007, p. 158).

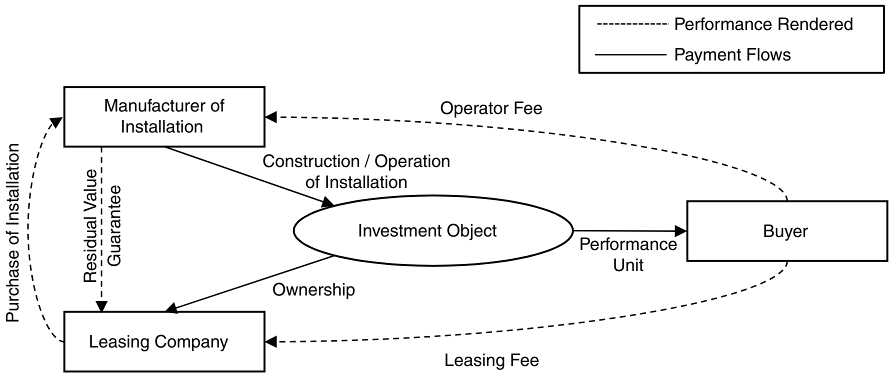

Fig. 7.26 Integrating a leasing company into the performance contracting concept

the life cycle of the installation. This results in a significant extension of the cash-to-cash cycle. This is defined as the time span between payment outflow for raw materials and payment inflow for finished products.[62] If the performance contracting business is only a small percentage of total sales, the provider is often able to close this financing gap on its own. But as soon as this business segment gains importance or if the capital equipment concerns high-priced products, the inclusion of third parties will be necessary for the purpose of financing. This may be either through a leasing company (Fig. 7.26) or through a project company (Fig. 7.27). For the purchasing company, these financing models generally bring about a continuous payment flow instead of a non-recurrent payment.

The basis of financing through a leasing company is the concept of operated leasing since financial leasing would result in reporting it on the buyer's balance sheet. The provider sells the installation to a leasing company but continues to be responsible for its operation. To limit market risk, the leasing company can demand a residual value guarantee from the provider. The purchasing company has to remunerate the provider for the performance or the result. Additionally, the purchasing company as the lessee takes over the leasing payments. The provider may also appear as the lessee so that remuneration is only paid to the provider. In this case, plain manufacturer leasing is concerned. Purchasing guarantees can be avoided by ensuring minimum revenues, which would result in being reported on the buyer's balance sheet. Instead of such guarantees, comprehensive service contracts are concluded, which serve the same purpose.

Within the scope of financing through a project company is when this company is also the owner of the installation. Frequently, the project company and plant engineering company are connected by a shareholder agreement. Depending on the design of the performance contracting concept, a service or operating agreement will be concluded between the two players. The performance or result is agreed upon between project company and buyer. Plant manufacturer and buyer endeavour to

[62] Cf. Hofmann et al. (2011, p. 18).

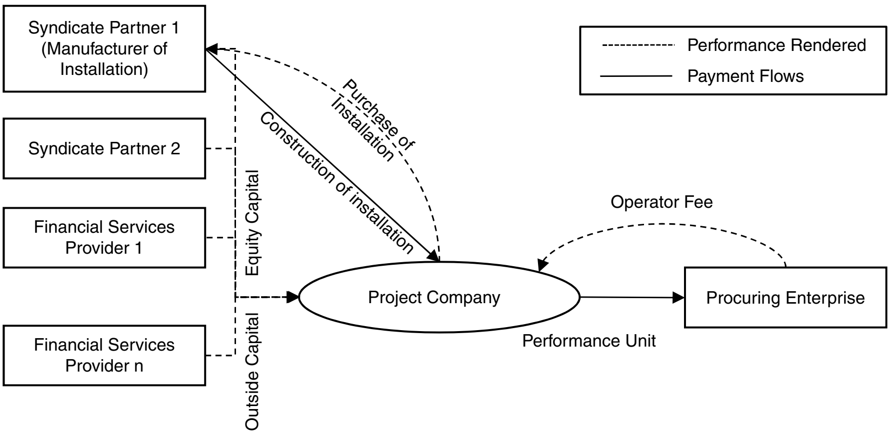

Fig. 7.27 Integrating a project company into the performance contracting concept. (Wildemann 2008, p. 149)

provide off-balance sheet financing—as with financing through a leasing company. Outside capital is, therefore, raised from financial services providers (e.g. banks or specialised leasing companies). If the contract design is highly complex, secondarily involved economic units are tied in—such as consulting services that support legal, business or technical issues. The provider might even guarantee operation to the buyer. To reduce the default risk of the project company, financial services providers can demand further guarantees from the provider.[63]

On one hand, the owners of the project company want to have the best possible control over the project company; on the other hand, they strive for the lowest possible financial and balance sheet consequences for their own company. According to the statutory accounting regulations of the USA (US-GAAP), Germany (HGB—Commercial Code) and the international accounting standards (IAS), the balance sheet reporting of equity investments can be avoided as far as minority investments are concerned. This requirement would be complied with if the equity capital were divided among three players each having a less than 50% interest in the project company. However, most countries have the obligation of consolidation if entrepreneurial influence can be brought to bear on the project company.

7.4.5 Contract Design in Performance Contracting

Since performance contracting is frequently a new business model for supplier and buyer, and because the web of relations frequently has a complex structure, painstaking care is advisable, especially in contract design. Incomplete contracts bring

[63] Cf. Mast (2004, p. 20).

about informational asymmetries, which may result in undesirable adverse selection[64], moral hazard[65] and hold-up potentials.[66] For the reasons above, the contract should include not only a preamble about behaviour in terms of trust and fairness but also regulations and procedures when differences of opinion arise (good face close). Termination regulations (prerequisites and due dates) should also be stipulated beforehand as well as downtime payments in the case of technically caused installation downtimes. It is indispensable to provide unambiguous task assignments as well as a clear agreement on interfaces and responsibilities prior to the beginning of the project. Moreover, the contract should lay down any agreed upon guarantees (e.g. contract duration and volumes) and conditions or terms for any possible contract extension.[67] Product specifications and quality standards should also be clarified in advance.[68] To provide adequate incentives, a bonus-malus system can be introduced, which is coupled to the availability of the installation.

7.4.6 Control under Performance Contracting

The buyer of the performance contracting service should implement the control of performance contracting both at a strategic level and at an operative level. Risks should be monitored at the strategic level. Moreover, the basic profitability of the performance contracting model should be ensured. It is helpful to prepare a SWOT[69] analysis because, especially at the beginning of the project, no long-term statements can be made regarding overall success. A scenario analysis taking into account the expected income and expenditures will enable—by calculating the net present value—a comparison of the performance contracting solution and an internal investment.[70] The focus of the operative level is the planning and monitoring of sustained payment surpluses and, consequently, results optimisation.[71] Moreover, the competence level of the purchasing company should be examined regularly so that it does not depend on the supplier or project company and so that it could opt out of the performance contracting business, if necessary.

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[64] Asymmetries in knowledge or information existing upon contract signature may bring about suboptimum results. Cf. Guesnerie et al. (1989, p. 807).

[65] If the actions of one contracting party cannot be observed or checked, this party might try to influence the contractual result after contract conclusion. Cf. Guesnerie et al. (1989, p. 807).

[66] This problem of contract theory is caused by an incomplete contract. In this case, each party will fear that it would have to accept adverse conditions after contract conclusion. Cf. Koss and Eaton (1997, p. 457 et seq.).

[67] Cf. Mast (2004, p. 25).

[68] Cf. Wildemann (2008, p. 175).

[69] Strengths, weaknesses, opportunities and threats.

[70] Cf. Siemer (2004, p. 183 et seq.).

[71] Cf. Wildemann (2008, p. 179).

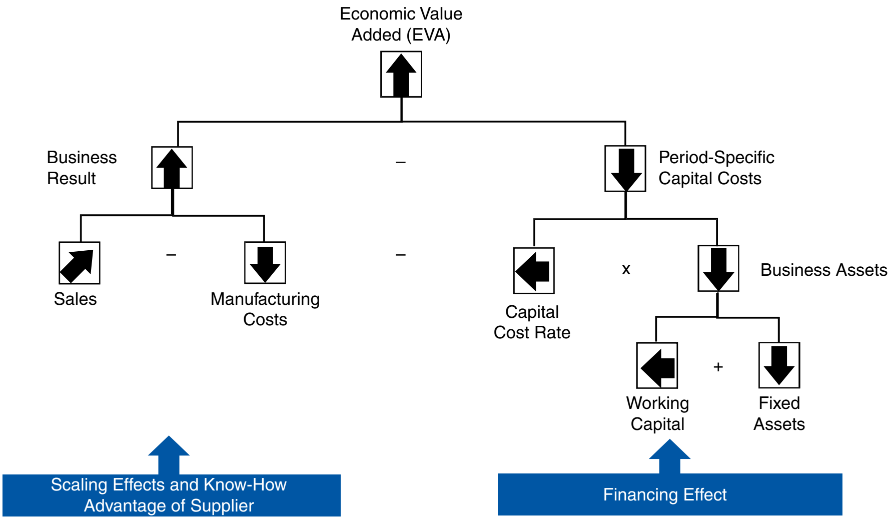

Fig. 7.28 Influence of performance contracting on corporate value. (Hofmann et al. 2011, p. 21)

In the operative implementation of control by the buying company, the comparisons of key figures and ratios allow findings to be realised about the profitability of the company. For example, the key figures and ratios of the current period can be compared with those from past periods or with projected figures. Moreover, comparisons can be benchmarked against other companies.[72] Suitable key figures include economic value-added (Fig. 7.28) or return on net assets since they reflect very well the investment character of performance contracting by taking into account operative costs and sales effect, on one hand, and the capital costs because of balance sheet changes, on the other.[73]

Since the buyer does not own the capital equipment used through performance contracting, this results—in the key figure system of economic value-added—in lower installation assets and business assets, thus providing a positive effect on capital costs (financing effect). Moreover, lower production costs should be expected from the optimised operating management because of the supplier's know-how and also as a result of volume advantages by bundling customer orders; the buyer will also profit in the form of price reductions. The manufacturing costs of the procuring company can thus be reduced. In addition, product quality increases because of the access to new technologies, which before had been too cost-intensive for the buyer. This presents a competitive advantage that lastingly and positively influences the buyer's sales.

The consideration of key figures and ratios frequently results in the difficulty that primarily short-term monetary variables flow into the model, but long-term

[72] Cf. Reichmann (2006, p. 59).

[73] Cf. Siemer (2004, p. 188 et seq.).

non-monetary variables such as customer satisfaction and process quality are neglected.[74] Breaching this gap between operative and strategic control in capital equipment performance contracting can be realised with the concept of the balanced scorecard.[75]

7.4.7 Procurement Process of Performance Contracting Solutions Using a Wind Turbine as an Example

Within the scope of capital equipment purchasing, various special characteristics should be taken into account with performance contracting. The following section presents the procurement process of performance contracting solutions based on an example of the procurement of a wind turbine.

In a first step, the procuring company determines whether there is a need for a wind turbine. If the requirement or possibility of a new wind turbine is ascertained or if an existing wind turbine is deemed to need to be replaced, a team is formed that brings together the key personnel of various departments and integrates top management. The problem to be solved, namely the acquisition of the wind turbine, is described based on the definition of the results (construction of the wind turbine) and on the decision about the performance parameters (e.g. high-speed rotor figure, mean annual wind velocity), as well as the determination of the current power level. Within the scope of market research, private and public solutions are examined as are the contracts of existing wind turbines. The market research will be documented as well. A performance contracting feasibility study analyses the relevant activities for performance contracting such as wind turbine setup, financing, maintenance and repair as well as the purchase of primary energy. The processes in terms of compatibility with performance contracting are examined. Additionally, the service providers and manufacturers of wind turbines are analysed, which is oriented on performance contracting. A scenario analysis is also carried out to ascertain the ideal performance contracting form, for example linking remuneration to the availability or the result. For wind turbines, it is conceivable to use a results-oriented payment in the form of a bonus-malus system. The plant manufacturer will be paid based on the generated energy. Also possible is a dual price system that comprises a fixed basic price (e.g. €/month) and a variable working price (e.g. €/kWh). As a result of the performance contracting decision, the implementability of the scenarios are assessed. Subsequently, an economic feasibility study is performed and the scenario fixed. For the development of specifications, the key performance indicators (KPIs)[76] that are relevant for payment are selected and defined; a concept is also prepared for presenting the KPIs in the IT system. For wind turbines, possible KPIs

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[74] Cf. Siemer (2004, p. 190); Reichmann (2006, p. 584).

[75] Cf. Girmscheid (2010, p. 139 et seq.).

[76] Cf. Parmenter (2010, p. 4 et seq.).

might be kilowatt hour production, average kilowatt output or the availability of the installation.

For the selection of contract partners, suppliers are first preselected. Subsequently, they are visited and the final supplier is selected. To prevent conflicts arising after contract conclusion, it is necessary to painstakingly select partners because performance contracting is understood as a long-term partnership based on trust, characterised by high investments and long overall periods and terms with a large number of parties involved. The contract design includes laying down the contract contents, as well as the terms and conditions. With regard to the construction of a wind turbine, there are standard contract contents, such as the type, quality and quantity of the goods, their prices and delivery and payment conditions. But it can also be specifically stipulated who will bear the risks and costs of delivery and assembly as well as the risk of premature wear and tear of the wind turbine and which party has to keep the wind turbine in the proper condition at the party's own costs and do the necessary repairs. In addition, termination regulations should be defined, as should interfaces and responsibilities. Furthermore, a return debit clause in the case of a technically caused failure of the installation should be included. Moreover, target values need to be established for individual KPIs and a bonus-malus system for remuneration.[77] This step concludes the contract. Thereafter, within the scope of performance contracting implementation, the start of performance contracting is prepared and the wind turbine is subsequently operated. Performance contracting is controlled by a regular service review as well as a periodic statement of accounts about the stipulated performance parameters. Finally, the experiences gained within the scope of the overall project can be used for the organisation and expansion of the performance contracting knowledge base.

7.4.8 Conclusions Regarding Performance Contracting

Performance contracting is inspired by the lean management principle and, under suitable framework conditions, it should result in a more efficient and more economical production of goods and services, with suppliers as well as buyers profiting. Performance contracting is principally suitable if the percentage of acquisition costs in total life cycle costs is rather small and the customer benefit does not arise because of the ownership of the capital equipment but rather because of the utilisation of another performance. It is essential for the success of such a project that the players involved have relations with each other based on trust and fairness.

Since performance contracting is an innovative and complex concept, its evaluation requires different specialised knowledge and know-how in different areas. Before the demand assessment, a team (buying centre) should be set up to bundle the competences from research & development, operation, maintenance and repair,

[77] With bonus-malus systems, the desired behaviour should be controlled by positive and negative incentives. Cf. Denuit and Dhaene (2001, p. 13).

control and purchasing. This should be integrated into the different steps of the procurement process (cf. Fig. 7.24).

Earlier performance contracting models have already been used in large-scale projects, such as power plant construction. This concept has so far been used, *inter alia*, in the areas of energy production, heating, compressed air, industrial trucks, transportation, tool making, paint shop facilities and press lines. Currently, there are also initiatives for the setup of data communications networks (e.g. LTE technology), energy supply networks (e.g. wind power from the North Sea) and transportation networks (e.g. railroad) via operating companies. In the future, it can be assumed that performance contracting will increase in importance regarding the production of regenerative energies—be it the construction and operation of wind turbines such as the Greater Gabbard offshore wind park in the North Sea[78] or solar power facilities in African deserts.[79]

[78] Cf. Siemens Aktiengesellschaft (2011).

[79] Cf. DESERTEC Foundation (2011).

Chapter 8
Overall Conclusions on Capital Equipment Purchasing

8.1 Summary: Key Points on Capital Equipment Purchasing

The worldwide volume of the capital equipment industry has already reached several trillion euros and it is still increasing. Furthermore, capital equipment has a multitude of special characteristics compared with the other main procurement groups. Major differences exist even within the capital equipment group, for example in terms of standardised and individualised capital equipment as well as tangible and intangible capital equipment. These special characteristics also affect capital equipment purchasing. This is characterised, for example, by procurement in the form of so-called buying centres, procurement at irregular intervals, high financial stakes, long procurement periods and decisions that depend on other investment decisions. Accordingly, the process of capital equipment purchasing requires particular attention and systematic procedures.

Based on these special characteristics, there are numerous challenges within the scope of capital equipment purchasing. Examples include the difficulties of performance measurement, the vital importance of award decisions, the necessity of taking total costs into account and the complexity and versatility of the procurement process. To meet and overcome these challenges, a process model was subsequently presented, as well as special instruments and methods for capital equipment purchasing.

Although capital equipment generally has individual characteristics, the process for its procurement is similar in many cases. The process herein presented offers a suitable framework for capital equipment purchasing. It comprises 17 process steps from demand assessment to divestment and it can be roughly subdivided into a preparatory phase, an agreement phase and an execution phase. These steps are accompanied by cross-sectional activities of interdependence management, evaluation and project management that run parallel.

The presented instruments and methods can be differentiated in terms of the players involved and the properties of capital equipment. They each support and professionalise capital equipment purchasing. Each of the illustrated instruments and methods is also arranged in the overall process for the procurement of capital equipment and explained based on a case study of wind turbine procurement.

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Relevant instruments and methods in terms of the players involved in capital equipment purchasing include:

- Compliance management: In complying with laws, standards and regulations, economic risks should be minimised and liability risks and damage to reputations avoided.
- Savings measurement: In the context of procurement controlling, different methods for measuring the monetary purchasing performance were presented and examined for their suitability to the capital equipment purchasing process.

Instruments and methods in terms of capital equipment properties in capital equipment purchasing include:

- LCC and TCO: These approaches are used to record the total costs connected with the procurement of capital equipment over the entire life cycle.
- Optimum useful life and optimum replacement time: In purchasing and operating capital equipment, the question concerns the economically optimum useful life and the economically optimum replacement time. To answer this question, different methods were presented for the determination of maximum payment surpluses.
- Real options for the evaluation of investment alternatives: Real options present a method of decision-making that takes into account the uncertainty of the investment and the flexibility of management. The mode of operation was explained based on the case study.
- Performance contracting: In performance contracting, the procuring company acquires a complete solution in the form of a performance bundle of benefits and services. For this model, we discussed not only chances and risks, but also possible financing models, contract design, controlling the model and the procurement process.

The process, instruments and methods presented do not provide a final framework for capital equipment purchasing. Nonetheless, they are a comprehensive set of methods for mastering the presented challenges so that—in implementing them—capital equipment purchasing can be handled more successfully and in a more structured manner.

8.2 Outlook: Where is Capital Equipment Purchasing Heading?

Capital equipment purchasing has a major effect on the economic success and performance of an enterprise. On one hand, it is generally connected with very high acquisition costs. On the other hand, yet higher follow-up costs are caused, and the productivity of an enterprise is also affected for a long time. However, the degree of the professionalisation of capital equipment purchasing has not yet reached the required level in many companies.

Accordingly, a multitude of functions for process improvements results in practice with regard to capital equipment purchasing. These can be addressed with the help of the presented elaborations. One major component is the calculation of TCO or LCC for any type of capital equipment purchasing. Only by ascertaining these costs can objective statements be made in terms of the advantageousness of alternatives. Moreover, it should be taken into account that there are numerous alternatives for the traditional purchase of capital equipment. This includes the use of alternative financing instruments (e.g. rental and leasing) as well as the implementation of operator models (e.g. performance contracting). These alternatives should be carefully identified and evaluated. Another subject so far insufficiently implemented in corporate practice concerns the implementation of performance measurement for capital equipment purchasing and its combination with corresponding incentive systems for the players involved. Although this seems complex at first, it is worthwhile tackling this subject. Numerous studies have shown that performance measurement in purchasing has positive effects on purchasing success and corporate performance. Moreover, a large number of practical examples show that many companies have a considerable need to catch up in terms of compliance management for capital equipment purchasing. With its avoidance of not only material damage and image damage but also fines, as well as its necessary measures, the consistent implementation of compliance management also has economic benefits for enterprises, and it should accordingly be proactively implemented.

However, capital equipment purchasing is highly relevant from an academic point of view as well. Compared with other disciplines in business management studies, the whole area of purchasing and procurement remains relatively under-investigated. This applies especially to capital equipment purchasing, which has so far been investigated more from a marketing viewpoint. Numerous areas thus need scientific analysis. One example of performance contracting in capital equipment purchasing is the further theoretical development of profitability assessment, procurement process and risk management. From an academic viewpoint, questions are additionally presented in terms of the organisational structure and procedure in implementing savings measurement, technology forecasts and complexity management in capital equipment purchasing. Case study research and large empirical investigations are required to investigate the application of instruments and methods for capital equipment purchasing in corporate practice and their effects on purchasing success and corporate performance. Moreover, formal analytical models should be developed for different areas, such as savings measurement, incentive systems, bonus-malus agreements and risk assessments.

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