Product development in the transitioning German energy market: Introducing an integrative innovation process with eco-design and strategic foresight. Process model and implications for the technical product development unit of WEMAG

VARENA JUNGE

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Product development in the transitioning German energy market: Introducing an integrative innovation process with eco-design and strategic foresight.

Process model and implications for the technical product development unit of WEMAG

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Product development in the transitioning German energy market:

Introducing an `integrative innovation process´ with eco-design and strategic foresight

Process model and implications for the technical product development unit of WEMAG

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Thanks to

<table>
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<tr>
<th>Larsgöran Strandberg</th>
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<td>for his critical feedback, guidance on scientific work and overall support</td>
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<th>Caspar Baumgart and Raymond See</th>
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<td>for their constructive collaboration and open sharing of their insights and experiences</td>
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<th>the Technical Product Development team of WEMAG</th>
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<td>for their general openness and their insights about their daily innovation work</td>
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<td>for their love and for always having my back</td>
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Non-Disclosure Agreement / Redacted version

The master thesis contains information on technical appliances and/or techniques as well as business insights that must be retained for competitive purposes for the organization involved, namely WEMAG AG.

This master thesis is underlying a non-disclosure agreement signed by the author, Varena Junge, since it contains information that is subject to professional confidentiality. Therefore, the thesis cannot be openly accessible, publicized or distributed among people outside the non-disclosure agreement.

The version at hand has been redacted in order to allow public disclosure. Therefore several subchapters which contain specific company-related information have been obscured with black print.
Abstract

Scientific studies on the advantages of environmental management and futures research integration have been increasingly published during the last years. WEMAG, a traditional German energy provider, aims to benefit from the energy market transition by offering innovative and sustainable energy solutions. However, the whole industry lacks experience with innovation management and beyond that also lacks knowledge on how to integrate eco-design and strategic foresight. Currently, theoretical contributions do not provide practice-relevant and interdisciplinary solutions due to a research gap on integrative perspectives of innovation, environmental and futures research streams and applied research approaches. This thesis is a first attempt to bridge the research gap and to provide a practice-relevant concept by introducing an integrative innovation process model, which benefits from eco-design and strategic foresight. Following an applied design theory methodology, requirements for the new process model-building are derived from literature review and qualitative insights from company material scanning, interviews and a workshop. The results show that integrating eco-design and strategic foresight into innovation management on a strategy and process level offers major advantages for managerial practice, especially in uncertain environments. It provides the opportunity to explore future developments while having normative guidance towards environmentally-friendly solutions, which also provide unique advantages for market positioning and succesful competition.

Key words: product development, innovation management, futures research, strategic foresight, environmental management, eco-design
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<td>EMAS</td>
<td>Eco-Management and Audit Scheme</td>
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<td>EMS</td>
<td>Environmental Management System</td>
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<td>ISO</td>
<td>International Standardization Organization</td>
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<td>PDCA</td>
<td>Plan-Do-Check-Act</td>
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<td>PSS</td>
<td>Product-service-systems</td>
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<tr>
<td>STEEP</td>
<td>Social, technical, economical, environmental, political</td>
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<td>TPD</td>
<td>Technical product development</td>
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<td>Vs.</td>
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1 Introduction

It is becoming impossible to ignore the impact human activities have on the planet. Climate change, resource depletion, declining biodiversity, air pollution and further issues show the need for a sustainable development (WCED, 1987; Millenium Ecosystem Assessment, 2005; IPCC, 2007) especially in the energy sector. In Germany, especially the risk associated with nuclear energy, increasing dependency on unstable energy imports and the climate change combating goals¹ have led to a decision by Chancellor Angela Merkel to a transition the national energy plan towards renewable energy, having become internationally recognized as the ‘Energiewende’ project (BMU, 2012). It is the first time a highly-industrialized, densely populated nation aims to overthrow its energy landscape towards renewable energy.

Even though the greatest contribution in the efforts to reduce greenhouse gas emissions so far has come from the energy production sector, more efforts are required to reach the set targets (Matthes, 2012). A sustainable transition towards a high market penetration of renewable energy and self-sufficient energy systems is needed, by combining technological modernization with sustainable development (Wangler, 2010). The core question consequently is how to redesign our industrialized energy sector - as well as the way society uses energy - in a sustainable way (BMU, 2012). This redesign needs to be addressed on several levels – policy, business and consumer, but this study is focusing on the corporate level.

The system transition leads to various shifts in the German energy market, one major being the core business activities of energy providers (Deloitte, 2010). These providers face increasingly complexity paired with uncertainty about political, technological and economic circumstances and a highly dynamic and speedy change of business models. These shifts bear a strong force to adapt their traditional business model for any energy provider, but also offer huge opportunities to expand in the emerging market (Deloitte, 2010). Energy providers can have a chance to benefit from the shift when aligning their strategy in time and by offering new services to their clients in the area of decentralized, self-sufficient and renewable energy systems (Roland Berger, 2013).

Strategic management and innovation management have traditionally provided the basis for aligning business models or products with changing environments. Recently, environmental management becomes increasingly important due to consumer and regulatory demands while the research stream on corporate foresight offers interesting options to embrace uncertainty. Both areas could add value to traditional innovation management.

However, only few publications link some of these theories and even fewer develop a concept that allows for implementation on a company level. This leads to the intention of this thesis to develop an integrative process model for environmental innovations, where the interdisciplinary design approach builds on systems thinking. At the same time, practical implementation of research outcomes are regarded as highly valuable, especially in the light of sustainable development of industries. Therefore, this study also aims at providing an implementable management concept with detailed recommendations for the German energy provider WEMAG.

¹ European Union climate protection goals require a 40-percent reduction of greenhouse gases by 2020 over 1990 levels (BMU, 2012).
1.1 Aim and objectives

The aim of this thesis is to introduce a theory-based conceptual model that can be used in a corporate environment. The model aims at integrating environmental and future management into an innovation management process.

The study aims at integrating innovation management concepts with the idea and methods of environmental and future management using an interdisciplinary approach that supports the process of decision-making on new environmentally-friendly products and services in transitional markets.

The contribution of this thesis is directed towards theory and practice. Thus, the first theoretical contribution is a study of research results and gaps on innovation theory, processes and methods in connection with environmental and future management in complex and dynamic business environments. The second theoretical contribution is the development of a conceptual process model for environmentally-friendly innovations.

The third contribution focuses on managerial/business practice and therefore integrates practical requirements into the process model and analyses the implications for the strategy of the WEMAG technical product development (TPD) department.

For a better understanding a separation of the thesis aim and the aim of the proposed model is crucial. The aim of the thesis is to develop a suitable, conceptual model for an innovation process that integrates environmental and future management, while the goal of the proposed model is to be implemented to develop environmentally-friendly products.

Accordingly, eight objectives have been formulated as shown in Table 1.

Table 1. Objectives of the research project (Author’s compilation)

<table>
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<tr>
<th>OBJECTIVES</th>
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<tr>
<td>1 DESCRIBE THE RESEARCH STRATEGY</td>
<td>Overview on research questions, methodology, approach and limitations</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>4 EXPLORE THE PERCEIVED PROBLEMS BY WEMAG AND TPD</td>
<td>Qualitative data collection and exploration within a workshop and interviews to collect perceived problems and to derive form and content requirements</td>
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<tr>
<td>5 ASSESS THE REQUIREMENTS FOR AN INTEGRATIVE PROCESS MODEL</td>
<td>Development of a conceptual process model including a detailed description of its features and organisational embedding</td>
</tr>
<tr>
<td>6 DESIGN AN INTEGRATIVE PROCESS MODEL</td>
<td>Development of a conceptual process model including a detailed description of its features and organisational positioning</td>
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<tr>
<td>7 CONDUCTING A CRITICAL ASSESSMENT</td>
<td>Discussion on the advantages and shortcomings of the proposed process model</td>
</tr>
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<td>8 COMPILATION OF IMPLICATIONS</td>
<td>Advice and suggestions for managerial action and further academic research</td>
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1.1.1 RESEARCH QUESTION

Due to the bidirectional goals of this thesis regarding theory and practice, two research questions are formulated:

Theoretical research question: How can a strategic innovation process in uncertain environments look like and benefit from environmental and future management?

Business research question: How should a strategic innovation management of the technical product development (TPD) department of the WEMAG AG look like to position them favourably in regards to the current transitions in the energy market in Germany?

1.2 Research design

Research can be understood as a systematic effort to gain in-depth new knowledge (Gregor, 2006; Kothari, 2009; Faste and Faste, 2012), offering several roads of getting there. Accordingly, there are several ways to distinguish research approaches, which will be introduced followed by a statement on where this thesis can be located. The research design serves as the methodological framework in which the research activities are conducted.

1.2.1 RESEARCH PURPOSE: THEORY TYPE

Studies on research methodology show that there is a range of possible research purposes, for example explanatory, expository, descriptive, prescriptive, historical, explorative or diagnostic (Simon, 1969; Herbst and Coldwell, 2004; Gregor, 2006; Kothari, 2009; Fendt and Kaminska-Labbé, 2011; Ahlemann, Arbi, Kaiser and Heck, 2013).

Gregor (2006) gives a good overview on general theory and theory development discussion in literature, concluding with five types of theory to distinguish: (1) theory for analysing, (2) theory for explaining, (3) theory for predicting, (4) theory for explaining and predicting, and (5) theory for design and action. The latter theory types – predicting, design and action – are applied rather than fundamental approaches. Predicting goes beyond the identification of outcomes or problems and looks at possible further developments. Design or action research is prescriptive in offering solutions. Therefore, prescriptive or design research comes with a proposal for “how to address a known problem space” (Ahlemann, Arbi, Kaiser and Heck, 2013, p.45) by offering decision options. Most prescriptive or design research is based on a first stage of descriptive research. However, prescriptive research has a rather mathematical or foresight angle, while design research looks at products or processes.

The purpose of this thesis is to design a new process as a solution to the constituted problems of the company at hand. Therefore, design theory will be introduced more in detail.

The purpose of design theory is defined by Simon (1969) as to design solutions to real-life problems. Design research is essentially based on the simple observation that organisations “out there in the real world engage in design on a daily basis: they design new products and services, new organisational structures, processes and procedures, new images of themselves. Therefore, to
remain pertinent, management research must involve itself with design”² (Fendt and Kaminska-Labbé, 2011, p.225).

While experiencing a quite recent development, there is already a large body of research recognizing design as science (Purao et al., 2008; Faste and Faste, 2012). Reviewing the diverging views of design theory and its relationship with other types of theory, Gregor (2006) highlights the work of March and Smith (1995) on four products of design science: constructs, models, methods, and implementations. In recent years, design studies have further expanded from their traditional arts and humanities background by offering methods and solutions to the organisation and management discussion (Swann, 2002; Purao et al., 2008). McKelvey (2002) acknowledges the rising need of science to propose solution to organisations, but argues the link between theory and reality is not directly but by modelling. “Models are at first derived from existing theories and then frequently modified to account for variations between the model and the phenomena until the researcher concludes that either the model is or is not adequate. In either case, the results of the model serve (…) to formulate tentative theoretical propositions awaiting further empirical validation” (Fendt and Kaminska-Labbé, 2011, p.225).

Jonker and Pennink (2010, p.123) state that “designing makes what needs to be organized visible”. The authors argue that managing organizations is mainly about establishing a set of coherent actions and processes.

Faste and Faste (2012, p.3) conclude that the ultimate goal of design research is “to improve, not to study” and they cite Charles Eames who defined design as “a plan for arranging elements in such a way as to best accomplish a particular purpose”.

This thesis uses the design approach to develop a model that describes an innovation process for environmentally-friendly new product development. The goal of the model is to accomplish an improvement of the current situation of the TPD department and offer a blueprint for beneficial interaction of innovation processes with environmental and future management.

1.2.2 RESEARCH APPROACH: DEDUCTIVE VS. INDUCTIVE

Deductive approaches are theory-testing, meaning that the research results have been derived from an existing body of theory, while inductive approaches aim at theory-building based on data and information (Saunders, Lewis and Thornhill, 2003; Gregor, 2006; Fendt and Kaminska-Labbé, 2011; Faste and Faste, 2012). However, Fendt and Kaminska-Labbé (2011) provide a critical analysis stating that both ways delegate the job of determining truth to procedures. The authors note that dialectics recognizes that truth is a social construct, thus concluding that differing processes and pluralism are better ways of producing truth in situations especially in the field of management (Fendt and Kaminska-Labbé, 2011).

This thesis derives its results from an existing body of theory as well as insights from the practical business world, thus the traditional separation of deductive and inductive research is not sufficient. The author suggests an understanding of this thesis as model-building from pluralism by combining different existing bodies of theory. The build model can be understood as a proposal for new theory

² This understanding of design research has to be separated from the definition of design as aesthetically informed form-giving craft or the artefact itself (Henver et al., 2004; Faste and Faste, 2012).
that needs to be further induces by additional data and tested by various hypotheses in a following research process.

1.2.3 RESEARCH METHOD: QUANTITATIVE VS. QUALITATIVE

Quantitative methods are based on the collection and analysis of data and information that can be expressed in terms of quantity or amount. Qualitative methods use descriptive terms to analyse phenomena, relations and logical flows based on interviews, case studies and conversations with the subject of the investigation (Gregor, 2006; Kothari, 2009; Zanoni, 2012).

According to Zanon (2012) qualitative methods are useful for data reduction, display, abstraction and interpretation.

Following the design theory and model-building approach, qualitative methods are important to integrate qualitative data into the design process. In addition, the limited resources for a master thesis barely allow for required quantitative analysis in new model-building.

1.2.4 RESEARCH TYPE: APPLIED VS. FUNDAMENTAL

“Research can either be applied research or fundamental research. Applied research aims at finding a solution for an immediate problem facing a society or an industrial/business organisation, whereas fundamental research is mainly concerned with generalisation and with the formulation of theory.” (Kothari, 2009, p.3)

Herbst and Coldwell (2004) use demand and supply to explain to contrast the focus of each research type. Universities and academic institutions that create knowledge represent the supply side. The demand side, i.e. practitioners, offer practical insights and they have a need for knowledge. In this regard, knowledge creation without focus on utilisation of the research by practitioners is of fundamental nature. And collaborative or integrated research between demand and supply side is applied research that produces practical relevant knowledge. They conclude by proposing a virtuous circle of theory and practice, “through which research on managerial practice informs practically derived theory. This in turn becomes a blueprint for managerial practice, thereby increasing the stock of relevant and practical management knowledge” (Herbst and Coldwell, 2004, p. 6).

Faste and Faste (2012) summarize the various domains of research between two axes: scientific vs. practice-based and theoretical vs. empirical work. They define basic research as “systematic activities carried out to increase knowledge of fundamental and replicable principles for understanding the physical world” (Faste and Faste, 2012, p.1).

Applied research has a special responsibility, since their practical recommendations or implementations can have societal consequences far broader and complex than perhaps envisaged (Herbst and Coldwell, 2004).

Within the area of applied research, the terms ‘research-practice gap’ or ‘relevance gap’ are central to an on-going debate among scientists and practitioners. They describe the failure of either scientific research to essentially contribute to real world problems or management to base practices on best available evidence (Herbst and Coldwell, 2004; Fendt and Kaminska-Labbé, 2011).

Keeping in mind the responsibility and challenges coming with knowledge generation for the practical world, this thesis offers an applied research approach. The twofold objectives for theoretical and practical contribution already indicate the location of this study right in the middle of
scientific- and practice-based, and the integration of qualitative as well as model-building methods further stretches the location between theoretical and empirical.

The chosen research approach needs to allow the author to provide both context-specific advise and interpretation the corporation can use as well as a model that is potentially generalizable to a wider range of companies.

1.2.5 RESEARCH REQUIREMENTS: GENERALITY AND CAUSALITY

Valid research requires generality and causality (Gregor, 2006; Kothari, 2009). The generality of a theory is indicated by its boundaries, ranging from formal theory with a broad conceptual area, over mid-range theory referring to moderately abstract theory with limited scope, to substantive theory for a specific area of inquiry (Gregor, 2006).

Causality describes the regularity of an effect one event has on another. Notions of causality can be law-like, statistical probability or causal explanations including teleological-type causes like an event or state than can be caused by will by an acting subject (Gregor, 2006).

The practical subject of the model-building approach by qualitative methods in this thesis is best suited for substantive theory and causal explanations.

1.2.6 RECENT DEVELOPMENT TOWARDS INTERDISCIPLINARITY

Remarkably during the last years, the notion of using several theories to explore, explain or solve a problem is increasing. This discussion is very vibrant in environmental and sustainability science as well as some management research streams. The comprehensive work of Herbst and Coldwell (2004) highlights the fact, that “using knowledge from a range of disciplines enables management research to gain new insights that cannot be obtained through all of these disciplines separately” (Herbst and Coldwell, 2004, p.6).

Van Aken (2005) highlights the potential for ‘cross-fertilization’ by combining description- as well as solution-oriented theory, referring especially to organization and management theory. Conelissen and Durand (2012) recently published an article that seeks an understanding of, what they call, ‘conceptual blending’. They state, that analogical thinking with its way of blending concepts and relations, is a core element for conception of new theory (Conelissen and Durand, 2012). The blend of new assumptions within a separated situation can lead to a change of view of the corresponding situation and “may indeed, upon reflection, capture and explain novel and important aspects of organizations” (Conelissen and Durand, 2012, p.152). Arto (2013) adds that existing theories are too single-sided, leading to the importance of cross-disciplinary combinations of several existing theories, which he calls theory-combining studies

In the environmental research area Gregor (2006) and explicitly Schaltegger (Schaltegger and Synnestvedt, 2002; Figge, Hahn, Schaltegger and Wagner, 2002; Schaltegger, Beckmann and Hansen, 2013) have focused on the development of the research area towards interaction with management studies and general inter\textsuperscript{3} and transdisciplinarity\textsuperscript{4}. Schaltegger, Beckmann and Hansen (2013, p.221)

\textsuperscript{3} Interdisciplinarity describes the purposeful integration of various pieces of disciplinary knowledge. It starts with joint problem definition by different disciplines, which collaborate to jointly investigate a problem (Schaltegger, Beckmann and Hansen, 2013).

\textsuperscript{4} Transdisciplinarity is a structured and intensive exchange of academic and societal actors towards a normative goal (Schaltegger, Beckmann and Hansen, 2013).
start their argumentation for more transdisciplinarity with the “need to reintegrate knowledge in a problem-oriented way”. They assume that a solution, which requires reintegration of diverse knowledge can highly benefit from methodologies that increase diversity by enhancing interdisciplinary scientific exchange and – as best case – collaboration of science and non-science partners to create knowledge relevant in practice (Schaltegger, Beckmann and Hansen, 2013).

Gregor (2006, p.620f.) states that “research in the environmental management filed examines more than just the environmental system, or just the strategic or organisational system, or even the triple perspectives side by side” and concludes that environmental management research needs to investigate the interaction of those disciplines, working at the “intersection of knowledge of properties of physical objects (products), knowledge of the environment and knowledge of processes”.

Even though this master thesis does not aim at developing a whole new theory, it follows the idea of interdisciplinary and conceptual blending to stimulate reflectivity and interaction on the given theories of environmental, innovation and future management. The chosen research type, approach and method highlights the interdisciplinary design of this thesis.

### 1.3 Research methodology

In order to fulfil academic and business purposes, three methodological approaches are used:

1. **Literature review and information collection for two purposes:**
   a. To provide a clear problem description based on the current situation in the markets
   b. To analyse secondary data from already existing academic publications. The theory requires an understanding about the interaction and different contributions of innovation, future and environmental management.
   c. Analysis of theory-based form- and content-related requirements for a new process model

2. **Empirical work as qualitative analysis:**
   a. Collection of perceived opportunities and problems by the TPD team
   b. Collection of perceived opportunities and problems by the executive management and TPD manager
   c. Material analysis of the organisational structure, processes and applied innovation, environmental and future management within the TPD department
   d. Analysis of practice-based form- and content-related requirements for a new process model

3. **Conceptual work in the form of a new process model-building based on the integration of the previously studied theoretical work and practical insights**
   a. Introduction of the major elements constituting the new process model
   b. Outline of new integrative innovation process model benefiting from eco-design and strategic foresight
   c. Recommendations for strategic focus and organizational change

To construct our model, we first use the collected information on available processes and methods from the literature review. Secondly, the practical requirements derived from the empirical analysis are added. All requirements are separated into form- and content-related requirements. Form-
related requirements apply to the style and organization of the content, while content-related requirements are relevant for the substance.

In a third step, the findings are synthesised into a model that explains how an innovation process that integrates future and environmental management elements can look. The synthesized integration of theoretical and empirical results in a conceptual work allows a blending of academic and practical knowledge.

In addition, recommendations for strategic focus and organizational embedding are given.

### 1.4 Thesis outline

The objectives and the research approach are reflected in the thesis outline. A visual overview of the thesis outline is given in Figure 1.

After this introduction, the next chapter (Chapter 2) provides the problem description of the current and coming transitions of the German energy market.

To derive insights from theoretical contributions Chapter 3 reviews basic and recent literature from the innovation, future and environmental research streams.

This is followed by practical insights through a threefold qualitative methodology in Chapter 4. Here, company material, manager interviews and a team workshop provide data for analysis. The literature review as well as the qualitative analysis finishes with interim results, where the requirements for the process model-building are derived.

Providing the main contribution of this thesis, Chapter 5 presents the integrative innovation process model based on the insights and requirements derived before.

Ultimately, Chapter 6 covers the discussion part including a short summary of the results, interpretation of the results, evaluation of the research design and finally implications for the company and future research.

Figure 1. *Flow chart of thesis outline* (Author’s compilation)
1.5 Limitations

Obviously, this thesis is accompanied by limitations that are on the one hand due to time and resource constraints, and on the other hand due to the chosen research design, methodological and system boundaries.

The focus on a company from the energy industry in Germany reflects the importance of the energy industry for an environmentally-friendly and sustainable development in accordance with the set goals by the German and European governments. Traditional companies from the energy sector in Germany are in a special situation due to the transitional market that requires innovation, flexibility and environmentally-friendly solutions.

The detailed limitations of each method (literature review, qualitative analysis and conceptual modelling) will be discussed separately in the corresponding chapter.

The system boundaries are set by the framework within which this thesis is developed. The framework is given by the collaboration partner WEMAG AG, a mid-sized, community-owned company set in the transitioning German energy market. The results, which are bound to the thesis, focus on formal processes and structures, not on personnel assessment, team psychology or other empirical assessment options. The results should be applied within the TPD department, and where necessary a separation of short-/medium or long-term time frames is given.

Keeping in mind the responsibility of this study for its implementation within the real world, it needs to be highlighted that the proposed process model aims at defining a framework and giving recommendations to improve the current situation, however it should not be seen as a sole pathway that leads straight to economic success.

One major concern is the missing integration of social aspects, which could have moved this thesis from a sole environmental management perspective towards a more holistic sustainability science approach. Yet, the thesis already is ambitious in combining innovation, future and environmental management and a broader focus would have diffused the results.

However, strong limitations also give a thesis stronger results that are very applicable to the given context. Application for other countries, industries or companies will be debated in the discussion chapter but cannot be guaranteed.
2 Background: Transition of the German energy market

In this chapter some background information is given regarding the problems faced in the changing German energy market. A special focus is put on the role of traditional energy providers.

2.1 Changes in the German energy market

Ringland (2010, p.1493) gives a comprehensive description of the general change towards more dynamic and complex markets: “The pace of change in the next decade will challenge the ‘traditional’ methods of organizational planning. Most organizations are ill-prepared to deal with this new world of turbulence. They often lack common values and shared narrative, the ability to undertake fundamental strategic thinking, and to take the results of strategic thinking into action.”

One of those turbulences is the transitioning of the German energy market (Wangler, 2010). The German politics and society set a challenging framework, when aiming at the whole energy system to change through technological restructuring of the society and industry towards a sustainable energy pathway: “By 2020, Germany wants to cut its greenhouse gas emissions by 40 percent compared with 1990, and by 80 to 95 percent by 2050.” (BMU, 2012)

Needless to say, the expected outcome of a society based on environmentally-friendly, renewable energy is desperately needed. The following sections further explain the current challenges and faced problems. The energy generation in Germany was – and still is – highly dependent on conventional, fossil-fuel-based energy technologies, which are exhaustible and are responsible for a long list of environmental problems (Wangler, 2010). The acknowledgement of this lack of sustainability has spread increasingly during the last decade (Abold, 2011). In June 2011 the German parliament came to a decision to phase out nuclear energy while still following the 40-percent reduction of greenhouse gases goals and fostering the renewable energy roll-out. Thus, the renewable energy industry is the underlying motor for the national energy system transition (Oschlies, 2012).

In addition, an EU directive requires a transformation of from monopoly markets into open markets. This has led the introduction of new suppliers and a huge loss of customers for traditional utility providers, changing the market “from a supplier into a consumer market” (Abold, 2011, p.262). Abold (2011) concludes, that energy providers must deal increasingly with individual consumer profiles and fluctuating buying behaviors.

The market for renewable energy has grown heavily (Abold, 2011). The renewable energy industry is characterized by multiple and diverse firms, ranging from engineering and manufacturing of the energy technology, to project development, electricity generation, and further to transmission and distribution (Oschlies, 2012). This complexity is combined with a high level of uncertainty from technological, political and economic developments (Lewis et al., 2007; Wehrlin, 2011). Technological challenges are the lack of dominant designs, technological diversity that complicates the reaching of grid parity, underdevelopment of electricity grids, and the lack of reliable storage technologies (Jacobsson et al., 2000). Statistically every sixtyeth German citizen is an energy provider (Tenbrock, 2013), thus domestic energy production has become an emerging market that is still growing rapidly. New markets surrounding smart home and sustainable living are still emerging and not set yet. Oschlies (2012) concludes that regulations and political decisions are subject to frequent changes.
Furthermore, stakeholders are becoming increasingly aware of the need for environmental protection and sustainable development (Figge and Schaltegger, 2000; Jamali, 2008). Consumer choices are increasingly based on the environmental impact of products and services.

As a result, the “renewable energy industry is stated as context in which strategic management is particularly challenging and strongly influenced by contextual factors” (Oschlies, 2012, p.3). This results in a need for professional and comprehensive strategic management of firms (Meijer et al., 2007). Such a strategic management needs to integrate external influencing factors, innovations for renewable energy technologies and include or promote a sustainability perspective.

### 2.2 Challenges for traditional energy providers

The above described transition has led to a widely acknowledged in research and media, pressure on energy providers (Sander, 2008; Deloitte, 2010; Piller, Wagner and Antons, 2012; Roland Berger, 2013), since their core business of purely distributing energy or managing the energy grid is vanishing. Liberalization led to market entrance of many new, small competitors that can react in a more agile and flexible manner (Funke and Schlör, 2013). At the same time, new market segments and niches develop, which are not yet explored by traditional energy providers (Wagner and Kristof, 2013).

The re-regulation of the European energy market structures lead to numerous changes, which require a strategic re-positioning and innovative business models (Kroha, 2002; Rennhak and Benad, 2013). Sander (2008, p.14f.) give an overview of options for strategic re-positioning of energy providers, ranging from internal adjustments towards more efficiency to new growth strategies (Sander, 2008). New business opportunities can be realized by extending the value chain into areas such as smart home, energy management, domestic renewable energy production, electricity storage, and sustainable mobility solutions – among others (Rennhak and Benad, 2013). Therefore, new customer segments, new distribution channels and new products need to be explored. Those new markets also require a focused innovation management while providing agile and flexible adaption to changes (Wagner and Kristof, 2013).

Yet, the majority of energy providers are not acquainted with product development, innovation management or extensive environment screening and competences in regard to these new requirements are also low (Piller, Wagner and Antons, 2012). Nevertheless, this offers early adapters to this dynamic situation a first mover advantage. And it might be crucial for traditional energy providers to adapt in order to survive (Roland Berger, 2013).

### 2.3 Interim results: Critical situation of energy providers in transitioning Germany energy market

The external environment – being the transitioning German energy market – is in general characterised by high complexity, high dynamics and high uncertainty. Renewable energy production is growing, society and politics demand non-dependency on imported and fossil energy sources and the wish for decentralised energy systems is intensifying. The transitioning market is becoming additionally dynamic due to its liberalization, which leads to new, small market players such as citizens, energy co-operatives and start-ups. In addition, different stakeholders increasingly demand sustainable energy solutions and environmentally-friendly products.
The traditional energy providers experience a decreasing core market due to the market liberalisation and the market entrance of several new, small competitors. So far, there is rather low involvement in emerging markets and new product segments. But the need for innovative business models is high, requiring targeting specific customers, using new distribution options, developing new products and positioning with agility and flexibility. However, the traditional energy providers lack experience with emerging markets, and they have no familiarity with innovation management and tangible product development. In addition, they show low agility and ability to adapt and mostly have no knowledge about foresight activities.
3 Literature review: Contributions by innovation, future and environmental research

This chapter starts with an introduction to the applied methodology for a comprehensive literature review. The following subchapters then guide along the major contributions of each research field including interconnections to the other areas, empirical challenges and research gaps.

In addition to innovation, future and environmental management, the concepts of complexity, uncertainty and systems thinking are first briefly described due to their relevance for the following review. Second, strategic management will be introduced since it serves as a basis for all the following research areas.

3.1 Literature review method

A literature review can be explained as “account of what has been published on a topic by accredited scholars and researchers” (Herbst and Coldwell, 2004, p.31). A systematic literature review has a clear stated purpose, a defined search approach and produces a qualitative appraisal of articles (Jesson et al., 2011).

3.1.1 DESCRIPTION OF CHOSEN LITERATURE REVIEW METHOD

This literature review serves three purposes,

(1) to describe the current relationship between the research streams and highlight research gaps,
(2) to identify key topics and findings within each research streams, and
(3) to withdraw valuable basis and needs for the building of a new, integrative process model.

The research approach is to concentrate on those issues and aspects of the innovation, future and environmental management research field that specifically relate to the research question. Thus, an emphasis is put on the processes of each research field and their interconnectedness with the other two research fields. Ultimately, challenges and research gaps are highlighted to indicate the relevance of this thesis and identify areas for further research.

With the following chapters, the thesis author tries to keep the balance between exemplary and exhaustive literature review as on the one hand it should concentrate on the specific research question, while on the other hand it needs to guide along the representative work and necessary background of the research field. The underlying aim is not to be exhaustive as far as the relevant literature is concerned, but to cover the most noteworthy and recent contributions. Hence, the most important interconnections, processes, challenges and research gaps were identified.

This chapter therefore incorporates varying viewpoints in order to give an overview of the discourse in the field. The sections are organized by research streams and ideas rather than by authors or works, sometimes a publication is emphasized when it gives exceptional insights that are not covered by other authors.
3.1.2 LIMITATIONS

The literature review is exhaustive, but still cannot cover all relevant literature. This was also limited by accessibility of literature. The thesis author tried to use most recent contributions, however sometimes importance aspects were only covered in older publications and for historical referencing according sources were used, too. Most sources are articles from academic journals, but other sources were used as well. This was necessary to sometimes gain practical insights from industry reports or add other aspects that were not covered yet by scientific research.

An analysis of the set of limitations of each research publication cannot be carried out; however it should be kept in mind that those limitations could have a far broad and far reaching effect on the results and research findings.

Finally, the review was carried out with high sensitivity toward validity and reliability of publications.

3.2 Uncertainty and systems theory

The problem formulation and the empirical part of this thesis are set in an uncertain environment characterized by high complexity and dynamism as described in the previous Chapter 2. As will be seen later, all following research streams put major efforts towards coping with uncertainty. In addition to the concept of uncertainty, systems theory is introduced in the second section. Systems thinking is an underlying approach of this thesis to cope with complex problems and models.

3.2.1 COMPLEXITY, DYNAMISM AND AMBIGUITY

A threefold definition of uncertainty is given by the Business Dictionary (WebFinance, 2013) as a “situation where the current state of knowledge is such that (1) the order or nature of things is unknown, (2) the consequences, extent, or magnitude of circumstances, conditions, or events is unpredictable, and (3) credible probabilities to possible outcomes cannot be assigned.”

The first aspect is complexity, which can be further characterised by “(1) heterogeneity of drivers of change and new events in the business environment; (2) the relationships and mutual influences among drivers of change, and the relationships of each driver with a large number of components of the micro and macro environments; and (3) the low rate of evolution of drivers of change” (Vecchiato, 2012, p.439). In general, high complexity occurs when drivers of change are heterogeneous with tight links to each other and longer development times.

The second feature is dynamism, which is the result of “the frequency of the rise of new and disruptive drivers of change” and “the speed of the evolution of these drivers” (Vecchiato, 2012, p.439). In general, high dynamism is characterized by a frequent emergence of rapidly developing and disruptive drivers of change.

The third aspect describes a lack of ability to clearly define or even calculate the complexity or dynamism (Vecchiato, 2012). Research by Davis, Eisenhardt and Bingham (2009) suggests that uncertainty arises, when decision-makers do not feel confident that they understand what the major events or changes in their business are and when they feel unable to make accurate predictions. Schrader, Riggs and Smith (1993) called this a feeling of ambiguity.

Assessment of most organizational environments shows an increase in complexity and dynamism and thus uncertainty due to, among other factors, progressing globalization, improvements in
information and communication technology, accelerated technology innovations and introduction of market liberalizations (Gausemeier, Fink and Schlake, 1995; Müller, 2008; Brem and Voigt, 2009; Badura, 2011; Weiss and Legrand, 2011). After all, business environments are inherently unstable and uncertain, a status characterized by complexity, dynamism and ambiguity (Davis, Eisenhardt and Bingham, 2009; Chermack, 2011; Schuh, Drescher and Wemhöner, 2012; Vecchiato, 2012). This should neither be ignored nor neglected, but needs to be embraced and incorporated into interconnected problem descriptions, holistic mental models and flexible strategies (Wilson, 2000; Jenschke et al., 2012).

3.2.2 SYSTEMS THINKING

Systems thinking refers to understanding complex realities from different perspectives as a holism of interconnected and uncertain situations defined by their networks of relationships. It focuses on understanding, taking into account different perspectives and improving the situation rather than providing single, dogmatic and reductive solutions. This “soft thinking” (Checkland, 2000, p.11) approach uses systems as a learning device to draw conclusions for our real world and take into consideration chaotic and complex structures, whereas hard thinking provides us with technical assessments of our environment that can produce figures for accounting and control, but only limited reliability for complex situations. Its basic transdisciplinary approach, which includes a variety of actors, is thinking in open constructs of reality, which depend on their environment and react in response to changes (Jackson, 2003; Reynolds and Holwell, 2010).

The word systems refers to a set of elements and their interactions, which border this set from the environment. Environment hereby is defined as the mass of objects outside the system, where characteristics can be changed by the system or that can influence change within the system, thus leading to action-reaction processes (Sommerlatte, 2002).

The use of different perspectives with the baseline of holistic, open systems thinking supports better understanding of complex, interrelated problems and thereby informs the decision-maker better of possible problems, trade-offs and benefits on different scales and levels (Finnveden and Moberg, 2005; Fischer, 2007). Sustainability science is heavily based on systems thinking due to its interdisciplinary approach in describing and solving complex and dynamic problems (Lindgren and Bandhold, 2009). For decision-making in the context of corporate environmental performance, the idea of systems thinking has become highly important over the last years (Jackson, 2003; Fischer, 2007).

3.3 The strategic management perspective

In general, strategic management can be seen as a systematic and ration approach, coordinated at the top organizational level to align resources and actions with the overall objectives of the company and to set corresponding goals and milestones. Strategy is a description of decisions, measures and behaviour in regard to achieve set aims regarding sustainable value proposition. The aims should be based on the vision and mission of the company. The development and overall execution is the major task of top management supported by their middle and lower management (Mietzner, 2009; Wehrlin, 2011; Zanoni, 2012; Schallmo, 2013; Vahs and Brem, 2013).
In 1965 Ansoff published his “Corporate Strategy” – assessing the main components of strategic management and developing some primary instruments for its analysis – which is seen as the groundwork of strategic management (Wiltbank, Dew and Read and Sarasvathy, 2006).

In the second half of the 90s Porter’s article “What is strategy?” (1996) directed the focus towards competition and the industrial context, including the analysis of market forces, competitors, suppliers and customers. Porter already identified coping with uncertainty a key issue for maintaining a competitive advantage. Other researchers later integrated the environment as a force that actively shapes and is shaped by organizational actions (Courtney, Kirkland and Viguerie, 1997; Burgelman, 2002). The two polar views on strategy based on internal resources or external impacts have led to a third, rather integrated perspective that acknowledges both sides and promotes a balanced strategy between both extremes (Simon, 2004; Müller, 2008; Wehrlin, 2011).

3.3.1 CHARACTERISTICS

First, there are three layers for which strategies need to be developed within a company. A corporate strategy that applies to all business units, business strategies that are specific for one business unit and functional strategies for each functional unit within the business unit (Müller-Stewens und Lechner, 2003). The latter is often considered operational management rather than strategic management (Müller, 2008). The strategy is the central task for top management or the corresponding leadership at the business or functional level (Chakravarthy, Müller-Stewens, Lorange and Lechner, 2003).

Second, strategies should refer to the internal strength and weaknesses and external opportunities and threats, as mentioned above. But they also need to relate to the corporate vision and mission (Simon, 2004; Mietzner, 2009; Wehrlin, 2011).

Strategic management can be understood as decision-making about the direction of the future development of the company and continuous alignment of these set goals based on internal or external developments. Thus, it requires companies to discuss central questions regarding the future (Wehrlin, 2011).

Types of strategic management

Many theories exist on how to survive and win competitive battles, ranging from resource-based views over core competencies to imitation, diffusion and revolution strategies (Marcus, 2009). The research by Reeves, Deimler, Love and Tillmanns (2012) states that the best strategy style in environments that are dynamic, highly uncertain, unpredictable and only allow for low influence on external factors is an adaptive strategy. They additionally emphasize the need for strategic approaches in uncertain environments to tightly link or even embed strategy in operations.

Process of strategic management

In general, the strategic process is a virtuous circle with different phases that have to be adapted to each concrete application. The phases displayed in Table 2 are a summary of the evaluation and synthesis of contributions to the strategic management process by a broad range of authors and they follow the general Plan-Do-Check-Act (PDCA) cycle.

The evaluation phase is always connected to the initial assessment by a cyclic feedback loop including correction measures (Vahs and Brem, 2012).
Among the several challenges for successful strategic management, one major concern falls into the area of handling complexity and uncertainty. Many strategic management scholars formulate the increasing need to systematically screen the environment. Rohrbeck (2009) sees environmental scanning at the core of strategic management in order to enhance decision-making. He proofs that high performing companies have strong scanning systems for their macro environment. This creates knowledge about direction and magnitude of emerging discontinuities, which in turn can be used to propose management actions. Thus, it is a way to decrease uncertainty.

Table 2. Process of strategic management (Author’s compilation based on Chakravarthy, Müller-Stewens, Lorange and Lechner, 2003; Grietnitz, 2006; Laube and Schwander, 2006; Niemeyer, 2006; Wehrlin, 2011)

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The term macro environment includes the broad landscape surrounding a business. Social, technical, economic, ecologic and political spheres (STEEP) characterize this landscape; they provide simple categories for exploration of the external environment (Lind, 2002; Burmeister, Neef and Jannek, 2005; Brem, 2008; Brem and Voigt, 2009; Loveridge, 2009; Chermack, 2011; Vecchiato, 2012; Zanoni, 2012; Bensoussan and Fleisher, 2013). Due to their versatile connections and interrelations, the macro environment can generally be described as complex (Götz and Weßner, 2010; Rohrbeck and Bade, 2012).

Within each macro environment sphere, several stakeholders exist. Stakeholders are people or groups, which can affect or are affected by the activities of a corporation (Figge and Schaltegger, 2000). Stakeholder value is based on the argumentation that shareholder value is deeply influenced by stakeholder value, thus companies should aim at increasing their stakeholder value. A positive stakeholder value is created by joint outcomes from which stakeholders and the company benefit (Earl and Clift, 1999). In addition, many scholars indicate that a good image and brand are the greatest value of a company, which are at the same time most prone to damage by unsatisfied stakeholders (Figge and Schaltegger, 2000).
3.3.2 CHALLENGES, LINKS TO OTHER RESEARCH STREAMS AND RESEARCH GAPS

Among the exhaustingly long list of possible challenges of successful strategic management, one major challenge is the proper adaption and contextualization of strategic initiatives. Simon (2004) and Rohrbeck (2009) find that design of practice-relevant strategic cycles and processes remains an important shortcoming of corporate management.

Link to innovation management

In order to create value, companies develop new business models, products, processes or services (Wehrlin, 2011). They serve as a competitive advantage and are the core element of any business (Fagerberg, Fosaas and Sapprasert, 2011). Ideas that lead to marketable and successful business models, product, process or service developments are called innovations (Sommerlatte, 2002). The process of initiating, organizing and maintain those innovations is innovation management. As pointed out by several authors, the seizing of opportunities identified in macro environment scanning can also be categorized as innovation management (OECD, 1991; Vahs and Burmeister, 2005; Sattler, 2009; Duin and Hartigh, 2011).

Link to environmental management

The traditional strategic management research stream still offers limited involvement toward the sustainability or environmentalism debate. The common recognition of environmental concerns is within the macro environment scanning, where environmental regulations, customer demands for green products, environmentally-friendly technologies or ecological disasters can occur (Brem and Voigt, 2009; Götz and Weßner, 2010; Chermack, 2011; Zanoni, 2012; Bensoussan and Fleisher, 2013). However, the research on strategic management does not give any recommendation on how to address to ecological influences (as part of STEEP analysis) or environmental stakeholders demands.

Link to futures research

Some recent publications note the future-orientation of strategy, especially in the light of increasing macro environment analysis (Müller-Stewens and Lechner, 2003; Whittington, 2006; Rohrbeck, 2009; Vecchiato, 2012). Müller (2008) highlights that the integration of foresight activities into the strategic planning phase could increase effectiveness and acceptance.

Mietzner (2009) assumes that strategic foresight is a process prior to strategic planning and Duin and Hartigh (2011, p.49) accent the relationship between future and corporate management by saying “corporate strategy as a plan is almost by definition related to the future of a company, as a plan is highly likely to contain actions or guidelines that are to be carried out to achieve future objectives”. Though, Oschlies (2012) points out that research does not yet fully incorporate contextual dynamics, uncertainties and consequently future outlooks into strategic management studies. The importance of a foresight competency is highlighted by Pillkahn (2008, p.48) stating that “the capacity to anticipate changes and developments and to detect the opportunities and threats associated with them earlier than one’s competitors and to account for these in one’s business strategy will become one of the most important enterprise success factors in the 21st century”.

18
3.4 The innovation management perspective

Innovation management is the rational establishment of the innovation system including structures and processes, while its goal is to generate value for the company based on its innovation processes (Wehrlin, 2011). The term innovation is mostly used for new products, processes, services or business models. Fagerberg (2004) gives a summary of the three features of innovation, being (a) novelty, since innovation always display a new element; (b) implementation, since they are introduced into market and (b) modification, since they cause a change or an improvement.

Vahs and Brem (2013, p.2) conclude that innovation management is an “indispensable condition” for effective and efficient idea realization and a crucial success factor for companies in a dynamic and competitive market environment. Various research studies linking the innovativeness of company to high turnover and profit rates as well as higher corporate value and better survival exist, being nearly uniform in their conclusion that innovativeness is a crucial factor for companies (Sommerlatte, 2002)\(^5\).

The task of innovation management is twofold: it has to govern single innovation processes and it serves as a framework aiming at the overall design of an innovation system (Völer, Thome and Schaaf, 2012). “Innovation management involves the general principles of addressing innovation at an organizational level. At a lower level of detail there are innovation processes, where the specific activities of an innovation project are described” (Duin and Hartigh, 2011, p.57). Hauschildt (2004) also follows this two-folded view, calling it the system-theoretical and process-related perspective. The system-theoretical perspective sees innovation management as the rational generation of the institutions, within which innovation processes are supposed to run. The process-related perspective views innovation management as the rational generation of processes, which aim at creation and exploitation of innovations as projects.

Therefore, the innovation strategy – as part of the overall company strategy (Lemser and Brodhun, 2007) – defines where and how innovation processes and innovations itself should be realized to achieve business objectives best (Vahs and Brem, 2013). It should be kept in mind that innovation management by nature is characterised by high complexity due to its affects in the future, its diversity of possible outcomes and often dynamic and unstable external environments (Völer, Thome and Schaaf, 2012).

The OECD (1991, p.3030) defines that “innovation” is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology-based invention, which leads to development, production, and marketing tasks striving for the commercial success\(^2\). In academic literature the innovation process in general is divided into three stages called invention, innovation and diffusion, thus providing a more differentiated view on the term. The invention is often compared to the creation of an idea, but the term further includes the technical realization of an object, process, technique or concept that displays an element of novelty. An invention becomes an innovation, when it is firstly commercialised and to that effect put into practice. The spreading of this innovation through society is then called diffusion (Garcia and Calantine, 2002; Fagerberg, 2004; Vahs and Brem, 2013).

\(^5\) Even though the term innovation management is widely used in both scientific and practical community, there is no universally shared definition in the business literature (Hauschildt, 2004; Sattler, 2009).
Duin and Hartigh (2011) summarized the historical development of innovation management as four generations with distinguishing principles, as can be seen in Table 3. Their work highlights the combination of market pull and technology push factors. Market pull is innovation creation based on customer needs, and most scholars agree that it leads mainly to incremental innovations. Technology push derives from scientific discoveries that stimulate a new market demand. Several research contributions show that for companies with no explicit fundamental research activities, the combined integration of both factors creates successful innovations (Li, Priem and Verona, 2010; Duin and Hartigh, 2011; Piller, Wagner and Antons, 2012; Rennhak and Benad, 2013; Schilling, 2013).

Recently, there is a growing literature body regarding open innovation, a concept that describes collaborative idea generation and processing that actively integrates all or some selected stakeholders (Duin and Hartigh, 2011). 6

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<tr>
<th>GENERATION</th>
<th>PRINCIPLES OF INNOVATION MANAGEMENT</th>
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<tr>
<td>1950 – mid 1960s</td>
<td>Technology push, linear innovation process</td>
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<td>Mid 1960s – early 1970s</td>
<td>Market pull, linear innovation processes</td>
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<tr>
<td>Early 1970s – mid 1980s</td>
<td>Combined market pull and technology push, coupled innovation processes with feedback loops</td>
</tr>
<tr>
<td>Mid 1980s – early 2000s</td>
<td>Innovation in networks and systems, ‘open innovation’</td>
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3.4.1 CHARACTERISTICS

Due to the already discussed two perspectives on innovation management, its tasks are manifold and deeply rooted in the context. Within the innovation management research, two research streams are especially strong. One is concentrating on the team generating innovations and the other one explores the different types of innovations.

Innovation team

Many authors focus on enabler for successful innovation processes, Table 4 provides an overview on their major findings.

Research shows that guidance, autonomy and competences are major success factors for innovation management. A clear strategy, corresponding objectives, an innovation plan provide guidance, as well as a clear mandate of the innovation team. Autonomy empowers the innovation team and is mostly achieved by small teams, which should be shielded from administrative tasks and other corporate units to act more freely. Low hierarchies and decentralised decision-making give enough competences to the innovation team and support their self-sufficiency.

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6 Even though the authors Piller, Wagner and Antons (2012) discuss the open innovation concept within the energy industry, due to the general low maturity with innovation management at all such an advanced innovation concept is neglected in this thesis.
While Table 4 highlights top management commitment and support, Pavitt (2005) takes a different perspective, stating that in practice top-down corporate visions can be a poor guide to innovation strategies.

Pavitt (2005) also states that innovation processes are based on the character and determination of outstanding individuals that are highly experienced and show a special set of traits relevant for innovative thinking. However, Sommerlatte (2002) and Simon (2004) emphasize the integration of all kind of employees and their knowledge, to activate them, guide them and use their ideas.

Ansett (2005) indicates that committed individuals are the key for effective innovation management, such as promoters, boundary-spanner, gatekeeper and technology scouts. Boundary-spanner, also called foresighters, are people that scan the environment beyond the current market, they network to get access to all relevant information and have in-depth knowledge about coming environment changes (Nochur and Allen, 1992).

Rohrbeck’s (2009) study results in the idea of three distinct roles that need to be covered in successful innovation management: initiator, strategist and opponent. The initiator triggers innovation by identifying new customer needs, emerging technologies and new product or service concepts from competitors. The role of the strategist is to direct innovation activities by vision creation, strategic guidance, consolidating opinions, assessing and repositioning innovation portfolios and identification of new business opportunities. The opponent challenges the innovators to create better and more successful innovations by challenging basic assumptions, challenging state-of-the-art and by scanning for disruptions that might endanger current innovations.
Innovation types

Innovativeness describes the differentiation of innovations along the degree of change ranging from incremental to radical innovation. Incremental\(^7\) refers to changes in terms of modifications of existing technologies, products or services to enhance their performance, lower their costs or increase their desirability within the given frame of solutions. Radical innovation introduce a product or service totally new to the market, being disruptive and competence-destroying in nature since the technological trajectory is changed and a new framework introduced (Garcia and Calantone, 2002; Atuahene-Gima, 2005; Calantone, Chan and Cui, 2006; Norman and Verganti, 2012).

Norman and Verganti (2012, p.6) emphasize that radical innovations are driven by “technology changes, without any design research or formal analysis of needs”. They also introduce, what they call the “hill-climbing paradigm (HCP)” (Norman and Verganti, 2012, p.4) which is based on the notion that radical innovations are often inferior to previous existing solutions in design, costs and capability. Accordingly, “incremental innovation is necessary to transform the radical idea into a form that is acceptable to those beyond early adopters” (Norman and Verganti, 2012, p.6).

The most common separation is between product and process innovation. Product innovations target improving product effectiveness or new product development, they are introduced to the marketplace and help companies to protect their margins. Process innovations pursue to advance the efficiency of the firm or a specific commodity; they are only introduced in-house and to help companies in lowering their costs (Brodhun, 2008; Sattler, 2009; Duggan, 2013; Schilling, 2013). Another type is business model innovations, which often lead to the creation of new companies or start-ups within large companies. Rohrbeck (2009) finds that each type of innovation needs a separate strategy and different organizational structure.

3.4.2 ACTIVITIES AND PROCESSES

A process model serves as a standardization tool for innovation activities. Not only in literature, but also in practice, organizations have multiple and different types of innovation processes with differentiation in detail, tasks and objects (Van den Elst, Rol and Smits, 2006; Verloop, 2006; Brodhun, 2008). Many companies also decide to create a kind of contextual innovation management on the basis of their organisational needs (Duin and Hartigh, 2011). A major advantage of a process-oriented approach according to Herstatt and Verworn (2001) is the systematization of an often ad-hoc-development, it enhances a common understanding and clear communication. Thus, in practice process models are used as a management tool. The research focus is on activities and characteristics that can be found in every innovation management process (Verworn and Herstatt, 2002).

The research by Sattler (2009) clearly indicates that a sophisticated innovation process is a central predictor of successful innovation management. He further identifies experience with innovation development, deep understanding of the process, and formalization of the innovation process as achieving excellence in innovation process. This corresponds with the findings of Schilling (2013), who also names an in-depth understanding of innovations and their dynamics a key need for successful innovation management. The author adds two more key needs, being a well-designed process for implementing the innovation strategy and a well-crafted innovation strategy.

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\(^7\) Sometimes also called continuous innovation (Herstatt and Verworn, 2001, p.6)
**Innovation funnel**

With the growing interest in innovation management, the visualized model of an innovation funnel came up (Wheelwright and Clark, 1992; Dunphy, Herbig and Howes, 1996; Brem and Voigt, 2009). The model pictures how a variety of ideas is reduced to one or few real projects or products, as can be seen in Figure 2. Dunphy, Herbig and Howes (1996) coined the notion that in order to get one successful innovation, it is necessary to have as many ideas as possible in the beginning. The authors also described how inputs from the macro level of an organization led to ideas that were processed through micro level filters. The model is still used as a simplified graphic for idea management (Schilling, 2013, p.4f.).

![Figure 2. The innovation process funnel (Rohrbeck, 2009, p.5)](image)

**Stage-gate process**

The most-often cited and applied innovation process is the stage-gate process, which is mainly developed and updated by Cooper (1996, 2002, 2008). The innovation process focuses on the filtering and processing of an idea. Today, various adaptations exist, but the key features stay the same. The key features are, as suggested by the name, stages followed by gates that require 'kill' or 'go' decision. The stages cover all product development activities from idea to commercialization (Cooper, 1996).

Figure 3 shows a typical second-generation stage-gate process. The product development begins with an idea that derives from fundamental research, customer-based tools and creativity techniques. Gate one criteria are general attractiveness and feasibility plus criteria based on whether the idea fits corporate strategy that are seperated into must and should meet criteria before. The following stage one is a quick and low-cost description of technical feasibility, market potential, competitive advantage and financial estimations. The second gate assesses these information. If the idea gets a ‘go’ decision the detailed development of a business case, including an project action plan, in stage two follows. A business case contains among others estimated market share, targeted consumer segments, profitability calculations, risk assessment and technical appraisal. The business

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8 Similar innovation processes based on phases and gates can be found in the publications of Von Ahsen, Kuchenbuch and Heesen (2010), Herstatt (1999) and Pleschak and Sabisch (1996).
case is the basis of decision-making at gate three. In stage four a prototyp as well as marketing, sales and distribution plans are developed. These are assessed and compared in comparison to the initial business case at gate four. Gate four additionally inherits quality and project management deliverables criteria. In stage four the prototype is validated by several trials and test runs. Finally, gate five decides on production start and market launch, which are executed during stage five. A review is scheduled to compare actual with expected results and to assess the total project (Cooper, 1996; Cooper and Kleinschmidt, 2001; Verworn and Herstatt, 2002; Badura, 2011).

![Second-generation stage-gate process](image)

Figure 3. Second-generation stage-gate process (Cooper, 1996, p.46)

The underlying idea of Cooper’s (2002) gate orientation is to reduce the information gap with each stage, so resource input and financial commitment can be increased for the next stage due to reduced uncertainty and risk of failure. A crucial part is clearly defined and analogue executed kill criteria. This decision forces prioritizing scarce resources on the best project.

Cooper (2002, 2008) distinguishes between gatekeeper, project leader and project team. A clear distinction of their roles is supposed to avoid conflicts of interest and to support a common understanding. The gatekeepers are decision-makers from other business parts, building an interdisciplinary board of experts with sufficient responsibility and power to allocate needed resources for each stage. The project leader is part of the team, but without content task. The project leader’s task is to coordinate, steer the process and moderate between team and gatekeeper. The team works on the tasks outlined in the stage-gate process and produces an analysis report at the end of each stage as a basis for gate decision-making. The team should be put together from different business units to benefit from interdisciplinarity (Badura, 2011).

Two core principles emphasized by Cooper (2011) are (a) to ensure sufficient resources for projects in progress and (b) to give project manager and development teams’ sufficient authority and empowerment.

The latest, third-generation, stage-gate model strives for more flexible processes being not strictly sequential and less stringent (Cooper, 2008). Verworn and Haustatt (2002) primarily influenced
speeding up of the process by fluent transitions between stages and parallel performance of tasks. Badura (2011) acknowledges the fluidity that allows to move work packages to earlier phases without gate approval and the new focus on quick and efficient, parallel activities as strong improvements from the previous model. Cooper (2008) highlights that his process model is shaped by flexibility and adaption, fostered by decentralized decision-making.

3.4.3 CHALLENGES, LINK TO OTHER RESEARCH STREAMS AND RESEARCH GAPS

Bower and Christensen (1995) and later just Christensen (1997) challenge one major top management trajectory by stating that instead of fighting for their mainstream business, companies must be willing to see business units die and give space for disruptive innovations to realize their full potential in order to let the corporation live. Rohrbeck (2009, p.2) later calls this “willingness to cannibalize” and rates it a very important management character. Very similar to that, Simon describes a psychological effect noticed on managers called ‘terror by status quo’, where the current situation always seems to be less risky than any other undertaking, thus leading to resistance to change.

Marcus (2009) and Gassmann (2011) strengthen the finding that innovation activities always include more risk than other business segments, thereby being challenging to good management, which is typically based on an effort to minimize risk.

Bürgel, Reger and Ackel-Zakour (2005) studied 21 companies and found out that a key element to successful innovation management is to improve communication between top management and business units or innovation team to develop a consistent innovation strategy that is not only reflected on functional, but also on corporate level.

Inspired by the innovation funnel, Wheelwright and Clark (1992) name three major challenges: (1) widen the mouth, i.e. expanding the organisations knowledge base, (2) narrow the funnel neck, i.e. select ideas to focus resources on the most attractive opportunity and (3) ensure that the selected projects deliver on the anticipated objectives. Gassmann and Sutter (2001), Sommerlatte (2002) and Badura (2011) support this view showing that major deficiencies in innovation management are cross-functional teams, evaluation and systematic grading of innovation projects at check-points and channelling of generated ideas into a systematic process. Though, Badura (2011) raises caution against too high bureaucracy and process-orientation, fearing that the project might get less attention than the process. This fits with Wehrlin (2011), who demands a general flexibility and re-configurability of the phases as well as the structures and involved units.

While traditional innovation management literature highlights top management involvement, the research by Sattler (2009) names decentralization in decision-making a success factor.

Early phases of innovation management are highly important for innovation success, but lack structure and methodological support in theory as well as in practice (Gausemeier and Fink, 1997; Lindemann and Setter, 1997; Cooper and Kleinschmidt, 2001; Herstatt and Verworn, 2001; Khurana and Rosenthal, 2002). Particular problems within this phase are lack of systematic idea selection and fail to integrate customer and market factors. Herstatt and Verworn (2001), Khurana and Rosenthal (2002) and Brem and Voigt (2009) believe that these early phases, which they call the fuzzy front

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9 The early phases, which are also called front end, pre-development, pre-project activities or pre-phase (Haustatt and Verwron, 2001), range from idea generation to their approval for development or their termination.
end, have the highest impact on the results and determine to a great extent which projects will be executed. Cooper and Kleinschmidt (2001) found out that pre-development activities receive the least amount of attention and consequently, high failure rates of product developments are often related to insufficiencies, low management attention and poor financial support during the fuzzy front end. The long history of this problem in the literature body indicates the magnitude this challenge probably still has.

Vahs and Brem (2013), reviewing the simultaneous engineering approach, highlight the challenges of shortening product development times and continuous alignment with customer requirements. Minimization of cycle time by partly parallel development is further supported by the findings of Schilling (2013) and Verworn and Herstatt (2002).

Finally, Cooper (2002, p.83f.) draws conclusion from several studies to formulate seven challenges for successful product development processes in practice. The list reflects the findings of other studies introduced previously:

1. Holistic and high quality requirement for product development process,
2. Project selection based on corporate criteria,
3. Importance of time to market, support by parallel process execution,
4. Interdisciplinary team,
5. Market orientation,
6. Clear project specifications from the beginning and business case, and
7. Always focus on competitive advantage of new product.

**Link to environmental management**

In published scholar articles on innovation management from a regular business perspective hardly any direct reference to environmental management could be found. A white paper by Talonen and Hakkarainen (2010) touches the topic of sustainability concerns by identifying them as possible drivers behind a new business model.

In their article about future research on innovation management Horn and Brem (2012) name sustainability as step sixth out of seven steps, based on their assessment of future applications and trends that will be important in the short- or long-run. Snider, Hill and Martin (2003) conducted a survey among the largest companies worldwide showing that the companies do not question whether to integrate sustainability into the process of innovation at all, only how to do it.

**Link to futures research**

In 1995 Bower and Christensen published a critical review of foresight benefits for innovation management, stating that trying to find out what customers or society want before they know it themselves, has a risky nearness to fortune telling.

However, more recent contributions rather highlight the positive contribution. The link to future management has been quite recently explored by Duin and Hartigh (2011, p.56), showing the parallel development of both research areas and pointing out that innovation “involves coping with future

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10 Simultaneous engineering describes an approach of parallelization of the process parts with an continuous coordination and integration of necessary actions (Vahs and Brem, 2013), similar ideas are reflected by the terms cross-project management, overlapping activities, concurrent engineering or adequate staffing (Verworn and Herstatt, 2002).
uncertainty because an innovation will be marketed at a future date, when new developments may have changed the market situation. [...] Taken together, innovations form a kind of transition path to an envisioned future”. Their conclusion is that an innovation process should use technology forecast, especially in the early phases, but stay open to various inputs from future research (Duin and Hartigh, 2011). Thom, Rohrbeck and Dunaj (2010) discover that corporate foresight can contribute to the continuous environment scanning and monitoring activities of a company and thereby reduce uncertainty for the innovation process.

Cuhls (2011) describes a general overlay between foresight and innovation management in the phase of idea generation, however innovation management relates to following processes, too, while foresight is rather an input for strategic direction. Her research states, that the efficient design of the interface between innovation management and foresight is essential for further studies. She concludes that innovation management needs to be better interlocked with foresight to integrate today’s and tomorrow’s perspective.

Research gaps

Today, “a solid ground of theoretical and empirical literature has already been set for the use of innovation theories in management. Innovation concepts have more and more been adopted and applied in actual business practice” (Horn and Brem, 2012, p.939). Nevertheless, within the energy industry or the issue of renewable energy innovations no innovation management or process could be found, that was set up or evaluated by academics.

Finally, Vahs and Brem (2013) consider also problematic aspects of rather abstract process models, since they describe an ideal situation, which does not consider corporate’s individual circumstances. They emphasize that a process model should only be understood as a supporting tool to create a better understanding of innovations.

3.5 The futures research perspective

Futures research arises from the problem of increasing uncertainty and is concerned with open thinking in possible futures. During the last years, futures research has established itself as a substantial research area (Rohrbeck and Gemünden, 2006). Berkhourt et al. (2007, p.47) describe futures research as “describing, explaining, predicting, exploring and interpreting future developments and its consequences”.

Forecasting, which can be seen as the origin of systematic future studies (Pillkahn, 2008), is the description of the future based on predictions and projections through analysis of past events for example observed regularities (Bell, 2003; Cuhls, 2003; Tiberius, 2011). In the 80s the view of “technological and societal developments as non-linear and chaotic – and therefore as not easily predictable – came to be more widely accepted” (European Commission, 2006, p.7).

Thus, the focus shifted from forecast to foresight11 (Ringland, 2006; Tiberius, 2011), as a method to describe and anticipate possible, plausible developments of the future and the according pathways (Rohrbeck and Gemünden, 2006). Foresight is a display of alternative development options for

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11 There are several publications that use „foresight“ based on other definitions. For example: Burmeister, Neef and Jannek, 2005, p.15: Foresight is a method to orientate required short-term activities with long-term strategic goals.
multiple futures that depend on various factors and relationships. Foresight includes, besides the
development of alternative futures, also the discussion upon their challenges and implications such
as preparation and other proactive measures (Tsoukas and Shepherd, 2004; Lichtenthaler, 2005).

In general, futures research is not a scientific discipline itself rather a scientific area where several
disciplines, like sociology, policy science and nature science contribute (Mietzner, 2009; Duin and
Hartigh, 2011). Therefore, future studies can be characterized by interdisciplinarity. Future
management requires that individuals and teams think in system’s terms, thereby including all
factors which may affect the success of their undertakings (Loveridge, 2009).

The scientific object of futures research is alternative futures (Kreibich, 2000). According to Mietzner
(2009) futures research is used for (a) reduction of uncertainties, (b) identification of opportunities
and threats, (c) information collection, aggregation and processing and (d) communication and
visualization.

Futures research can and has been used on supranational, national and corporate level (Cruz-Castro
and Sanz-Menendez, 2005; Rohrbeck and Gemünden, 2006). The comprehensive research by
Rohrbeck and Gemünden (2006) categorizes two types of futures research depending on their
normative or explorative character. Normative futures research includes the development and
design of preferable or preventable futures (Grosu, 2007; Tiberius, 2011), often used for creation of a
shared vision (Müller, 2008). Explorative futures research aims at discovering possible or probable
futures (Kreibich, 2000), often coined by research regarding scenario methodology (Müller, 2008).

3.5.1 STRATEGIC FORESIGHT

In the corporate area, futures research can provide important knowledge to prepare and support
strategic decision making and pro-active strategy formulation (Ringland, 2006; Mietzner, 2009, p.26).
The application or usage of futures research within the business environment is by most authors
referred to as strategic foresight or corporate foresight12 (Burmeister, Neef and Beyers, 2004; Pina e
Cunha, Parma and Guimaraes da Costa, 2006; Ringland, 2006; Neef, 2009; Wehrlin, 2011). The first
word indicates a deeper link with strategic management, thus including all system, processes,
methods and instruments of futures research and their integration into strategy development, and
will therefore be used throughout this study.

The starting point for futures research is the paradigm that corporate planning under uncertainty
needs to move away from forecasting and predicting towards identifying multiple possible futures
(Rohrbeck and Bade, 2012).

Müller (2008) provides a definition where strategic foresight integrates all systematic, at decision-
making oriented activities with a longer time horizon in a corporate environment. He highlights a
point of view where strategic foresight is not solely a method application but rather an analytical
anticipation and interpretation activity within an organisational, decision-supporting process with
interdisciplinary, participatory and strong communicational background. Following the understanding
of Steinmüller, Burmeister and Schulz-Montag (2003), strategic foresight is defined by its intention to
support strategic decision-making and to initiate planning and innovation-related activities. In
comparison to futures research, strategic foresight focuses more on corporate preparation for

12 Similar used names are organizational foresight, managerial foresight and corporate futures management (Müller, 2008;
Rohrbeck and Bade, 2012).
relevant developments, discontinuities or surprises in the environment of the company (Müller and Müller-Stewens, 2009; Cuhls, 2011).

3.5.2 CHARACTERISTICS OF STRATEGIC FORESIGHT

The UNIDO foresight manual (2005, p.268) gives a comprehensive summary of foresight characteristics, stating that foresight “is a process and not a (forecasting) technique, is an interdisciplinary endeavor, takes a long-term perspective, integrates various perspectives, including developments in technology, economy, politics and society, is a supporting tool for decision-making, but does not deliver ready-made corporate or political strategies, is an attempt to promote technological and social innovations in the public and private sector, is best implemented as a participatory process with the promoters who have to implement the decisions later.”

A study by Becker (2002) identifies three organisational forms for strategic foresight tasks. First, collecting post, which has a very specialised and narrow focus and is mostly embedded within the research and development unit. Second, observatory with medium specialisation and broader focus on several issues, it has the freedom to set its own focus and works autonomous. Third, think-tank with high specialisation grade and very broad focus, which sets its own agenda but also works on assigned tasks from corporate clients.

Ansett (2005, p.39) emphasises the importance of so-called boundary spanners in organizations, who “serve strategic roles [...] by gathering critical information, obtaining feedback and perceptions from the external environment through their stakeholder networks and then interpreting and translating that information back into their organisation.” He concludes, that “if the boundary spanner is effective, the process can lead to innovations in strategy, processes and products”. This focus is taken up by Rohrbeck (2009, p.2) who highlights “foresighters” as actors of particular relevance for strategic foresight activities.

Strategic foresight process

After reviewing a broad range on literature, Müller (2008) concludes that the majority of authors follow a common logic regarding the process, which can be summarized in three major phases as shown in Figure 4.

![Figure 4. Flow chart of strategic foresight process (Author’s compilation based on Müller, 2008)](image)

Müller (2008) adds an understanding of the filter function of the first phase, the aggregation function of the second phase and the translation function of the third phase. He describes the filter function as early identification and assessment of environmental changes and the aggregation functions as provision of an integral view of current and future states of the environment on a time and content scale. Finally, he describes the translation function as the competence to translate long-term and scientific or otherwise different information into the time plan and strategy of the company.

Ringland (2010, p.1494) emphasizes that “strategic foresight will need to be continuously updated as the external environment changes.”
Benefits of implementing strategic foresight

The work by Mietzner (2009) provides several requirements for successful futures management, such as active and future-open discussions, allowance for multi-contextual and multi-dimensional perspectives. In addition, she also names advantages of the methods of future management, being generation knowledge for orientation, allowing for long-term planning, plurality of views and high learning effects of participants.

Wehrlin (2011) and Ringland (2006) highlight the competitive advantage of companies that incorporate futures management due to the early knowledge of future developments to see what opportunities or threats are laying ahead and thus allow for early adoption or change of the company. Rohrbeck (2009) derives from a broad case study analysis that there are multiple examples in which strategic foresight activities had positive impacts on the innovation capability of companies.

Burmeister, Neef and Beyers (2004) emphasize the view on future developments within the external environment and name three main benefits of strategic foresight. They state that strategic foresight should (a) prepare strategic decision-making, (b) secure the competitiveness of companies in the long-term, and (c) strengthen the learning and innovation capability of a company.

Vecchiato (2012) argues that the main contribution of strategic foresight efforts lies not in predicting the future, but in preparing decision-makers of an organization to handle the future. He understands it as a learning process about the future, “which enables managers not to know opportunities and threats in advance, but to detect them more promptly and to react more effectively as soon as they start emerging” (Vecchiato, 2012, p.448).

In conclusion, Rohrbeck and Kallehave (2012, p.187) provide this comprehensive list of achievements by integrating strategic foresight:

1. “the possibility to systematically challenge dominant mental models and basic assumptions;
2. means to reduce ignorance toward external change;
3. methods to recognize the systematic nature of new market development;
4. an interpretation and response system;
5. a systematic approach to discover alternative strategic options and create shared visions;
6. means to counterbalance inertia induced by the management systems;
7. tools to break away from path-dependency;
8. a method to create a sustainable organizational design for the firm of the future.”

3.5.3 METHODS OF STRATEGIC FORESIGHT

The discussion on applicable methods for futures management is widely spread in research (Rohrbeck and Gemünden, 2006; Müller, 2008; Cuhls, 2011). For example, Kreibich (2000) gathered more than 200 methods, many from other research disciplines, that could be used within future management. Rohrbeck and Gemünden (2006) support the aspect of cross-disciplinary cooperation in regard to futures research methods.

Besides the discussion on which method to use in particular, it can be summarized that foresight methods can be of both quantitative and qualitative nature, however, mostly a combination of qualitative methods is used. Futures management methods can be separated into market-based methods, technology-based methods and integrated methods, similar to the development of innovation management generations. Market-based methods are qualitative interviews, customer
survey, competitors analysis and trend extrapolation, whereas examples of technology-based methods are publication or patent analysis, technology scouting or life cycle analysis. Several author’s conclude, that roadmapping and scenario techniques are the two major methods for integrated analysis (Rohrbeck and Gemünden, 2006; Kreibich, 2000; Tiberius, 2001; Pillkahn, 2008).

3.5.4 CHALLENGES, LINK TO OTHER RESEARCH STREAMS AND RESEARCH GAPS

Providing an insight on the practical implementation of future management, Gausemeier, Fink and Schlake (1995, p.54f.) conclude that the major challenge is not the development of possible futures but rather the thinking in explorative possibilities of the future. This new perspective often requires a change in decision-making, company culture and organizational structure, which is historically more based on hard facts and detailed, precise information.

Wiltbank, Dew, Read and Sarasvathy (2006) warn of the fact that thinking in alternative futures increases decision-making and operation complexity massive. Müller (2008) states that due to the long-term orientation of strategic foresight activities and research, the managerial measurement of their success is hard.

Research by Savioz (2002) on strategic foresight practice in small to medium-sized companies blames failure of strategic foresight systems to a large extent on a lack of focus on the needed traits and skills. Vecchiato (2012) shows that in practice there is little available knowledge on organizational frameworks and formal systems that could coordinate foresight efforts and activities. The author suggests a strategic foresight method based on environment scanning. Additional research by Thom, Rohrbeck and Dunaj (2010) indicates that not the information gathering but rather utilization of this information remains a weakness of many companies. Other empirical evidence indicates that firms mainly lack systems to continuously integrate strategic foresight (Rohrbeck, 2009; Bootz, 2010; Rohrbeck and Bade, 2012).

**Link to innovation management**

Several futures research studies highlight the interconnection of strategic foresight with innovation and strategy management, especially in the light of decision-making (Neef, 2009; Wehrlin, 2011). Van der Duin and den Hartigh (2011, p.48) provide a simple explanation, “because innovation processes have to do with creating new products, services or processes, they provide ample opportunities to incorporate new (future) developments”. Accordingly, Becker (2002) emphasized that foresight has a supporting and advisory function to strategy development. He also sees it as a tool to orchestrate and coordinate ideas from disperse sources. From an outside-in perspective, Behrendt (2010) acknowledges an increased corporate need for early detection and monitoring of technological, political, societal and economic developments due to growth in dynamic and complexity of the external environmental conditions.

Müller (2008) sees the increasing demand for strategic innovation management as an impulse for foresight activities to increase process effectiveness and acceptance. His empirical study witnesses a trend in companies to use foresight for strategic planning and innovation projects. Müller (2008) provides a first example on how integration into strategic decision-making could look like. In the beginning, strategic foresight aims at irritating the existing future assumptions. In addition, new information is continuously forwarded into the company and is therefore a relevant part of agenda setting inside the company (Müller, 2008).
Rohrbeck and Gemünden (2006) note that strategic foresight is progressively becoming a key success factor for innovativeness of companies.

The article by Duin and Hartigh (2011, p.58) is especially relevant, since they explore the link of futures research with innovation and strategy process. They state that innovation and future are related in an almost natural way, where “the future can serve as a source of inspiration to innovators”. Most added values from futures research can be gained throughout the early phases. Additionally, Duin an Hartigh (2011) raise concern to the independence of future and innovation management at the level of content. Even though the authors advise to involve futures research into the decision-making process of companies, they stress that it is necessary to keep this connection on a process and not outcome-defining level.

**Link to environmental management**

There is very low integration or even simple links of environmental management research into futures research. It should be noted, that on a normative level future studies and sustainability science are closely linked since both look at today’s and coming generations (Cuhls, 2011). Cuhls (2011) adds that strategic foresight can generate insights for a proactive environmental management strategy.

**Strategic foresight research gaps**

The major research gap noted in relevant literature concerns the practical application of the theory. Blackman (2001, p.4) points out that “a much better understanding of exactly how futures thinking can be integrated into business decision-making” is needed. He further highlights the relevance of the context, thus calling for studies with a clear industrial focus and specific impacts and requirements. Müller (2008) also notes that very few authors consider contextual or situational factors in their studies regarding foresight activities in companies. Duin and Hartigh (2007; 2011) and Burmeister, Neef, Albert and Glockner (2002) repeat the call for scholar to build practical tools for manager to integrate strategic foresight into organizational structures and processes. In addition, Vecchiato and Roveda (2010) show that many companies put much effort into strategic foresight, but there is still a lack of a general framework to define how foresight activities should be carried out in a firm and integrated to support strategic decision makers at corporate, business and functional levels.

Rohrbeck and Bade (2012) call for more cross-fertilization of different research streams. They state that even though strategic foresight publications are often referencing towards innovation management literature, there is low integration of strategic foresight from an innovation management perspective. The author team concludes that management research is lacking models that tie the different research streams together. They explicitly appeal to academics to produce better recommendations for managers on how to build an organizational future orientation and drive organizational adaption. Rohrbeck’s (2009) study concludes that the question how to integrate strategic foresight in organizational practice remains open.

Furthermore, several publications indicate a deficiency of applicable, managerial concepts to integrate strategic foresight into innovation management. For example, Rohrbeck (2009, p.8) draws from an extensive case study analysis the conclusion that there is “still no clear understanding of how corporate foresight and innovation management should be linked”. And Thom, Rohrbeck and Dunaj (2010) provide review of journal articles that shows how foresight and innovation literature repeating laments of the failure of translating future insights into managerial actions. So far, the call
to connect futures research more with management functions has remained largely unanswered (Duin and Hartigh, 2009; Rohrbeck and Bade, 2012).

3.6 The environmental management perspective

Today, environmental management is mainly considered one dimension of the triangle of corporate sustainability management13, the other two dimensions being social and economic responsibility.

In 1972 the Club of Rome published their report “The limits to growth” (Meadows, Meadows, Randers and Behrens), simulating the interdependencies of our global society and nature and arguing that an international, long-term perspective is needed to stop resource depletion and pollution. Since then, numerous studies and reports show a growing consensus that the current patterns of production and consumption are not sustainable (Millenium Ecosystem Assessment, 2005; Stern, 2006; IPCC, 2007; UNEP, 2010).

Many authors have come to the conclusion that a decoupling of economic growth from resource use needs to become the global aim for this century (Jackson, 2008; Barbier, 2009; Liedtke, Welfens, Rohn and Nordmann, 2012). Economic activities need to happen within the natural system boundaries, therefore companies, governments, institutions and individuals have to learn how to cope with the challenges and opportunities of this transition (Liedtke, Welfens, Rohn and Nordmann, 2012). During the last decade, concepts have evolved from reactive end-of-pipe solutions in the mid-eighties via cleaner production in the 90s towards proactive eco-design and system innovations today (Buysse and Verbeke, 2003; Abele and Feichkert, 2005; Hallstedt, 2008; Wimmer et al., 2008). This development was partly forced by environmental regulation and policies, partly demanded by a growing number of conscious consumers (Behrendt, 2010) and to some part also by increasing efficiency and cost-effectiveness (Hallstedt, 2008).

The latest developments within the environmental management research show a shift from a complementary topic, which was managed in parallel or in addition to core business activities, to an integrative and sometimes even transformative driver of companies and markets (Schaltegger, Beckmann and Hansen, 2013).

The vision of a sustainable future is driven by a policy and business approach. The policy approach tries to organize economy and consumption in a fair and balanced way with environmental and social needs (Behrendt, 2010). The business approach concentrates on voluntary changes of a business towards higher environmental responsibility.

The European Commission (2011) identifies three major characteristics of environmental responsibility by enterprises, (a) the proactive approach going beyond legislative compliance, (b) the aim of maximising shared value for stakeholders and society at large and (c) the identification, prevention and mitigation of possible adverse impacts.

Environmental management aims at integrating a strong environmental perspective into the business decision making in contrast to traditional business decisions that focus solely on financial terms.

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13 The phrases corporate sustainability and corporate social responsibility are used in parallel, often without a clear definition to distinguish them. Today, most researchers rather use the term corporate sustainability (Schaltegger and Burritt, 2006; European Commission, 2011) to avoid misunderstanding regarding the integration of social and environmental as well as economic aspects.
Schaltegger and Wagner (2006) describe a sound management framework that first links environmental objectives with the business and competitive strategy and management, and secondly integrates environmental information with economic business information and reporting.

There are two well-known standards for environmental management systems (EMS): ISO 1400114 and the Eco-Management and Audit Scheme (EMAS)15. Both tools allow for certification by external authorities and thus can be used as marketing and communication asset. However, they provide only guidance and a framework but no specific criteria for assessment or evaluation.

Nevertheless, EMAS provides a helpful overview of several stages that have to be accomplished to realize a working and fruitful environmental management scheme in a company (European Commission, 2013), similar to the ISO 14001 standard they follow the general PDCA (“Plan – Do – Check – Act”) cycle (ISO, 2009). It starts with an environmental review, second the adoption of an environmental policy and third, the development of an environmental program with specific environmental objectives and targets. Based on the environmental policy and program, the fourth stage is to establish an EMS. This includes setting responsibilities, means to achieve objectives, operational procedures, training needs, monitoring and communication systems. Fifth, carry out an environmental audit and finally, providing an environmental statement where the current status of the environmental performance, the set environmental objectives and targets and the future steps to be undertaken are laid out (European Commission, 2013).

3.6.1 CHARACTERISTICS OF ENVIRONMENTAL MANAGEMENT

Environmental management can follow an either reactive or proactive strategy, which mostly relates to either extrinsic or intrinsic behavior. Proactive approaches go way beyond adopting environmental legislations and tackles environmental problems in a holistic and integrative way. Proactive strategies further anticipate future sustainable consumer needs and designs products for an environmentally-friendly living. Chen, Chang and Wu (2012) findings imply that companies aiming at a proactive approach should develop and cultivate their internal origins such as environmental leadership, environmental culture and environmental capability. Buysse and Verbeke (2003) add that proactive environmental strategies are associated with broad and deep stakeholder management.

The chosen strategy mainly defines the goal and aims of the environmental management, which can differ highly among companies. Managing environmental businesses, and within it developing environmentally-friendly solutions, is a complex and evolving issue according to Charter and Clark (2008). To progress towards sustainability, there will need to be a clear vision, commitment, objectives and strategy driven from the top.

Benefits of integrating environmental management

Several studies show, that implementing a corporate environmental strategy offers companies a range of opportunities in the areas of market positioning and product innovation. In addition, cost savings are possible. Overall, most authors provide an optimistic perspective on environmental strategy implementation (Vernon et al., 2009). Furthermore, Nidumolu, Prahalad and Rangaswami

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14 ISO 14001 sets requirements for an EMS and guidance for establishment, implementation, maintenance and improvement. It is a framework to assess and control environmental performance of an organization (ISO, 2013).
15 EMAS is a voluntary tool designed by the European Union to support organization in improving their environmental performance. It aims at companies of all seize and branches, naming performance, credibility and transparency as its key elements (European Commission, 2013).
(2009) show that sustainability integration can lead to loads of organizational and technological innovations that yield both bottom-line and top-line returns. However, those benefits are mainly granted when adopting a proactive environmental management approach (European Commission, 2011).

Another very current literature review by Cheng, Chang and Wu (2012) state that the relationship between green innovations and competitiveness is positive (Chen, Chang and Wu, 2012). Their publication further argues that there are several contributions and acknowledgements to environmental management by various economic theories, such as resource-based view and competitive advantage theory. The resource-based view acknowledges environmental management as a unique capability and proactive environmental strategies are regarded as beneficial to the competitive advantage.

Additionally, corporate environmental or social activities can greatly affect the stakeholder value, thus reducing the risk of image of brand damage (Figge and Schaltegger, 2000).

**Environmental management drivers**

Several drivers push companies to consider implementing environmental management. Epstein (2008) categorizes theses drivers as follows: regulations (noncompliance costs, corporate reputation, industry codes of conducts), community relations (critical public, license to operate, corporate reputation), cost and revenue imperatives (increased sales through corporate reputation, lowered costs through process improvements and decreased fines) and societal and moral obligations (personal concern for environmental and social impact)\(^{16}\). Horbach, Rammer and Rennings (2011) state that governmental regulations and costs savings are important motivator for process improvements, material substitutes and increasing recycability of products. Customer demands are a source for product development with an explicit environmental functionality.

**3.6.2 ECO-DESIGN**

This subchapter is giving a more detailed introduction to environmental product development\(^{17}\), which results in eco-innovations. Hallstedt (2008, p.1) calls product development a “particularly critical intervention point for the transformation of society towards sustainability”. From a process perspective, Hallstedt (2008) highlights the importance of the decisions made during product development that determine nearly all product impacts during its life cycle. Following similar argumentations, many authors push the concepts eco-design and integrated product planning. Integrated product planning focuses on the policy making approach, while eco-design is a business approach.

The concept of eco-design\(^{18}\) emphasizes the early design phase of product development; it is a “practice by which environmental considerations are integrated into product and process engineering design procedures. Eco-design practices are meant to develop environmentally compatible products and processes while maintaining product price, performance and quality standard” (Tukker and Eder, 2000, p.12). Most authors of publications in regard to eco-design follow

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\(^{16}\) Similar drivers can be found in the publication from Pigosso, Rozenfeld and Seliger (2011).

\(^{17}\) The additional integration of social factors is called sustainable product design or design for sustainability (Jones, Harrison and McLaren, 2001).

\(^{18}\) Design for Environment is a synonymously used term to describe preventive measures taken during the product development (Johansson, 2001; Trela, Omhover and Aoussat, 2012).
similar definitions where eco-innovations are the product of eco-design (Ferrendier, et al., 2002; Lemser and Brodhun, 2007; Hallstedt, 2008; Pigoso, Rozenfeld and Seliger, 2011; Liedtke, Welfens, Rohn and Nordmann, 2012). But Jones, Harrison and McLaren (2001) have a different understanding, where eco-design only changes products while eco-innovations aim to develop new products. Since this opinion seems to be a single case, the former understanding will be followed throughout this thesis. Yet, Jones, Harrison and McLaren (2001, p.30) provide an interesting differentiation between four levels of environmental product design:

“Level 1: Incremental improvement to existing products;
Level 2: `Green limits`: radical redesign of existing products;
Level 3: `Product alternatives`: new product or service concepts; and
Level 4: Design for the sustainable society.”

Kobayashi (2006) states that it is crucial to take into account environmental aspects in the early-design phase to greatly affect the eco-effectiveness of a product. The work by Liedtke, Welfens, Rohn and Nordmann (2012) shows that design is a determining factor for ecological effects of products and their value chain. For eco-design the multi-criteria approach of life cycle thinking is especially important to avoid displacement of impacts and therefore trade-offs between life cycle phases (Finnveden and Moberg, 2005).

Research shows, that eco-design is only successful if it is not an add-on but built into all stages of the design procedures of a company (Ferrendier, et al., 2002). Ferrendier et al. (2002, p.16) further recommend to customize the integration of eco-design into the product development process “according to the company’s culture, and the characteristics of its products and processes”. If possible, the environmental criteria should be integrated into the existing design methods. The authors highlight early intervention in design, senior management commitment and an extended design team that considers eco-design from the beginning.

Lemser and Brodhun (2007) call the use of eco-design as an additional functional advantage an offensive strategy. In this case, the products’ higher functionality due to environmental product characteristics should be communicated openly.

**Sustainable product-service-systems (PSS)**

A growing literature body indicates a shift towards a new type of innovations called product-service systems (PSS) as a solution for environmental problems and the new academic area of green innovation research19 (Baines et al., 2007). PSS are creations based on a combination of products and services, going beyond the conventional product development and looking at the system and its use throughout its life cycle (Wimmer et al., 2008).

A definition is given by Tietzke, Schiederig and Herstatt (2011, p.3): “[PSS are] an integrated offering of tangible products, intangible services and the enabling infrastructure providing a product-unspecific functional value. While the user and the offering firm engage into an enduring contractual relationship, the ownership remains with the offering firm with the user becoming the temporary proprietor enabling a high use-flexibility.”

Lemser and Brodhun (2007) highlight the increasing sustainability-related stakeholder requirements and conclude that new product characteristics are needed. An article by Mont (2002) emphasizes

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19 Similar concepts are system innovations (Wimmer et al., 2008) and hybrid offerings (Shankar, Berry and Dotzel, 2009).
several means by which PSS can minimize the environmental impact of consumption. The major advantage is the provision of functional and non-functional benefits for the consumer despite the fact that at the same time fewer resources are used and less emission produced. This system innovations are nevertheless economical viable and a source for companies growth and wealth. Such a systematic approach requires new ecological services merged with adequate business models (Wimmer et al., 2008). It is often been argued that PSS offer firms the possibility to combine their economic objectives with sustainability (Baines et al., 2007; McDonough and Braungart, 2009). Johnson and Suskewicz (2009) make new value creation systems even a requirement for change towards a clean-tech economy.

Life cycle thinking

A key characteristic of environmentally-friendly products is their life-cycle orientation. The European Commission (2003) advices that successfully integrated product policy can only be based on environmental life-cycle thinking.

McDonough and Braungart (2009) go as far as suggesting designing products with their full disassembly in mind, where all materials are re-used or recycled. A life cycle perspective is crucial for environmental decisions in order to see all related processes of a product or service and include all relevant information regarding the overall environmental impact due to energy and material resource usage in all stages, from raw material extraction to waste management (Finnveden and Moberg, 2005). In general, a life-cycle includes raw material extraction, material processing, part manufacturing, assembly, product use and end of life. The key aim of life cycle thinking is to avoid burden shifting (Tukker and Eder, 2000).

3.6.3 METHODS OF ECO-DESIGN

Pigosso, Rozenfeld and Seliger (2011) separate between eco-design operational practices and supporting methods and tools. Their review based on literature and a survey, names eco-design strategies and guidelines as major practices. In addition, they identified over 100 methods and tools that should be applied in accordance to different maturity levels of a company. These have been developed for different purposes, such as for assessment of environmental impacts, identification of environmental critical aspects, comparison of environmental design strategies, comparison of product solutions and prescription of improvement strategies.

The authors Pigosso, Rozenfeld and Seliger (2011) recommend that the integration of environmental considerations should be a process over time where more and more tools are introduced – until all aspects are covered. Recommended tools for companies with low maturity are checklists, manuals, guidelines, matrices and multi-criteria assessments such as radar plots, spider webs or eco-compass (Wimmer et al., 2000; Trela, Omhover and Aoussat, 2012).

Jones, Harrison and McLaren (2001) introduce a multi-criteria tool called the life-cycle design strategy wheel, where a products impacts should be estimated based on six axes. The six axes are new concept development, low impact materials, reduction of materials, optimization of production techniques, efficient distribution, reduction of impact in the use phase, optimize initial life-time and optimize end-of life systems (Jones, Harrison and McLaren, 2001, p.30ff.).
More time consuming and expensive tools can provide more accurate and detailed assessment of the environmental impacts. Therefore, eco-design approaches often incorporate life-cycle assessment\textsuperscript{20} or carbon footprinting\textsuperscript{21} to identify the hot spots\textsuperscript{22} of a product (Rebitzer et al., 2003; Trela, Omhover and Aoussat, 2012).

### 3.6.4 CHALLENGES, LINKS TO OTHER RESEARCH STREAMS AND RESEARCH GAPS

The literature review also shows several practical challenges, in implementing environmental management and eco-design, identified by empirical research.

Rohrbeck and Kallehave (2012) found out that many firms do not engage in lasting environmental programs, because the main driver is still the expected impact on profit, which is not achieved in short-term. Many environmental innovations have a mid- or long-term payback horizon. If implemented, environmental approaches mainly still follow a reactive, not fully integrative approach, where only existing processes are assessed and environmental objectives are not implemented equally important to financial, marketing and design functions (Tukker and Eder, 2000; Behrendt, 2010). The main focus of environmental considerations still lies on eco-efficiency and top-line contributions are not focused on (Tukker and Eder, 2000; Nidumolu, Prahalad and Rangaswami, 2009).

#### Link to innovation management

Besides the general notion of green innovations, there is a vibrant discussion in the research community on how to pursue, promote and integrate those ideas into traditional innovation management.

The contribution by Andersen (2008) provides a first systematical approach to environmental innovation research, concluding that it is still in a very early phase with only “very few actual innovation researchers working with environmental issues” (Andersen, 2008, p.3). A similar conclusion was already drawn by the European Commission (2001) with a call for development of management tools to facilitate integration of environmental considerations into innovation management.

The link between environmental and innovation management is explicitly studied by Schiederig, Tietzke and Herstatt (2011) and published in their article on green innovation. Their findings show that only very few scholars from the innovation management field have conducted research towards new product development of green innovations.

The research by Hottenrott, Rexhäuser and Veugelers (2012) focuses on the complementarity of green and organizational innovations with respect to companies’ productivity. Their study indicates that introduction of green technology without organizational change leads to lower productivity, while firms with a combined introduction of green technology and organizational change yielded a

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\textsuperscript{20} Life-cycle assessment (LCA) is a quantitative tool to assess the impact of goods or services on for example climate change, stratospheric ozone depletion, eutrophication, acidification and water use. Based on the identified material, energy and water flows and impacts, strategies to reduce those impacts can be considered (Tillman, 2000; European Commission, 2003; Rebitzer et al., 2003; ISO, 2013).

\textsuperscript{21} Carbon footprinting is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product.” (Wiedmann and Minx, 2008, p.4). Many carbon footprint calculations do not solely use carbon dioxide but rather carbon dioxide (CO\textsubscript{2}) equivalent indicators, thus being similar to the global warming potential (GWP) indicator used in LCA (ISO, 2009; Weidema et al., 2009).

\textsuperscript{22} High impact areas identified through life-cycle assessment.
higher productivity. The authors conclude that changes in a companies’ organizational structure are crucial for successful introduction of green innovations. This correlates with findings by Baroulaki and Veshagh (2007) and Rohrbeck and Kallehave (2012), who argue that enabling corporate sustainability requires change of organizational design including human resource management, reward and recognition systems, organizational information processes, product or process design, marketing strategies and business unit structures. Charter and Clark (2008) highlight that organizational structures need to be created that enable learning and change in a dynamic setting.

In regard to the assertiveness of innovations, Behrendt (2010) assumes that climate protection and resource conservation are increasingly becoming a criterion for success. The author derives this assumption from rise in institutional environmental requirements as well as market and customer sensitivity for environmental issues. This is further triggered by media coverage and influential stakeholder organizations (Buysse and Verbeke, 2003).

**Link to futures research**

Kobayashi, Kato, Maewawa and Sano (2011) briefly discuss the integration of futures research into environmental management in the form of backcasting or forecasting and sustainable scenario development. Bengston, Kubik and Bishop (2012) highlight the close link of environmental and future management due to their interdisciplinary approach and foundation within systems science. The authors promote that environmental management could be strengthened by strategic foresight by anticipating changes in the environment and by creating sustainable future scenarios.

Rohrbeck and Kallehave (2012) discuss how corporate foresight helps to overcame barriers to a sustainable future. They argue that a joint trend and emerging issues analysis provides a good perception of long-term trajectories of change. The authors also name roadmapping as a planning tool to provide a shared understanding of what might happen and what actions need to be taken. No further links from environmental science to future research could be found in other sources.

**Research gaps**

Several research gaps and opportunities are identified by the previously introduced authors. Schiedrig, Tietze and Herstatt (2011) find that the majority of publications focuses on economic topics on macro-level of innovation science instead of managerial topics, hence they suggest to emphasize the firm level for future research. Charter and Clark (2008, p.274) more explicitly demand research on the linkages between business and sustainability, in order “to create and launch sustainable solutions, there is the need to integrate and embed sustainability considerations into the innovation process and appropriate organisational structures, systems, incentives, programmes and tools will need to be designed”.

In 2001 the European Commission published a report on integrated product planning, asking how to effectively develop environmentally-friendly products and efficiently drive their acceptance by consumers. Part of the outlook chapter is the authors search for business product innovation processes that sufficiently integrate environmental product planning.

On a methodological level, Schaltegger, Beckmann and Hansen (2013) emphasize the benefits of using inter- and transdisciplinary approaches especially in the light of companies with complex environments.
Several business leader surveys identify the environment as a major issue of concern (IBM, 2008; McKinsey, 2009). However, additional surveys show that there are high uncertainties about how to address the challenges of environmental sustainability (Parris and Kates, 2003; IPCC, 2007; NIC, 2008). Elliot (2013) suggests, that the persistent level of corporate uncertainty might be due to the complexity of the issues and difficulties in profoundly capturing this complexity.

An article by Pigossso, Rozenfeld and Seliger (2011) summarizes that there is first a lack of integration of eco-design into the broad context of product development processes and product life cycle management, and secondly eco-design is poorly integrated into corporate strategy and management.

3.7 Interim results: Findings from literature review

The acquaintance with complexity, uncertainty and systems theory as underlying factors of this thesis is given by the first part of this chapter. The brief introduction into those terms provides an understanding of those issues as emerging management and research concerns, while systems theory offers a general solution to structure these kinds of problem.

The conducted literature review shows the main research perspective on strategic, innovation, environmental management and futures research. Some introduced publications already explore the possible enrichment of those theory bodies when merged, but not many. Major research gaps have been identified regarding the integration and combination of these research areas to benefit from the special contributions of each research stream.

The following Figure 5 provides a visualization of the current interconnections. It shows that futures research and environmental management seem more actively search for interconnections with innovation management, which might be due to their general interdisciplinary approach.

Figure 5. Interconnections of strategic, innovation, environmental management and futures research (Author’s compilation)

Futures research can provide both, strategic and innovation management, with strategic foresight to better gather, assess and interpret changes of the macro environment. Futures management argues that foresight capabilities are needed by firms to anticipate external changes and thereby to retain their competitive advantage. The support of proactive environmental management by futures research is not yet fully discovered.
Environmental management energetically tries to influence traditional management theory with its concepts of strategic environmental management and eco-design, both pushing environmental objectives as equal criteria to conventional aspects. Here again, the link to future research by providing scenarios of sustainable futures is still weak.

References from innovation management to environmental management or future research, on the other hand, were found only rarely. They are not enough to speak of an active approach towards integration. Nevertheless, some publications have identified environmental management as a potential driver for new business models and the potential of future management recently receives more attention in the academic community.

Strategic management serves more as a background for managerial activities in general, nevertheless it is included into the Figure 5 to emphasise the corporate need for innovations to ensure long-term survival and competitiveness.

Acknowledging, that research on interconnections between innovation, futures and environmental management is a very young, currently just emerging academic field, the major research gaps are normal. The author of this thesis sees them as an opportunity to generate some input for the emerging research field and its agenda.

**3.7.1 ADVANTAGES OF FUTURES RESEARCH AND ENVIRONMENTAL MANAGEMENT**

The literature review provides a deep understanding of the benefits that environmental management and futures research, i.e. eco-design and strategic foresight, contain for companies in complex, dynamic and uncertain external environments.

Futures research helps companies to filter and orchestrate information from all different kind of sources and to early detect and monitor environmental changes. Thus, it clearly communicates possible future developments and thereby reduces uncertainty. Foresight is a key factor for successful innovations through proactive market cultivation. Besides generating input for idea generation by offering opportunities to seize, foresight units also serve an advisory function to decision-making and can set the agenda. Its major contribution is systematic exploration and interpretation of future developments that might shape or be shaped by the company. It opens up the horizon of possible decision-making and integrates environment changes into strategic planning.

Studies on environmental management implementation show a range of opportunities in the areas of market positioning, identification of market niches, additional innovations, unique capability and competitive advantage; all of them yielding top- or bottom-line returns. An eco-design approach for product planning explicitly promotes green innovation ideas and thereby shapes a unique market position and product-service-systems with higher technical, environmental and commercial functionality. In addition, environmental management can greatly affect the stakeholder value. An environmental strategy offers normative guidance for decision-making in uncertain environments and throughout future developments. It also helps to actively pursue a chosen alternative, more sustainable future scenario and thus contribute to sustainable development.

Both research streams have deep roots in systems thinking and interdisciplinary solution finding, thereby allowing embracing and solving problems in their complexity.
3.7.2 MAJOR RESEARCH GAPS

All research streams share an on-going debate about the application of research results in organizational practice, including the common notion that recommendations for best practice are lacking and processes are designed without keeping a specific corporate context in mind. A deficiency of innovation, environmental and future research is applicable, managerial concepts for integration.

Nevertheless, futures research and environmental management directly aim at integration into regular innovation activities, but so far they lack knowledge on how to be implemented and how to support relevant organizational processes and structures in detail. Innovation management inherits a large basis of processes and managerial concepts, but there is no scientific publication on either environmental or future management integration into an innovation process or organizational structure. In addition, there is no specific application to energy providers or companies within the energy sector in total. This specific context might have been neglected so far, due to the rather low involvement of the industry with innovation management at all.

3.7.3 DERIVED FORM- AND CONTENT-RELATED REQUIREMENTS FROM LITERATURE REVIEW

The following sections give a short summary of the literature findings and therefrom-derived form- and content-related requirements. Form- and content-related requirements are interdependent and in combination provide a unity for further analysis.

**Strategic management requirements**

The concept of strategic management is a general basis to all managerial activities. Major issues identified by strategic management are how external forces shape the company and adaption of internal capabilities to cope with those changes. Hereby, strategic management explicitly highlights the characteristic uncertainty of environment developments. Nevertheless, a formulated corporate strategy guides all corporate activities, which are coordinated by top management.

![Form-and content-related requirements from strategic management research](Author's compilation)

**Figure 6. Form- and content-related requirements from strategic management research (Author’s compilation)**

**STRATEGIC MANAGEMENT**

<table>
<thead>
<tr>
<th>FORM-RELATED REQUIREMENTS</th>
<th>CONTENT RELATED REQUIREMENTS</th>
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<tbody>
<tr>
<td>• Guidance by corporate strategy</td>
<td>• Focused corporate strategy</td>
</tr>
<tr>
<td>• Integration of feedback loops for evaluation</td>
<td>• Aligned business and functional strategy</td>
</tr>
<tr>
<td>• Strategic coordination by top management</td>
<td>• Macro environment screening</td>
</tr>
<tr>
<td>• Clear embedding in organizational structure</td>
<td>• Adaption of internal capabilities</td>
</tr>
</tbody>
</table>
A general basis for management is provided by the strategic management cycle with some important feedback loops to allow for adaption and evaluation. Figure 6 describes the requirements derived from the literature review on strategic management. The strategic management requirements are named, since they basically are a requirement for any process designed for businesses.

**Innovation management requirements**

Innovation management is generally split between its system-theoretical and process-related function, thus an organizational setting and well-crafted innovation strategy is as important as a well-designed and formalized innovation process. The innovation strategy needs to be different in regard to the type of innovation. Research shows four generations of innovation management leading to the combined market pull and technology push thinking. Innovations can be radical or incremental, visualized by the hill-climbing paradigm. The innovation funnel with micro-filters and its later advancement into Cooper’s stage-gate-process provides the basics for any innovation process. In addition to an interdisciplinary innovation team, an initiator, strategist and opponent should escort any innovation process. The team needs sufficient guidance, autonomy and competences. Top management can provide guidance, but some publications warn that it should refrain from micro-management.

Regarding the process itself, stages should be fluid and flexible, at best allowing for simultaneous engineering, while gates need to be taken serious, equipped with senior management gatekeepers and provision of proper evaluation and grading of project ideas. Two major challenges regarding the fuzzy front end are exploring opportunities and processing them into ideas and finally projects.

**INNOVATION MANAGEMENT**

![Form- and content-related requirements derived from innovation management research](Author's compilation)

Even though Pavitt (2005) argues that innovation success is basically based on strong individuals with long experience and explicit traits, this thesis does not follow his point of view. First, because the literature review has shown that a focused strategy, an interdisciplinary team and well-designed and executed process are important success factors, too. Second, because the thesis context, being an
already existing product development unit at a German energy provider, does not allow for putting together an absolute new team of outstanding individuals with long experience in innovation management. Thus, solutions need to keep the current resources and structures in mind. Several other innovation business units probably face a similar challenge, as can be seen in the summarized research gaps and practical challenges presented at the beginning of this subchapter. Figure 7 describes the requirements derived from the extensive literature review on innovation management.

**Environmental management requirements**

In order to be effective, research suggests a proactive, transformative environmental strategy that is embedded within a sound environmental management system that is supported by top management commitment. In addition, commitment to environmental management also requires a commitment to organizational change. An EMS further needs an environmental policy, program and objectives. Environmental management helps organizations to navigate their operations, in dynamic settings described by complexity and uncertainty, towards sustainable development.

Eco-design provides a valuable concept to integrate environmental considerations into product development from the beginning, promoting four different levels of environmental product design. An emerging issue is the promotion of sustainable product-service-systems as a hybrid innovation type with explicit environmental functionality. Later, offensive communication should be used to highlight the environmental functionalities. The focus of eco-design lies on the early phases of product development, where all features of a product or service are defined. The integration of eco-design is facilitate by several methods such as multi-criteria assessments, life-cycle design strategy, life cycle assessment and carbon footprinting; underlying the idea of life cycle thinking overall. Figure 8 describes the requirements derived from the extensive literature review.

**ENVIRONMENTAL MANAGEMENT**

![Form-related and content-related requirements derived from environmental management research](image)

**Futures research requirements**

Strategic foresight, being the business application of futures research, can be a supporting tool with advisory and communication purpose to corporate decision-making, but also serve as a source of
Integrative innovation process model with eco-design and strategic foresight

inspiration for innovation management. Here, integration is emphasised within the early phases of product development.

There are three major tasks, which are represented in the filter, aggregation and translation function of foresight activities. In detail, these are defining problem fields for environment scanning, information gathering and coordination and finally interpretation and analysis of future developments. Scenario and roadmapping techniques both mutually integrate market pull and technology push factors from the environment, being good methods for qualitative analysis and planning.

Major challenges when integrating strategic foresight is resistance against thinking in possible, multiple futures as well as insufficient operative implementation, shown by weak utilization of information, non-continuous set up and lack of focus on needed skills and traits. The idea of a boundary spanner is given. Figure 9 describes the requirements derived from the extensive literature review on futures research.

**FUTURES RESEARCH**

![Form-related and content-related requirements derived from futures research](Author's compilation)

This chapter provides theoretical requirements from different research streams, focusing on their practical challenges to overcome and successful integration into an innovation process. The next chapter explores practical requirements from the specific context of the German energy provider WEMAG.

These requirements on the one hand serve as guidance for the development of the integrative process model; on the other hand they can be used for evaluation of the proposed model in the end.
4 Empirical analysis: Challenges and opportunities of WEMAG AG

This chapter starts with an introduction to the applied methodology, followed by the results of the conducted qualitative analysis methods. Finally, interim results are compiled to describe the derived requirements from the empirical insights.

4.1 Qualitative analysis methodology

A qualitative approach to gather and analysis empirical data was chosen based on the aim and available resources. Since the aim is an exploration of opinions by several individuals, a quantitative analysis is not suitable. Furthermore, a thorough quantitative analysis, i.e. of a range of individuals from several companies, is beyond the scope of this thesis. Qualitative analysis is recommended in literature for exploration of problems (Mayring, 1990; Menz, 2002). It is an “attempt to understand a specific organizational reality and occurring phenomena from the perspective of those involved” (Jonker and Pennink, 2010, p.77).

Within this thesis three qualitative methods are used: company material evaluation, guided interviews and focus group evaluation within a workshop setting. These inductive approaches are useful when the object of research is highly complex and shows little support by currently existing literature (Heinze, 2001; Jonker and Pennink, 2010). The use of three different approaches was chosen to embrace the different target persons and to gather high amount of available data with constraints in available time and other resources. It also serves as an approach of triangulation to utilize, include and combine different data sources in order to clarify a number of aspects of reality at the same time (Jonker and Pennink, 2010).

The target persons in this case can be seen as experts following a definition by Mieg and Näf (2006, p.9), where expert are defined by their societal function: “The expert possess technical process and interpretation knowledge, which derives from his specific professional and occupational action field. Therefore his or her expert knowledge is not only systematic, reflexive and theoretical expertise but has to a large extent the character of functional and practical knowledge [...]”. Accordingly, expert is relative term that has to be defined depending on research question and field. Here, experts are the team members of the business unit being studied and the business unit manager as well as the executive management board. They are defined as relevant experts due to their different insights into organizational structures, daily operation and strategic direction. Their workplace is a context where people can learn through collective acting and reflecting, thus providing learning opportunities and exchange of experiences (Schulz and Geithner, 2010).

4.1.1 DESCRIPTION OF CHOSEN QUALITATIVE METHODS

The material evaluation is understood according to Jonker and Pennink (2010, p.79) as “statements [that] are derived from all kinds of data with the objective of obtaining theoretical insights”. Following Myers (2009) advice they are used as a supplement source to interviews. All documents have been checked for authenticity and representativeness.

Guided interviews allow an open exchange between interview partners and a focus on issues within the general research context decided by the interviewee (Mayring, 1990; Gläser and Laudel, 2009).
They are also called semi-structured interviews due to their use of pre-formulated questions, even though there is no strict adherence to them (Myers, 2009).

The workshop setting for evaluation of and discussion on the internal procedures, structures and strategy allows for a high information density and systematic display of problem areas. In addition, it offers flexibility to discuss arising issues and move the focus during the evaluation depending on the input by the participants. Focus group interviews purpose is to get collective views on a certain defined topic of interest from a group of people who are known to have had certain experiences. The interviewer or moderator directs the enquiry and the interaction among respondents. Focus groups allow participants to engage in thoughtful discussions (Myers, 2009).

In general, limited significance, validity and reliability have to be taken into account due to the input by only a small group of people (Mayring, 1990). Therefore, their input has only a supplementary/supporting function aiming at exploration of the practical realm and consolidation of information/knowledge gained from theory (Bogner, Littig and Menz, 2002).

The procedure is in line with examples by basic literature on qualitative research (Bogner, Littig and Menz, 2002; Mayring 2005; Gläser and Laudel, 2009), but has been refined to fit purpose and scope.

(1) Preparation: interview guideline, workshop agenda based on previous literature review
(2) Conducting of interviews and workshop, taking notes
(3) Display of gathered information in concise summary
(4) Deduction of main requirements
(5) Combination of manager and team inputs

4.1.2 LIMITATIONS

The findings of these qualitative research methods have to be regarded as highly specific and within the company’s context. These results does not allow for generalization for innovation teams or managers overall. They serve an inductive purpose, thus they can be understood as hypothesis that could be tested by further research against other settings. The chosen qualitative method also inherits a low repeatability and open end character. Moreover, qualitative research is closely linked to researcher’s subjectivity with sometimes poor distinction between facts and interpretations.

The derived requirements, for further use to develop the innovation process, are not weighted since the limited source base does not support a relevant weighting. Therefore, all named requirements are considered equally important.

Even though a design research approach is followed throughout this thesis, the underlying impact of the introduction of a research project needs to be acknowledged. Jonker and Pennink (2010, p.60) state that the “sheer act of announcing a research project is already an intervention in a specific reality. […] the moment you are starting a research project in an organization that organization will change – albeit modestly and imperceptibly”. Thus, the diagnoses, interpretation, design and change of an organizational problem needs to be accepted as a fluent process without strict borders.

In general, the triangulation by using three different methods is used to mitigate possible limitations as good as possible.
4.2 Company material analysis

The WEMAG AG is a regional, community-based energy provider who could benefit from the current transition. As a regional utility company the WEMAG AG provides not only green electricity and natural gas, but is due to its corporate group subsidiaries also the grid operator for Mecklenburg-West Pomerania and a contractor for medium to large size solar, wind and combined power and heat production facilities (WEMAG, 2013). Since January 2010 WEMAG AG is majority owned by the municipalities of their supply area. The company achieves with a total of 542 employees a consolidated turnover of 405 million Euros (WEMAG, 2013). However, in the last year the company experienced high losses in the business customer segment (WEMAG, 2013). Their regional business is especially vulnerable due to increasing electricity prices in Mecklenburg-West Pomerania due to low population density and at the same time high transmission charges from increasing investments into renewable energy power capacity (WEMAG, 2013).

The transition of the German energy industry increasingly shows challenges and difficulties to the company. The company is broadly affected by the upcoming changes described in Chapter 2. A strategic direction has been implemented to react on the changing environment while acknowledging the need for a sustainable energy system. Regional attachment, environment protection and a sustainable business model determine the actions of WEMAG according to their webpage (WEMAG, 2013). Since 2009 WEMAG builds renewable energy production facilities to add further value to their certified 100% renewable electricity product for domestic customers. In 2012 WEMAG established a business unit for technical product development (TPD) to further facilitate product innovations for the energy market.

4.2.1 STRUCTURE OF WEMAG AND ITS TECHNICAL PRODUCT DEVELOPMENT UNIT

[REDACTED TEXT]
4.2.2 STRATEGY OF WEMAG [REDACTED TEXT]

WEMAG externally communicates four core values for all their actions, being “ecological, fair, independent, competent” (WEMAG, 2013j). These four strong branches are set up to support the company’s growth and guide them in the future. Their profile states that “regional ties, environmental protection and sustainability determine our actions” (WEMAG, 2013j).
4.2.3 ECOLOGICAL STRATEGY OF WEMAG [REDACTED TEXT]

Externally, WEMAG (2013j) acts with a clear ecological strategy: “As an environmentally conscious company, we are conserving resources and take account of the nature. Looking at the energy revolution we are already thinking about tomorrow.”

The five product areas are all set up as part of WEMAG’s ecological strategy (WEMAG, 2013d):

1. Sustainable energy (green electricity, gas and geothermal)
2. Renewable energy production (Photovoltaic and wind projects)
3. Electric mobility (Cooperation with automotive manufacturers, electric mobility services)
4. Energy efficiency (Energy efficiency consultant office, contracting solutions, domestic production)
5. Energy storage (Power-to-Gas, Battery power plant, domestic storage solutions)

4.2.4 TECHNOLOGICAL PRODUCT DEVELOPMENT DEPARTMENT [REDACTED TEXT]
The ReeVOLT! brand focuses on the product development in the area of self-sufficient, autonomous, sustainable energy system applications for private households and small-sized corporate clients. In addition, TPD engages in large-scale pilot projects for electricity storage and frequency balancing of renewable energy grid feed-in.

Innovation and futures management

Environmental product policy

Currently, the ReeVOLT! product portfolio includes photovoltaic-based energy production, a domestic electricity storage device and electric mobility services. All products serve the purpose of offering solutions for domestic renewable energy production and use from a system perspective. The domestic electricity storage device re-uses batteries from electric bicycles and one electric mobility offer is to substitute combustion engine of passenger cars with an electric drive and battery23.

23 This thesis does not aim at an environmental assessment of the existing products. Yet, it seems useful to shortly introduce the already existing environmental advantages of the developed products to understand the inherent environmental attributes of the products.
4.3 Interviews with management

This section provides the design, limitations and results of the conducted interviews. The protocols from both interviews can be found in Appendix A and B.

4.3.1 INTERVIEW DESIGN

To guide the interview open, leading questions were formulated. They serve as guidance throughout the interview; however the concept of leading questions allows changing, skipping or rephrasing them during the interview. The questions should be seen as non-exhaustive but orientative. The interviewees were given the opportunity to bring up their own points which they thought of as relevant in regard to the general issue.

Leading questions:

1. What is the strategy of TPD and the correlating objectives and justification?
2. What is the focus of the business unit – solely research and development (R&D), product development or startup within the company that incorporates all activities?
3. What are the major problems you are facing in regard to TPD?
4. What is the role of TPD within the corporate sustainability strategy?
5. Is there any environmental product design requirement or strategy?
The answers provided within this section are based on notes from the interview that were condensed afterwards focusing on the most relevant statements in the light of the research questions.

The following rules were followed by the author during conducting the interviews:

- Ask open questions and allow for in-depth answers and descriptions of current situations
- Allow the interviewee to focus on specific issues if he or she thinks they are most important for the research framework
- Guide the interview along the major research questions
- Staying neutral as interviewer
- Enable better understanding by asking helpful questions and clarify terms and issues

### 4.3.2 LIMITATIONS [REDACTED TEXT]

It is important to note that the focus of the qualitative analysis does not lie on the persons themselves, but rather on their opinion based on their experience and knowledge as well as their description of activities that are under their supervision. At the same time, Myers (2009) describes the Hawthorne effect, were interviews are intrusive and can potentially change the situation and influence interactions.

Another methodological constraint is known as the construction of knowledge. This theory states that interviewees want to be seen as knowledgeable thus they might construct knowledge during the interview selling it as experience or otherwise previously gained understanding. These limitations require high awareness when integrating the interview results into the body of knowledge, keeping in mind limited reliability and validity of the information. In the light of this thesis, the statements were thus included as individual requirements from major decision-makers based on their interests and experience but with regard to their power and importance in later implementing the thesis results.

### 4.3.3 CONSOLIDATED INTERVIEW RESULTS [REDACTED TEXT]
4.4 Workshop with technical product development team

This section introduces the applied workshop design and relevant limitations before presenting the consolidated protocol of the discussion. See Appendix D for full documentation of the workshop and a summarized protocol of the discussion.

4.4.1 WORKSHOP DESIGN

The workshop for evaluating the team experiences, concerns and views was conducted without any supervisor around to allow for free and open exchange of opinions and discussions. Two evaluation charts on big papers on the wall were prepared with two matrixes. They served as a method to quickly get an overview of the opinion of all team members without tracking it back to any individual. The participants were asked to mark their opinion within the matrix. If they had no experience or insight into any of the topics, they were asked to leave that row blank. The workshop was divided into two parts; first the participants filled the two evaluation matrixes (a) working environment and (b) tasks, competences and support. The second phase was a moderated discussion on the identified issues based upon the matrix evaluation and other relevant issues brought up by the participants during discussion. During the discussion notes were taken and later condensed to within this thesis.

The following guidelines for good moderation (Herrero, 2012) were followed:

- Ensuring involvement and participation of all participants
- Be neutral and objective
- Create a non-judgmental environment for open discussion
- Keep focus on the important matters
- Enable better understanding by asking helpful questions and clarify terms and issues
- Raise questions for the group to reflect upon and encourage discussion

4.4.2 LIMITATIONS [REDACTED TEXT]

The focus of the qualitative analysis does not lie on the persons themselves, but rather on their opinion based on their experience and knowledge. Limitations of the conducted workshop derive also from general group psychology problems. One major concern could be that the majority is not formed by equal participation but by opinion leaders and minor opinions are not taken into account even though they might pose interesting aspects. Skillful and sensitive workshop moderation can counteract, by directing guiding and facilitating a fair and fruitful discussion.

The workshop setting might mislead to understand the research approach as a participatory method, but this is not the case. The setting was only used in order to allow an open discussion on the evaluation findings.
4.4.3 CONSOLIDATED WORKSHOP RESULTS [REDACTED TEXT]

4.5 Interventions

As stated previously in the research design Section 1.2.1 and limitations Section 4.1.2, the applied design approach of this thesis might lead to changes during its conduction. This actually happened during the execution of the thesis work, influenced and partly initiated by this thesis’ author.

4.6 Interim results: Findings from empirical analysis of WEMAG/TPD

This chapter gained empirical insights by applying three qualitative analysis methods.

4.6.1 ADVANTAGES OF WEMAG AND THEIR TPD DEPARTMENT [REDACTED TEXT]

The company has realized the need for new business models and innovation in the renewable energy sector, their new business unit TPD being evidence. The company attempts to understand and to some degree anticipate the changes in its environment. An advantage of the TPD team is its cross-functionality, including commercial and technical employees as well as support by two sales and
distribution experts. However, the TPD department inherits a creative and innovative culture, which is supported by low hierarchies and decentralized decision-making.

Yet, there is currently no other community-owned energy provider in Germany, who covers this specific and innovative product portfolio in regard to decentralized, self-sufficient energy system solutions including solar energy production, electricity storage and electric mobility. Thus, they inherit a unique competitive advantage as a first mover and provider of system solutions, even though they face high competition in regard to each single product.

4.6.2 MAJOR PRACTICAL CHALLENGES [REDACTED TEXT]

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Table 5. Advantages and challenges of the TPD department of WEMAG AG (Author’s compilation)
4.6.3 DERIVED FORM- AND CONTENT-RELATED REQUIREMENTS FROM QUALITATIVE ANALYSIS [REDACTED TEXT]

Based on the findings of the qualitative analysis, the requirements for a useful innovation management by the participating employees and managers of WEMAG AG are presented in Figure 12. Figure 12 reflects the requirements stated during interviews, workshop and derived from the company material. The synthesis of the list of requirements from each separate qualitative analysis method can be seen in Appendix F. The derived needs are divided into structure-related and content-related requirements as.

**QUALITATIVE ANALYSIS**

**FORM-RELATED REQUIREMENTS**
- Guiding strategy and clear task understanding
- Defined organisational embedding
- Integration of simple, easy-to-use methods
- Flexible structures
- Decentralised decision-making competences
- Streamlining of innovation process

**CONTENT-RELATED REQUIREMENTS**
- Focused strategy for market positioning
- Filter information overload
- Overview on future developments
- Assessment of relevant environment changes
- Generate and collect ideas systematically
- Select ideas transparently and reproducible
- Have a strong market orientation
- Have better information on product environmental performance
- Integrate marketing and distribution plan into product development
- Competence for decision-making

*Figure 12. Form- and content-related requirements derived from qualitative analysis (Author’s compilation)*
5 Synthesis of theoretical and practical findings: Integrative innovation process model

Following the applied design theory approach, this chapter presents the results based on the previous findings from the literature review and qualitative analysis. The major result is a new, integrative process model. This process aims at serving the specific requirements of innovation management in transitional markets and is therefore enriched by concepts and methods of future and environmental management. To secure the practical relevance of the new process model, requirements derived from empirical research are integrated as a second basis.

5.1 Model building methodology

A mental model is an abstract representation of reality. It is a theoretical construct that shows the conjunction of all the characteristic features of something (Jonker and Pennink, 2010). It often serves as a scheme or framework illustrating logical relationships or steps between aspects that matter. In general, a mental model is at first an intellectual idea that gets formalized via several drafts that finally show a visualized mental model with the help of symbols (Dresbach, 1996). This model can be seen as a scientific contribution based on theoretical notions that provide a solution, which can be applied and implemented in reality (Jonker and Pennink, 2010).

Dresbach (1996) cites Bretzke’s (1980) four ways of modelling, (a) by interpretation as in experiences by a person, (b) by describing an intended situation as a decision-proposition, (c) by description of several alternatives as a broad room of action or (d) by building expectations about events and/or their dynamics.

5.1.1 DESCRIPTION OF CHOSEN MODEL BUILDING APPROACH

This thesis follows the second way of modelling, supported by a constructivist model understanding, which refers to model building as a way of modelling the solution to a problem.

The author Dresbach (1996) concludes that the evolutionary act of building the model provides the solution itself. Thus, building a model is an approach to problem solving by analytical means (Sommerlatte, 2002). It further serves explanatory purposes, by simplifying and visualizing an idea, concept or world view. He further makes the link to systems theory, stating that a model puts a problem within its semantic context. Keeping in mind systems theory, a model should take into account the whole picture including interrelations and variables (Sommerlatte, 2002; Jackson, 2003; Jonker and Pennink, 2010). Thus, a model can be understood as a schematic description of an aspect of reality that accounts for all its properties.

The design research type of this thesis is mainly reflected in this part – the process model building. This thesis supports Faste and Faste’s (2012, p.3) conclusion that the ultimate goal of design research is “to improve, not to study” and the definition by Eames (in: Faste and Faste, 2012, p.1) of design as “a plan for arranging elements in such a way as to best accomplish a particular purpose”. It is important to acknowledge, that the process of designing makes “what needs to be organized visible” (Jonker and Pennink, 2010, p.123).
Therefore, this model includes, besides the process, an idea for organizational structure and recommendations for implementation. Only by offering this comprehensive model, the problem can be tackled with all its facets. By this, it covers two products of design science: models and implementations (March and Smith, 1995, in: Gregor, 2006). The proposed management system and recommended implementation plan reflects the applied research type of this thesis. The applied research rationale is met by offering practitioners’ valuable knowledge and applicable methods and processes adapted to the context their company acts in.

Gregor (2006) offers that models can be evaluated for completeness, simplicity, consistency, ease of use, and the quality of results obtained through implementation or use of the model.

5.1.2 LIMITATIONS

The model-building process itself cannot be documented; it requires the conceptual penetration of the problem and analytical solution finding expressed in visualization. Only the final visualization and a description of the elements can be given. Even though it includes form- and content-related requirements, Faste and Faste (2012) warn to not put function over meaning. However, another argumentation by design theory states that form can be meaning by itself (Fendt and Kaminska-Labbé, 2011). The following subchapter will provide a functional model including a description of its content and additional recommendations regarding essential features. Thereby, a balanced approach between function and meaning should be achieved.

However, this integration of different organizational issues leads to limitations regarding the description of details. In order to provide a solution to the problem as a whole, not all parts could be defined in very detail. Those details need to be decided on during the implementation of the model in practice.

5.2 Integrative innovation process model with eco-design and strategic foresight

The previous chapters provided us with valuable insights into theoretical gaps and practical challenges, and derived requirements.

First, the external environment – being the transitioning German energy market – is in general characterised by high complexity, high dynamics and high uncertainty. In addition, different stakeholders increasingly demand sustainable energy solutions and environmentally-friendly products. Second, research shows that traditional innovation management processes do not include foresight or eco-design aspects, even though a range of publications indicate that they could highly benefit from such integration. And third, the need of WEMAG for innovative products is high and their first step was to set up the TPD department, which now lacks a structured process that reaches from environment information to successful products.

Both, research gaps and practical challenges are supposed to be tackled by the introduction of an integrative process model for innovation management enriched with corporate foresight and environmental management. The integrative process model is developed based on the insights and requirements from literature review and qualitative analysis.

Based on the general concept of an idea funnel in combination with the stage-gate-process a new process model is developed incorporating futures research, i.e. strategic foresight, and
Integrative innovation process model with eco-design and strategic foresight

environmental management, i.e. eco-design. The process model is going to be introduced in two steps, to explain from the outside in. First, the general parts are introduced and second, the steps within the innovation process are explained.

Following the systems thinking approach, the new innovation process has interconnections with other elements that are described, too. Figure 13 shows the general outline of the model with four distinctive parts – macro-environment, corporate units, environmental management, the foresight observatory and the innovation process. Each part is described in detail in the following paragraphs.

The corporate units include the WEMAG AG, representing the corporate management and the TPD department, being the innovation business unit.

![Figure 13. General outline of the elements within the integrative innovation process model (Author’s compilation)](image)

### 5.2.1 MACRO-ENVIRONMENT

The macro environment in Figure 13 describes the social, technical, ecological, economic and political environment of the company. Each external environment is represented by several stakeholders, such as customers, competitors, governments, partner, suppliers or research institutes. They can be separated into push or pull factors for new developments. Market player present pull factors (demand-side), while technologies are push factors (supply-side). Regulatory approaches can be either push or pull factors, depending on whether they are designed as an economic incentive or regulatory command and control.

### 5.2.2 CORPORATE UNITS [REDACTED TEXT]

The grey frame with WEMAG AG in Figure 13 represents the corporate vision, mission and strategy, which is the responsibility of the corporate executive management. Here, the executive decision-makers develop a vision, mission and strategy that guides the company overall. In addition, their task
is to facilitate strategic planning and adapting of the corporate strategy and corresponding resources to the changes in the external market.

A department head leads the innovation business units and sets its vision, mission and strategy – often in collaboration with the innovation unit team and within the framework of corporate strategy.

5.2.3 ENVIRONMENTAL MANAGEMENT

To identify and effectively management the potential environmental impact of the company, first an environmental management unit needs to be implemented into core business activities with environmental objectives being equal to economic and social objectives.

The environmental management should follow the general PDCA cycle. The implementation of an environmental management system needs the development of a company environmental policy, strategy and environmental objectives. Those need to be supported by corporate instructions, practices and standards that govern all operations.

The development of the environmental management system is influenced by requirements set by stakeholders and their influence on the company, as indicated by the arrow in Figure 13.

The corporate environmental management unit leads all corporate environmental activities among all business units. Its structure and program needs to be designed to integrate environmental considerations throughout the company’s operations, visualized by the arrows downwards to the innovation unit and sales and distribution department.

This model puts a special focus on the implementation of the environmental objectives in product development. Therefore, a guiding eco-design policy needs to specify environmental objectives for product performance and production following the eco-design principles.

The model indicates this with the arrows from the overall environmental management system down to the environmental product policy, which guides the integration of environmental considerations into the innovation process.

5.2.4 FORESIGHT OBSERVATORY

The observatory in Figure 13 covers the foresight activities and has a trinomial range of duty aiming at structuring information from the fuzzy front end and systematically feeding it into the innovation funnel. It is integrated between the macro environment and the innovation process, highlighting this filter function. Its main task is to feed relevant information into the innovation process to direct idea generation towards emerging opportunities. In addition, it supports strategic planning of the top management as well as strategy formulation of the TPD department. Finally, it also filters stakeholder developments and requirements that are relevant to the environmental management system. The outgoing arrows visualize all these links. Figure 14 pictures the three tasks in detail.

The character required to fulfill the tasks is the boundary-spanner, who can get support from other units and open up a dialogue with external partners of his choice to get additional information or
opinions on current developments. He can either approach these external partners directly or via Delphi studies, round tables, conferences or surveys.

Problem-relevant search fields

The definition of relevant search fields is guided by a given strategic focus. This focus can either derive from corporate executive management, from the TPD department strategy or identified search fields by environmental management. This is reflected in the model by the incoming arrows.

A search field can be a country, a technology, a customer group, an industry branch or any other spatial or temporal boundaries. They set the system boundaries for the main search; however it is the responsibility of the boundary spanner to add other fields when she/he feels they might become interesting as a threat or opportunity to the company or innovation unit. The search fields need to be updated intervallic.

Environment scanning and information gathering

The next step is continuous screening of the environment and gathering of information from external sources.

External sources can be for example, research publications, technology patents, industry or branch reports, media articles, journal articles, economic outlooks, national scenarios, conference papers and round tables with industry experts. In addition, communication with cooperation partners, supplier and distributors can provide a valuable source of information for emerging changes, too.

By using a collaborative online mind mapping tool, information can be easily presorted while keeping a rich information base. The mind map needs to have a collaborative interface to allow other employees to add facts, a link or material quickly, when they discover interesting information.

Additional tools that cover market, technology or regulatory views are trend analysis, market studies, competitors’ analysis, technology scouting, publication analysis and technology life cycle analysis.

Interpretation and contextualization

The most demanding task is to interpret the gathered information and edit it for further use by the innovation unit team or strategic decision-makers. Two integrated methods that cover market and technology views are roadmapping and scenario planning; both can be used to put the information into context.

As indicated by the semi-circle arrow, the observatory is not a one-time only activity but a continuous process of information gathering, interpretation and again setting of search fields.

5.2.5 INNOVATION PROCESS FUNNEL

Figure 14 shows the detailed process model including visualized tasks in each phase and gates with four criteria categories (market, technics, eco and finance). Furthermore, the sales and distribution unit is included since this unit has an important overlay with the innovation unit in the area of commercialization of a product. The market entry phase of the innovation process needs to have the combined support of both units.
Integrative innovation process model with eco-design and strategic foresight

Figure 14. Detailed model of integrative innovation process with eco-design and strategic foresight (Author’s compilation)
The innovation process itself consists of six major phases and gates. A phase represents work in regard to generate content, while a gate is a check-point where criteria guide the evaluation of the outcome of the phase. Each phase has a specific outcome that is generated with the support of specific methods. For each phase, involved participants are named, too. Participants can be innovation unit employees, employees of other corporate departments or external partners and stakeholders.

Each gate has gatekeeper and gate criteria. The gatekeepers need to have enough power to clear the needed resources for the next phase; the decisions have to be made by consensus.

The gate criteria are divided into market, technical, environmental and financial criteria. They weight differently during each gate, indicated by the strong or soft color. To strengthen the environmental considerations, environmental criteria are incorporated equally important to market, technical and financial criteria.

Depending on whether the criteria is met or not, a go, kill or defer decision is made. A go means the allocation of additional resources to facilitate project progress. Until gate three, the process costs are low to medium deriving mainly from personnel costs. From gate three major financial resources are needed, but tough criteria should ensure low risk. A go decision in gate three includes allocation of rather substantial investments for real product development, maybe even production setup, and expert market studies for the marketing plan.

Killed projects land in the idea bin, but deferred projects are moved to the idea bank for recycling. A defer decision option is included, in addition to the simple go or kill decision proposed by Cooper, to allow re-use of an idea at a later point in time. For example, a project could be deferred to the idea pool when it does not seem suitable to the market or strategy yet. The idea pool feeds them back into the second phase, when their suitability has improved.

The gatekeepers are mostly the innovation team, the project team and the head of department, thus ensuring an interdisciplinary perspective and decentralized and rather quick decision-making. Since in gate three and five major resources must be allocated, all senior managers who own those resources need to be gatekeeper. Appendix G provides a table, where the methods and participants respectively criteria and gatekeepers are listed in detail.

Even though not indicated by additional arrows, it is possible to execute work packages from later phases to increase project speed. This does not mean that gates can be skipped, but activities or deliverables can be bypassed or omitted. However, repetition and detours between product development and product testing are normal and therefore explicitly marked by bold white arrows in Figure 14.

Another important aspect is the differentiation between the innovation team, which includes all employees of the innovation business unit, and a project team, which is an interdisciplinary team with technical, marketing, environmental and financial knowledge set up for a project of specific product development. The initiator role needs to be played by all innovation unit employees and the department head during regular brainstorming sessions for idea generation. The head of the innovation department is the strategist, who sets the general strategy and decides which products or projects to process from a strategic perspective. The opponent is covered by the interdisciplinary team, here each team member serves as an opponent to ideas by others and needs to check them based on his or her knowledge and experience.
In order to enhance the learning curve for products and the product development process, a product review and a process evaluation is integrated.

The product review focuses on the commercialization phase, where experience with the product from customers and the sales and distribution department needs to be gathered and channeled to either new idea generation or product improvements during product development. The feedback should be collected continuously and evaluated, when new ideas are generated or the product needs further development.

The process evaluation should take place periodically every three months to exchange experience with problems and solution during product development and adapt process structures or flows if necessary.

5.3 Recommendations for strategic focus and organizational change

Based on the insights gained through the literature review and qualitative methods application, additional recommendations for the strategic focus of the TPD department and its position within the company’s structure are formulated.

5.3.1 RECOMMENDATION FOR STRATEGIC FOCUS OF TPD [REDACTED TEXT]

5.3.2 SUGGESTION FOR ORGANIZATIONAL STRUCTURE [REDACTED TEXT]
Another medium-term achievement should be the implementation of an environmental management support unit under executive management leadership as shown in Figure 15. This unit is responsible for developing and implementing the environmental management system based on an environmental vision, mission, strategy and policy. The unit is further responsible to provide guidance and supporting tools for implementing the environmental requirements throughout the company.

Similar argumentation applies for the strategic foresight activities, therefore a transition of the observatory from a direct business unit functionality towards an executive management support unit is recommended. Thereby, the observatory can support other business segments, too. However, such a transition requires financial and personal resources. In the long run it might be useful to have one strategic foresight observatory and several boundary-spanner in each business segment, thus being able to relate the information from and to each business segment with its special needs and search fields.

Figure 15. Suggestion for organizational structure (Author’s compilation)

5.4 Interim results: Advantages of the integrative innovation process model with eco-design and strategic foresight

The integrative innovation process model is a conceptual and operational blueprint for generating innovations from opportunity seizing to commercialization. Besides improving effectiveness and efficiency, it integrates future and environmental management for strategic planning, adaption and focus.

Based on the combined form- and content-related requirements derived from theory and practice, an integrative process model has been introduced. The model has four distinctive parts: the macro-environment, corporate units, environmental management, the foresight observatory and the innovation process.

In detail, the foresight observatory has a threefold-task that feeds into corporate and business strategy formulation and strategic planning as well as into the innovation funnel to support idea generation.
The innovation management is separated into phases and gates to systematically channel ideas into projects and finally into products that are marketable. Key features are (a) the equal integration of market and environmental criteria in addition to common technical and financial criteria, (b) phases with clear deliverables, applicable methods and responsible staff and (c) gates that support transparent and effective decision-making and provide the needed resources for the next phase.

Furthermore, recommendations for a strategic focus and organizational change for better structuring of the TDP department are given.

The proposed focus of strategy supports a clear competitive profile and strategic positioning as a provider of sustainable, high-quality system solutions supporting the German energy market transition.

The changed organizational embedding provides better strategic alignment with emerging market conditions and strengthening of corporate competitive advantage by diversification of its business models.
6 Discussion

This chapter starts with a summary of the research results, followed by an evaluation of the integrative innovation process model based on the derived requirements. Furthermore, the conducted research is evaluated from a methodological point of view. Finally, the author advises on essential activities for the company WEMAG and possible future research activities by the scientific community.

6.1 Summary of thesis course and results

For better guidance and overview, Table 6 on the next page schematically summarizes the course and major findings and results of this thesis.

The problematic situation outlined in Chapter 2 introduced the transitional German energy system and the deriving challenges for traditional energy providers. A highly uncertain business environment with many challenging shifts was identified. Complexity, dynamism and ambiguity require an interdisciplinary systems approach to develop applicable solutions. While previous solution-seeking focused on analytical and linear thinking, today more systematic and interactive approaches are essential.

Based on this, the following Chapter 3 provides a literature review of relevant research streams and their contributions and gaps. Major research gaps and resulting requirements are named. Parallel to the literature review a qualitative analysis was conducted, with the results presented in Chapter 4. A combination of several qualitative methods provides the identification of major practical needs and requirements. Both, theoretical and practical findings, provide a strong foundation for the model-building.

Finally, a synthesis of those theoretical and practical findings and the derived requirements leads to the modelling of a new, integrative innovation process model presented in Chapter 5. In addition, assisting recommendations for strategic focus and organisational structure are stated.

These results provide the answer to the theoretical and practical research questions specified in the beginning of the research project.

The detailed results are stated in the interim result Sections 2.3, 3.7 and 4.6, Table 6 summarizes these findings. The following sections evaluate the results and thesis work in two steps. First the integrative innovation process model is discussed according to the fulfilment of the derived requirements. Second, the thesis work is evaluated in regard to its methodology. Finally, implications for future WEMAG activities as well as future research are stated.
### Table 6. Summary of thesis course and results (Author’s compilation)

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<th>PRACTICAL RESEARCH QUESTION</th>
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<td><strong>THEORETICAL RESEARCH QUESTION</strong></td>
<td>How can strategic innovation processes in uncertain environments benefit from environmental and future research contributions?</td>
<td>How should a strategic innovation management of the technical product development (TPD) department of the WEMAG AG look like to position them favourably in regard of the current transitions in the energy market in Germany?</td>
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<th>CHALLENGES FOR TRADITIONAL ENERGY PROVIDERS</th>
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<td><strong>TRANSITION OF GERMAN ENERGY SYSTEM</strong></td>
<td>Complex and dynamic business environment</td>
<td>Low experience with tangible products</td>
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<td>Increase of regulations targeting environmental product performance</td>
<td>Need for product innovations</td>
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<td>Uncertainty about future developments</td>
<td>Change towards product-service-innovations</td>
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<td>Demand for environmentally-friendly products</td>
<td>Lack of structured innovation process</td>
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<th>RESEARCH INSIGHTS</th>
<th>RESEARCH GAPS</th>
<th>PRACTICAL NEEDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESEARCH GAPS</strong></td>
<td>Missing link between innovation management and corporate foresight and environmental management</td>
<td>A structured innovation process</td>
</tr>
<tr>
<td></td>
<td>Lack of practice-relevant, contextual innovation processes</td>
<td>Transparent, rationale and guided idea and project selection</td>
</tr>
<tr>
<td></td>
<td>Insufficient processing of ideas into tangible product-service-innovations</td>
<td>Systematic idea generation and processing</td>
</tr>
<tr>
<td></td>
<td>Lack of method support for systematic seizing of opportunities</td>
<td>Better future preparedness</td>
</tr>
<tr>
<td></td>
<td>Missing integration of eco-design into product development</td>
<td>Constant market-orientation and insights</td>
</tr>
<tr>
<td><strong>PRACTICAL NEEDS</strong></td>
<td>Integration of simple environmental assessment tools</td>
<td>Integration of strategic foresight for environment scanning and exploration</td>
</tr>
<tr>
<td></td>
<td>Organisation of high amount of unstructured information</td>
<td>Interconnections with corporate and business unit management</td>
</tr>
<tr>
<td></td>
<td>Guiding strategy and common understanding</td>
<td>Recommended strategic focus</td>
</tr>
<tr>
<td></td>
<td>Flexibility and decentralised decision-making</td>
<td>Focus on unique environmental competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Soft approach towards change</td>
<td>Focus on sustainable energy product-service-systems</td>
</tr>
<tr>
<td></td>
<td>Clear organizational embedding</td>
<td>Suggested organizational embedding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESULTS</th>
<th>THEORETICAL RELEVANCE</th>
<th>PRACTICAL RELEVANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THEORETICAL RELEVANCE</strong></td>
<td>Integrative innovation process model benefiting from strategic foresight and eco-design</td>
<td>Integrative innovation process model benefiting from strategic foresight and eco-design</td>
</tr>
<tr>
<td></td>
<td>Systematic planning and processing of opportunities into marketable products and services</td>
<td>Interconnections with corporate and business unit management</td>
</tr>
<tr>
<td></td>
<td>Systematic integration of environmental objectives into product development</td>
<td>Recommended strategic focus</td>
</tr>
<tr>
<td></td>
<td>Systematic integration of strategic foresight for environment scanning and exploration</td>
<td>Focus on unique environmental competitive advantage</td>
</tr>
<tr>
<td><strong>PRACTICAL RELEVANCE</strong></td>
<td>Mid- and long-term transition of current organizational structure to strategic foresight and environmental management support units</td>
<td>Focus on sustainable energy product-service-systems</td>
</tr>
<tr>
<td></td>
<td>Suggested organizational embedding</td>
<td>Suggested organizational embedding</td>
</tr>
</tbody>
</table>
6.2 Evaluation of the results

This subchapter focuses on the evaluation of the results presented in Chapter 5, being the integrative innovation process model and recommendations for strategic focus and organizational structure. The evaluation is conducted along the derived requirements from theoretical and practical analysis, which can be found in the interim result Sections 3.7 and 4.6.

6.2.1 BENEFITS OF INNOVATION AND STRATEGIC MANAGEMENT FROM INTEGRATION OF ECO-DESIGN AND STRATEGIC FORESIGHT

Strategic management content-related requirements benefit mainly from strategic foresight activities, since the observatory work allows a better strategic planning and focused corporate strategy in regard to future developments. It is especially beneficial for the macro environment screening by structuring and systematizing the screening activities. This reflects the findings from previous studies as stated in the literature review. A detailed list with an evaluation of each strategic management requirement is given in Appendix H.

The content-related requirements regarding aligned business and functional strategy as well as regarding the adoption of internal capabilities cannot be assessed within the model. Reason being that they can only be fulfilled by executive management or head of department in reality. However, they are an important foundation for the successful execution of the innovation process model.

The twofold task of innovation management is reflected within the model, since it does not only describe the innovation process in detail (process-related role), but also its embedding and interconnections with relevant elements such as executive management, business units and macro environment (system-theoretical role). Its process-related role should not mislead the use of the new process as a tool for micro management by executive management, auditors or others. It is explicitly designed to support the TPD department by streamlining their product development activities and provide guidance for successful innovation management.

The front-end, often identified as problematic and fuzzy, is strongly supported and guided by the introduction of the observatory and its included methods. Nevertheless, the balance between promoting creativity while at the same time trying to structure the generation of ideas better stays a crucial aspect of innovation management. Besides including decentralized decision-making and work package shifting, there are probably other aspects that could further facilitate the flexibility of the process, which are not included in this model. Other studies name for example simultaneous engineering to increase fluidity and flexibility.

The observatory further supports the integration of market, technology and legislation pull and push factors. Even though this gives a strong market orientation in the beginning, direct communication channels from market insights gained within the observatory throughout the whole process might be useful to ensure continuous updating and alignment. Here, the integration of the idea pool for recycling allows postponing and re-using ideas for which the time to market does not fit at the time of their appearance.

The eco-design approach gives a clear focus and unique selling argument. Managers’ willingness to cannibalize is not included in the model, since it presents a change of rather psychological nature of each manager. A detailed list with an evaluation of each innovation management requirements is given in Appendix H.
The introduced integrative innovation process model inherits some strong advantages over traditional innovation processes that do not include environmental management or futures research aspects. The environmental product policy gives normative guidance in uncertain environments and the eco-design integration provides market niches and a unique competitive advantage. At the same time, strategic foresight activities support explorative opening of a company and its innovation unit to proactively anticipate changes and think in possible futures. The observatory puts environment analysis into a system of screening, analysis and interpretation.

These advantages are consistent with previous findings in literature that describe the benefits of environmental management and strategic foresight. However, the integrative innovation process model incorporates them into a traditional innovation process and shows their interaction, thus providing a systematic approach to integrating the previously rather one-sided perspective from either innovation, environmental or futures research streams.

In short, the major advantages of the introduced model are:

1. holistic process and interaction description
2. transparent decision-making
3. strong focus on environmental considerations as advantages
4. strong market orientation while keeping technology and legislation factors integrated
5. continuous screening and analysis of the environment and its changes

### 6.2.2 INTEGRATION OF ENVIRONMENTAL MANAGEMENT AND STRATEGIC FORESIGHT REQUIREMENTS

The conducted research and its result are significant to the environmental management, i.e. eco-design, and futures research, i.e. strategic foresight, scientific and practical debate due to their interdisciplinary and applied perspective. This perspective provides an outlook in regards to how environmental management and strategic foresight can be beneficial for traditional management theory and practice. Both research streams have been deeply integrated into the new innovation process model.

A difficult aspect is to keep the balance between simple, easy-to-use methods that allow for quick integration and complex methods that generate more detailed and valid information. The reviewed literature focuses more on complex life cycle analysis tools; simple methods are mainly named and merely explained.

Most of the futures research requirements are met. Yet, a cultural change towards open thinking in multiple futures is hard to assess, to integrate and to promote. This aspect should be part of any future research regarding the successful integration of strategic foresight into innovation management.

One major shortcoming of the proposed model so far is its missing use of the observatory at a later phase during product development. To further enhance its cross-functionality, other units besides the innovation department should benefit from it too. In addition, there is no connection to each single project team yet, even though they might be in need of information regarding the macro environment at a later point after idea generation.

A detailed list with evaluation of each environmental management and futures research requirement is given in Appendix H.
6.2.3 INTEGRATION OF PRACTICAL REQUIREMENTS

Evaluation of conducted research
This subchapter discusses the conducted research from a scientific perspective, arguing whether aim, objectives and research questions are met and how research design and applied methodologies influenced the results. Finally, the generalization of the results is discussed.

6.3.1 AIM, OBJECTIVES AND RESEARCH QUESTIONS [REDACTED TEXT]

The objectives are accomplished throughout the thesis, guiding the work towards the aim. The aim of the study is achieved by the provision of the integrative innovation process model, which can be used by the TPD department of WEMAG. Environmental management features as well as futures research features are supporting the innovation process, thereby supporting the process of decision-making for an environmentally-friendly new product and service development in the transitional German energy market.

**Theory research question**

The introduced integrative process model shows how a strategic innovation process in uncertain environments like transitional markets can benefit from environmental and future management. Thereby it answers the theoretical research question, which is guiding this thesis:

“How can a strategic innovation process in uncertain environments look like that benefits from environmental and future management?”

The proactive integration of environmental product policy into the innovation process positions the products in favour of future market developments, strengthens the competitive advantage of the products, opens up new market niches and target groups and can even lead to financial savings due to eco-design of the product itself and its production. In addition, eco-designed products support a progressive corporate image and stimulate positive stakeholder perception.

The observatory allows for early and systematic identification, evaluation and editing of relevant changes in the environment that can lead to threats or opportunities to the company or its innovation activities. The fuzzy front end of innovation management is systematically assessed and structured with the support of several relevant methods. Information is filtered and edited for communication throughout the company. The results from the observatory decrease uncertainty and put information into context. The observatory further directs strategic planning and thereby promotes the adaption of the whole innovation process when market conditions change. New and emerging markets are anticipated early by the boundary-spanner and proactive market cultivation is stimulated.

**Practical research question**

Furthermore, the proposed integrative innovation process serves as a valuable basis for a strategic management of the TPD department. Consequently, the practical research question “How should a strategic innovation management of the technical product development (TPD) department of the WEMAG AG look like to position them favourably in regard of the current transitions in the energy market in Germany?” is answered.
6.3.2 RESEARCH DESIGN

The followed design theory type provides the best framework for developing academic solutions to real-life problems of managerial decision-makers. Besides designing models, their implementation can also be part of design theory. Unfortunately, implementation of the developed process model was not possible with the given time constraints. Thus, the model waits for further empirical verification.

The thesis also shows elements from deductive and inductive research. On one hand, the collection and synthesis of practical needs with common innovation management challenges shows a great overlay, which can be understood as theory-testing of innovation research assumptions by empirical evidence. On the other hand, the shown advantages by integrating eco-design and strategic foresight into an innovation process can be understood as a first step in theory-developing.

Not only did the literature review show a relevance gap, by academic results not contributing to practice problems, but the qualitative research also discovered a need for in-depth understanding of innovation management and related scientific findings. Hence, the applied research approach provided insights for theory and practice.

By combining different research disciplines, this thesis follows a clear interdisciplinary understanding. Cross-fertilization is strongly achieved, as shown by the gained benefits from integrating other research streams into management studies to provide sustainable solutions.

In general, the chosen research design provided a good framework and guidance to achieve the set aim and to answer the research questions.

6.3.3 APPLIED METHODOLOGIES

The literature review helped to introduce the different research streams and their unique perspectives, while highlighting their interconnections or lack of integration. Besides the identification of those links and research gaps, the focus on identified challenges and benefits from practical implementation gave a valuable basis for developing the innovation process model.

The qualitative analysis explored challenges and needs perceived by the innovation team of TPD and its management. However, the results are quite limited due to the low number of participants and the focus on one single company. Nevertheless, the previous findings from theory are reflected in the empirical findings. Thus, the derived practice insights are most likely common challenges of innovation management. After all, the qualitative analysis was necessary to ensure that that developed innovation process fits its specific context and is implementable by the company.

As introduced in the model-building methodology chapter, there are five criteria for model assessment: completeness, simplicity, ease of use, consistency and quality of results.

Completeness is achieved to a large degree by including all relevant actors influencing and shaping the innovation process, such as the macro environment stakeholder, executive management, the sales and distribution department and the innovation management unit itself. The model also contains all information it needs to describe the functionality of the system. The macro environment
focuses on the different environment spheres, but a detailed description of relevant stakeholders is not given. In addition, other business units e.g. finance, controlling, public relations, human relations, are not included. They are partly not included due to their low relevance and less complex connection to the innovation process, partly due to the trade-off between completeness and simplicity. In order to provide a comparatively simple model, only major elements and their interconnections were included based on the theoretical and practical findings. Keeping the applied research approach in mind, simplicity is also desired so that managers understand the model. Therefore, ease of use is of high importance for success. The visualization aims at providing this easy application. Yet, the ease of use can only be tested during implementation. The third criterion for assessment is consistency. Consistency is achieved when the model is coherent with similar models and fits into the rest of the organization. The model is based on traditional innovation processes and recommendations for embedding it within the current organization are given. Nevertheless, during implementation new challenges might occur that require some adaptations to improve its fit.

Finally, quality of results can only be obtained through implementation or use of the model and this is explicitly not part of this thesis. Therefore, the assessment of the criteria could be part of a future research project which monitors the implementation of the built model.

6.3.4 GENERALIZATION OF RESULTS

The generality of the results is limited to a specific inquiry within substantive theory. Application of the results to other companies or a different context is questionable. Still, the literature review also includes practical challenges identified by research thus adding a more general perspective to the results from the qualitative analysis. The high analogy of practical challenges listed in innovation theory and the practical challenges identified through qualitative analysis indicates a generality of those challenges and thus their possible application to other companies and their innovation processes, especially within the German energy market.

In regard to the advantages gained from integrating environmental management and strategic foresight into an innovation process, it is very likely, as indicated by the literature review, that these can be gained also by other concepts of integration as long as the requirements are met, too. In general, the integrative innovation process is a blueprint and as that can be used by other companies with similar context, too. However, the existing innovation department at WEMAG is an essential foundation, which would need to exist or to be set up by any other company pursuing to implement an innovation process for product development.

Naturally, the recommendations for strategy and organizational structure are very specific.

The causality of the thesis is hard to assess, since it has a qualitative not quantitative character. Nevertheless, the thesis gives causal explanations how the implementation of this integrative innovation process model can lead to substantial benefits for the company, when implemented by executive management or the head of department.

Ultimately, a generalization of the results is possible but needs further scientific verification. The generalization applies especially to other traditional energy providers in the German energy market due to their similar problems and environment conditions. Validity of the research results is given by its possible generalization and basic causality, but additional research to further validate the results is needed.
6.4 Implications for WEMAG practice and scientific research

The findings show important implications for future research and practice. This subchapter offers suggestions how the findings should be used within the company as well as within the research community.

6.4.1 OUTLOOK FOR WEMAG [REDACTED TEXT]

Before implementing the integrative innovation process model the right foundation must be laid. Therefore, some essential aspects regarding commitment and resources must be agreed on beforehand.

Overall, the implementation should go along with an initiative directed at change management within the company and a project management approach for micro management of the ideas and products in the innovation department. Part of the implementation is also to further define and align the criteria and deliverables of each phase and gate.

Table 7. Essential foundation for implementing the integrative innovation process (Author’s compilation)

Without commitment to these essentials, implementing the process and trying to gain success from it is prone to fail.

Demands on top management (executive managers)
Demands on senior management (head of innovation department)

Since the innovation’s team major task is to deliver the phases of the innovation process, there are not so many demands beforehand. After all, their job is less building the foundation and more daily implementation of the innovation process.

Nevertheless, the willingness to cannibalize is important for the team, too, since they need to be able to let go of ideas or products they often feel personally bond to. A special requirement for team work within this context is to equally integrate experts with different backgrounds, i.e. business administration, technology, marketing or eco-design, and try to benefit from those different

Demands on innovation team (TPD department team)

Since the innovation’s team major task is to deliver the phases of the innovation process, there are not so many demands beforehand. After all, their job is less building the foundation and more daily implementation of the innovation process.

Nevertheless, the willingness to cannibalize is important for the team, too, since they need to be able to let go of ideas or products they often feel personally bond to. A special requirement for team work within this context is to equally integrate experts with different backgrounds, i.e. business administration, technology, marketing or eco-design, and try to benefit from those different
perspectives. The team needs to commit to follow the phases and gates, except the possibility to move work packages as discussed previously. Besides situational flexibility, the process needs to be evaluated in set intervals to be able to adapt the process to new conditions. The team members need to take time for evaluation, in addition to their operative workload.

6.4.2 PROSPECTS FOR FUTURE RESEARCH

Instead of taking the different research streams perspective from the beginning of this thesis, here the integrative, interdisciplinary research is highlighted as the major issue for future studies. The results of this thesis provide a good starting point for this integrative perspective, which combines interdisciplinary research with an applied approach thereby bridging theory and practice. Thus, this thesis also is a first attempt to fill the current research-relevance gap.

Interdisciplinary, applied research strategies are an underlying recommendation for all future study suggestions here.

The build model should be understood as a proposal for a new, interdisciplinary innovation theory that needs to be further induced by additional data analysis and tested by various hypotheses in a following research process.

Looking at the innovation process itself, future research should first assess its implementation. This means assessing the results of the implementation within this specific company WEMAG, but also other companies and possibly also from other branches. Thereby, more practical insights can be gained and the model further adjusted.

Theoretical research should focus on methodological support for idea or product assessment, with a focus on environmental assessment and integration of foresight insights. An overview of a broad range of methods and their suitability for different experts, situations or needs would be helpful.

From a futures research perspective better integration of strategic foresight activities throughout the whole innovation process is an important topic to study and present solutions.

From an environmental management perspective, the benefits of integrating it into corporate activities are well document, but the still lacking detailed process integration should be focused on. Here, relevant criteria and their assessment could be one aspect for future studies. Taking into consideration product-service-systems, the criteria and their assessment should be developed with this specific kind of product development in mind.

Since the research on product-service-system is still developing, more qualitative as well as quantitative studies are obviously needed. Here again, an interdisciplinary approach that for example includes futures research and environmental management aspects from the beginning would be interesting.

Finally, this thesis touches a broad range of subjects, due to its interdisciplinary approach but also due to the interconnections of the highlighted research streams with other research fields, which should be taken up and explored more thoroughly. Two major fields are change management towards innovative, open and life cycle thinking and transformation management to get from the current to the target state. As indicated in the literature review, the fourth generation of innovation management currently discusses open innovation concepts; their relevance for product-service-systems should be looked into, too.
Besides the corporate perspective taken by this thesis, the political level is important, too. Since the transformation of the German energy market is a political decision, an analysis of corresponding political measures is important and should be part of the focus of future studies.
7 Concluding remarks

Throughout this project the main aim was to identify possible enrichment of innovation management from futures research and environmental management integration. Following the applied research approach, this integration should be within a practice-relevant model.

This was ultimately achieved through an extensive literature review as a method to identify where the major advantages and research gaps lie. Eco-design and strategic foresight were recognized as especially relevant to product development activities. In addition, form- and content-related requirements for the model-building process were derived. The practice context of the company WEMAG, i.e. its technical product development department, with its specific needs and requirements was analysed through material evaluation, interviews and a team workshop.

The integrative process model and accompanying recommendations serve as a blueprint and decision memo for WEMAGs innovation management. Furthermore, they can possibly stimulate a new research field on interdisciplinary, applied innovation, environmental and futures management. The results are thoroughly discussed and evaluated from a substantial and methodological perspective. The implications for practice and research represent the author’s findings through literature review and qualitative analysis.

After deep analysis, the author concludes that integrating eco-design and strategic foresight into innovation management on a strategy and process level contains major advantages for managerial practice, especially in uncertain environments. It provides the opportunity to explore future developments while having normative guidance towards a sustainable development, which also provides unique advantages for market positioning and successful competition. The integrative innovation process model offers a tremendous opportunity for WEMAG to incorporate their ecological strategy and to professionalize their innovation activities. The results do not only present a model ready for implementation, but also support its successful realization by strategic recommendations as well as identifying the required foundation on all levels.

In addition, the interdisciplinary approach based on systems thinking appears to be a valuable method to conduct theoretical analysis of activities and processes in complex and dynamic environments and is therefore highly recommended for further studies.

Consequently, the transition towards sustainable development of the energy market – including energy generation, distribution, usage and storage – requires strong involvement of all stakeholders from all societal levels, i.e. consumers, business leaders and political decision-makers. The product development department of WEMAG is a very good start, but from a macro economic perspective more innovation activities like theirs need to happen to increase competition and speed of market transition. Finally, these corporate processes should be paralleled by political discussion and corresponding measures to promote environmentally-friendly innovations and their diffusion among all social groups. As long as there is no social and cultural coherence, no sustainable product-service-system, no matter how innovative it is, can change the environment-destroying path society is heading to.
Bibliography


Integrative innovation process model with eco-design and strategic foresight


Integrative innovation process model with eco-design and strategic foresight


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WEMAG, 2013b.

WEMAG, 2013c.

WEMAG, 2013d.

WEMAG, 2013e.

WEMAG, 2013f.

WEMAG, 2013g.

WEMAG, 2013h.

WEMAG, 2013i.

Integrative innovation process model with eco-design and strategic foresight


Appendices

Background information and detailed lists of findings in addition to the main report.

Appendix A: Interview protocol [REDACTED TEXT]
Appendix B: Interview protocol

[REDACTED TEXT]
Appendix C: Detailed list of findings from conducted interviews
[REDACTED TEXT]

Table A-1. Derived requirements from conducted interviews (Author’s compilation)

<table>
<thead>
<tr>
<th>REQUIREMENTS STATED IN CONDUCTED INTERVIEWS</th>
<th>EXECUTIVE MANAGEMENT</th>
<th>SENIOR MANAGEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better integration into traditional WEMAG business activities and culture</td>
<td>Integration of development of marketing and distribution plan into product development</td>
<td></td>
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<tr>
<td>Transparent decisions</td>
<td>Integration of market insights (customer demands and market developments) into product development</td>
<td></td>
</tr>
<tr>
<td>Clear risk assessment</td>
<td>Use future management as observatory support</td>
<td></td>
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<tr>
<td>Integrate future management for better insights</td>
<td>Keep low hierarchies</td>
<td></td>
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<tr>
<td>Allow for flexible strategy</td>
<td>Allow for self-responsibility and decentralized decision-making</td>
<td></td>
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<tr>
<td>Focus on external drivers for environmental management</td>
<td>Professionalize product development activities</td>
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<tr>
<td>Keep trial and error culture</td>
<td>Provide better product information/project management</td>
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<tr>
<td>Use available capacities</td>
<td>Keep flexible approach</td>
<td></td>
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<tr>
<td>Better market orientation</td>
<td>Develop overall, guiding strategy</td>
<td></td>
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<tr>
<td>Top management decision on general direction and organizational set up</td>
<td>Environmental assessment integration with low resource capacity</td>
<td></td>
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<tr>
<td>Sales department inclusive &gt; needs other competences than current</td>
<td></td>
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</table>
Appendix D: Workshop documentation (flipchart and discussion)  
[REDACTED TEXT]

Figure A-1. Photography of flipchart evaluation about working environment (Author’s licence)
Table A-2. Translation of flipchart evaluation about working environment (Author’s compilation)

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>GENERAL RATING</th>
<th>COMMENTS DURING DISCUSSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I know the goals and major tasks of TPD</td>
<td></td>
<td></td>
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</tbody>
</table>
| Intermediate with tendency to bad                                       |                | Where do we belong? Is organizational chart still right? /
| Unsure about core activities of TPD                                      |                | /
| no Vision and mission of TPD                                            |                | /
| I feel sufficiently informed about TPD activities                       |                | Minor good points, others intermediate with tendency to bad /
| Difficult to keep balance between general and specific information need |                | /
| More projects add to information overflow, not all information relevant for everyone |                | /
| Good methods exist to collect ideas                                     |                | Intermediate with tendency to bad /
| Collection of ideas happens but absolutely uncoordinated and without evaluation |                | /
| I have sufficient time for idea generation                             |                | Intermediate with tendency to bad /
| Improvement ideas found during activities but new product ideas need more creative space and time |                | /
| I can drive my ideas                                                   | Good          | I can realize my ideas /
| Intermediate with tendency to good                                      |                | Canalization of ideas not professional, organized or somehow structured /
| I can cope with my work load without compromising on quality            | Range from good to bad, light tendency to intermediate | Still okay and phases during year are very different, in total often balanced /
| I feel myself well supported by TPD management                          | Good, slight drift to intermediate | Sometimes a little bit lost without guidance /
| High responsibility for decision making /
| Good trial and error culture                                            |                | I feel myself well supported by other units /
| Intermediate and good balanced                                          |                | Sometimes Feel like lone warrior against traditional WEMAG/other departments /
| I feel myself well supported by my team                                 | Good          | Team sticks together, very good team culture /
| I feel myself good supported by top management                          | Intermediate | Communication by top management sometimes unclear, hard to understand their strategy and general direction /
| Wish for clear commitment and perspective                               |                | Collaration with other units works well /
| Intermediate and good balanced                                          |                | Personal contacts work well /
| General structures less good                                            |                | I am interested into environmental impacts of TPD /
| Broad range from good to intermediate                                   |                | Intrinsic interest /
| Acknowledgement of driving customer demand /
| Stakeholder awareness                                                  |                | Knowledge differs /
| No information available /
| General feeling, that products have low environmental impact and compared to other solutions – are the best option in regard to renewable energy use |                |
Figure A-2. Photography of flipchart evaluation about task distribution (Author’s licence)
Table A-3. *Translation of flipchart evaluation about task distribution* (Author’s compilation)

<table>
<thead>
<tr>
<th>TASK</th>
<th>CURRENT SITUATION</th>
<th>TARGET SITUATION</th>
<th>PERSONAL COMPETENCES</th>
<th>COMMENTS DURING DISCUSSION</th>
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</table>
Discussion protocol – team workshop:

The discussion brought up two major issues that are regarded as very challenging by the team. First, decision-making on products in market entry phase is difficult due to lack of evaluation and lacking structures to kick a product out. Within this issue all team members wish for better project management, professionalization of their own work and streamlining of currently undefined processes. The second major issue is lack of knowledge about the general business unit strategy and how it is embedded in corporate strategy. The team stated a high need for top management decisions and clear communication about the department’s future, structure and goals.

During the discussion, several other topics were touched. The team endorses the flexibility, low hierarchy, high self-responsibility and decentralized decision-making. Even though, they sometimes miss guidance, when being unsure about future developments. Most team members also expressed their wish to concentrate more on idea generation and channeling of those ideas into product drafts. The high information income is not evenly met by any evaluation approach. Decisions are made rather ad-hoc without clear knowledge about possible future developments. At the same time, they acknowledge the limited resources they have. All employees are involved in product development of existing products, which is regarded as important to not lose their first mover advantage on the market. Some participants also expressed the problem of them spending too much time on marketing efforts for the ReeVOLT! brand, e.g. fairs and exhibitions. On one hand they articulate their experience that support from other departments does not really help due to (a) lower identification with the products and (b) the general high explanation need of technical, customized products that cannot be learned in a day. On the other hand, valuable TPD employees should be better allocated for core product development activities.

Finally, the discussion let to the notion that working with limited resources is a constant constraint and requires thoughtful but clear priority setting and better support and allocation of resources from other departments via top management decision. Collaboration with other departments works out very differently, depending on personal contacts. In general, the team would like to hand over products completely to sales and distribution but they fear low commitment to those products by the other departments. In addition, information transport is challenging due to the ongoing changes of products even during market entry. Another lack of information issue regards the environmental performance of the products. Most participants feel certain about the positive impact during usage phase, but they have no accessible information about impacts by other phases.
Appendix E: Detailed list of findings from team workshop [REDACTED TEXT]

Table A-4. Derived requirements from the team workshop (Author’s compilation)

<table>
<thead>
<tr>
<th>REQUIREMENTS DERIVED FROM TEAM WORKSHOP</th>
<th>FLIPCHART EVALUATION AND DISCUSSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear strategy</td>
<td></td>
</tr>
<tr>
<td>Clear organizational embeddedness of TPD</td>
<td></td>
</tr>
<tr>
<td>Coordinated feeding of innovation funnel</td>
<td></td>
</tr>
<tr>
<td>Evaluation of idea in funnel</td>
<td></td>
</tr>
<tr>
<td>Guidance on decision-making</td>
<td></td>
</tr>
<tr>
<td>Clear arrangements with other units</td>
<td></td>
</tr>
<tr>
<td>Top management support and commitment</td>
<td></td>
</tr>
<tr>
<td>Better environmental information and assessment</td>
<td></td>
</tr>
<tr>
<td>Integrated sales &amp; distribution experts</td>
<td></td>
</tr>
<tr>
<td>Close links to marketing and sales</td>
<td></td>
</tr>
<tr>
<td>Better project management</td>
<td></td>
</tr>
<tr>
<td>Evaluation of projects/products</td>
<td></td>
</tr>
<tr>
<td>Streamlining of processes</td>
<td></td>
</tr>
<tr>
<td>Keep flexibility</td>
<td></td>
</tr>
<tr>
<td>Keep low hierarchies and decentralized decision-making</td>
<td></td>
</tr>
<tr>
<td>Organize handover of products</td>
<td></td>
</tr>
<tr>
<td>Better insights into future issues</td>
<td></td>
</tr>
<tr>
<td>Allow for kick-out of products</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix F: Synthesis of qualitative findings into requirements

[REDACTED TEXT]

Table A-5. Deduction of practice requirements from different qualitative analysis methods (Author’s compilation)

<table>
<thead>
<tr>
<th>PRACTICE REQUIREMENTS</th>
<th>MATERIAL ANALYSIS</th>
<th>INTERVIEW EXECUTIVE</th>
<th>INTERVIEW DEPARTMENT HEAD</th>
<th>WORKSHOP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORM-RELATED REQUIREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guiding strategy and clear task understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defined organisational embedding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration of simple, easy-to-use methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decentralise decision-making competences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Better integration into traditional WEMAG business</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrate hand-over of products to sales department</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streamlining of innovation process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CONTENT-RELATED REQUIREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Handle the information overload</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generate overview on future developments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrate impact by external events or factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generate and collect ideas systematically</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select ideas transparently and reproducible</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a strong market orientation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Include features to enhance the internal learning curve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have better information on product environmental performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrate marketing and distribution plan into product development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix G: Detailed methods, criteria and participants of each phase/gate of the integrative innovation process [REDACTED TEXT]

Table A-6. Methods, criteria and participants of each phase/gate of the integrative innovation process (Author’s compilation)

<table>
<thead>
<tr>
<th>PHASE/GATE</th>
<th>METHODS</th>
<th>PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>INNOVATION UNIT</td>
</tr>
<tr>
<td><strong>IDEA GENERATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunity seizing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st gate: Initial Screen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product idea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2™ gate: General feasibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CONCEPT CREATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product concept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3™ gate: Business Case</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROJECT PIPELINE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4™ gate: Post-development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5™ gate: Pre-launch</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMERCIALISATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product launch &amp; market entry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th gate: Hand-over</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix H: Detailed list of evaluated theoretical requirements

Table A-7. Detailed evaluation of requirements derived from strategic management theory (Author’s compilation)

<table>
<thead>
<tr>
<th>EVALUATION OF REQUIREMENTS DERIVED FROM STRATEGIC MANAGEMENT</th>
<th>REFLECTION IN RESULTS</th>
<th>BENEFITS FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM-RELATED REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guidance by corporate strategy</td>
<td>Yes, element “corporate unit” and arrow down from corporate strategy to innovation strategy</td>
<td></td>
</tr>
<tr>
<td>Integration of feedback loops for evaluation</td>
<td>Yes, intervallic process evaluation which feeds into innovation strategy</td>
<td></td>
</tr>
<tr>
<td>Strategic coordination by top management</td>
<td>Yes, element “corporate unit” and arrow down to innovation business unit and sales and distribution unit</td>
<td></td>
</tr>
<tr>
<td>Clear embedding in organizational structure</td>
<td>Yes, process is embedded in innovation business unit with hand-over to sales and distribution unit. In addition, a new organizational embedding of the TPD department is recommended.</td>
<td></td>
</tr>
<tr>
<td>CONTENT-RELATED REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focused corporate strategy</td>
<td>Not explicitly formulated, but supported by insights from strategic foresight and focus on environmental advantages.</td>
<td>Strategic foresight &amp; environmental management</td>
</tr>
<tr>
<td>Aligned business and functional strategy</td>
<td>Included in the model by superior corporate strategy over business unit strategy, but needs to be proven in reality.</td>
<td></td>
</tr>
<tr>
<td>Macro environment screening</td>
<td>Yes, highly supported, structured and systemized by strategic foresight observatory.</td>
<td>Strategic foresight</td>
</tr>
<tr>
<td>Adaption of internal capabilities</td>
<td>Not directly in the model, needs to be fulfilled by executive management and head of department through shifting resources, training personal and hiring needed experts.</td>
<td></td>
</tr>
</tbody>
</table>

Table A-8. Detailed evaluation of requirements derived from innovation management theory (Author’s compilation)

<table>
<thead>
<tr>
<th>EVALUATION OF REQUIREMENTS DERIVED FROM INNOVATION MANAGEMENT</th>
<th>REFLECTION IN RESULTS</th>
<th>BENEFITS FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM-RELATED REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System-theoretical role</td>
<td>Yes, given by embedding innovation process into surrounding elements and drawing interconnections</td>
<td>Eco-design</td>
</tr>
<tr>
<td>Process-related role</td>
<td>Yes, strong process focus by detailed description of phases and gates, showing how a project moves within the innovation process.</td>
<td></td>
</tr>
<tr>
<td>Clear and strong project checkpoints</td>
<td>Yes, checkpoints are included as gates after each phase and have four criteria categories (market, financial, technical, environmental) to evaluate each idea or project from several perspectives.</td>
<td>Strategic foresight</td>
</tr>
<tr>
<td>Structured fuzzy front end</td>
<td>Yes, fuzzy front end is overseen and structured by observatory, which has clear tasks and deliverables.</td>
<td></td>
</tr>
<tr>
<td>Methodological support for fuzzy front end</td>
<td>Yes, each task of the observatory is supported by different methods, e.g. roadmapping, mind mapping, scenario-analysis.</td>
<td>Strategic foresight</td>
</tr>
</tbody>
</table>
**Table A-9. Detailed evaluation of requirements derived from environmental management theory (Author’s compilation)**

<table>
<thead>
<tr>
<th>CONTENT-RELATED REQUIREMENTS</th>
<th>REFLECTION IN RESULTS</th>
<th>BENEFITS FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration of market and technology developments</td>
<td>Yes, simultaneous screening of market, technology and legislative pull and push factors by observatory.</td>
<td>Strategic foresight</td>
</tr>
<tr>
<td>Focused innovation strategy</td>
<td>Yes, given by integration of eco-design requirements, recommendations for strategic focus on unique environmental advantage and focus on external developments.</td>
<td>Eco-design &amp; strategic foresight</td>
</tr>
<tr>
<td>Defined unique selling point of products</td>
<td>Yes, idea generation and evaluation strongly focuses on eco-design features highlighting environmental benefits and product-service-systems as unique selling points.</td>
<td>Eco-design</td>
</tr>
<tr>
<td>Project selection based on corporate criteria</td>
<td>Yes, first idea grading is based on corporate strategy, environmental impact and market attractiveness.</td>
<td></td>
</tr>
<tr>
<td>Transparent grading</td>
<td>Yes, all criteria of each gate are required to be published within the company to allow reproducibility and increase transparency.</td>
<td></td>
</tr>
<tr>
<td>Managers´ willingness to cannibalize</td>
<td>Not included in the model, but needs to be prerequisite for implementing the model.</td>
<td></td>
</tr>
<tr>
<td>Interdisciplinary team</td>
<td>Highly recommended and supported by marketing and eco-expert.</td>
<td></td>
</tr>
<tr>
<td>Continuous market orientation</td>
<td>High market orientation through input from observatory in the beginning. Later market criteria exist, but no continuous input from strategic foresight throughout the innovation process is included.</td>
<td>Strategic foresight</td>
</tr>
<tr>
<td>Innovation competences</td>
<td>Skills required by the team, which need to be ensured by the head of department. Not directly included in the model.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EVALUATION OF REQUIREMENTS DERIVED FROM ENVIRONMENTAL MANAGEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORM-RELATED REQUIREMENTS</strong></td>
</tr>
<tr>
<td>Embedding in environmental management system</td>
</tr>
<tr>
<td>Input by environmental policy, program and objectives</td>
</tr>
<tr>
<td>Integration of eco-design in early phases</td>
</tr>
<tr>
<td>Integration of simple methods</td>
</tr>
<tr>
<td><strong>CONTENT-RELATED REQUIREMENTS</strong></td>
</tr>
<tr>
<td>Proactive environmental strategy</td>
</tr>
<tr>
<td>Transformative organizational adaption</td>
</tr>
<tr>
<td>Shift towards product-service-systems</td>
</tr>
</tbody>
</table>
Integrative innovation process model with eco-design and strategic foresight

Impact assessments are often rather complex and thus opposite to simple methods. But LCA is recommended.

En-of-life scenarios not emphasized during product development, this might need a stronger focus.

Table A-10. Detailed evaluation of requirements derived from futures research theory (Author’s compilation)

<table>
<thead>
<tr>
<th>EVALUATION OF REQUIREMENTS DERIVED FROM FUTURES RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORM-RELATED REQUIREMENTS</td>
</tr>
<tr>
<td>Cross-functional set-up</td>
</tr>
<tr>
<td>Special unit structure</td>
</tr>
<tr>
<td>Integration in early phases</td>
</tr>
<tr>
<td>Continuous work</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CONTENT-RELATED REQUIREMENTS</th>
<th>REFLECTION IN RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter function</td>
<td>Yes, the observatory explicitly serves a filter function. Information about the macro environment is filtered before send to corporate units.</td>
</tr>
<tr>
<td>Aggregation function</td>
<td>Yes, the filtered information is interpreted and analyzed.</td>
</tr>
<tr>
<td>Translation function</td>
<td>Yes, the macro environment screening and interpretation results in identified opportunities and threats, which are communicated to relevant decision-makers.</td>
</tr>
<tr>
<td>Inspiration source for idea generation</td>
<td>Yes, the observatory describes opportunities that can be seized by ideas.</td>
</tr>
<tr>
<td>Integrated market pull and technology push view</td>
<td>Yes, the proposed roadmapping and scenario technique combine market and technology factors. In addition legislative factors are covered, too.</td>
</tr>
<tr>
<td>Culture of open thinking in multiple futures</td>
<td>This needs to be guided and exemplified by executive and senior management. Culture change in general requires long time.</td>
</tr>
<tr>
<td>Boundary spanner</td>
<td>Yes, the observatory is equipped with a boundary spanner, who is mainly responsible for the second and third task.</td>
</tr>
</tbody>
</table>
### Appendix I: Detailed list of evaluated practical requirements

Table A-11. Detailed evaluation of requirements derived from qualitative analysis (Author’s compilation)

<table>
<thead>
<tr>
<th>EVALUATION OF REQUIREMENTS DERIVED FROM QUALITATIVE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FORM-RELATED REQUIREMENTS</strong></td>
</tr>
<tr>
<td>Guiding strategy and clear task understanding</td>
</tr>
<tr>
<td>Defined organisational embedding</td>
</tr>
<tr>
<td>Integration of simple, easy-to-use methods</td>
</tr>
<tr>
<td>Flexible structures</td>
</tr>
<tr>
<td>Decentralised decision-making competences</td>
</tr>
<tr>
<td>Better integration into traditional WEMAG business</td>
</tr>
<tr>
<td>Integrate hand-over of products to sales department</td>
</tr>
<tr>
<td>Streamlining of innovation process</td>
</tr>
<tr>
<td>Include features to enhance the internal learning curve</td>
</tr>
</tbody>
</table>

| **CONTENT-RELATED REQUIREMENTS**                           | **REFLECTION IN RESULTS** | **BENEFITS FROM** |
| Focused strategy for market positioning                     | Yes, a recommendation for strategic focus is given, focusing on unique environmental advantage and product-service-systems. | Eco-design |
| Filter information overload                                 | Yes, the observatory is introduced to filter, aggregate and translate macro environment information. | Strategic foresight |
| Overview on future developments                             | Yes, the observatory also gives an overview on general future developments. | Strategic foresight |
| Assessment of relevant environment changes                  | Yes, the observatory assesses environment changes and their importance to the company and its products. | Strategic foresight |
| Generate and collect ideas systematically                   | Yes the innovation process includes brainstorming, mind mapping and other creativity techniques for idea generation. |  |
| Select ideas transparently and reproducible                 | Yes, the gates and their criteria fulfill this requirement. |  |
| Have a strong market orientation                            | Yes, each gate has strong market-oriented criteria. |  |
| Have better information on product environmental performance| Yes, the integration of an environmental product policy and the corresponding eco-design objectives and methods support the environmental assessment. | Eco-design |
| Integrate marketing and distribution plan into product development | Yes, marketing experts are part of the team to develop that plan and support alignment of marketing and technological requirements. |  |
| Competence for decision-making                              | Giving every gatekeeper the competence for decision-making requires, besides the formal permission, a trained and skilled gatekeeper. This needs to be taken care of by the executive and senior management. |  |