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Process for Climate Strategy Development in Industrial Companies

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Abstract

Climate neutrality has been gaining more and more attention as a long-term goal for companies among different industries. Since this goal can hardly be achieved in the short term and requires a complex interaction of different measures, it calls for a strategic approach. This article presents a strategy process for manufacturing companies striving for climate neutrality. The strategy process consists of three macro phases: preparation phase, strategy development phase and operational implementation phase, which are iteratively carried out. The macro phases are each divided into different meso phases, which include guiding questions that must be answered by different internal stakeholders and process participants. Moreover, necessary results are described which must be available after each phase to enter the next one. The procedure is based on existing models for the description of strategy processes and approaches from the field of energy and environmental management. It combines them into a strategic approach for deriving climate strategies of industrial companies. The developed strategy process is applied to and evaluated at the ETA factory at the Technical University of Darmstadt.

Keywords

Climate Strategies; Climate Neutrality; Carbon Footprint; Transformation Paths; Transparency

1. Introduction

In order to fulfil the targets set in the Paris agreement [1], the European Union is striving to achieve climate neutrality by 2050 as the first continent and reduce its emissions by 55 percent until 2030, compared to 1990 levels [2]. These will affect industry as a large emitter of greenhouse gases [3], forcing industrial companies to systematically reduce their impact on the climate. To do so, industrial companies need to develop climate strategies which include gaining transparency about current emissions, setting targets, and identifying measures to reduce their respective emissions. After the analysis of existing strategy processes, the paper therefore proposes a process for developing and implementing a climate strategy. It is illustrated how the different steps are interlinked, what the outputs of each phase are and which persons or departments inside a company should participate in each step. Finally, the proposed process is applied to a use case examined in the ETA Factory of the Technical University of Darmstadt, a real production site for research purposes dedicated to the machining industry.

2. State of the Art

The long-term goal of climate-neutral production poses specific requirements on the corresponding strategy process. Both the term climate-neutral production and strategy processes in general are discussed in this section since these to aspects are the building blocks for the specification of the proposed process for climate strategy development.

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2.1 Climate-neutral Production

In contrast to carbon neutrality, the term climate neutrality additionally considers other climates effects which are not caused by CO2 or other greenhouse gases. It describes the state in which changes or increase in global temperatures can be avoided. Since some effects on climate change exist that are not directly measurable or directly related to company activities, the term climate neutrality is often used synonymously with greenhouse gas neutrality in the industrial sector [4,5]. Globally, the industrial sector accounts for 36 percent of the total greenhouse gas emissions (including energy consumption) [6], marking the relevance for companies to lower these emissions. Besides the ecological impact, other reasons like the importance of climate targets for investors, the demand for climate-neutral products from the customer side as well as rising energy prices strengthen companies' motivation regarding the topic of climate-neutral production [7].

Strategies to reach climate neutrality are often based on the principles of minimisation of emissions, substitution of emission-causing processes and compensation of the remaining emissions [8]. To start minimising emissions or substituting processes, transparency about the related emissions is needed as a fundamental step [9]. In a previous paper by Bardy et al. [10], success factors for the climate-neutral production were derived based on literature analysis. These success factors include the increase of energy and material efficiency, reuse of waste heat or the electrification of energy demands. Besides these measure-oriented success factors, required employee competencies for climate-neutral production can be defined. These include a certain awareness regarding the environmental impact of companies as well as the ability to see the potentials of climate friendly technologies [11].

2.2 Existing Strategy Processes

The process of developing a strategy belongs to the field of strategic management [12]. It is also referred to as strategic planning [13]. Strategic process research has existed since the early 1960s [14], originating from a purely economic perspective such as divestment or merger strategies [15]. In Bowman and Ash [16], strategy formulation is simplified and divided into the phase of identification of opportunities followed by a phase of selection. Other sources also include a target/goal definition phase [17] and/or an implementation phase [18,19]. Lynch differentiates between three aspects of strategic management: strategic analysis, strategy development and strategy implementation [12]. Mintzberg describes five different approaches to strategies (5Ps): plan, ploy, pattern, position and perspective [20]. This reflects that other factors besides planning also have an impact on the strategy. Some aspects of the strategy are usually not the result of strategic planning but rather emerge from the organisation's behaviour. This is called an emergent strategy [20]. Because of changing environmental conditions strategy processes do not only require a single phase of planning and implementation of the strategy but also a feedback loop from the implementation phase which includes monitoring the outcomes of the strategy's implementation by comparing it to the strategic targets [12].

The PDCA-cycle, first introduced in 1940 by Shewhart for the topic of Quality control [21,22], is a widely known methodology for continual improvement and implementing strategic targets. It consists of four phases. In the Plan-phase (P), goals are set and measures to reach the goals are defined. These measures are then implemented in the Do-phase (D), followed by a check-phase (C) to evaluate the effectiveness of the measures regarding the set goals. In the final Act-phase (A), required adjustments are made to eventually reach the goals defined in the Plan-phase. The PDCA cycle is defined as an iterative process, setting new goals as soon as the initial goals are reached. The PDCA cycle can be applied to a wide range of topics; it is used for example as a basis for the ISO 50001 standard [23] for energy management systems to identify and implement energy efficiency measures and in the ISO 14001 standard [24] for environmental management systems. Despite its broad applicability, it is not solely sufficient to tackle the topic of climate strategies.

Especially regarding the planning phase, more guidance is needed for companies to set effective goals regarding greenhouse gas reduction and choosing effective measures for implementation. To do so, and as

already suggested 1987 by Huff and Reger [15], the strategy development process needs to be linked with the examined content – in the case of this paper, climate-neutral production.

3. Process for Climate Strategy Development

The process for the development of climate strategies is based on the literature on strategy processes and the specific requirements arising from the topic of climate-neutral production. In addition, the authors' experience from industry projects concerning the transformation of the energy system of companies towards climate neutrality is incorporated into the description model. The experience comes both from projects with individual companies and from the project ETA-Transfer [25], which systematically investigated the implementation of measures to reduce emissions for energy systems of manufacturing companies in nine case studies.

The model differentiates between three macro phases: In the *preparation phase*, the company begins to discuss climate strategy issues, gathers preliminary information, and proposes its general objective. The following *strategy development phase* is characterised by the transformation of these general objectives into a specific strategy, according to which the company proceeds with the subsequent transformation. Thus, this phase includes the *analysis of the current situation*, *target specification*, *scenario development* and *assessment* and *decision making* based on the available scenarios. Finally, implementation takes place in the *operational implementation phase*. It includes both the *organisational* and the *technical implementation* of the strategy. The three macro phases each consist of meso phases, which are described in more detail in the following sections. The steps to be completed in the meso phases are referred to as micro phases and are not included in Figure 1, which shows the overall process schematically.

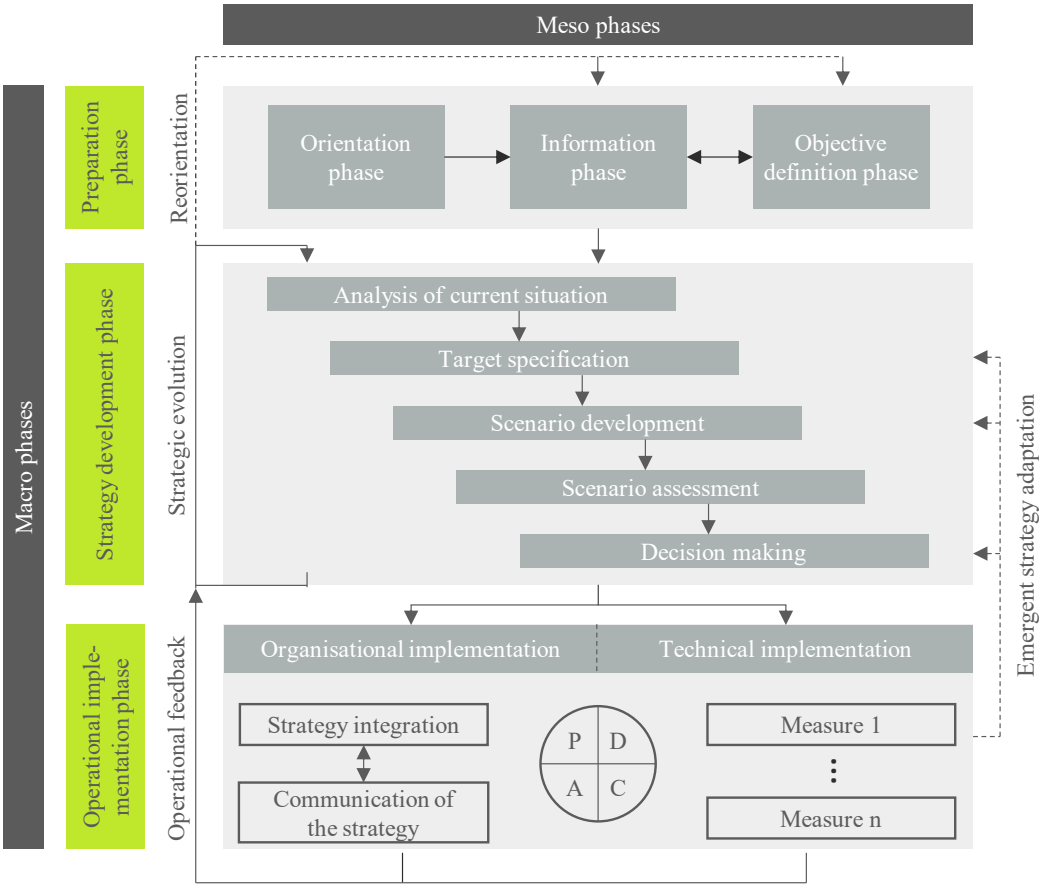

Figure 1: Process for the development of climate strategies

Since a climate strategy must be regularly adapted to changes in the company and in the technical and social framework conditions, the macro phases are not strictly traversed sequentially, but rather iteratively. After going through the *strategy development phase*, a *strategic evolution* can follow to adapt the strategy. In some cases, or at longer intervals, a *reorientation* and thus a re-entry into the *preparation phase* may become necessary. This makes sense, for example, if the strategy is to be fundamentally renewed. Experiences from the *operational implementation phase* are incorporated into subsequent *strategy development phases* through *operational feedback*.

In addition to the planned strategy development, there may also be *emergent strategic adaptations*. These originate in the operational implementation of the strategy, which may deviate from the initially planned strategy, either intentionally or unintentionally. Thus, the implementation can have effects on the *target specification*, *scenario development* and *decision making* in the *strategy development phase*. The three macro phases with their respective meso phases are described in more detail below.

3.1 Preparation Phase

The *preparation phase* initiates the process of developing a climate strategy as the first macro phase. It consists of the *orientation phase*, *information phase* and *objective definition phase*. Depending on the maturity of the company in the field of climate strategies, they are passed through one after the other or it is possible to start in the *information phase* or *objective definition phase*. During the *orientation phase*, questions are raised regarding what the company can do for climate protection, which effects climate issues have on the company and a decision is made whether to initiate the strategy process. In the subsequent *information phase*, the company obtains basic information about climate strategies in a more targeted manner and establishes initial competencies in order to shape the strategy process in an informed matter. In the *objective definition phase*, the first general goals of the climate strategy can be set, such as the scope in which climate-neutral production is to be achieved [26]. The *information phase* and the *objective definition phase* can be carried out iteratively or in parallel. Table 1 summarises the essential aspects and required participants of the *preparation phase*.

Table 1: Preparation phase

	Orientation phase	Information phase	Objective definition phase
Key question	Does our company need a climate strategy?	How do we develop a climate strategy?	What goal do we want to achieve?
Description	Individual employees or management raise the question of what the company can do in terms of climate protection and get an initial overview about the topic.	Further information on the development of climate strategies is obtained in a systematic manner via a specific department. Initial competencies are gained.	The goal of the climate strategy is roughly outlined.
Participants	Management, individual highly committed employees	Appropriate departments, individual highly committed employees	Management and appropriate departments
Outcome	Decision on whether to initiate climate strategy process	Information basis for designing the strategy process	General goal for the subsequent strategy development

3.2 Strategy development process

The core of the strategy process is the *strategy development phase*. In this phase, the climate strategy is created. The *strategy development phase* consists of five meso phases*: analysis of current situation*, *target specification*, *scenario development*, *scenario assessment* and *decision making*, as summarised in Table 2.

First, the *analysis of current situation* examines the current climate impact of the company. In particular, this means that energy and resource consumption are analysed and the carbon footprint is calculated. The *strategic evolution* covering subsequent iterations of the *strategy development phase* means the implementation progress of the climate strategy is being continuously monitored in this phase. After establishing a quantitative overview of the initial situation, the *target specification* is next. In this phase, the specific targets of the climate strategy are defined, e. g. the desired emission reduction with a timeline for reductions in specific parts of the company. This specifies the general objectives from the *preparation phase*. Subsequently, various scenarios are developed to achieve the climate targets. Scenarios are characterised by specific measures such as electrification, energy efficiency measures, integration of renewables, substitution of certain materials etc. The next phase is the *scenario assessment*, which compares the scenarios in terms of target fulfilment based on various company-specific criteria. For example, the involved costs or the availability of competencies required to implement the scenario are considered. Finally, *decision making* takes place based on the *scenario assessment*. The company's climate strategy is then defined in a first draft. It is described by the chosen scenario and characterised by specific measures. Further iterations of this process or parts of it may follow. The strategy must then be implemented operationally. This takes place in the third macro phase, the operational implementation phase. The five meso phases do not strictly need to be carried out sequentially. They can overlap in time or be handled iteratively if changes are necessary.

Table 2: Strategy development phase

	Analysis of current situation	Target specification	Scenario development	Scenario assessment	Decision making
Key question	What is the current climate impact of our company?	What targets are we aiming for and by when?	How can the goal be achieved?	How do the scenarios differ in terms of target fulfilment?	Which scenario best fits the company's goals?
Description	Analysis of the initial situation (energy and resource consumption, carbon footprint, etc.)	Definition of the strategic goal, scopes to be considered, desired emission reduction	Elaboration of different scenarios to meet the set climate target	Comparison of the scenarios based on company-specific criteria	Decision on scenario to be implemented
Participants	Appropriate departments including shop floor management	Management	Appropriate departments	Management and appropriate departments	Management
Outcome	Quantitative overview of initial situation regarding the company’s climate impact	Specific climate targets for the company	Scenarios for achieving the climate targets	Assessed climate scenarios for the company	Specification of a target scenario for the climate strategy

3.3 Operational implementation phase

In the *operational implementation phase*, the chosen scenario with its characterising measures within the climate strategy is implemented. Two processes take place in parallel and are interlinked with each other: *organisational implementation* and *technical implementation*. Both processes are characterised in Table 3. In the *organisational implementation*, the strategy is integrated into existing strategies and corporate structures. In addition, communication of the strategy takes place both internally and externally. *Technical*

implementation involves the implementation of the technical measures defined in the strategy to reduce the climate impact of the company. The technical measures can be partially processed in parallel and organised in PDCA cycles corresponding with the *organisational implementation*. This form of organisation also ensures the possibility to integrate it with existing standards such as ISO 50001 for energy management and ISO 14001 for environmental management.

Table 3: Operational implementation phase

	Organisational implementation	Technical implementation
Key question	How is the climate strategy being implemented in the organisation?	How is the climate strategy transferred into operational measures?
Description	Documentation, organisationally established and communicating the climate strategy	Implementation of measures according to the target scenario in parallel PDCA cycles
Participants	Management, appropriate departments, marketing, entire workforce	Appropriate departments including shop floor
Outcome	Organisationally established climate strategy	Coordinated implementation of technical measures

4. Application to the ETA-Factory

The developed strategy process is applied to the ETA research factory at the Technical University of Darmstadt [27] focusing on the energy system and thus on the energy related emissions (mainly scope 1 and 2 emissions of the greenhouse gas protocol [28]). The ETA research factory was built as demonstrator for energy efficiency in manufacturing systems. It operates a production line with machine tools, cleaning machines and a heat treatment furnace. Moreover, a learning factory and offices are included. The energy system of the ETA research factory consists of three thermal networks with respective heat storages and energy converters operating on electricity and gas. Moreover, compressed air, electricity and gas are supplied to the production systems. Although efficiency measures such as waste heat utilization and thermal cross-linking via heat exchanger and heat pump technology are highly integrated within the factory, the energy system still relies on fossil fuels in gas and electricity supply. The energy system as well as an exterior and interior view of the factory are depicted in Figure 2.

Since opening in 2016, the ETA research factory and its energy system were improved and expanded through different research projects. Within the research projects, measures were applied for increasing energy efficiency, implementing new energy converters, and integrating energy flexibility and digitalization to embody and demonstrate the research and gather knowledge and results within the research group. New challenges in climate goals and research on sustainable production underscores the necessity of climate-neutral operation of the ETA research factory. Thus, the presented strategy process accompanies the transformation within the ETA research factory.

Within the *preparation phase*, the dependencies, but also differentiation between energy efficiency and flexibility compared to climate neutrality were addressed. Moreover, a first qualitative analysis of the emissions, especially fossil fuel consumption within the ETA research factory were conducted. As a result of the *preparation phase*, the ETA research factory team decided that the research factory should become climate-neutral until 2025. Within the objective, climate neutrality was defined based on scope 1 and 2 emissions.

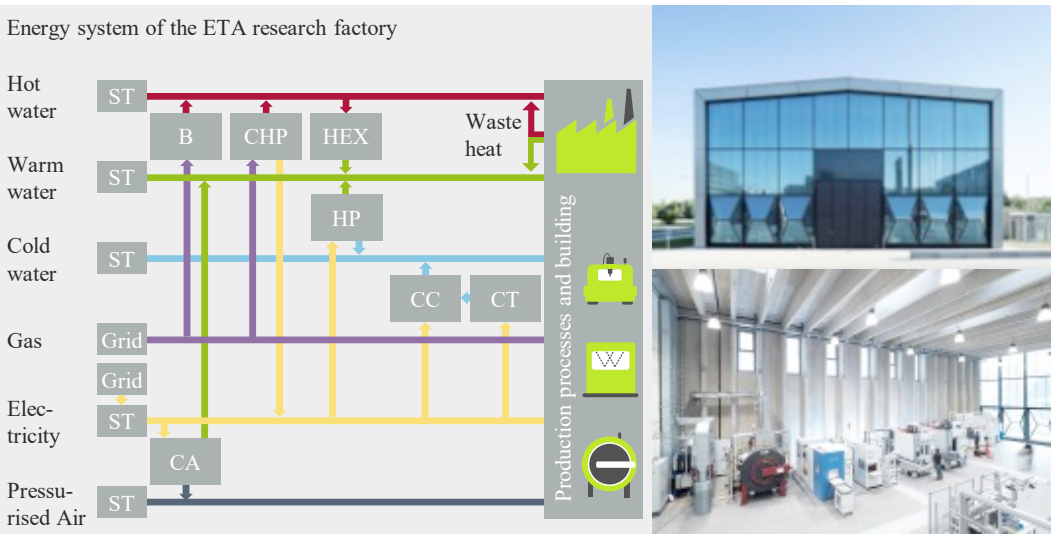

Figure 2: Left – energy system of the ETA research factory, ST: storage, B: boiler, CHP: combined heat and power, HEX: heat exchanger, HP: heat pump, CC: compression chiller, CT: cooling tower, CA: compressors for pressurised air; upper right – exterior view; lower right – view on production line, photo credits Eibe Sönnecken.

In the *strategy development phase*, the analysis of the current situation resulted in a quantitative analysis of emissions, but also in the analysis of possible measures which can be carried out by the institute's research group. Some of the measures such as energy efficiency or flexibility can be carried out directly by the research group, others are dependent on the responsible department within the university, e. g. the purchase of green electricity cannot be decided by an institute itself. Therefore, the objective of climate neutrality was adjusted and targets defined. The targets include climate neutrality in scope 1 and 2 emissions by integrating auto-production and increasing self-consumption of renewable electricity and heat without external electricity supply. Furthermore, a reduction of scope 3 emissions is set as a target. First scenarios were developed to achieve the targets. New research projects should be initiated for the specific assessment of different scenarios. With this assessment, a decision on a scenario and specific measures can be carried out.

The overall strategy process is not concluded yet, but first steps for the *operational implementation phase* have already been taken: it must be organisationally implemented that the team gains knowledge around climate neutrality and newly acquired projects are aligned with the objectives. The technical integration and implementation of new energy technologies should be carried out within new research projects linked to current research. The current results of the meso phases within the strategy process are outlined in Table 4.

Table 4: Results in the strategy process for the ETA research factory

	Results
Orientation phase	• Energy efficiency and flexibility are no longer sufficient when discussing climate change in manufacturing processes and sites
Information phase	• Climate neutrality is the main goal within different sectors to address climate change: research on definition and impact, discussion in team • Qualitative analyses of emissions within the factory: gas demand of combined heat and power units, boiler and furnace, electricity supply, materials • Information on potential technologies to be installed within the energy system of the ETA research factory
Objective definition phase	• Climate neutrality within scope 1 and 2 emissions
Analysis of current situation	• Quantitative technical energy data analysis of the overall system • Analyses of the possible measures by the research group (electricity supply contracts cannot be changed by institute)

Target specification	• Climate neutrality in scope 1 and 2 without external electricity supply until 2025 • Integration of renewable electricity and heat until 2025
Scenario development	• Electrification of processes and energy supply • Integration of hydrogen usage • Integration of photovoltaic system, geothermal heat pumps • Additionally: Increasing energy efficiency and flexibility for self-consumption of renewables
Scenario assessment	• Ongoing acquisition of new research project to further evaluate the scenarios
Decision making	• To be defined
Organisational implementation	• (New) research assistants must gain knowledge in climate neutrality; newly acquired projects must strive towards the organisational objectives
Technical implementation	• Integration and implementation of new energy technologies within new research projects

5. Conclusion and Discussion

In this paper, we present a strategy process for industrial companies striving for climate neutrality. The strategy process is divided into three macro phases: *preparation phase*, *strategy development phase* and *operational implementation phase*, which can be carried out iteratively. The process begins with the *preparation phase*, when the company initiates discussing climate strategy issues, gathers initial information, and proposes its general objective. During the *strategy development phase,* the general objective is transformed into specific targets and scenarios. At the *operational implementation phase* the strategy is implemented both organisationally and technically. The macro phases are divided into different meso phases. The meso phases include guiding questions that must be answered by different process participants. Moreover, necessary results are described which should be available after each phase.

The developed strategy process is applied to and evaluated at the ETA factory at the Technical University of Darmstadt. The team of the ETA research factory defined the objective that the research factory should become climate-neutral until 2025. The guiding questions and necessary results within the meso phases of the strategy process help structure the overall process. The following implementation of the strategy offers further opportunities to explore and re-assess the strategy process. This particularly applies to the *operational implementation phase*, which is still ongoing. The insights gained in this phase can also be used to examine the micro phases more closely within the meso phases, including the requirements for successful implementation and the steps of *operational feedback* and *emergent strategic adaptation*. In this context, it can also be analysed how measures influence each other and which chronological sequence must be followed during the implementation. As climate targets become more relevant, production targets are extended to include this aspect. This requires companies to acquire additional competencies for the development and implementation of climate strategies. The required competencies differ depending on the phase of the strategy process. Especially small and medium-sized enterprises (SMEs) without specialized departments for these tasks face new challenges. Future research should therefore examine which specific competencies are required for each phase and how these can be provided within the company or externally, for example by performing a case study in an SME. Additionally, the described meso phases are to be described in more detail separately for each phase to provide companies with a methodological toolbox for each phase. This can contribute to a more systematic preparation, development and actual operational implementation of climate strategies in manufacturing companies.

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Biography

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