Chapter 31
Sustainability Improvements Through Efficient Asset Management Networks

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Abstract Asset management supports long-term planning of physical assets and offers a structured approach for more sustainable manufacturing. Asset management aims to improve profitability of the production by supporting life cycle decision making by developing and applying optimal maintenance, capacity planning, and investment strategies. So far the impacts of networked business models and demands for sustainability have not been widely dealt with. The paper presents results from a road map exercise that aimed to identify future needs for sustainable manufacturing models, and focuses on the use of company networks for efficiency of physical assets. The main research questions addressed here are as follows: How does asset management contribute to the demands for more sustainable manufacturing and what implications the demand for more sustainable manufacturing has to asset management strategies?

31.1 Introduction

Asset management supports long-term planning of physical assets and offers a structured approach for more sustainable manufacturing. Asset management aims to improve the profitability and efficiency of the production by supporting life cycle decision making by developing and applying optimal maintenance, capacity planning, and investment strategies. Asset management is closely linked to other governance and management processes as it deals with the creation, maintenance, and improvement of profit-making capacity of production assets, maintaining and optimization of the net asset value of production assets, and improvement of

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sustainability and safety of asset solutions [1]. In manufacturing industry, the lifetime of production assets is influenced by a variety of exogenous and internal factors as illustrated in Fig. 31.1.

With increasing operation time of a production facility numerous rebuilds, modifications, replacement, and expansion investments typically take place. All of these decisions together with the chosen maintenance strategies and operational models affect the condition and productivity of assets. The life cycle view is reflected, e.g., in the definition given by the European Federation of National Maintenance Societies [3], which states that asset management is "the optimal life cycle management of physical assets to sustainable achieve the stated business objectives."

Sustainable manufacturing objectives are expressed in well-known sustainability's dimensions, i.e., in economic, environmental, and social dimensions. Integrating these factors of sustainability into strategic decision making is an essential prerequisite for moving toward sustainable development. Sustainable manufacturing can be defined as the ability to address limitedness of natural resources, to mitigate the excess of environmental load of manufacturing activities, and to enable an environmentally benign life cycle of products and services, while continuing to improve the quality of human life [4, 5]. When emphasizing long-term profitability, asset management offers a structured approach for more sustainable production [6].

In traditional manufacturing industry, suppliers, lead producers, and customers are seen as independent sequential operators in a value chain, whereas novel collaboration models can rather be described as networks [7, 8]. This development calls for new models for both network governance and performance of manufacturing operations, including also asset management procedures [9]. These models should enable clear identification of the network actors and stakeholders who influence and can be influenced by the sustainability of the product in the course of its life cycle [10]. Moreover, new models should help in integrating sustainability into companies' as well as entire networks' core strategies and thus support the alignment of business processes according to sustainability objectives [11].

Asset management procedures are commonly applied to improve production efficiency in manufacturing industry. What is the significance of asset management as a part of efforts toward more sustainable manufacturing networks? And what are the implications to asset management strategies? The paper presents results from a road map exercise that aimed to identify future needs for sustainable manufacturing models and focuses on efficiency of use of physical assets in company networks. The road map exercise was carried out in the SustainValue project (SustainValue is the acronym for the FP7-funded research project entitled "Sustainable Value Creation in Manufacturing Networks," see www.sustainvalue.eu) that aims to develop industrial models, solutions and performance standards for new sustainable and more performing production and service networks.

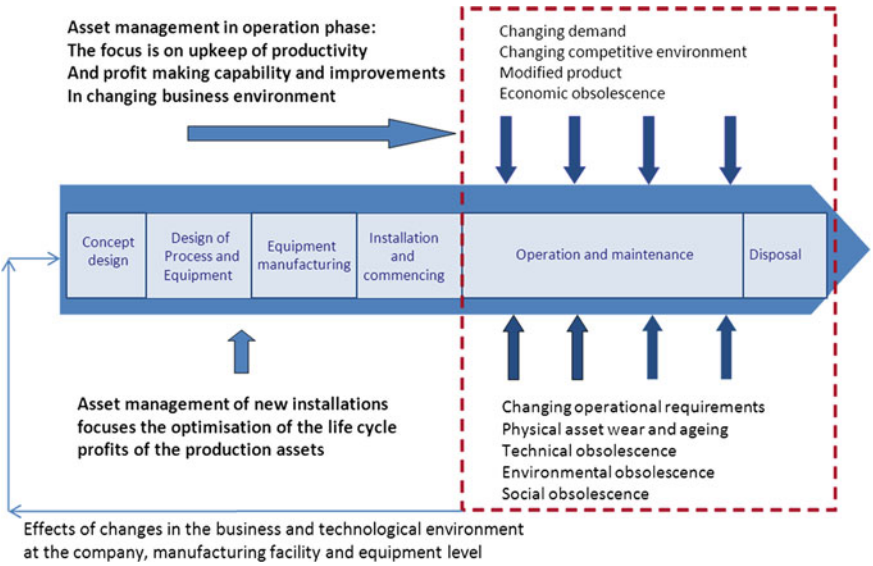

Fig. 31.1 Driving forces to asset management (modified from [2])

31.2 Roadmapping Process

Road maps are regarded as strategic tools for creating deeper understanding and setting agendas for development and change. Visionary socio-technical road maps are visualizations of knowledge based on expert assessment. They combine economic, societal, and technological issues with explicitly stated visions of the future. The road map process is planned to identify elements and issues of development that have strong potential for producing the outcomes that the vision presents. Road maps are not intended to forecast the future in a deterministic way, but they are based on the assumption that future development is likely to include some elements that are presented in these road maps [12, 13].

As the SustainValue project deals with business models and broad concepts like sustainability, the visionary road map process was chosen to guide the work. The chosen time periods were short, middle (5 years), and long term (10 years). The future development was assessed from five perspectives, namely stakeholders, business ecosystem, success criteria, benefits/value, and catalysts/obstacles. The road map process starts by defining a vision which serves as a target against which the current state is compared and the needed changes discussed. The vision for sustainability within the manufacturing industry was stated as *New forms of business models and value networks together enable knowledge-based transformation of the manufacturing industry and improve all three dimensions of sustainable value* (*economic, environmental, and social*) [10].

In the workshop, participants were asked to define the current state of sustainable manufacturing from the different perspectives and then to identify and discuss which changes are required to reach the vision. Furthermore, catalysts and obstacles of the development toward the vision were discussed. A total of 14 experts participated in the workshop on the spot, and two further experts through online from remote locations. The experts presented a wide spectrum of knowledge from industrial enterprises (4), universities and research organizations (11), and a standardization organization. After the expert workshop, the raw data were organized and reworked by the core group of the study, and the material was also iterated and commented within the rest of the expert group.

In the workshop, a Group Support System (GSS) tool consisting of networked computers and dedicated software was used to collect and display participants' responses. With the tool, the input could be used to stimulate new ideas and discussion and they could also be organized and evaluated through prioritizing and voting. One of the strengths of the GSS method is that the tool allows a simultaneous collection of ideas, thus making it possible for every participant to contribute equally. Moreover, when using a computerized GSS, all responses are fully documented in the system, and the data can be easily used also after the workshop (see [14]).

31.3 Findings from the Roadmapping Process

The SustainValue road map exercise aimed to identify future needs for sustainable manufacturing models and address also the efficiency of use of physical assets in company networks. As the road map (see [10]) covers all aspects of sustainability, only a part of identified elements are relevant from asset management point of view. The collected data were analyzed by the authors from this perspective in order to identify those development items and issues that are significant from physical asset's point of view and which could have implications to asset management strategies. The findings are collected in Tables 31.1 and 31.2.

31.3.1 Stakeholders

The willingness to change toward sustainable manufacturing remains an important issue throughout the road map period. Rising energy and raw material prices and increasing awareness of limited natural resources are drivers for a change from price-centerd thinking toward long-term models, especially in investment decisions. It was recognized that all stakeholders should be included in strategic company decisions. The consumption trajectory is expected to change toward

Table 31.1 sustainvalue sub-road map for asset management-related items

Road map level	Timescale		
	Present/Short term	Middle term (5 years)	Long term (10 years)
Stakeholders	Willingness for change	Willingness for change	Changing customer behaviour
	Long-term thinking	Proliferation in standards and certifications	Advanced remote collaboration solutions
		Flexibility in the use of resources	
		Individual and efficient solutions	
		New cooperation/interfaces with stakeholders	
		Product and service bundles	
		Consequences for all stakeholders should be considered in strategic decision-making	
Business ecosystem	Cooperation of stakeholders	Value network innovation is needed, i.e., innovation with consumers and customers	Development of value networks is a way to achieve sustainability goals
	Methods that support the value network's target definition	Taking manufacturing processes closer to the end users (e.g., licensing, subcontractors)	Adoption for closed-loop business models
	Analyzing and updating current business models	Adoption of new business models in manufacturing networks more widely	

(continued)

Table 31.1 (continued)

Road map level	Timescale		
	Present/Short term	Middle term (5 years)	Long term (10 years)
Success criteria	Seeing the benefits of sustainable business	Partnering	Business success would be measured by taking into account all sustainability pillars together with the product value chain and life cycle approach, i.e., measuring performance using triple bottom line approach (economical, environmental, and social value)
	Need for a new, dynamic relationships with customers	Standardized KPIs	
	KPIs/certificates/new performance measures	Sustainability integrated into business functions and into product and business model development in an early stage	
	Changing the focus from products to services		
Benefits/ value	Promoting resource conservation at every stage of the life cycle	New business and markets, more employment	Efficient processes and new technologies for recycling and materials reuse
	Methodology and tools for life cycle data management (e.g., integrating participants in value chain)	Longer lifetime, good spare part, and lifetime service	
		Indicators of operational performance during the development process	

Table 31.2 Identified catalysts and obstacles for a change

Catalysts for a change	Integrated product–service solutions, increasing know-how of new technologies
	Systemic thinking methodology, requirement for transparency, and accountability of solutions
	Scarcity of natural resources and environmental regulations to limit exploitation of natural resources, increased variation in prices of energy and raw material
	Standardization trials in many industries
	End-of-life requirements of products
	Developed markets demand products with a high degree of process-integration
	Education and dissemination
	Rising professionalism in many industries leads to application of new methods and technologies + cross-industry knowledge transfer
	Economic recession, new competition from the emerging new economies
Obstacles for a change	ICT solutions to support transparent efficiency data for all stakeholders during production processes are not available
	Current integration of technical products and services does not support sustainability goals
	Just in time principles have to take sustainability goals into account
	Industrial customers can have problems to comprehend the real value or life cycle perspective when selecting a product
	Global dispersion of manufacturing operations—cultural and managerial differences exist
	Attitudes and resistance against any changes to current methods and business models
	Partnerships although significant for manufacturing companies can create hindrances due to differences in individual objectives
	Short-term perspective on sustainability, profitability, and sustainability collide

sustainable and transparent life cycle of production assets. The demand for services as well as performance-based contracts is expected to increase as customers will consider also the intangible part of a product. As industrial customers pay more attention to all elements of sustainability pillars, they will acquire consulting services to make a better use of the asset, apply advanced maintenance services, and support for the environmentally sustainable disposal of products.

Manufacturing industry uses advanced remote collaboration solutions, and the development of value networks is perceived, an improved way to achieve sustainability goals for the business ecosystem. This could be promoted by standards and certifications which create more transparency and catalyst the development of value networks.

31.3.2 Business Ecosystem

The manufacturing industry is starting to build dynamic relationships with customers, suppliers, and other stakeholders. The expert group expects that manufacturing networks have adopted new business models like product–service systems more widely. The suppliers add information services or decision-making support to their (tangible) products, thus helping to use products in a more sustainable way. Companies are starting to take manufacturing processes closer to the end users. This is implemented by using subcontractors, licensing, and franchising. The development of ICT technology supports this trend. According to the expert group, more profound understanding of business models will be important for gaining mutual benefits. New methods to support the value network's target definition in the long term are required; service contracts as an example. In a long run, development of value networks is perceived as a good way to achieve sustainability goals for the business ecosystem. Industrial actors will create a more holistic approach for looking the whole value chain from a life cycle perspective. Closed-loop business models are implemented. A closed-loop business model includes up-front design of products that can be manufactured using materials reclaimed throughout the manufacturing process and at the end of a product's life.

31.3.3 Success Criteria

There is a need to make sustainability measureable and to define clear and relevant success criteria for each stakeholder. Thus, also the benefits of sustainable business will be more visible. New performance measures and KPIs should be standardized, and they should include, e.g., safety, quality, and environmental impact, use of natural resources, energy, and life cycle cost. In the future, business success is measured by taking into account all sustainability pillars. Companies are able to calculate the value of sustainable image, and sustainability is embedded in all products, services, and lifestyles.

In the supplier industry, focus has changed from products to services supporting the use and maintenance phases of the product life cycle. This change is enhanced by more close and dynamic relationship with the customer and a systemic view and creates a need to change the distribution of knowledge and the management of systems to be maintained and systems needed for maintenance, i.e., systems for logistics support. This creates a need for strategies for the transformation, new business models like leasing, sharing, cooperation, and new revenue streams. This is expected to bring success as product–service providers are specialists and can provide competences, technologies, and resources.

Sustainability demands can be measured during the development, and decision-making tools that take the quantitative evaluation of sustainability into consideration have been developed. This means that the definition of which inputs are

required in order to measure the sustainability of the outputs of the different processes of a company is available. Also the life cycle cost and profit decision-making tools are being used during the development process of solutions.

31.3.4 Benefits and Value

Reduction in waste and emissions is considered one of the current benefits of the sustainability, but companies have also realized that sustainable life cycle solutions offer opportunities for more efficient operation and use of resources, new disposal concepts, and cooperation between stakeholders. These factors need to be embedded in the business model in order to avoid considerable short-term costs. Methodology and tools for life cycle data management, consumption of natural resources, and calculation of economic benefit of the environmental friendliness have been introduced integrating different stakeholders.

Equipment life cycles are longer and more performing in respect to raw material and energy consumption. Efficiency can be increased by making the current performance transparent and using indicators of operational performance during the development and innovation process of new solutions. Good spare part service and lifetime service is implemented. The operational efficiency of physical assets has increased. In long term, efficient processes and new technologies for recycling and materials reuse in the end of life of products are well established.

31.3.5 Catalysts and Obstacles

During the workshop session, the catalysts and obstacles for the change toward sustainable manufacturing were also identified (see [10]). The findings related to asset management are listed in Table 31.2.

31.4 Discussion and Conclusions

Asset management is, in its basic nature, an iterative process. The independent development of each sub-area is possible, but the issues are strongly interlinked. As a consequence, it is difficult to link various topics within the timescale. The visionary road map process proved to suit well for studying future trends, challenges, and possibilities of asset management in striving toward sustainable manufacturing. The paper presents results from a road map exercise that aimed to identify future needs for sustainable manufacturing models. It collects the views and opinions of those experts that took part in the workshop and the following rounds of commenting. Therefore, a challenge relating to the method used and to

the results is the number and competencies of the experts that participated in the study. As the number of experts was rather small, the results may be regarded as preliminary.

Road map exercise raised up several issues dealing with the key elements of asset management. The trends toward sustainable manufacturing and increasing networking seem to have significant effects also to current asset management practices. 'Cradle to grave' thinking and management of life cycle of physical assets gain increasing importance, new business models restructure the asset management practices in manufacturing companies, services and collaborative models of operation necessitate common targets and standardized KPIs also to asset-related issues, and distributed operations call for novel maintenance solutions. All these changes are expected to create needs for new governance and management methodologies and tools for asset-related decision making.

One of the key issues of asset management and sustainability considerations is *the management of asset life cycle*. Sustainable development also emphasizes recycling, reuse, and remanufacturing of production assets, which makes life cycle data collection even more important than today. Sustainability demands lead to extension of asset life cycles and higher performance and operational efficiency demands. From the asset management point of view, this will pose increasing demands on spare part and lifetime services and probably also require revisions on maintenance strategies and resources.

The emerging trends like *distributed operation models* and developing offering of *intangible service products* offer opportunities for more dynamic customer relationship but create challenges in organizing efficient and effective maintenance function. Technological means like advanced remote maintenance solutions and intelligent logistics systems support local operations requiring skilled workforce and spare parts. In the long run, suppliers will include advanced maintenance services, information services, or decision-making support to their offering. As new business models spread, asset ownership may be totally or partly replaced by performance-based contracts, leasing, sharing, or other forms of collaboration. The arising collaboration models call for common definitions and target setting for asset performance, asset management strategies, and application of new risk sharing models.

With increasing awareness, companies pay more attention to all elements of sustainability. In manufacturing networks, the performance measurement has to be based on commonly accepted and applied measures of *key performance indicators* which are transparent and make it possible to define clear and relevant success criteria for each stakeholder. As asset management strategies typically aim to improve the economically profitable use of assets, key indicators may conflict with this. *Methodologies and tools* for life cycle data management, life cycle cost, consumption of natural resources, and calculation of economic benefit of the environmental friendliness should be introduced in a way that integrates different stakeholders. This leads to profound discussion on the common objectives in the manufacturing networks. More comprehensive methodologies and tools to support

asset management-related decisions such as investment, renovation, and maintenance strategy decisions are required.

The main research questions addressed here are as follows: How does asset management contribute to the demands for more sustainable manufacturing and what implications the demand for more sustainable manufacturing has to asset management strategies? Asset management aims to improve profitability of the production by supporting life cycle decision making by developing and applying optimal maintenance, capacity planning, and investment strategies. In this context, demand for sustainable manufacturing seems to pose challenges to current asset management practices. On the other hand, asset management offers structured approaches to achieve sustainability targets.

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