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Urban Factory – Developing Resource Efficient Factories in Cities

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Abstract. Urban factories are situated in an urban environment that acts as a multifunctional settlement area with complementary uses for production entities in close proximity. Today factories in cities are commonly associated with negative impacts. By cooperation, production sites in urban environments are able to contribute to an overall resource efficiency of the factory-city-system. To establish a functional cooperation, it is vital to understand the underlying trade-offs between factories and cities. These trade-offs are shaped by the interests of the stakeholders in the factory-city-system. For logistics these interests are examined and merged into a common management control system to identify and make use of unused potentials for more resource efficient factory-city-systems.

1 Introduction and Background

Cities and urban agglomerations are subject to societal and spatial change. As a result, many factories are pushed from their urban production site to the outskirts of the city, abroad or to greenfield sites. However, many businesses strive to maintain their urban production sites in order to generate business advantages such as innovativeness in technology and products or attractiveness as employer. The urban factory as a vision of future urban production sites acknowledges that factories in an urban environment are also able to create additional benefits for their surrounding quarters, e.g. by energy production and collaborative consumption or provision of manufacturing and social infrastructure.

This vision relies on the connectedness of all relevant stakeholders, first and foremost, on the factory itself and the residents and neighbours. But also many other stakeholders such as local authorities, employees, proprietaries or service and trade businesses should be considered. By cooperating, this stakeholder network will enhance efficiency with regard to significant resources thermal and electric energy, fuel, space and the urban community.

Hence, production also provokes conflicts with the principal functions of urban quarters such as living, leisure, service and trade. Especially, private and commercial transport are in conflict and compete for infrastructure, which often has already reached its capacity limits. Therefore, cooperative measures and actions of the stakeholders supporting the vision of cooperative resource efficiency have to include transport related concepts, which on the one hand ensure stable logistics for the factory and on the other hand reduce tension for the urban community.

2 Urban Manufacturing

Manufacturing is a vital part of the economy in almost all countries around the world. In the year 2014 manufacturing contributed 22.3% to the GDP in Germany and 15.3% in the European Union [1].

A factory is a place of transformation and value creation [2]. The production system of a factory transforms raw materials, energy and media.

Production processes use information and personnel and are supported by technical building services into products, by-products, emissions and waste (fig. 1).

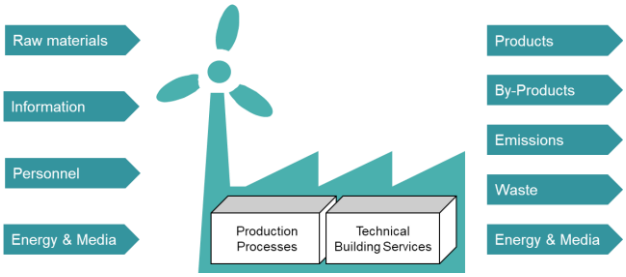

Figure 1. Input and Output of an Urban Factory.

Energy, i.e. waste heat, is released into the environment during the transformation process and in some cases conditioned media is emitted to the environment as well. By its operational efficiency and effectivity, the manufacturing equipment utilized for the transformation process determines the amount and type of waste generated. Auxiliary materials and media further contribute to the waste generation of a factory and depend on the manufacturing equipment employed.

An urban factory is defined by [3] as a factory situated in an urban environment that acts as a multifunctional settlement area with complementary uses for production entities in close proximity. In general, two motivations can be identified for research on urban factories. The first objective is to minimize the negative impacts of factories originally erected outside urban areas that have subsequently been reached by city growth. As these unintended urban factories were not planned as production sites within cities, several conflicts arise with neighbouring usages. A second objective of research on urban factories is for companies to utilize the potentials of urban areas for the factory. The positive or negative impacts of urban factories on their environment and vice versa are manifold and complex. Today, factories in cities are commonly associated with negative impacts. As companies currently are pursuing more sustainable business models, production technologies are becoming more energy and resource efficient and thus, are lowering the negative impacts of urban factories on their environment [4].

3 Urban Manufacturing Logistics

One of the major fields of action for urban factories is logistics. Besides its spatial dimension of being situated in an urban environment, manufacturing of urban factories influences logistics in a temporal and physical dimension.

The temporal dimension is covered by production timing. The production schedule of a factory influences not only the flow of materials and products, but also the transport induced by the factory personnel. The utilization of storage facilities and their operation strategy are commonly used to make the connection of logistic demand and production system more flexible in the temporal dimension.

In the framework of the physical dimension, all material flows in and out of a factory building such as raw materials, products or personnel have to be considered. These processes generate logistic demand that has to be handled by the urban infrastructure. From the product perspective, the product dimensions weight and shape have a strong impact on the input and output flows of a factory at the interface to logistics. These are key indicators for the logistic demand induced by the products. For example, a high product mass correlates not only with the logistic effort on-site (e.g. forklifts, HGV terminals, storage facilities), but can also determine the necessary infrastructure off-site (e.g. roads, bridges, factory buildings). By means of the materials utilized for a product and their physical and chemical properties, constraints can be set to the transport modes available e.g. by legislation.

On the assumption that the great majority of the logistic effort in connection with urban factories is caused by the production system, the influencing parameters at the production-logistics interface can be identified (see fig.2).

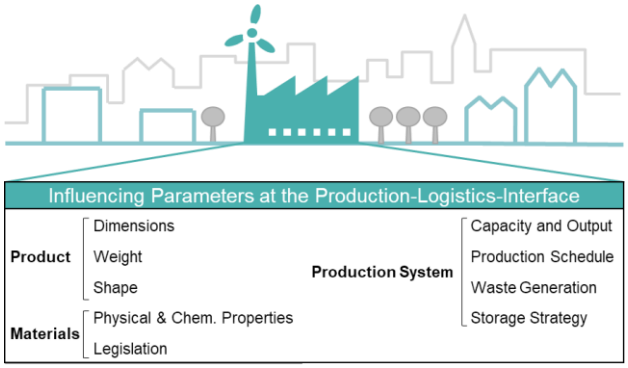

Figure 2. Interfaces of Production and Logistics.

4 Logistic Interfaces of Urban Factories

For the sustainable integration of urban production sites and the development of resource efficient factories in cities, an in-depth understanding of the interface between the factory, its induced logistics and the urban environment with its heterogeneous stakeholders (e.g. authorities, residents, trade and leisure etc.) is required.

Logistics at production sites is the subject of the management control system. In order to plan, coordinate and manage logistic activities as well as processes, organisations use manifold methods and instruments. In general, core of these methods and instruments are performance indicators ([5][6]). Examples for these indicators are

- delivery reliability
- mean number of deliveries per time period

- number of suppliers
- degree of storage capacity utilization
- mean transport distance per shipment.

To maintain profitable logistics and production, these indicators are measured to meet the objectives set by the factory Additionally, these indicators are applicable to assess the logistic workload, which has to be handled and sustained by the city and its stakeholders. Consequently, the description of the interface between factory and city in terms of logistics is based on the management control system of the factory. This factory-centred view has to be matched and broadened by the city-centred interface description. The city-centred description is more complex due to the heterogeneity of the stakeholders. Regarding logistics, a general approach to assess the trade-off between factory and city is developed. To do so, the following three key interest groups can be identified.

- City authorities
- Transport users and other transport participants
- Residents/urban society

On the one hand, authorities' interests in transport and mobility can be described by the objectives determined by transport planning (e.g. capacity of traffic infrastructure, infrastructure utilization, level of service). On the other hand, city authorities pursue transport safety and ecological efficient and silent transport, which is not harmful to health [7]. As a result, the interests of these two stakeholders are opposed to each other. (In order to integrate the factory-centred and city-centred view on the logistics interface of urban factories, it is reasonable to operationalise of the management control system framework, which is used in the factory-centred interface description. The performance indicators of the factory's logistics are measured and evaluated concerning internal, organisational objectives. However, the city-centred view is based on municipal and societal objectives. In the city-factory-system as vision of future urban production sites, these objectives are combined. The factory's logistics operations are additionally measured with regard to municipal and societal objectives.

However, imposing additional objectives on the factory's logistics does not necessarily result in benefits for the factory and the city in terms of more resource efficient symbiosis. Especially for the factory, the efficiency of logistics operations could be reduced. Therefore, the resources meeting the objectives are extended as well. To achieve the combined objectives, the factory is able to use the city's resources, which currently are not accessible by the factory. Factory and city – in the future – will cooperate in terms of common objectives and a common resource basis to identify and use the overall resource efficient transport and logistics operations.

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