The European Production Giganet – Towards a Green and Digital Manufacturing Ecosystem

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Abstract

The European Production Giganet contributes to the twin green and digital transition of the EU strategy to become climate neutral by 2050. The digitalization offers high potential for reducing the greenhouse gas emissions drastically in value creation networks that form data spaces to enable common use of data and services. The Gaia-X initiative for a common data and infrastructure ecosystem based on the EU legal framework offers a unique opportunity to build the future industry's internet where the requirements of self-sovereign data holders and fair business models are met. This creates trust and transparency in the value creation network to collaboratively company-wide reduce the product carbon footprint in the product manufacturing process. In this paper, the methodological approach is presented using plastic injection molding as an example.

Keywords:

product carbon footprint, twin transition, injection molding, Gaia-X

1 Introduction

There is high potential in CO_2-equivalent (CO_2e) emission reduction when using digital technologies that enable a sovereign data economy. Efficiency measures are more and more less effective on a small-scale system level. The climate change is a generational obstacle that can only be solved on a cross-company, cross-sectoral and European wide level. The EU commission highlights in the Green Deal in 2019: "It takes 25 years – a generation – to transform an industrial sector and all the value chains." [1].

2 State of the Art

This chapter explains the EU twin transition and presents demonstrators and standards for CO_2e accounting and reporting.

2.1 The EU strategy of twin transition

The EU commission published the Green Deal with the objective to reduce net greenhouse gas emissions by 55 % by 2030, compared to 1990 levels [1]. The industry domain still has a percentage of 26 % of the final energy consumption in 2020 in the EU [2]. Industrial processes and industrial use of products are responsible for 9 % of the CO_2e-emission in the EU in 2019 [3]. The digitalization in Europe is the second generational transformation taking place in every domain. The EU commission published its data strategy in 2020. The amount of data will be increasing by factor of five from 2020 to 2025 [4]. Additionally, the constitution of the European industry is dominated by small and medium-sized companies by 99 % [5]. There are 24 % of the personal staff of SMEs working in the manufacturing sector [5]. The requirements of those companies are protection of knowledge and human rights as expressed in the GDPR of 2018 [6]. They demand a high trust level in their partnerships and reliability in digital business operations. Due to the current crisis events since 2020 with the COVID-19 pandemic, disrupted supply chains, the Russian attack war against Ukraine, the European industry seeks for safe, secure, resilient, and sustainable production spaces. With the Digital Europe Program, the European Commission fosters the creation of Manufacturing Data Spaces according to their digital strategy. Three major topics are of high importance in the functionality of the Manufacturing Data Spaces. The supply chains in the industry must transform into multilateral agile and resilient networks. The assets of the infrastructure ecosystem must be dynamically manageable using digital twins for predictive and prescriptive maintenance. The companies share data for circularity, recycling, and remanufacturing in a horizontal plane. There will be two funded Manufacturing Data Spaces estimated to start by mid-2023. [7] The European commission formulates the strategy of twin transition meaning that the high potential of CO_2e-emissions reduction and the objective of a climate-neutral Europe by 2050 is only achievable with the digital transformation [8].

2.2 Demonstrators for CO_2e-emission reporting

The Platform Industrie 4.0 and CESMII together with the LNI 4.0 developed a testbed for the calculation of the CO_2e-footprint of a production along the value chain using the standardization of the asset administration shell (AAS) to share CO_2e-reports across companies [9]. The association for electrical and digital industry ZVEI in Germany developed a demonstrator for the creation of a PCF of a control cabinet using the asset administration shell for data exchange [10]. Each assembly of the control cabinet provides its respective PCF via the standardized digital nameplate according to DIN SPEC 91406:2019-12 which defines the automatic identification of physical objects and information on physical objects in IT systems. The kind of use of a digital nameplate providing structured, relevant product information is close to the definition of a digital product pass as proposed in the action plan for circular economy of the EU. This action plan is a major part of the EU Green Deal and aims at creating a sustainable production and products concerning the use and reuse phase in terms of recycling, refurbishing, or remanufacturing along its lifecycle [11].

2.3 Basic standards for CO_2e accounting

The evaluation of the companies related CO_2e-emissions during the production process. Here the basis is set by DIN EN ISO 14064 (2019) defining the so-called Scope 1 and Scope 2 respectively direct and indirect emissions of a company. The Scope 3 indirect emissions are defined for upstream and downstream activities relative to the system boundaries of a company's processes. A carbon report is generated according to the Greenhouse Gas Protocol (GHGP) Corporate Standard from 2015. To obtain the product carbon footprint based on the emission data from Scope 1, Scope 2 to Scope 3 general standards for life cycle assessment DIN EN ISO 14040 (2006) / 14044 (2021) and carbon footprints of products DIN EN ISO 14067 (2019) are adopted.

3 EuProGigant Implements Twin Transition

The presented work in chapter 2 focuses on the product carbon footprint to forward respective information in the supply chain and fulfil the legislative regulations. They do not provide approaches to reuse the PCF information and corresponding aggregated data in new self-sovereign business models of the ecosystem stakeholders to compare and optimize processes and finally reduce the CO_2e-emissions. The EuProGigant use case is called CO_2e-footprint in product engineering and manufacturing. The problem is stated as a lack of information access and digital readiness level of services to study the CO_2e-weighting effect of significant choices made and provoked during the product engineering phase before entering in the manufacturing phase. Core idea of the use case is the prognosis of the PCF through multilateral bidirectional offering and consumption of data and services with Gaia-X.

3.1 Use case for green transition

The methodology is based on the investment and economic efficiency calculation which will express values in CO_2e kg per part produced respecting the cross-company product design phase, mold manufacturing and injection molding machine manufacturing and the production process itself. Additional sources to deliver relevant information are databases for raw material like CAMPUS plastics, databases for energy and life cycle assessment data like ecoinvent. To study and model the information flow between the different stakeholders the MFCA method is transferred [12]. The calculation methodology is validated based on demonstrator components for plastics technology and machining production. Those are a clip for clamping tools in machine tool revolver made from plastics and the production of a gear shaft to verify the methodology in the metal industry. Optimization measures can be derived from applying methods from [13].

3.2 Use case connectivity for digital transition

EuProGigant builds an infrastructure and data ecosystem according to the principles and functionalities of Gaia-X using an open edge to cloud architecture [14]. This allows for enterprises to connect with each other to offer data and digital services respecting the requirements of data sovereignty, personal data protection and IT-security. The industry partner will integrate core functionalities of Gaia-X in their digital products and services to offer edge, on-premises, or cloud-based interoperable usage. The main functions are self-sovereign identity management and APIs to the organizational credential manager to adopt the Gaia-X Federation Services, portal functionality to browse for data and service offerings, data exchange connector to allow self-sovereign restricted access to information and services and Gaia-X Self-Descriptions that may serve as graph-based descriptor for behavioral interoperability of resources to implement resilience mechanisms [15]. Other functionalities can be consumed via trust service providers or the federator of the ecosystem.

4 Summary

This paper presents the transfer of the EU strategy of green and digital twin transition to the European Production Giganet use case of product CO_2e-footprint in the product engineering and manufacturing process using a methodology based on economic efficiency calculation for the prognosis of PCF through evaluation of different manufacturing system set ups in an iterative closed feedback loop. Gaia-X digital technologies are used to enable the use of the respectively needed data and digital services across companies.

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