Whitepaper 2023

Implementing Level 2 of the ZVEI-Show-Case PCF@Control Cabinet

Insights and experiences towards the Digital Product Passport 4.0 using the Asset Administration Shell

Electro and Digital Industry Association

1 Content

2 Abstract

This white paper describes hands on experiences with the implementation of the Digital Product Passport using the Asset Administration Shell in multi-level value networks. Using the example of the ZVEI-Show-Case PCF@Control Cabinet Demonstrator, which was set up for the first time in 2022, 16 manufacturers of electronic components provided their product and sustainability information via the Asset Administration Shell.
The bottom-up approach from the companies enabled the previously theoretical approaches to be tested in practice and findings to be passed back to the committees.

Key points of the whitepaper are:

- The unique identification of products and product types with the IEC Identification Link
- The assurance of data sovereignty through data retention by the vendor of the product
- The security of data by selective access to information through access rights managed by the supplier
- The life-cycle management of the digital product passport over decades through the modular structure of the asset administration shell
- The mapping of standardized information models, which will be further detailed and expanded over the coming years.
- The possibility of value-added services and monetization of data

1 Introduction and Motivation

1.1 Digital Product Passport

The digital product passport (DPP) is a concept for collecting, documenting and exchanging product information throughout the product life cycle. DPPs are currently intensively discussed, especially in regulations, and several development efforts are underway. With the battery passport, the first DPP for a single product category will be introduced in the upcoming years. DPPs for other product categories or general DPPs are expected thereafter as well. The aggregation and the exchange of product information among companies, users and other actors is seen as a key part for the creation of a circular economy. However, there is currently neither a common understanding of which information is required in a DPP, nor which technical solution should be used to operate the DPP.
In this paper, the question regarding the mandatory information will not be discussed further and the focus is instead on the technical side of the DPP. Known technical requirements include the functional suitability for different industry sectors, requirements regarding security, confidentiality and IP protections, interoperable usability of the product information with clear semantics, and more. A detailed overview of known and expected technical requirements can be found in the ZVEI discussion paper “DPP 4.0: An Architecture Proposal for a DPP-System to implement the EU Digital Product Passport for Industrial Products”.

1.2 Asset Administration Shell

Industrie 4.0 (I4.0) refers to the intelligent networking of machines and processes for industry with the help of information and communication technology. Today’s rigid and strictly defined value chains are replaced by flexible, highly dynamic and globally connected value networks with new forms of cooperation. The Asset Administration Shell helps implementing digital twins for I4.0 and creating interoperability across the solutions of different suppliers. The Asset Administration Shell (AAS) is the digital representation of an asset. The AAS consists of several submodels in which all the information and functionalities of a given asset – including its features, characteristics, properties, statuses, parameters, measurement data and capabilities – can be described (see Illustration 1). It allows for the use of different communication channels and applications and serves as the link between objects and the connected, digital and distributed world.[1]

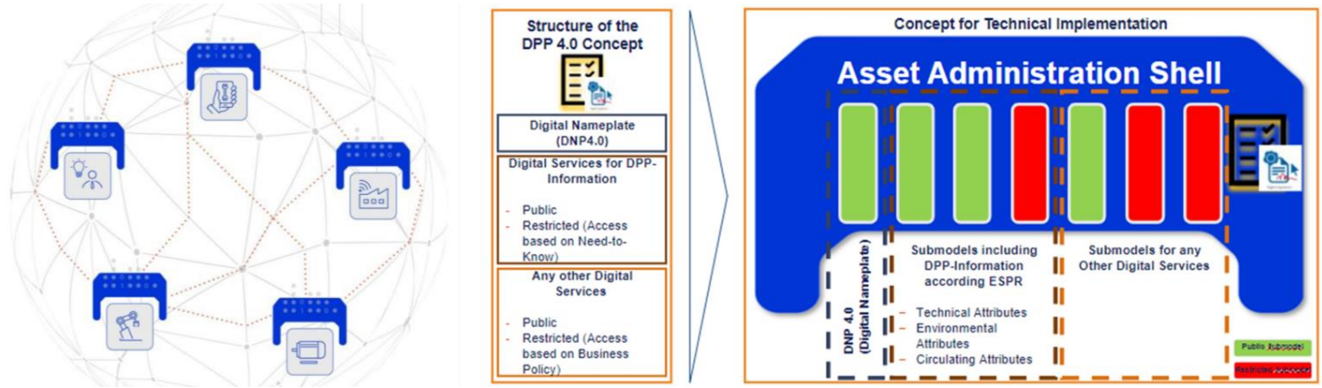

Illustration 1: AAS as Concept for Technical Implementation

For the AAS, the necessary standards are described in the publications of the Industrial Digital Twin Association (IDTA) and the IEC 63278-series (under development):

- IEC 63278-1 “Asset Administration Shell for industrial applications – Part 1: Asset Administration Shell structure”
- IEC 63278-2 Asset Administration Shell for industrial applications – Part 2: “Information meta model”
- IEC 63278-3 Asset Administration Shell for industrial applications – Part 3: “Security provisions for Asset Administration Shells”

[1] AAS Reading Guide, Industrial Digital Twin Association e. V. (https://industrialdigitaltwin.org/wp-content/uploads/2022/12/2022-12-07_IDTA_AAS-Reading-Guide.pdf)

1.3 ZVEI-Show-Case PCF@Control Cabinet

In order to fulfil the expected requirements for the digital product passport and to demonstrate a feasible technical implementation for companies, the concept of the Digital Product Passport for Industry 4.0 (DPP4.0) was created. DPP4.0 combines the established industry standards Identification Link (IEC61406) and Asset Administration Shell (IEC 63278) to identify products and grant different users access to relevant product information in a digital, machine-readable and interoperable format. The ZVEI-Show-Case PCF@Control Cabinet demonstrates, how DPP4.0 can be used to calculate the product carbon footprint (PCF) of an integrated system that contains a variety of products supplied by different manufacturers. For the project, each product manufacturer used DPP4.0 for their supplied products to document and provide the relevant product information including the PCF value of the product. The system integrator (manufacturer of the control cabinet) was then able to access the product information via the Identification Link applied to the products. The given PCF values of each supplied product were then automatically used to calculate the total PCF of the control cabinet.
Scope of the ZVEI-Show-Case is the cradle to gate footprint, collecting product passports from component manufacturers with the raw materials contained within. Some manufacturers also provide the bill of materials of the products, which allows deeper insights (see **Fehler! Verweisquelle konnte nicht gefunden werden.** 2). The control cabinet itself also shows its cradle to gate footprint. The Usage Phase and End-Of-Life Phase will be part of future considerations.

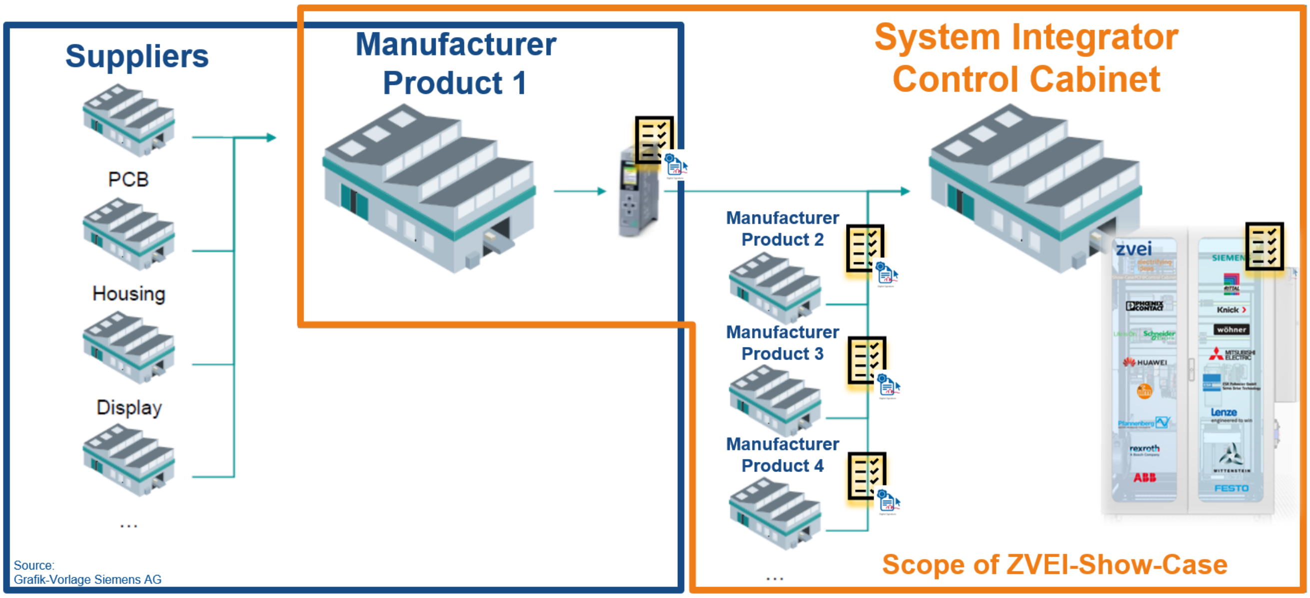

Illustration 2: Scope of the ZVEI-Show-Case PCF@Control Cabinet

2 Insights during Implementation

2.1 Unique Asset Identification

When identifying assets in an industrial context, it is not only the produced (instantiated) product that must be clearly identified, but also the asset during the engineering and planning phase (see Illustration 3). In the example of the control cabinet, virtual planning was carried out prior to the actual construction in order to take environmental impacts into account in advance. For this purpose, manufacturers already had to uniquely identify the asset types. Shipping units and services are increasingly being considered for the environmental analysis of transport routes.

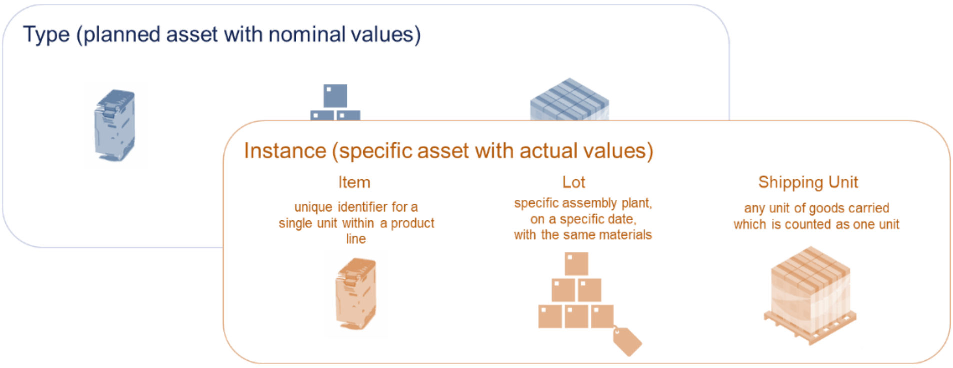

Illustration 3: Need for unique identifiers for types and instances

QR codes are already being used today, independently of the DPP, by industrial partners to identify products and provide paperless documentation. With the IEC 61406, a standard which specifies a globally unique identification of physical objects and constitutes a link to its related digital information was created. The Identification Link (ID-Link) can be customized to meet various requirements and can also serve as an identifier for non-physical objects (for examples see Appendix 4.1).

As shown in Illustration 4, the Identification Link can be attached to the device visually (QR, DMC, text) or electronically (RFID/NFC) via several technologies. The URL stored in the ID link can be created by any manufacturer without a central authority and leads users with a conventional reader directly to the manufacturer's information web page. The ID-Link is the preferred identifier for assets in the Asset Administration Shell and is thus also open to linking other specific AssetIDs online, thereby connecting domain or vendor-specific IDs.

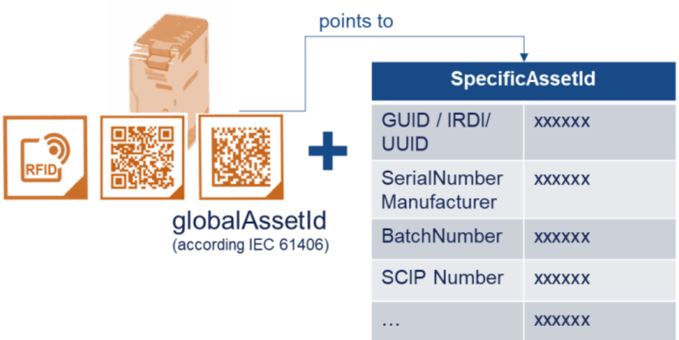

Illustration 4: IEC 61406 Identification Link realized via NFC-, QR-, or Data Matrix-Code with reference to specific IDs

In the ZVEI-Show-Case, it was noted that manufacturers need to pay attention to readability due to optical conditions such as reflective surfaces and contrasts when applying the standard. Also, readability was difficult due to the minimal size of the code, or if the code was not readable anymore when the product was installed. The Identification Link also does not provide any information about which product or even service the scanned asset is. This information must be retrievable online, via an AAS API.

2.2 Distributed Data Access and Data Sovereignty

Data is an important asset for every company. That is why they are so important for the company's success and must be particularly protected in networked value chains. For many companies' central cloud applications and central platforms do not seem to allow complete data sovereignty, which is why the data is preferred to be stored in company-owned repositories. This can be seen as an intermediate step towards trusted and decentralized dataspaces. The AAS and its infrastructure components support all scenarios equally.

The first version of the demonstrator (Level 1, 2022, Illustration 5 left) started with a single, central repository at ZVEI/control cabinet builder. Component manufacturers delivered AASX files, the package format of the AAS, via mail or via their exchange portals. However, with this copy of the data, the link to the manufacturer broke, making it difficult to update and to use the future potential of a data reflow of an asset's usage data. Also, the PCF app for calculating the summed PCF values of the entire cabinet is strongly tied to the repository and references within the AASs were not always maintained through the copy.
The second version of the demonstrator (Level 2, 2023, Illustration 5 right) relies on distributed repositories and architecture. Manufacturers remain in control of their data and communicate only "minimal information" to a central registry (IDs of assets, submodel endpoints, and submodel semantic information). This reduces the communication effort from the manufacturer repository to the registry when the content of the submodel changes, as long as the endpoints and semantic information remains the same. In addition, each manufacturer defines his own sovereign security access rules.

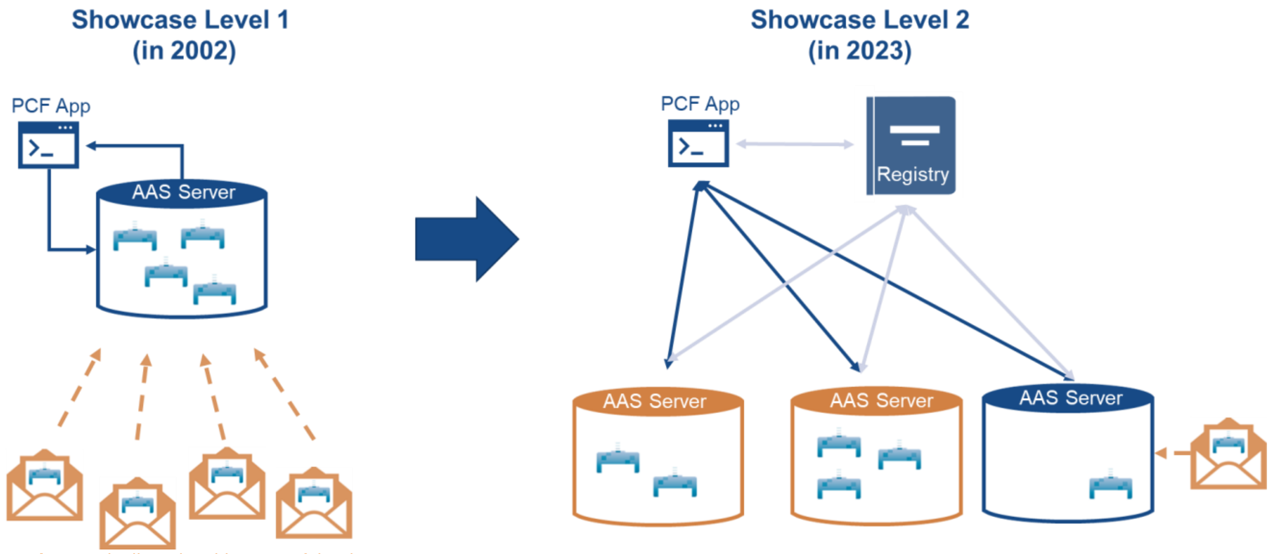

Illustration 5: Distributed architecture of the demonstrator

The AAS repositories and also the AAS registry refer to the V1.0RC03 (Release Candidate) of the API of the AAS published by Plattform Industrie 4.0 and IDTA.[2] For Hannover Messe 2023, this specification will be published with slight adaptations.
There were the following takeaways from the ZVEI-Show-Case implementation:

- Only part of the AAS API specification and serialization is required for the DPP4.0 use case. API profiles would be conceivable to reduce the implementation and testing effort for the DPP4.0 and to force a plug & play approach.
- Some manufacturers have existing AAS repositories which must be connected to the registry for the ZVEI-Show-Case. For this, matching behavior rules and access rights must be defined.
- The access and availability of information must be ensured by the repository operator. When retrieving several hundred asset administration shells and their submodels, latencies and performance must not be underestimated. If necessary, caching mechanisms must be implemented.

[2] https://app.swaggerhub.com/apis/Plattform_i40/AssetAdministrationShell-Environment/V1.0RC03

2.3 Security and Access Rights Management

Digital twins and the DPP contain extensive information, which access must be protected. In the demonstrator the security implementation shown in Illustrations 6 and 7 was implemented for an initial implementation and tested in practice. However, further work is needed to achieve easier scalability and a plug & play security infrastructure.

The following users and roles have been defined for the demonstrator:

- Anonym: Publicly accessible information. Allows to see regulatory required information
- Isabelle: Is integrator and builds the control cabinet. As a customer of the individual components, therefore, needs access to their contents.
- Steven: Is auditor for sustainability information (only access to Nameplate, BoM and CarbonFootprint)
- Mary: Is the manufacturer of a component of Component Manufacturer 1
- Albert: Is allowed to read everything for the demonstrator (All)

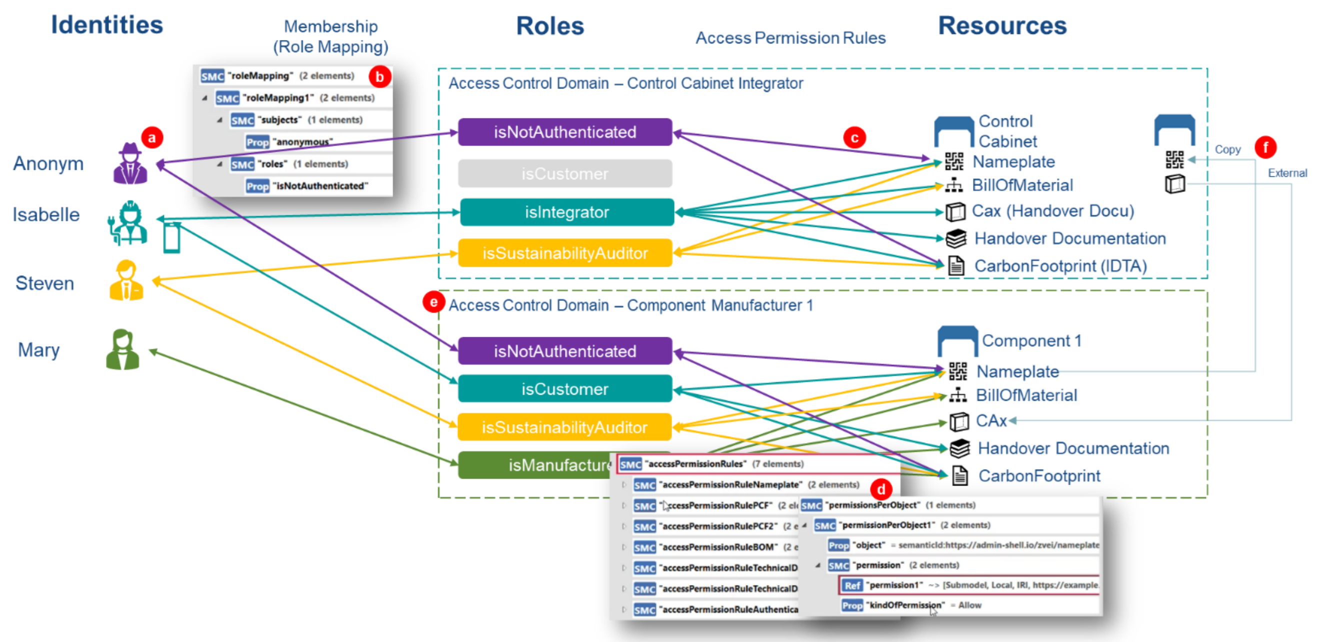

Illustration 6: Security Implementation Overview

a) Identities are determined by authentication. Since access initially takes place anonymously when the product is scanned, the role "isNotAuthenticated" must be taken into account in order to make regulatory information such as a nameplate accessible. A GUID or non-speaking PIN as AssetID in the QR code of the product could already represent an initial protection mechanism to prevent mass reading of this anonymously accessible information.

b) Example of role mapping. This mapping can also be based on ABAC attributes that are provided by the authentication (e.g., email domain).

c) Access rule applied to the entire AAS Repository or a single AAS. In this case the object of the rule is the semanticID to access ALL nameplates. This reduces the effort to access individual AAS.

d) Screenshots from AASX Package Explorer with example to reference the object and type of permission (Allow)

e) Cross-value chain scenarios are subdivided into different access control domains (ACD). Each rule can be set up and maintained from the domain owner, e.g., Company 1.

f) Implications that arise for security depending on whether an AAS or Submodel is copied (handover) or referenced.
   - **Copy:** Security of the Repository is taken over if there is no explicit deny rule within the AAS.
   - **Reference:** Steven (identity) must also be authorized in the ACD of the component manufacturer with the role of the Sustainability Manager to access the carbon footprint submodel of the component.

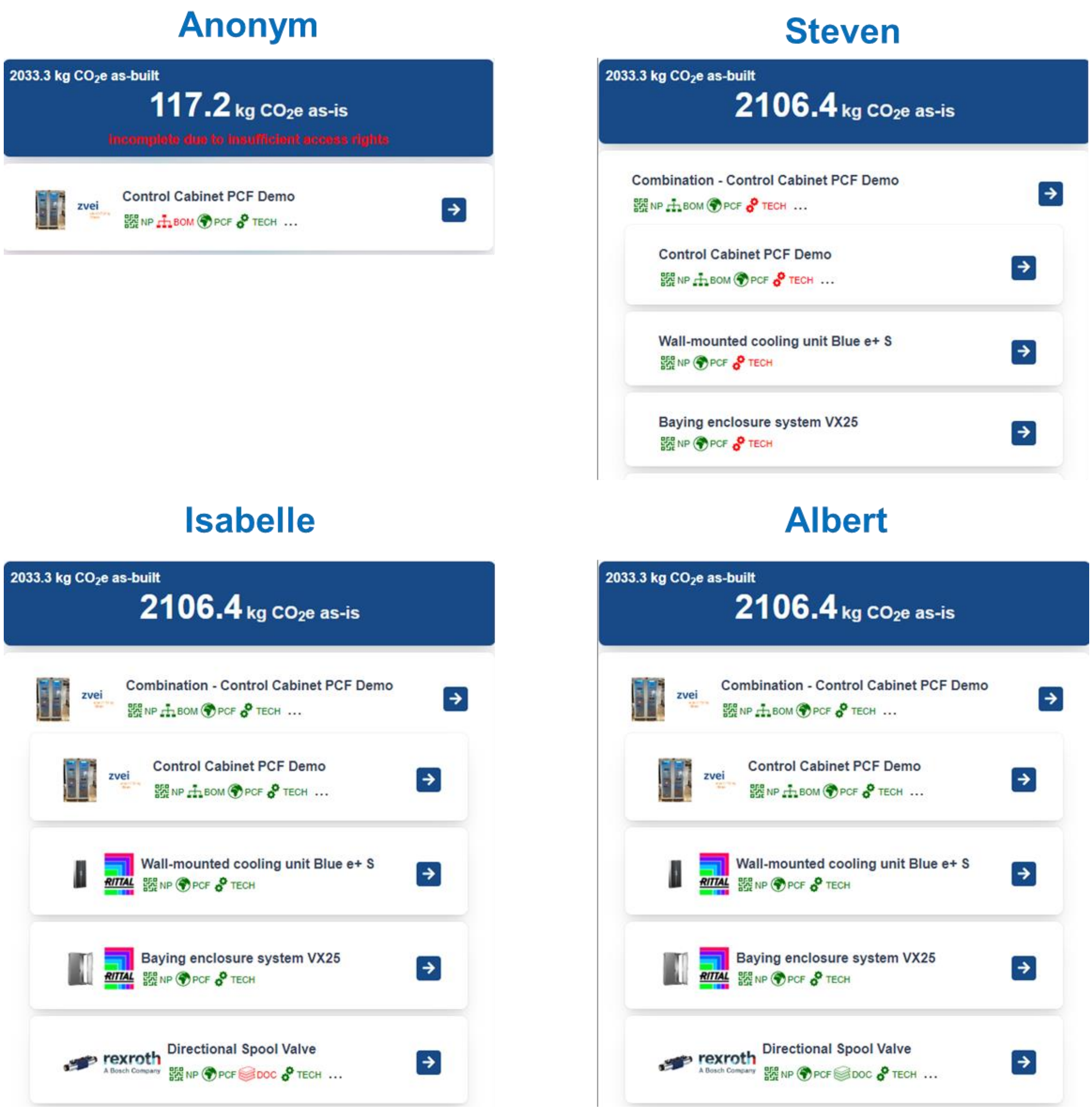

Illustration 7: Visibility of information based on access rights in the web application

2.4 Life Cycle Management - Dealing with Changes

This section is dedicated to the question: How can the DPP4.0, which has accompanied its product for decades, keep up with the fast-moving IT world and future new requirements?
The AAS is a lifecycle record of an asset that grows with it and must therefore be subject to versioning in its metamodel, interfaces, submodels and content. Versioning allows, to put in place content and settings, and then enforce them with reporting. Version control allows content and settings to be set up and then reconciled against regulatory requirements or requirements arising from the IT application.
The ZVEI Show-Case Version 1.0 used the infrastructure specified in the year 2022 and the submodels that had not yet been published. The project team agreed on the exact versions and started the implementation. ZVEI-Show-Case version 2.0 uses the same DPP requirements but is based on new infrastructure features and currently published submodel versions.

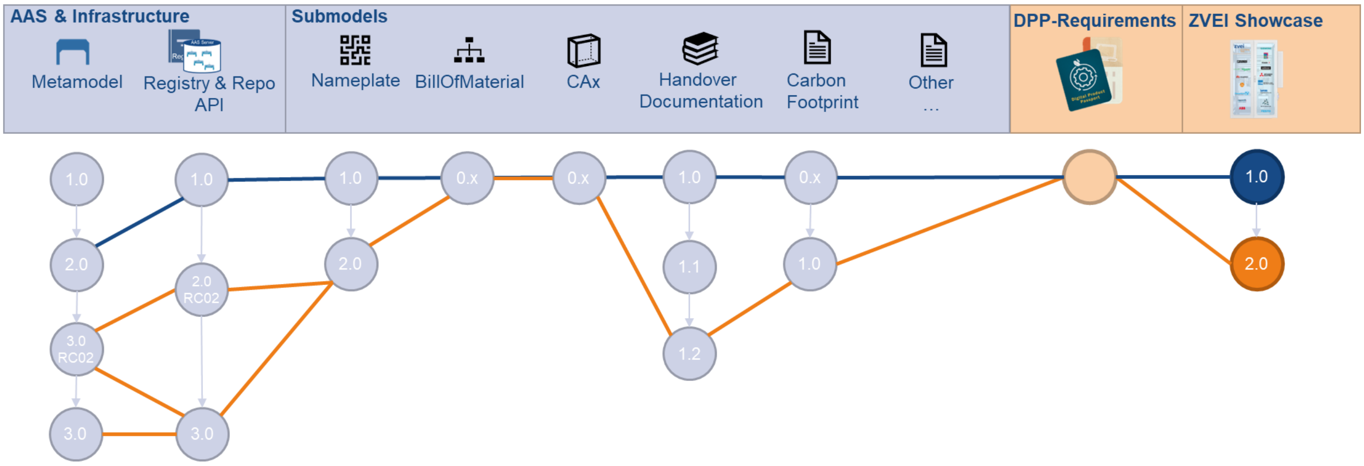

Illustration 8: Versioning of the AAS in the ZVEI-Show-Case

Experiences with Implementation of the Proof of Concept are:

- Existing Asset Administration Shells were supplemented with the needed submodels for the DPP requirements. This effectively reduces the integration effort for providers.
- DPP requirements can also be met with older submodel versions, if necessary. A version update can be performed by the supplier, if required.
- IT applications must be able to handle multiple versions, since not every vendor uses the same versions.
- Changes to the infrastructure versions must be tested against each other, which should be documented within the IDTA publications. Similar to the API profiles, entire infrastructure profiles for standardized rules of plug & play would be conceivable.
- Illustration 8 considers the versioning of the submodel templates and not their contents. For this purpose, submodel instances can be versioned if, for example, a PCF value is updated after some time.

2.5 The Way to Standardized Information Models

In addition to general standards for life cycle assessments (e.g., ISO 14044) and footprint calculations (e.g., ISO 14067 or Greenhouse Gas Protocol, ...), other standards are also included in the carbon footprint calculation and communication. However, these standards do not contain any concrete specifications on how exactly the Carbon Footprint (CF) is to be determined for individual products or transport routes. In the lack of such rules, the CFs of the same products from different companies are not yet fully comparable. The IDTA Carbon Footprint submodel supports the introduction of product-specific rules for the calculation in various industries to enable the same basis for the calculation. For this purpose, the submodel can be extended step by step and in a modular fashion.
The complexity and level of detail is low at the beginning and increases with the increasing specification of product category rules (see Illustrations 9 and 10).

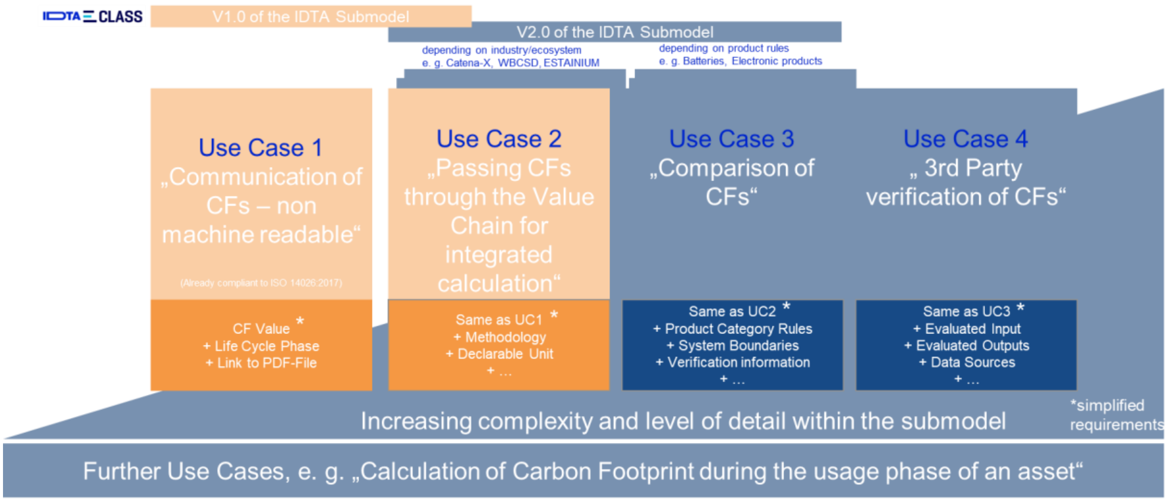

Illustration 9: Stage model for carbon footprint use cases and the submodel scope; source IDTA

ProductCarbonFootprintCradleToGate	
PCFCalculationMethod	ISO 14040
PCFCalculationMethod	ISO 14044
PCFCO2eq	4,3833
PCFReferenceValueForCalculation	piece
PCFQuantityOfMeasureForCalculation	1
PCFLiveCyclePhase	A1-A3
PCFGoodsAddressHandover	
Street	Flachsmarktstr.
HouseNumber	8
ZipCode	32825
CityTown	Blomberg
Country	DE

Illustration 10: Carbon Footprint Communication via AAS Submodel

The experiences made when implementing the proof of concept are:

- An increasing level of detail in the Carbon Footprint sub-model is only possible on the basis of standardized and clearly defined content.
- Close cooperation with other industry-specific bodies such as CATENA-X, WBCSD or ESTAINIUM is necessary in order to bring even different data models together through common semantics.

2.6 Potential for Value-Added Services based on DPP4.0

Through the DPP, a lot of information will become accessible, based on which further processing or analysis will take place. Standardized APIs and accurate data semantics will make it possible to create scalable value-added services, as seen in Illustration 11.
The following potential services can be derived from the ZVEI-Show-Case:

- Carbon Footprint Calculation Service: The footprint of the control cabinet is determined in the demonstrator at runtime, in which an algorithm uses the bill of material to sum up the carbon footprints of the components. Different life cycles and methods of the individual components must be taken into account. Such a service can, for example, provide rapid feedback to the developer in the product design phase, so that in the future the most sustainable product can be selected for comparable assemblies.
- Product Data as a Service: Manufacturers can offer additional detailed product data beyond what is required by law or, for example, additional primary component data.
- DPP4.0 Viewer Service: For consumers and users, the visualization of the contents of the DPP4.0 in a way that is suitable for the target group is essential in order to create not only transparency but also understanding through the information presented, in order to positively influence behavior when purchasing or recycling. Depending on the use case, the information provided in the DPP4.0 can be presented in a way that fits exactly.
- Bill of Material Scanner Service: Bill of materials can be easily added through the ZVEI-Show-Cases mobile app. The documentation of a removal or change of a component can also be carried out in an uncomplicated manner. The app's functionality could be used in engineering, on the production line or by a service employee to keep the DPP up to date throughout its lifetime. By removing a component, for example, its recycling or repair possibilities could be pointed out at the same time (see "Other potential future services").
- AAS Repository as a Service: For providers who do not want to store their product data in their own infrastructure, an AAS repository as a service is an option. Other additional services such as a registry or data integration services are conceivable. Archiving or long-term storage of submodels in particular also offer opportunities for service concepts.
- Other potential future services: Through the AAS, additional submodels can be integrated, which facilitate disassembly, service notifications or spare part services. Currently, the ZVEI demonstrator also only considers the cradle-to-gate lifecycle. Including the use phase of an asset (cradle-to-grave), IIoT data could also be considered for services and monitoring, or anomaly detection services could be applied. The increase in AI applications may be the subject of further expansion stages of the demonstrator.

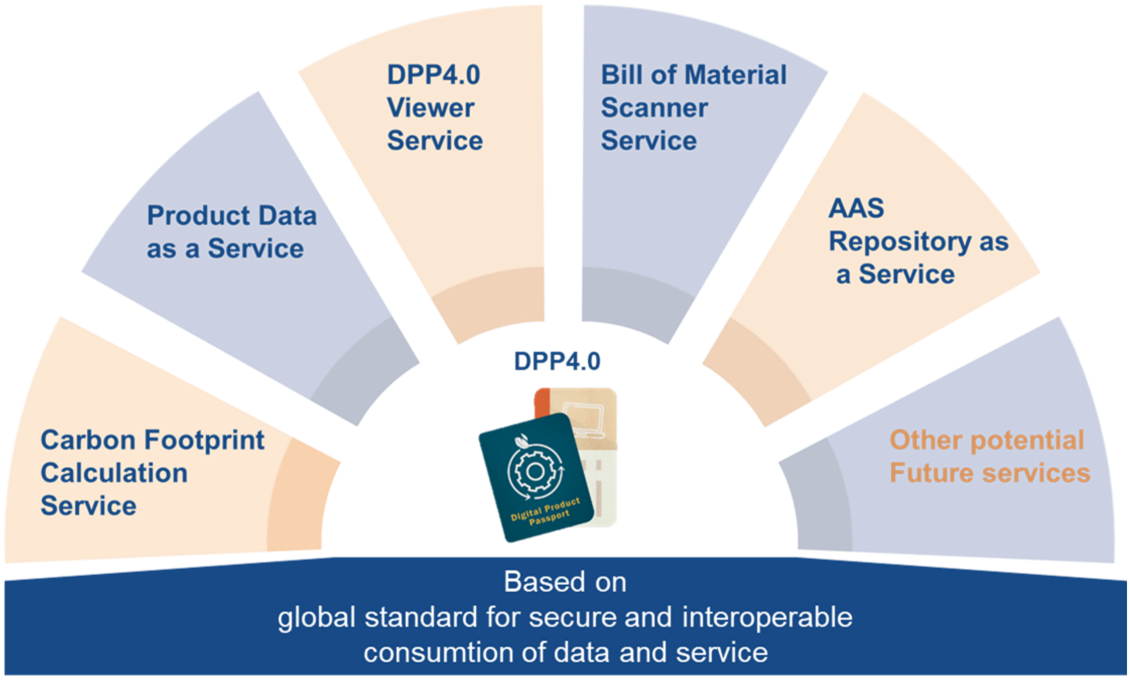

Illustration 11: Value-Added Services based on DPP4.0

3 Outlook

The demonstrator at the Hannover Fair 2023 impressively shows how product information can be made available with the help of the Asset Administration Shell (AAS) in conjunction with the Digital Nameplate (DPP4.0) and can be used automatically in relevant processes. This was exemplified by the calculation of the product carbon footprint (PCF) of the control cabinet across the supply chain.
Through this applicable technical solution for the provision of product information, the solution shown also represents a concept for a Digital Product Passport (DPP4.0).
The first approaches for distributed data access and access rights were demonstrated. These must be leveraged on a scalable basis in the further course of the project in order to simplify the secure plug & play approach. This can also lead to deeper integration into other networks like Catena-X und Manufacturing-X. Of particular interest is also an extension of the life cycle consideration to include the use phase in order to show operational data such as power consumption and losses of individual components.

For the further ZVEI-Show-Case roadmap (Illustration 12), Level 2 of the control cabinet will be exhibited on further trade shows and work will be done in parallel on the new digital infrastructure, which can be demonstrated in late 2023 or early 2024.

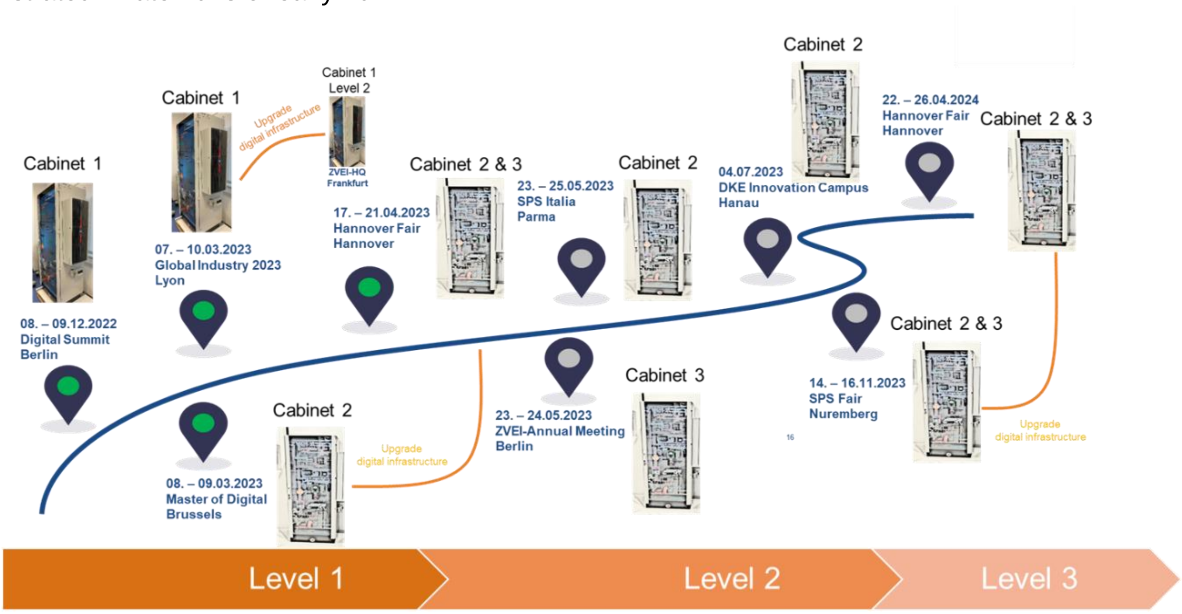

Illustration 12: Demonstrator-Roadmap and Implementation Level

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Lobbying Register ID.: R002101 • EU Transparency Register ID: 94770746469-09 • www.zvei.org

Date: 14.04.2023

4 APPENDIX

4.1 Examples of Identification Links from the Demonstrator

https://i.siemens.com/1P5SY4116-7
https://i.siemens.com/1P6ES7522-1BL01-0AB0+SC-Z0000801
https://i.siemens.com/1P6ES7521-1BL00-0AB0+SC-Z0000703
https://i.siemens.com/1P6ES7511-1AK02-0AB0+23SEC1C5D899A11+SC-Z0000602
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https://e.huawei.com/de/products/cloud-computing-dc/atlas/atlas-500
https://wgrp.biz/x3lSAQ2
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https://phoenixcontact.com/qr/2900542/3B
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https://www.dke.de/nr010201
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http://catalog.weidmueller.com/catalog/Start.do?ObjectID=2869000000&page=Product
https://www.woehner.de/de/produkte/01593.html
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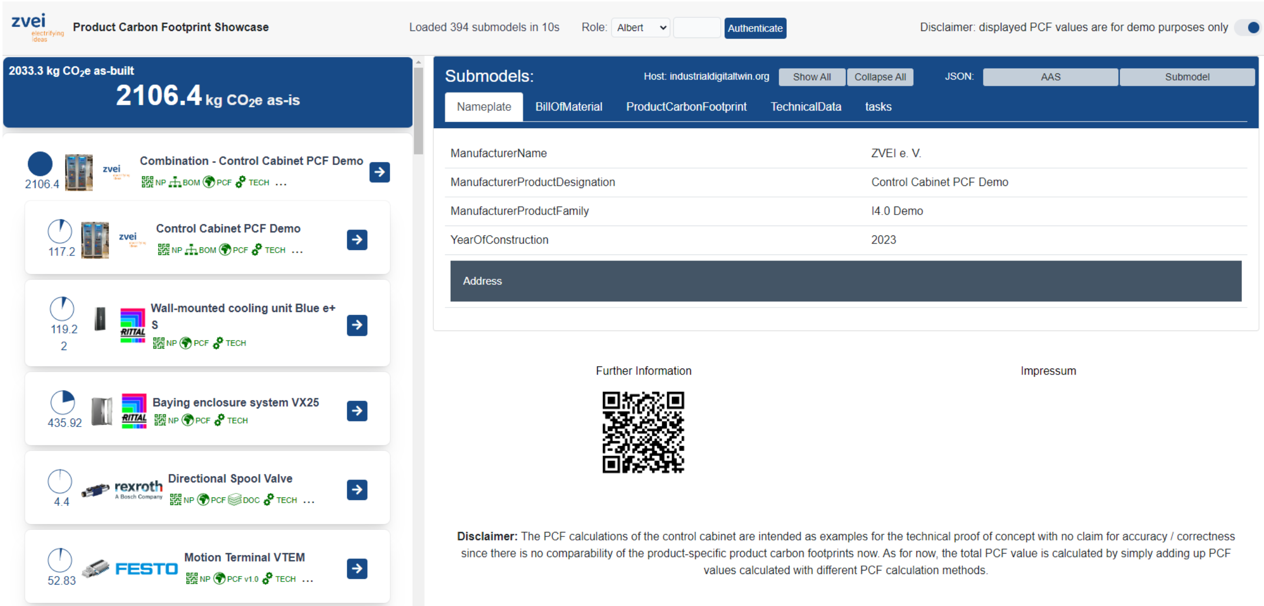
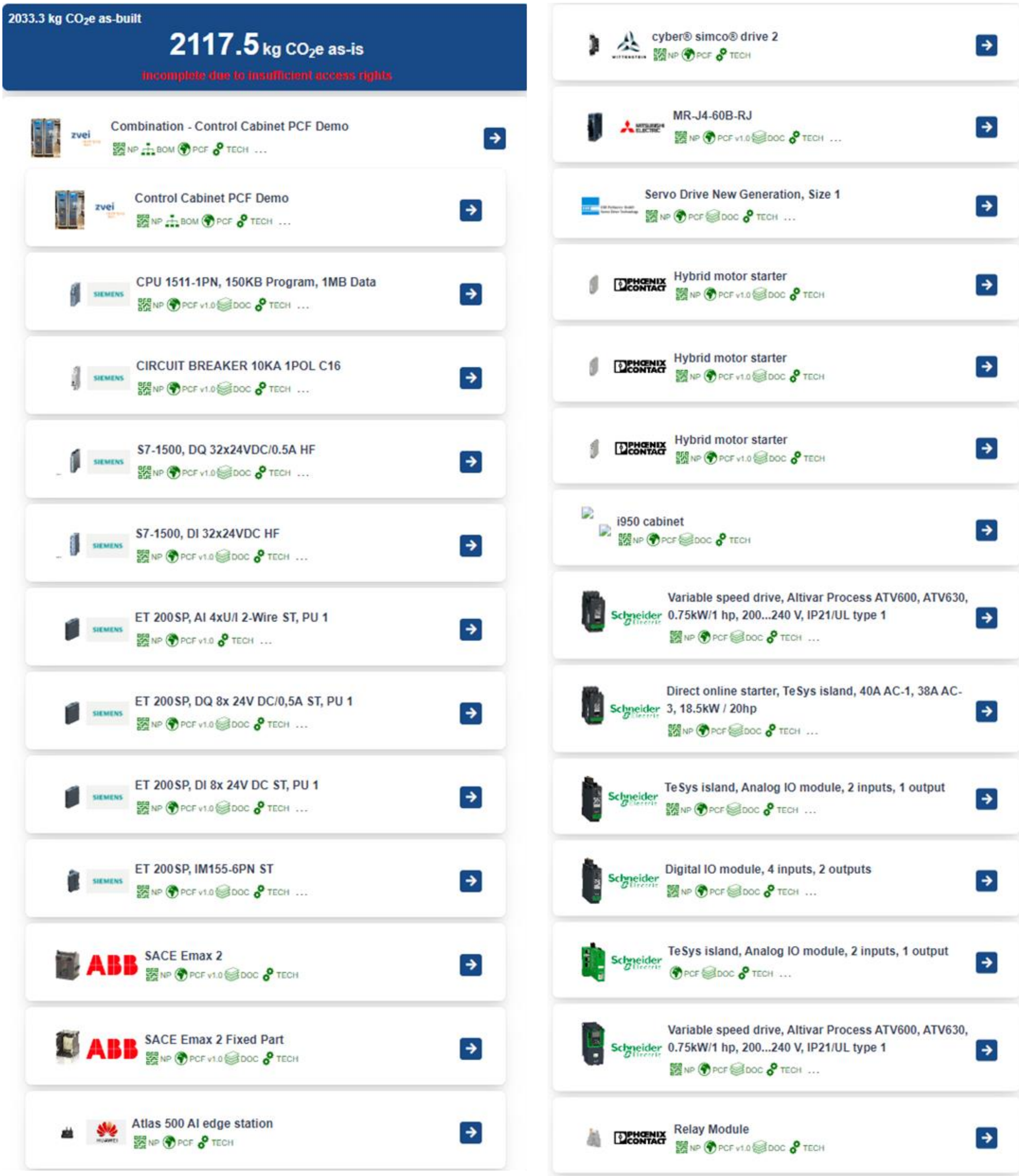
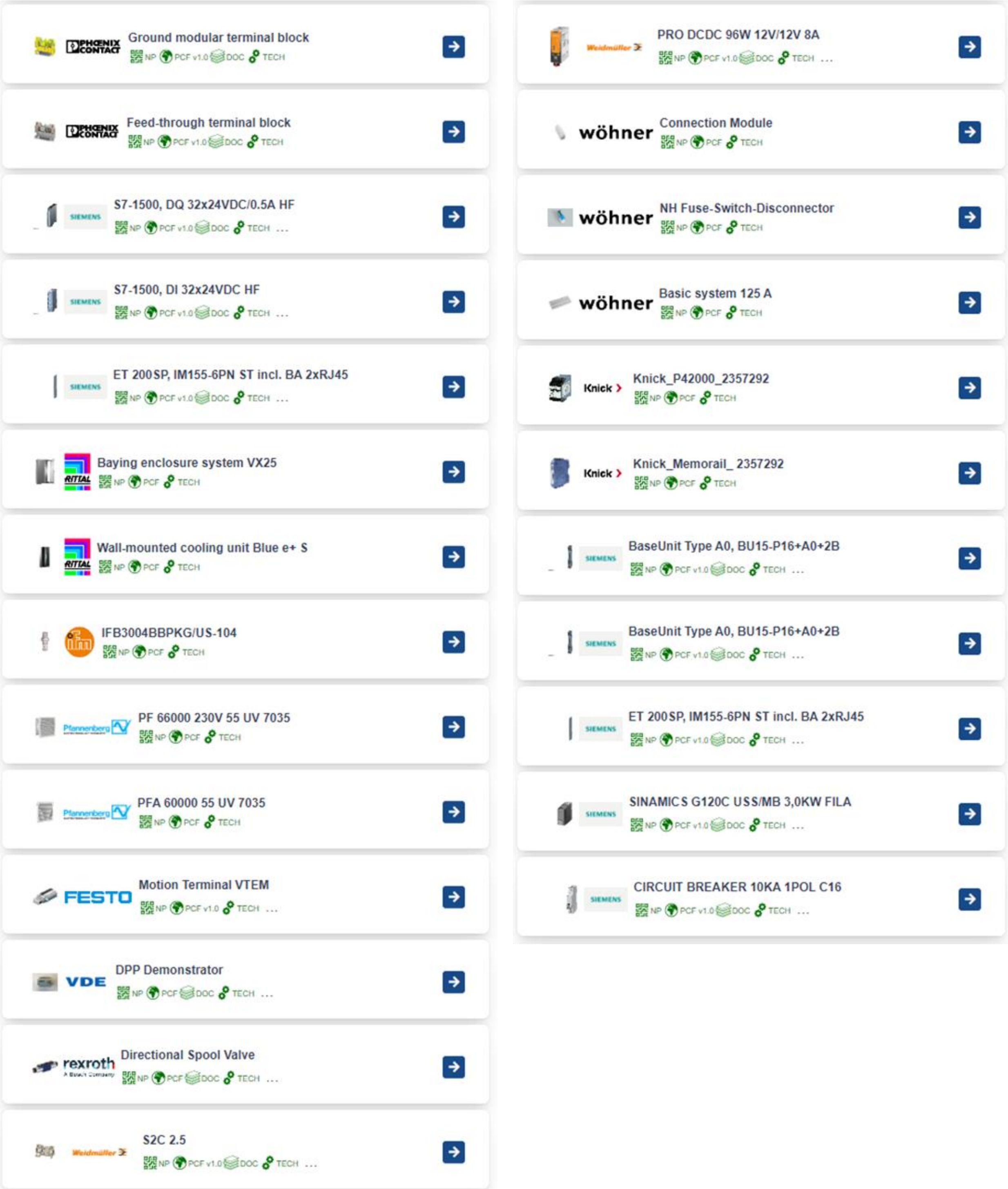
4.2 Overview of the Control Cabinet PCF Viewer and Calculator




2033.3 kg CO2e as-built
2117.5 kg CO2e as-is
incomplete due to insufficient access rights
Combination - Control Cabinet PCF Demo
NP BOM PCF TECH ...
Control Cabinet PCF Demo
NP BOM PCF TECH ...
CPU 1511-1PN, 150KB Program, 1MB Data
NP PCF v1.0 DOC TECH ...
CIRCUIT BREAKER 10KA 1POL C16
NP PCF v1.0 DOC TECH ...
S7-1500, DQ 32x24VDC/0.5A HF
NP PCF v1.0 DOC TECH ...
S7-1500, DI 32x24VDC HF
NP PCF v1.0 DOC TECH ...
ET 200SP, AI 4xU/I 2-Wire ST, PU 1
NP PCF v1.0 TECH ...
ET 200SP, DQ 8x 24V DC/0,5A ST, PU 1
NP PCF v1.0 DOC TECH ...
ET 200SP, DI 8x 24V DC ST, PU 1
NP PCF v1.0 DOC TECH ...
ET 200SP, IM155-6PN ST
NP PCF v1.0 DOC TECH ...
ABB
SACE Emax 2
NP PCF v1.0 DOC TECH
ABB
SACE Emax 2 Fixed Part
NP PCF v1.0 DOC TECH
Atlas 500 AI edge station
NP PCF TECH
cyber® simco® drive 2
NP PCF TECH
MR-J4-60B-RJ
NP PCF v1.0 DOC TECH ...
Servo Drive New Generation, Size 1
NP PCF DOC TECH ...
PHOENIX CONTACT
Hybrid motor starter
NP PCF v1.0 DOC TECH
PHOENIX CONTACT
Hybrid motor starter
NP PCF v1.0 DOC TECH
PHOENIX CONTACT
Hybrid motor starter
NP PCF v1.0 DOC TECH
i950 cabinet
NP PCF DOC TECH
Schneider
Variable speed drive, Altivar Process ATV600, ATV630, 0.75kW/1 hp, 200...240 V, IP21/UL type 1
NP PCF DOC TECH ...
Schneider
Direct online starter, TeSys island, 40A AC-1, 38A AC-3, 18.5kW / 20hp
NP PCF DOC TECH ...
Schneider
TeSys island, Analog IO module, 2 inputs, 1 output
NP PCF DOC TECH ...
Schneider
Digital IO module, 4 inputs, 2 outputs
NP PCF DOC TECH ...
Schneider
TeSys island, Analog IO module, 2 inputs, 1 output
PCF DOC TECH ...
Schneider
Variable speed drive, Altivar Process ATV600, ATV630, 0.75kW/1 hp, 200...240 V, IP21/UL type 1
NP PCF DOC TECH ...
PHOENIX CONTACT
Relay Module
NP PCF v1.0 DOC TECH



Ground modular terminal block
NP PCF v1.0 DOC TECH
Feed-through terminal block
NP PCF v1.0 DOC TECH
S7-1500, DQ 32x24VDC/0.5A HF
NP PCF v1.0 DOC TECH ...
S7-1500, DI 32x24VDC HF
NP PCF v1.0 DOC TECH ...
ET 200SP, IM155-6PN ST incl. BA 2xRJ45
NP PCF v1.0 DOC TECH ...
Baying enclosure system VX25
NP PCF TECH
Wall-mounted cooling unit Blue e+ S
NP PCF TECH
IFB3004BBPKG/US-104
NP PCF TECH
PF 66000 230V 55 UV 7035
NP PCF TECH
PFA 60000 55 UV 7035
NP PCF TECH
FESTO
Motion Terminal VTEM
NP PCF v1.0 TECH ...
VDE
DPP Demonstrator
NP PCF DOC TECH ...
rexroth
Directional Spool Valve
NP PCF DOC TECH ...
S2C 2.5
NP PCF v1.0 DOC TECH ...
PRO DCDC 96W 12V/12V 8A
NP PCF v1.0 DOC TECH ...
wöhner
Connection Module
NP PCF TECH
wöhner
NH Fuse-Switch-Disconnector
NP PCF TECH
wöhner
Basic system 125 A
NP PCF TECH
Knick
Knick_P42000_2357292
NP PCF TECH
Knick
Knick_Memorail_ 2357292
NP PCF TECH
BaseUnit Type A0, BU15-P16+A0+2B
NP PCF v1.0 DOC TECH ...
BaseUnit Type A0, BU15-P16+A0+2B
NP PCF v1.0 DOC TECH ...
ET 200SP, IM155-6PN ST incl. BA 2xRJ45
NP PCF v1.0 DOC TECH ...
SINAMICS G120C USS/MB 3,0KW FILA
NP PCF v1.0 DOC TECH ...
CIRCUIT BREAKER 10KA 1POL C16
NP PCF v1.0 DOC TECH ...

4.3 Scanner App