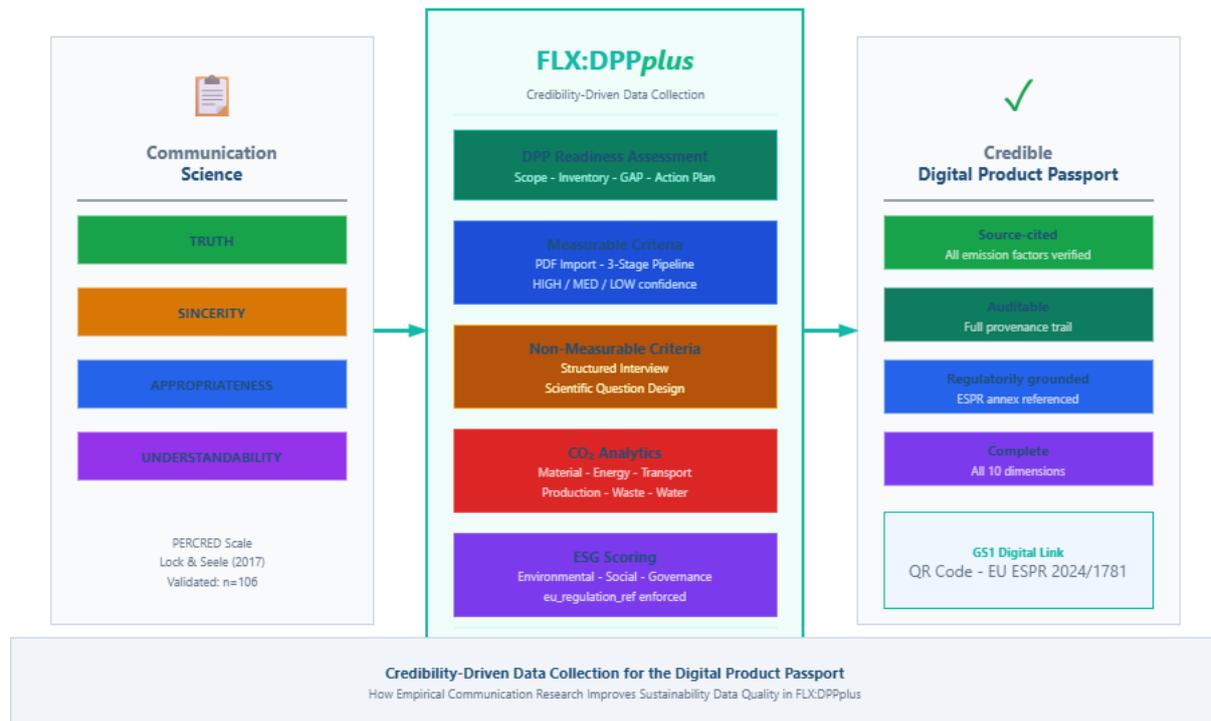


Credibility-Driven Data Collection for the Digital Product Passport

How Empirical Communication Research Improves Sustainability Data Quality in FLX:DPPplus



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Abstract

The European Union's Ecodesign for Sustainable Products Regulation (ESPR, Regulation 2024/1781) mandates Digital Product Passports (DPPs) for an expanding set of product categories starting 2027. With over 30 affected product groups and thousands of manufacturers across Europe facing immediate compliance obligations, the DPP has become one of the most consequential regulatory data challenges in EU product policy history. The societal imperative is equally clear: the European Commission estimates that up to 80% of a product's environmental impact is determined at the design and production stage, making systematic lifecycle transparency a prerequisite for any credible circular economy strategy. Markets are responding accordingly: sustainability transparency has shifted from a competitive differentiator to a legal requirement, and organisations that fail to build the underlying data infrastructure risk both regulatory non-compliance and reputational exposure to greenwashing allegations.

This paper presents FLX:DPPplus, a production-grade, multi-tenant SaaS platform designed to make DPP creation fast, structured, and repeatable across recurring compliance cycles. The platform addresses two fundamentally different data collection challenges: measurable criteria (materials, energy, transport, production) captured automatically through PDF bill-of-materials import and digital measurement pipelines, and non-measurable criteria (supplier compliance declarations, ESG assessments, certifications) collected through a scientifically grounded structured interview workflow. Before data collection begins, FLX:DPPplus guides users through a four-step DPP Readiness Assessment: identifying the applicable product scope and ESPR deadline, inventorying existing data, producing a structured GAP analysis, and generating a prioritised action plan for closing identified gaps.

The core platform implements a 50-table relational schema spanning two PostgreSQL schemas with cross-schema tenant isolation, a multi-dimensional Life Cycle Assessment (LCA) engine covering 10 environmental dimensions with formal CO2 computation algorithms, and a self-learning catalog classification system that bridges rule-based material matching with AI-ready data pipelines. The platform processes PDF bill-of-materials imports through a three-stage matching pipeline (keyword -> catalog -> fallback) with explicit confidence scoring, implements materialized CO2 aggregates across materials, energy, transport, production, waste, and water dimensions, and supports EU ESPR-compliant publishing with GS1 Digital Link integration. With ~420 columns, ~85 foreign key relationships, and ~96 REST API endpoints, the system represents a significant contribution to the emerging field of regulatory data engineering for sustainability.

Kurzfassung

Die europäische Ökodesign-Verordnung für nachhaltige Produkte (ESPR, Verordnung 2024/1781) schreibt Digitale Produktpässe (DPP) für eine wachsende Zahl von Produktkategorien ab 2027 vor. Mit über 30 betroffenen Produktgruppen und tausenden von Herstellern in Europa, die unmittelbaren Compliance-Pflichten gegenüberstehen, ist der DPP

zu einer der folgenreichsten regulatorischen Datenanforderungen in der Geschichte der EU-Produktspolitik geworden. Die gesellschaftliche Relevanz ist ebenso eindeutig: Die Europäische Kommission schätzt, dass bis zu 80 % der Umweltwirkung eines Produkts in der Design- und Produktionsphase festgelegt werden, sodass systematische Lebenszyklus-Transparenz Voraussetzung für jede glaubwürdige Kreislaufwirtschaftsstrategie. Märkte reagieren entsprechend: Nachhaltigkeitstransparenz hat sich von einem Wettbewerbsvorteil zu einer gesetzlichen Pflicht entwickelt, und Organisationen, die keine ausreichende Dateninfrastruktur aufbauen, riskieren sowohl regulatorische Verstöße als auch Reputationsschäden durch Greenwashing-Vorwürfe.

Dieses Paper stellt FLX:DPPplus vor, eine produktionsreife, mandantenfähige SaaS-Plattform, die DPP-Erstellung schnell, strukturiert und für wiederkehrende Compliance-Zyklen wiederholbar macht. Die Plattform adressiert zwei grundlegend verschiedene Datenerhebungsherausforderungen: messbare Kriterien (Material, Energie, Transport, Produktion), die automatisch über PDF-Stücklistenimport und digitale Messpipelines erfasst werden; sowie nicht-messbare Kriterien (Lieferanten-Compliance-Erklärungen, ESG-Bewertungen, Zertifikate), die über einen wissenschaftlich fundierten strukturierten Interview-Workflow erhoben werden. Vor der eigentlichen Datenerfassung führt FLX:DPPplus Nutzer durch ein vierstufiges DPP-Readiness-Assessment: Bestimmung des anwendbaren Produktumfangs und der ESPR-Frist, Inventarisierung vorhandener Daten, Erstellung einer strukturierten GAP-Analyse sowie Generierung eines priorisierten Maßnahmenplans zur Schließung identifizierter Lücken.

Die Kernplattform implementiert ein relationales Schema mit 50 Tabellen über zwei PostgreSQL-Schemata mit schemaübergreifender Mandantenisolation, eine mehrdimensionale Ökobilanz-Engine (LCA) über 10 Umweltdimensionen mit formalisierten CO₂-Berechnungsalgorithmen sowie ein selbstlernendes Katalog-Klassifikationssystem, das regelbasiertes Material-Matching mit KI-fähigen Datenpipelines verbindet. Mit ca. 420 Spalten, ca. 85 Fremdschlüsselbeziehungen und ca. 96 REST-API-Endpunkten leistet das System einen wesentlichen Beitrag zum entstehenden Feld des regulatorischen Dateningenieurwesens für Nachhaltigkeit.

1. Introduction

1.1 Regulatory Context and Motivation

The European Green Deal and its implementing legislation represent a paradigm shift in how products are documented throughout their lifecycle. The ESPR (Regulation 2024/1781) requires manufacturers to create Digital Product Passports containing comprehensive environmental, social, and governance (ESG) data for each product placed on the EU market. Beginning with batteries and textiles in 2027, the regulation will progressively expand to cover construction products, furniture, electronics, and virtually all product categories by 2030.

The work presented in this paper is grounded in practice rather than theory. FLX:DPPplus was developed in direct response to customer inquiries from construction companies and industrial manufacturers who recognised the approaching ESPR deadlines but lacked the data infrastructure to comply. These organisations faced a common set of challenges: fragmented material data spread across PDF bills of materials, no systematic CO₂ accounting, and no connection between lifecycle data and regulatory reporting. The architecture described in the

following sections represents the engineering response to these real-world requirements: each design decision, from the self-learning catalog system to the materialised CO2 aggregates, traces back to a specific operational need encountered during customer engagements. The system has been validated through production deployment and live demonstrations with prospective clients, confirming both technical feasibility and practical usability.

From a data science perspective, this regulation creates an unprecedented challenge: organisations must capture, compute, and publish structured environmental data across heterogeneous product types, integrate supply chain information from multiple tiers, and maintain audit trails that satisfy regulatory authorities. The data volumes are substantial. A single construction project may generate hundreds of material entries, dozens of transport records, and multi-dimensional energy consumption profiles, all requiring accurate CO2 quantification.

1.2 Automatic and Manual Data Collection for DPP Criteria

A central design insight of FLX:DPPplus is the recognition that DPP data does not originate from a single source and cannot be collected through a single method. The platform therefore distinguishes two fundamentally different categories of DPP criteria, each requiring its own collection workflow.

Measurable Criteria: Automatic Collection

Measurable criteria are those for which verifiable, quantitative data exists or can be derived from primary sources: material composition from bills of materials, energy consumption from meter readings or invoices, transport distances and vehicle types, production process data, waste volumes, and water consumption. FLX:DPPplus captures these through automated pipelines: a PDF bill-of-materials import extracts material designations via a three-stage classification pipeline (keyword matching -> catalog lookup -> fallback), assigns official emission factors from UBA/TREMOD 2024 reference data, and computes CO2 equivalents across six dimensions. Each data point carries explicit confidence scoring (HIGH / MED / LOW / NONE) and provenance metadata, creating a fully auditable and reproducible calculation chain. This automated approach dramatically reduces the manual effort required for recurring compliance cycles and ensures consistency across product variants and product lines.

Non-Measurable Criteria: Structured Interview Workflow

Non-measurable criteria cannot be read from a sensor or extracted from a document; they require organisational self-disclosure: supplier compliance declarations (LkSG, CBAM, conflict minerals), ESG assessments, certifications, SVHC substance declarations, and DPP visibility decisions. For this category, FLX:DPPplus implements a structured interview workflow informed by empirical communication research (Wehle, 2026). The key finding from that research is that factual, source-cited communication generates significantly higher credibility than framing without evidence. This finding translates directly into interview question design: every non-measurable criterion is elicited through questions that require a verifiable reference, a responsible party, a regulatory anchor, or an explicit completeness confirmation. This approach structurally prevents vague or unsubstantiated entries from entering the DPP, addressing the root cause of greenwashing at the data collection stage rather than at the communication stage.

DPP Readiness Assessment: Before Data Collection Begins

Prior to initiating either data collection workflow, FLX:DPPplus guides users through a four-step DPP Readiness Assessment designed to prevent the most common failure mode in DPP projects: beginning data collection without a clear picture of what already exists and what is missing.

- Step 1: Product Scope: Determine which product category applies, which ESPR annex governs the product, and what the binding compliance deadline is (2027, 2028, or 2030).
- Step 2: Data Inventory: Systematically assess what data is already available across all 10 lifecycle dimensions: BOM, supplier records, energy bills, transport logs, ESG documentation, and certifications.
- Step 3: GAP Analysis: Identify missing data by dimension, estimate the collection effort required, and prioritise gaps according to regulatory urgency and CO2 materiality.
- Step 4: DPP Readiness: Map identified gaps to the appropriate FLX:DPPplus collection workflow (automatic pipeline for measurable criteria, structured interview for non-measurable criteria) and generate a prioritised action plan.

The output of the Assessment is a structured GAP Report that documents what data exists, what is missing, and what steps are required to achieve a publishable, EU ESPR-compliant Digital Product Passport. This assessment capability positions FLX:DPPplus not merely as a data entry tool, but as an end-to-end compliance management platform that guides organisations from initial readiness evaluation through to published DPP.

1.3 Research Questions and Contributions

This paper addresses four research questions at the intersection of data architecture, sustainability analytics, and compliance workflow design:

- RQ1: How can a relational data model support polymorphic product types while maintaining computational efficiency for CO2 aggregation across 10 lifecycle dimensions?
- RQ2: What data pipeline architecture enables self-learning material classification that improves with usage while maintaining full explainability, a critical requirement in regulated environments?
- RQ3: How can a structured assessment and GAP analysis workflow be designed to guide organisations from DPP readiness evaluation to compliant data collection?
- RQ4: How can the data architecture be designed as AI-ready from inception, enabling future machine learning integration without schema migration?

Our contributions include: (1) a formalized 50-table data model implementing Class Table Inheritance for polymorphic DPPs; (2) a six-dimensional CO2 aggregation algorithm with materialised caching; (3) a three-stage self-learning classification pipeline with confidence scoring; (4) a four-step DPP Readiness Assessment with structured GAP analysis output; (5) a scientifically grounded structured interview workflow for non-measurable criteria; and (6) an analysis of AI-ready architectural patterns for regulatory data systems.

1.4 System Overview

Figure 1 presents the complete system architecture, illustrating three layers: the platform governance layer (left), the DPP domain model with its lifecycle dimensions and catalog system (centre), and the analytics, compliance output, and AI-readiness layer (right). The lower section of Figure 1 additionally shows the DPP Readiness Assessment flow and the scientific grounding of the non-measurable criteria interview workflow. The following sections examine each layer in detail.



FLX:DPPplus is deployed as a module within fix:Cockpit, a multi-tenant SaaS platform built on FastAPI (Python 3.11), PostgreSQL 15, and a CDN-based JavaScript frontend (~8,460 lines). The platform currently manages ~96 API endpoints with JWT-based authentication, role-based access control (RBAC) with four tenant roles, and comprehensive audit logging of all operations.

2. Theoretical Background

2.1 Sustainability Communication and the Credibility Challenge

Sustainability communication has become a strategic priority for organisations across all industries, driven by regulatory pressure, investor scrutiny, and growing consumer awareness. At the same time, the credibility of such communication is under increasing strain. The proliferation of unsubstantiated environmental claims has created widespread scepticism among stakeholders, and regulatory bodies in both the EU and the US have responded with stricter anti-greenwashing frameworks [1, 2]. The EU Green Claims Directive, currently under development, and the ESPR Regulation 2024/1781 represent the legislative response to this

credibility crisis: environmental claims must be substantiated by verifiable, structured data rather than marketing language [3].

Empirical research confirms that the way sustainability information is communicated directly affects how credible it is perceived to be. A study on sustainability message perception (Wehle, 2026, n = 106) demonstrated that factual, evidence-based messages were rated significantly more credible than emotionally framed messages without factual support. Messages that combined factual data with emotional tone partially recovered credibility, confirming that substantive content is the primary driver of perceived trustworthiness. This finding has a direct implication for DPP data collection: the credibility of a published Digital Product Passport depends not on how the data is presented, but on whether the underlying data entries are source-cited, verifiable, and complete.

2.2 The PERCRED Framework as a Design Lens

The PERCRED scale, developed by Lock and Seele [4], operationalises credibility in sustainability and CSR communication through four dimensions grounded in Habermas's theory of communicative action: Truth (accuracy and factual support), Sincerity (authenticity of intentions), Appropriateness (alignment with normative context), and Understandability (clarity and completeness). These four dimensions map directly onto the data quality requirements of a credible Digital Product Passport.

FLX:DPPplus applies this framework as a design lens for two specific use cases. First, for measurable criteria, the platform enforces the Truth dimension by requiring source citations for all emission factors, confidence scoring for every classification, and provenance metadata for all calculated values. Second, for non-measurable criteria, the platform's structured interview workflow is designed to satisfy the Sincerity and Appropriateness dimensions: each interview question requires the user to identify a responsible party, reference a specific regulation or standard, and confirm completeness across all lifecycle dimensions. The Understandability dimension is enforced through a publication readiness check that prevents DPP publication until all mandatory fields are populated.

2.3 The Digital Product Passport under EU ESPR

The EU Ecodesign for Sustainable Products Regulation (ESPR, Regulation 2024/1781 [3]) establishes the legal framework for Digital Product Passports across the EU single market. The DPP is defined as a structured digital record that must accompany a product throughout its lifecycle, containing verifiable environmental, social, and governance data accessible via a GS1 Digital Link [5] and QR code. The regulation mandates DPPs for textiles and batteries from 2027, construction products and furniture from 2027 to 2028, and all remaining product categories by 2030.

The practical implementation challenge is significant. Organisations must collect and maintain structured data across up to 10 lifecycle dimensions per product, integrate supplier data from multiple tiers, satisfy different regulatory requirements depending on product category, and maintain a complete audit trail for regulatory review. Existing lifecycle assessment tools such as GaBi, SimaPro, and openLCA address parts of this challenge but were designed as standalone expert systems, not as multi-tenant SaaS platforms capable of managing recurring compliance cycles across diverse product portfolios [6, 7]. FLX:DPPplus was developed specifically to address this implementation gap, combining automated data collection for

measurable criteria with a structured interview workflow for non-measurable criteria, and preceding both with a systematic DPP Readiness Assessment.

3. Research Gap and Contribution

Existing research on Digital Product Passports focuses primarily on data interoperability standards and lifecycle assessment computation [8, 9]. Communication research on sustainability credibility addresses message design and framing effects [10, 11] but does not engage with the question of how data collection processes shape the credibility of the outputs. Neither stream has addressed the practical challenge of guiding organisations through a readiness assessment before data collection begins, or of distinguishing between automatic and interview-based collection methods depending on the nature of the criterion.

This paper addresses that gap through two concrete contributions grounded in the FLX:DPPplus platform. The first contribution is a DPP Readiness Assessment framework that systematically evaluates an organisation's data readiness before any collection activity begins, produces a structured GAP analysis across all 10 lifecycle dimensions, and generates a prioritised action plan aligned with applicable ESPR deadlines. The second contribution is a credibility-grounded interview workflow for non-measurable DPP criteria, derived from empirical communication research and structured around the four PERCRED dimensions. Together, these contributions position FLX:DPPplus as an end-to-end compliance management platform rather than a pure data entry tool, and demonstrate how communication science can inform the design of regulatory data systems.

4. Credibility-DPP Mapping Framework

4.1 Mapping Logic

Both FLX:DPPplus use cases described in Section 1.2 require a principled answer to the same question: which data collection decisions make the resulting DPP credible? The DPP Readiness Assessment identifies what data is missing; the interview workflow determines how non-measurable criteria are collected. In both cases, the quality of the output depends on whether the data collection questions are designed to satisfy the communicative demands of each PERCRED dimension [4].

The mapping rests on a straightforward observation: each PERCRED dimension specifies what a credible sustainability message must demonstrate, and each DPP lifecycle domain specifies what data must be collected. If data collection questions are designed to satisfy both requirements simultaneously, the DPP output is structurally credible. This is not a post-hoc communication exercise; it is a data engineering decision made at the point of system design.

Table 1 presents the full mapping across the four PERCRED dimensions, their sub-indicators, the corresponding DPP data domains, and their implementation in FLX:DPPplus.

Table 1: PERCRED-DPP Dimension Mapping

PERCRED Dimension	Sub-Indicators	DPP Data Domain	FLX:DPPplus Implementation
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Truth	Accuracy, Truthfulness, Facts	Emission factor sources (UBA/TREMOD), mass data, measurement methodology	Source citation fields, confidence scoring (HIGH/MED/LOW), unit factor provenance
Sincerity	Intentions, Trustworthiness	Supply chain compliance data, audit trail, data entry authorship	Audit log per entry, LkSG/REACH compliance flags, user attribution
Appropriateness	Norms, Context, Legitimacy	Product category classification, regulatory alignment (ESPR, GS1), industry benchmarks	Subject type taxonomy, eu_regulation_ref fields, GS1 Digital Link compliance
Understandability	Technical clarity, Meaning, Completeness	Completeness of lifecycle data across all 10 dimensions, structured output format	Mandatory field enforcement, CO2 dimension completeness check, DPP publication readiness score

Source: Authors, based on Lock and Seele [4] and Wehle and Wehle [13].

4.2 Key Mapping Insights by Use Case

Use Case 1: DPP Readiness Assessment

In the Assessment workflow, the GAP analysis must be credible to be actionable. The Truth dimension requires that every identified gap is tied to a specific, verifiable lifecycle dimension rather than a vague category. The Appropriateness dimension requires that each gap is mapped to the regulatory obligation that makes it mandatory, referencing the specific ESPR annex and deadline. The Understandability dimension requires that the GAP Report covers all 10 lifecycle dimensions without exception, so that the organisation receives a complete picture of its readiness position. A GAP report that is factually grounded, regulatorily anchored, and structurally complete is, by the PERCRED framework, a credible assessment output.

Use Case 2: Structured Interview for Non-Measurable Criteria

For the interview workflow, the PERCRED mapping translates directly into question design. The empirical finding from Wehle [12] that factual, source-cited communication generates significantly higher credibility than framing without evidence means that every interview question must require a verifiable input rather than a declaratory statement. Truth requires source citations for all quantitative inputs. Sincerity requires the identification of a responsible party and a reference document for each self-disclosure entry. Appropriateness requires that each compliance declaration references a specific regulation or standard. Understandability requires explicit confirmation that all lifecycle dimensions have been addressed before the interview workflow closes.

A concrete illustration: in the FLX:DPPplus supplier compliance workflow, the question is not "Is your supply chain sustainable?" but "Is your primary supplier LkSG Section 5 compliant? Reference document and verification party: ____". The first question invites framing; the second enforces the Sincerity and Appropriateness dimensions. The FLX:DPPplus confidence scoring system (HIGH/MED/LOW/NONE) structurally captures this distinction at the data model level.

5. Credibility-Enhancing Question Taxonomy for DPP Data Collection

5.1 The Four Question Types

Drawing from the PERCRED-DPP mapping, and grounded in the two FLX:DPPplus use cases, we propose a taxonomy of four data collection question types. Each type targets a specific credibility dimension and applies to both the Assessment workflow (where it determines which questions the GAP analysis asks about existing data) and the Interview workflow (where it determines how non-measurable criteria are elicited). Table 2 presents the taxonomy with examples.

Table 2: Data Collection Question Taxonomy

Code	Question Type	Purpose	Example
Q-TRUTH	Factual-Quantitative	Verifiable numeric inputs with source citation	What is the CO2 emission factor of this material (kg CO2e/kg)? Source: ____
Q-SINC	Provenance-Traceability	Data origin and accountability metadata	Who verified this data entry? Reference document: ____
Q-APPR	Contextual-Regulatory	Normative alignment and completeness for the applicable regulation	Does this product category fall under ESPR Regulation 2024/1781? Which annex?
Q-UNDER	Structural-Completeness	Coverage across all mandatory lifecycle dimensions	Are all 10 lifecycle dimensions populated? Which dimensions are missing?

Source: Authors.

5.2 Design Principles

Four principles govern the application of this taxonomy across both use cases. They apply equally to the automated data collection pipeline for measurable criteria and to the structured interview for non-measurable criteria.

- Principle 1, Source Obligation: Every numeric input (mass, emission factor, energy consumption) must be accompanied by a mandatory source field. The question is not "What is the emission factor?" but "What is the emission factor and which standard or database specifies it?" This applies in both the PDF import pipeline (where the source is the UBA/TREMODO catalog entry) and in the interview (where the source is a supplier declaration or certification).
- Principle 2, Confidence Transparency: The data collection interface must explicitly display the confidence level of each entry. Users must see that an EXPLICIT measurement (HIGH) produces more credible DPP output than a CATALOG_TYPICAL estimate (MED). This transparency is built into the FLX:DPPplus confidence scoring system and surfaces directly in the GAP Report.
- Principle 3, Regulatory Grounding: For every ESG criterion and compliance flag, the question must reference the specific regulation, article, or standard. In the Assessment workflow, this means each identified gap is annotated with the regulatory requirement that creates it.
- Principle 4, Completeness Enforcement: Missing lifecycle dimensions must be visible in both workflows and must block DPP publication until resolved. Completeness is not a quality goal; it is a credibility prerequisite. The FLX:DPPplus publication readiness check enforces this at the system level.

6. Concrete Question Set for FLX:DPPplus

Table 3 presents the complete set of 14 credibility-enhancing data collection questions for FLX:DPPplus, organised by lifecycle dimension, question type, question text, and corresponding platform field or logic. These questions are derived from the PERCRED-DPP mapping and apply across both use cases: they inform which data the Assessment workflow checks for completeness, and they form the question set for the structured interview workflow for non-measurable criteria.

Table 3: Credibility-Enhancing Data Collection Questions for FLX:DPPplus

Lifecycle Dim.	Type	Data Collection Question	FLX:DPPplus Field / Logic
Material	Q-TRUTH	What material type is this? Select from catalog or enter custom.	cat_material_types catalog lookup; confidence scoring HIGH/MED/LOW
Material	Q-TRUTH	What is the mass of this material (kg)? State measurement basis (EXPLICIT / ESTIMATED).	mass_method field: EXPLICIT, CATALOG_PROFILE, UNIT_IS_MASS
Material	Q-SINC	Which data source confirms the emission factor? (UBA, ecoinvent, supplier declaration)	emission_factor_source field; provenance stored in mass_explain text
Energy	Q-TRUTH	What energy carrier is used in production? (electricity, gas, district heat)	cat_energy_types catalog; kWh input with fuel_type metadata
Energy	Q-APPR	What is the grid electricity emission factor applicable? (Region, year of reference)	Region-specific EF catalog; temporal versioning via assessment_period
Transport	Q-TRUTH	What vehicle type and fuel type transported this product? Distance in km?	cat_transport_types matrix; distance_km x EF(vehicle, fuel) x trips_count
Transport	Q-UNDER	Is the transport leg complete (origin, production, distribution, end-of-life)?	Completeness check across subject_transport entries
Production	Q-TRUTH	How much production energy was consumed per unit? Unit: kWh/unit	subject_production table; energy_kwh field with direct EF multiplication
Waste	Q-TRUTH	What percentage of this material is recycled at end of life? Source?	recycled_content_pct, recyclable boolean; source attribution
Water	Q-TRUTH	How many cubic meters of water were consumed in production? Measurement basis?	water_m3 field; EF from cat_water_types
ESG	Q-APPR	Which ESG assessment criteria apply to this product under ESPR? Weighted score?	cat_assessment_criteria with eu_regulation_ref; weighted ESG score computation
Supply Chain	Q-SINC	Is the primary supplier LkSG-compliant? CBAM-relevant? Conflict-mineral-free?	suppliers table: lksg_compliant, cbam_relevant, conflict_minerals_free flags
Supply Chain	Q-UNDER	Are SVHC substances present above 0.1% threshold? SCIP notification status?	svhc_substance, svhc_concentration_pct, scip_notified in subject_materials
Publication	Q-APPR	At which visibility level should this DPP be published? Public / Authority / Supply Chain?	3-level visibility system: public, authority, supply_chain

Source: Authors. Q-codes refer to the taxonomy in Table 2.

6.1 Implementation Status and Development Priorities

Several of these questions are already implemented in FLX:DPPplus through the confidence scoring system, the three-stage material matching pipeline, and the audit log [13]. The following gaps represent the primary development priorities for completing the credibility-by-design implementation across both use cases.

- Source citation is currently optional in the `cat_material_types` catalog. Making `emission_factor_source` a mandatory field for all HIGH-confidence entries would enforce Q-TRUTH at the data model level and strengthen the credibility foundation of both the Assessment GAP Report and the published DPP.
- The ESG assessment criteria reference `eu_regulation_ref`, but the data entry interface does not yet surface this field prominently during the interview workflow. A UI update that shows the regulatory anchor at data entry time would directly satisfy Principle 3 for non-measurable criteria.
- The publication readiness check validates presence of lifecycle dimension entries but does not yet weight by confidence level. A composite credibility score combining completeness and average confidence would give users an operational quality metric visible both in the Assessment GAP Report and in the pre-publication checklist.

7. FLX:DPPplus Project Flow: Furniture Industry Sample

7.1 Overview

This chapter illustrates the complete FLX:DPPplus project flow using the furniture industry as a concrete sample. Furniture manufacturers face a DPP obligation expected around 2027/2028 under ESPR Regulation 2024/1781, making this one of the most immediately relevant product categories. The sample is based on the FLX:DPPplus furniture implementation (v1.3.0, March 2026), which covers 51 predefined material types across 7 categories, 21 manufacturing process types, 4 production set templates, and 32 EU ESPR-specific data fields per product subject [13].

The project flow follows the four-step structure introduced in Section 1.2: DPP Readiness Assessment, followed by automatic data collection for measurable criteria, followed by structured interview for non-measurable criteria, followed by DPP publication. The furniture sample demonstrates how the credibility-by-design principles from Chapters 4 to 6 translate into practical platform workflow.

7.2 Step 1: DPP Readiness Assessment for a Furniture Manufacturer

The assessment begins with a 3-seat upholstered sofa as the target product. Based on the FLX:DPPplus furniture data model, the sofa has 8 material components across 4 categories (frame, upholstery, cover fabric, fittings), a manufacturing set of 14 process steps consuming approximately 67 kWh, and a typical CO₂ footprint of 120 to 200 kg CO₂e per unit [13]. Table 4 shows the Assessment output for this product.

Table 4: DPP Readiness Assessment Output , 3-Seat Sofa Sample

Assessment Step	Question	Furniture Sample Answer	ESPR Implication
Step 1: Product Scope	Which product category and ESPR deadline applies?	Upholstered furniture (3-seat sofa); DPP mandatory approx. 2027/2028 under ESPR Delegated Act	ESPR Regulation 2024/1781; CEN/CLC JTC 24 harmonised standards apply
Step 2: Data Inventory	Which lifecycle dimensions have verified data?	Materials: partial (BOM available, emission factors missing for 3 of 8 materials); Energy: annual consumption known; Transport: undocumented; ESG: not assessed	GAP identified in Transport (Q-TRUTH) and ESG (Q-APPR); blocks DPP publication
Step 3: GAP Analysis	What is missing and how critical is each gap?	Critical: transport EF for 500 km road leg; supplier LkSG status for Tier-1 fabric supplier; VOC emission class for lacquer surface	LkSG Section 5 compliance (Q-SINC); REACH SVHC declaration for fabric (Q-SINC); EU ESPR furniture-specific fields (Q-APPR)
Step 4: DPP Readiness	Which collection workflow closes each gap?	Transport: automatic pipeline (vehicle type + distance input); Supplier LkSG: structured interview (Q-SINC); VOC class: certificate upload (Q-APPR)	After gap closure: all 10 dimensions populated; confidence score HIGH/MED across materials; DPP publication enabled

Source: Authors, based on FLX:DPPplus v1.3.0 furniture implementation [13].

The Assessment identifies three critical gaps for this product: the transport emission factor for the 500 km road delivery leg, the LkSG Section 5 compliance status of the Tier-1 fabric supplier, and the VOC emission class for the lacquer surface treatment. Each gap is annotated with the regulatory requirement that makes it mandatory and mapped to the appropriate FLX:DPPplus collection workflow. Measurable gaps (transport distance, energy consumption) are routed to the automatic pipeline. Non-measurable gaps (supplier compliance, VOC declaration, ESG assessment) are routed to the structured interview workflow.

7.3 Step 2: Automatic Data Collection for Measurable Criteria

For the furniture sample, measurable data collection covers materials, manufacturing energy, transport, waste, and water. FLX:DPPplus handles this through two mechanisms. First, the PDF bill-of-materials import classifies each of the 8 sofa materials through the three-stage pipeline (keyword matching to catalog, fallback to manual entry) and assigns emission factors from Okobaudat 2024, GaBi 2024, HIGG MSI 2024, and Ecoinvent 3.9. Second, the manufacturing set template for upholstered furniture automatically creates all 14 process steps with pre-configured energy consumption values that the manufacturer adjusts to their actual machine data.

Each automatically collected data point carries a confidence score. For the sofa sample, Massivholz Buche (beech frame) classifies at HIGH confidence with a catalog-matched emission factor of 0.45 kg CO₂e per kg from Okobaudat 2024. The Webstoff cover fabric classifies at MED confidence because the specific 300 g per m² grammage requires a unit factor derived from the catalog typical value rather than an explicit measurement. These confidence levels appear directly in the Assessment GAP Report, giving the manufacturer a clear picture of which material entries would benefit from supplier-provided declarations to reach HIGH confidence.

7.4 Step 3: Structured Interview for Non-Measurable Criteria

The three gaps identified in the Assessment are addressed through the structured interview workflow. Table 5 shows the six interview questions applied to the furniture sample, each derived from the PERCRED-DPP mapping in Chapter 4 and designed to satisfy the credibility dimension it targets. The questions follow the four design principles from Section 5.2: every question requires a verifiable reference, a responsible party, a regulatory anchor, or an explicit completeness confirmation.

Table 5: Structured Interview Questions , Furniture Sample

Criterion	Type	Interview Question (Furniture)	FLX:DPPplus Field
Supplier Compliance	Q-SINC	Is the primary fabric supplier LkSG Section 5 compliant? Reference document and verifying party: ____	suppliers.lksg_compliant; audit_log user + timestamp
SVHC Declaration	Q-SINC / Q-APPR	Are SVHC substances present in the upholstery fabric above the 0.1% threshold? SCIP notification submitted to ECHA?	subject_materials.svhc_concentration_pct; scip_notified
VOC Emissions	Q-APPR	What VOC emission class applies to the lacquer surface treatment? Measurement standard and test report reference: ____	furniture_details.voc_emission_class; voc_test_norm
ESG Assessment	Q-APPR	Which ESG criteria apply under ESPR for this product? EU regulation reference for each weighted criterion: ____	cat_assessment_criteria.eu_regulation_ref; subject_assessments.score
DPP Visibility	Q-UNDER	At which visibility level should this DPP be published: Public, Authority, or Supply Chain? Which data fields are restricted?	dpp_subjects.visibility_level; publication_status
Durability & End-of-Life	Q-UNDER	Is a disassembly instruction available? Estimated disassembly time (minutes) and tools required: ____	furniture_details.disassembly_instructions; disassembly_time_min

Source: Authors. Based on FLX:DPPplus furniture workflow and PERCRED mapping [4, 13].

The interview for the fabric supplier compliance question illustrates the Sincerity dimension in practice. The manufacturer cannot answer "Is your supply chain sustainable?" with a verifiable entry; they must name the specific supplier, the LkSG section that applies, the reference document (audit report or self-declaration), and the person responsible for verification. FLX:DPPplus stores all four elements: the compliance flag (lksg_compliant), the document reference, the verifying party via the audit log, and the timestamp. This data structure makes the non-measurable criterion as auditable as the measured CO2 value.

7.5 Step 4: DPP Publication

Once all Assessment gaps are closed, FLX:DPPplus runs the publication readiness check across all 10 lifecycle dimensions. For the furniture sample, the check validates that materials, energy, manufacturing, transport, waste, water, ESG assessment, supply chain compliance, certifications, and the 32 EU ESPR furniture-specific fields are all populated. The DPP status

moves from IN_PROGRESS through REVIEW to PUBLISHED, at which point the GS1 Digital Link and QR code are generated.

The published DPP for the sofa contains a full material breakdown with emission factors and confidence scores, a six-dimensional CO2 footprint (typically 120 to 200 kg CO2e for a 3-seat sofa including materials, manufacturing, and transport), supplier compliance status per Tier-1 supplier, a weighted ESG score across Environmental, Social, and Governance domains, and all furniture-specific ESPR fields including VOC emission class, disassembly instructions, durability certification, and flame retardant declaration. The QR code on the product label provides public access to all non-restricted DPP data, satisfying the GS1 Digital Link standard [5] and the ESPR transparency requirements [3].

8. Discussion, Limitations, and Conclusion

8.1 Discussion

This paper set out to answer a question at the intersection of communication science and regulatory data engineering: does the design of data collection questions affect the credibility of sustainability outputs? The evidence from two FLX:DPPplus use cases suggests it does, and that the effect is structural.

The DPP Readiness Assessment use case demonstrates that credibility begins before a single data point is entered. An assessment that maps available data against all 10 lifecycle dimensions, annotates each gap with its regulatory obligation, and routes each gap to the appropriate workflow produces a GAP Report that is factually grounded (Truth), complete (Understandability), and regulatorily anchored (Appropriateness). The furniture sample in Chapter 7 confirms this: the three critical gaps map to specific PERCRED dimensions and FLX:DPPplus fields, making the path from gap to closure traceable.

The structured interview use case demonstrates that credibility in non-measurable criteria is a function of question design. The empirical finding from Wehle [12] ($M = 3.55$ factual vs. 2.89 framed) translates into a design requirement: every question must require a verifiable input. Replacing a declaratory supplier compliance question with one requiring an LkSG section reference, a document, and a named verifier transforms a greenwashing-prone self-disclosure into an auditable compliance record.

Taken together, both use cases support the central claim: credibility is a data engineering decision. Organisations designing DPP data collection around the PERCRED dimensions produce structurally more credible outputs, regardless of how the DPP is subsequently communicated.

8.2 Limitations

First, the PERCRED-DPP mapping and question taxonomy have not yet been validated through user studies measuring whether DPPs produced with the question set are perceived as more credible by procurement managers, auditors, or regulatory authorities. Such validation is the most important direction for future research.

Second, the furniture sample covers one product category. Non-measurable criteria differ substantially across the seven FLX:DPPplus product types and a full cross-category validation of the question taxonomy remains future work.

Third, the confidence scoring system does not yet produce a composite credibility score. Users must interpret confidence levels manually rather than receiving a direct readiness signal. Implementation is identified in Section 6.1.

Fourth, the empirical basis (Wehle [12]) used a general population sample. Generalisability to B2B DPP stakeholder audiences requires dedicated research with domain-expert participants.

8.3 Conclusion and Future Work

This paper has made two concrete contributions to regulatory data engineering for sustainability: a DPP Readiness Assessment framework as a four-step workflow in FLX:DPPplus, and a credibility-grounded interview workflow for non-measurable DPP criteria structured around four PERCRED dimensions and operationalised through four question types and 14 data collection questions.

The furniture sample demonstrates practical applicability: a 3-seat sofa DPP can be produced through a defined, repeatable workflow with a complete audit trail satisfying PERCRED credibility requirements at the data collection stage.

For organisations facing ESPR compliance from 2027, the practical implication is direct: start with an Assessment, not data entry. FLX:DPPplus makes this starting point accessible and the collection workflows repeatable across product variants and compliance cycles.

Future work will address four directions:

- **Credibility score validation:** empirical user studies with domain-expert participants measuring credibility perception of DPPs produced with and without the credibility-by-design question set.
- **Cross-category extension:** PERCRED-DPP mapping applied to all seven FLX:DPPplus subject types with product-category-specific question sets.
- **Composite credibility metric:** a score combining completeness, average confidence, and source citation density, visible in the Assessment GAP Report and pre-publication checklist.
- **AI-augmented classification:** LLM proxy for intelligent material recognition from PDF imports, measuring improvement in confidence score distribution.

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