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Digital enablement of businesses, government agencies and consumers to make green building product purchases

Nick Allison, Gary Hartley, Linden Eagles

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Contributors

Name	Role
Nick Allison	Project Lead
Gary Hartley	Researcher
Linden Eagles	Author
Sarah Anderson	Designer

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Glossary of terms

Term	Definition
Building Information Modelling (BIM)	Building Information Modelling (BIM) is an intelligent 3D model-based process that gives architecture, engineering and construction (AEC) professionals the insight and tools to plan more efficiently, and design, construct and manage buildings and infrastructure.
CEN	European Committee for Standardisation
Circular economy	A circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible.
Construction object	A data template can only be a common data structure for a specific set of similar products. This set of similar products is what is called a 'construction object'.
Data dictionary	According to EN ISO 23386, a data dictionary is a centralised repository of information about data, such as meaning, relationships to other data, origin, usage, and format.
Data model	Definition according to ISO/TS 10303-17: "description of the organization of data in the management information system of an enterprise."
Data sheet	Data input in line accordance with a Data template, which represents a real-world product, asset or requirement.
Designer	Designers (including architects, draughts persons, engineers, and quantity surveyors) prepare plans and specifications for building work. They also provide advice on the compliance of building work with the Building Code.
Environmental Product Declaration (EPD)	EPDs quantify a wide range of indicators, including climate change (carbon footprint), energy use and resource use, to provide a comprehensive view of a product's environmental impact to enable better decision-making. Each EPD is developed using standard Product Category Rules (following EN15804 and ISO14025), ensuring the products follow the same specification.
Globally Unique Identifier (GUID)	According to ISO 23386:2020, 3.13: "unique identifier generated using an algorithm."
Global Trade Item Number (GTIN)	GTIN can be used by a company to uniquely identify all of its trade items. GS1 defines trade items as products or services that are priced, ordered or invoiced at any point in the supply chain.
Infostructure	An organisational structure used for the collection and distribution of information; (now usually) the information technology infrastructure, comprised of hardware, networks, applications, etc, used by a society, business or other group. www.lexico.com/definition/infostructure
ISO	International Standards Organization
ISO 23387	Building Information Modelling (BIM) – Data templates for construction objects used in the life cycle of any built asset – Concepts and principles. www.iso.org/standard/75403.html

Term	Definition
ISO 23386	Building Information Modelling (BIM) and other digital processes used in construction – Methodology to describe, author and maintain properties in interconnected dictionaries. www.iso.org/standard/75401.html
ISO 22057:2022	The principles and requirements that enable environmental and technical data provided in Environmental Product Declarations (EPDs).
Merchants	Market participants who act as intermediaries, purchasing building supplies from suppliers, manufacturers or importers and selling to builders or other end users. These include: • major merchants in New Zealand, including Bunnings, Carters (operated by Carter Holt Harvey (CHH)), Independent Timber Merchants (ITM), Mitre 10 and PlaceMakers (operated by Fletcher Building) • smaller merchants and specialist retailers.

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New Zealand Green Building Association

Edge Environment, EPD Australasia

BRANZ

PlaceMakers/Mico Plumbing

Construction Information Limited (CIL)

Masterspec New Zealand

Independent Building Supplies (IBS)

Winstone Wallboards

Unitec Institute of Technology

Research summary

Across the world, there is a focus on the digital transformation of the construction sector. There is a refreshed drive for digital innovation and productivity, driven by the need to meet environmental sustainability targets and commitments to the circular economy.[1]

The New Zealand Government is one of the largest procurers of construction nationally. It needs to access usable Environmental Product Declaration (EPD) information in a digital format to demonstrably help meet New Zealand's commitment to a reduction of greenhouse gas (GHG) emissions targets and aims to be carbon neutral by 2050.[2] This research investigates the digital tools that are becoming available to meet this need.

The problem

It is well known that the building and construction sector is one of the least digitised industries worldwide, and digitisation is seen as a means of lifting both productivity and performance.[3,4]

New Zealand's commitment to a reduction of GHG emissions requires an improvement in the quality and availability of *digital* environmental information for building products. This will see the industry needing to manage substantially more data across the building lifecycle – from design to disposal. The industry urgently needs a standardised, common, digital language that supports interoperable data exchange between the different actors. Otherwise, it risks being overwhelmed by the duplication of data collection, documentation efforts and manual sharing of data using paper and PDFs which adds cost and inefficiencies.

Focus of our investigation

We investigated how Digital Data Templates (DDTs) might be used to support the exchange of construction object data, with a focus on EPDs[5] and generic Life Cycle Assessment[6] (LCA). DDTs are machine-readable, structured, and standardised data formats. These make data more accessible, shareable, and reusable, compared to Portable Document Formats (PDFs), spreadsheets or paper, which are the most used formats in the construction sector today.

Once loaded in DDT format, data can be used for multiple purposes, for example in Building Information Management (BIM) systems, or to support procurement decisions, or for facilities management throughout the construction life cycle. DDTs are a very recent development, and we assessed their utility and value in the New Zealand context, how they might be introduced into the domestic sector, and scaled.

Our approach

The development, adoption and commercial use of DDTs are being pioneered in the European Union (EU) and our research evaluated this progress and supporting policies.

Very few New Zealand industry stakeholders are aware of DDTs and their associated concepts and developments. To avoid purely conceptual discussions with stakeholders, we invested in the development of a DDT prototype for building objects. We demonstrated the prototype in stakeholder interviews, using a system developed by Norwegian-based IT platform provider, Cobuilder.[7] The product data was also transferred into a BIM format for demonstration purposes.

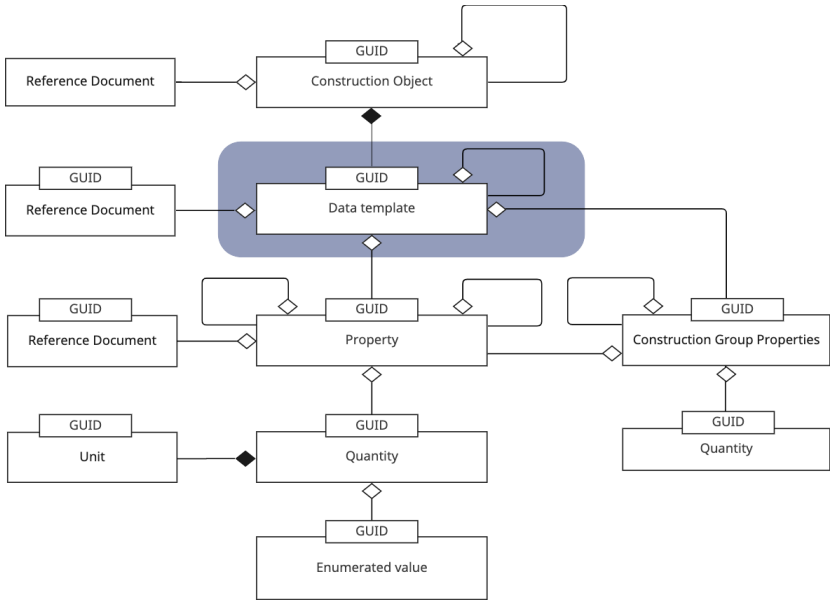
What is a Digital Data Template?

A digital data template is a common data structure describing the characteristics (properties) of an object (usually a product), according to a source of information. When a data template is completed with information, the output is called a data sheet. In practice, a data sheet includes the performance and the technical characteristics of the object. With an information exchange format, data sheets can be shared and used by different IT tools or digital environments.[8]

[1] https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
[2] www.branz.co.nz/environment-zero-carbon-research/framework/epds/
[3] Klosova, D (2021)
[4] Allison N, Hartley G (2020).
[5] www.branz.co.nz/environment-zero-carbon-research/framework/epds/
[6] https://lcanz.org.nz/lca-guidance/lca-intro
[7] https://Cobuilder.com/en/
[8] https://www.construction-products.eu/publications/digitalisation/

The underlying structure of a DDT is illustrated below in Figure 1, showing the use of a Global Unique Identifier (GUID) being a central feature of the template to link together properties, reference documents and units of measure to create a template of object characteristics.

Figure 1 - EN ISO 23387: The structure of the data template



Key findings and insights

European Union

- Digitalisation is seen as a key enabler of delivering on the European Green Deal (EGD). The objective is to move towards low-emission technologies to achieve climate neutrality by 2050.[9]
- Most EU Member States have policies targeting the digitalisation of the construction sector, including:
    - financial support in the form of grants, loans, or equity for digitisation
    - Technical assistance, such as for digital construction platforms
    - BIM requirements in place for public procurement processes
    - open sharing of government-generated materials and product data
    - The use of public-private partnerships
    - facilitating the uptake of digital technologies by providing e-services, such as issuing digital building permits and keeping registries of construction object properties.
- These initiatives are supported by EU-level policies, regulations, and other measures, including standards development and funding incentives. An example is the *High-Level Construction Forum* (HLCF) Digital Cluster Group's activities, which include the development of a common EPD framework to facilitate data sharing and the creation of a common data dictionary based on international standards. The EU has released draft regulations to establish *Digital Product Passports* (DPPs), which specify the use of international standards to uniquely identify products and associated information requirements.

New Zealand

- A key finding from the research interviews was a consensus that product information was not provided in standardised, machine-readable, interoperable formats, and was therefore not readily accessible to designers, builders, policy writers in government and Building Consent Authorities (BCAs).
- There is a common view that the product information used to inform environmental decisions, such as the EPDs or supplier product sheets, is primarily seen as a marketing tool. This undermines trust and confidence in information credibility and efficacy. The ability to compare products was also cited by

[9] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

interviewees as either being difficult, or not possible, given the information is generally not readily available.

- A recurring theme from interviewees was that the adoption of DDTs as a tool would support the construction industry to improve productivity performance, as well as help to achieve sustainability, safety, authentication, and efficiency goals.
- In June 2022, new regulations on building product information requirements were introduced by the New Zealand Government, requiring product information to be displayed online. While a significant step forward for product *information disclosure*, the regulations do not support digitalisation, including the globally unique product identification that is required for machine-readable data exchanges.
- The New Zealand Construction Sector Accord is a joint industry/government initiative that seeks to create a high-performing construction sector. The Accord was recently updated in July 2022 to include a work stream on digital enablement through innovation. To date, this has not been a focus.
- Of note, in August 2022, the New Zealand Commerce Commission delivered the findings of the *Building Materials Market Study.*[10] The study outlined a draft recommendation for the establishment of a *centralised* digital national key products registry to increase trust and confidence in residential building supplies.

New Zealand industry adoption and scaling of sharable digital records

New Zealand is far from the frontier of digitisation of construction products, objects and structured data templates, including technical standards supporting EPDs. While the new product regulations will enhance the amount of product information, they will also lead to a proliferation of data in formats that are not interoperable.

To develop policy actions that support the uptake and use of DDTs, or indeed other digital tools, it is important to recognise that New Zealand:

- is an international standards taker, not an international standards maker, so it is important to avoid bespoke localised data interoperability standards and digital templates
- imports many building products which is supported by EBOSS in their recent report on percentage of imported products and their country of origin,[11] and therefore in the future can ingest product data in digital formats, provided we are aligned with international standards.

Adopting an international approach is one mechanism that would help scale the input of source product data. It would also avoid costly, local and repeated data entry when seen in the context of the millions of building products available on the international market that are imported to New Zealand.

More challenging is building the local capabilities and *infostructure* needed to digitise the industry, to enable parties to digitally share information, and thereby rapidly scale the volume of product data available for use. While many of the interventions we identified in the EU may be useful, policymakers need to begin with the data sharing as the end game in mind.

Conclusion and next steps

An action plan needs to be developed to support the creation of a *decentralised* data management and sharing model. This would operate in the context of an industry aligned and agreed use of open, international standards. Otherwise, policymakers risk creating bespoke islands of data and applications that cannot be shared or integrated.

As a major actor in construction procurement in the economy, the government could act to coordinate its agencies to use DTTs, avoiding the costly duplication of data collection and management that takes place today. This coordination could play a key role in reducing data collection costs and enable the open sharing and reuse of digital product and materials data across the construction industry. It would also enhance the productivity of government agency operations through reducing their data collation costs.

[10] https://comcom.govt.nz/__data/assets/pdf_file/0028/289360/Draft-report-Residential-building-supplies-market-study-4-August-2022.pdf

[11] https://www.eboss.co.nz/construction-supply-chain-report/q3-2022

1 Introduction and approach

Our research focused on how a Digital Data Template (DDT) might be used as an enabler to inform business processes in the construction sector, such as purchasing and procurement, product implementation selection, product efficacy, and commitments to the principles of the circular economy. This data template model most importantly provides all actors with a common technical language that enables them to capture and share accurate and reliable information.

Having engaged more with stakeholders, we further refined our research question and developed a hypothesis:

> *That the use and implementation of Digital Data Templates and structured master data attributes will facilitate the e-procurement of fit-for-purpose 'green building' products, which can be developed, scaled and widely deployed for use in the construction sector's data supply chains.*

1.1 Research methodology

The research methodology utilised an exploratory qualitative study using semi-structured in-depth interviews. Key stakeholders' perspectives and experiences were petitioned and assisted in defining, identifying and displaying insights into current industry practice, potential use cases, barriers to adoption, and potential governance models for implementing DDTs within the New Zealand construction sector.

Working with Norwegian-based construction IT platform provider, Cobuilder,[12] we built and demonstrated a prototype DDT using their *Define Platform*. Product and attribute information of two construction objects were inputted into DDTs. The construction objects used in the demonstration were a window system and a length of Norwegian-grown timber; both objects are imported into New Zealand.

The demonstration was in real-time and designed to provide interviewees with an authentic, interactive experience. The data templates were developed to demonstrate how the core data fields within the *Define Platform* portal were developed and populated. The data template demonstration was extended to show how the core data, populated in the template, could be represented in Cobuilder's *GoBIM* portal. (For further information about the demonstration, see Appendix 1.)

Twenty-one (21) interviews were completed with key sector stakeholders representing sector merchants, product importers and suppliers, tertiary institutions, government departments, local government authorities, construction companies and industry associations.

Qualitative interview questions focused on the sector awareness of DDTs, product selection and procurement disciplines, the methods used to obtain product data, product data availability and efficacy, potential use cases for DDTs, DDT implementation and governance models, and barriers to implementing them in New Zealand.

[12] https://Cobuilder.com/en/

2 What is the problem?

2.1 Construction sector digitisation

For the New Zealand construction industry to be more productive and efficient, the issues of poor sector readiness and digital maturity that limit the sector's ability to adapt and evolve to meet the immediate challenge must be addressed and overcome. The New Zealand construction industry's poor productivity relative to other industry sectors is well documented, and one of the key reasons for this is the low rate of digital technology adoption.[13]

There are increasing expectations on suppliers and manufacturers within the sector to be more transparent and accountable when providing product information, and government has just regulated for product information disclosure requirements. In the last decade, as sustainability reporting has become more common, it has also become clear that sound environmental information is not easy to get and sometimes, unfortunately, there have been instances of greenwashing. It remains a risk today, and the consequences can be severe for companies exposed to poor information or exaggerated claims.

The industry urgently needs a standardised, common, digital language that supports interoperable data exchange between the different actors. This will facilitate easier, faster, more efficient and effective decision-making of complex but manageable information that will promote efficient and sustainable solutions for most situations. To achieve this, the goal must be to ensure that all industry stakeholders use one common strategy to deliver information.

Unfortunately, in New Zealand as our interviewees have indicated, the industry is fragmented, and this decentralised decision-making creates a wider implementation of an industry-good system very challenging. Therefore, we see data as siloed and there is no alignment on a common language of business or standards use.

2.2 The need for better construction sector environmental information

Multiple demands have initiated the need to improve the quality and availability of digital environmental information for building products. Demands include:

1. New Zealand's commitment to a reduction of GHG emission targets and being carbon neutral by 2050. MBIE has noted that the building industry contributes up to 20% of New Zealand's GHG emissions.[14]
2. The New Zealand Government is one of the largest procurers of construction products and needs to access usable EPD information in digital formats to demonstrably shape and drive change.[15]
3. The Building System Performance (BSP) branch of the Ministry for Business, Innovation and Employment (MBIE) has developed a National Emissions Reduction framework for the sector. Despite this, there appears to be limited impact and interest in the wider New Zealand building and construction sector.[16]
4. Private sector procurement businesses that GS1 New Zealand regularly works with cannot easily access EPD information to inform and influence their procurement choices, and what is available for supply to construction companies. If used at all, e-procurement systems provide a link to difficult-to-use PDFs.
5. International studies into the use of LCA and EPD efficacy exist, but there has been little effort to understand how usable the information is for different consumer needs and requirements.[17,18,19]
6. LCA information is not uniformly standardised across different regulatory jurisdictions.

[13] Allison, N, Hartley, G (2020).
[14] https://www.thinkstep-anz.com/resrc/reports/the-carbon-footprint-of-new-zealands-built-environment/
[15] www.branz.co.nz/environment-zero-carbon-research/framework/epds/
[16] www.mbie.govt.nz/dmsdocument/11794-whole-of-life-embodied-carbon-emissions-reduction-framework
[17] www.brandsandvalues.com/study1-epd-environmentalproductdecl/
[18] www.branz.co.nz/environment-zero-carbon-research/framework/epds/
[19] www.sciencedirect.com/science/article/pii/S1877705816300182

3 Digital data templates, value proposition and applications

In this section, we briefly outline the value proposition of DDTs, DDT concepts, structural models, and finally, the underlying standards.

Very few industry stakeholders are aware of DDT concepts and global developments. To interview stakeholders, we invested in the development of a DDT prototype of building objects to inform interviewees. We demonstrated the prototype using a live, online system that was developed by Norwegian-based IT platform provider, Cobuilder.[20] We provide screenshots of the DDT tool in this section to better inform readers.

3.1 Value proposition of digital data templates

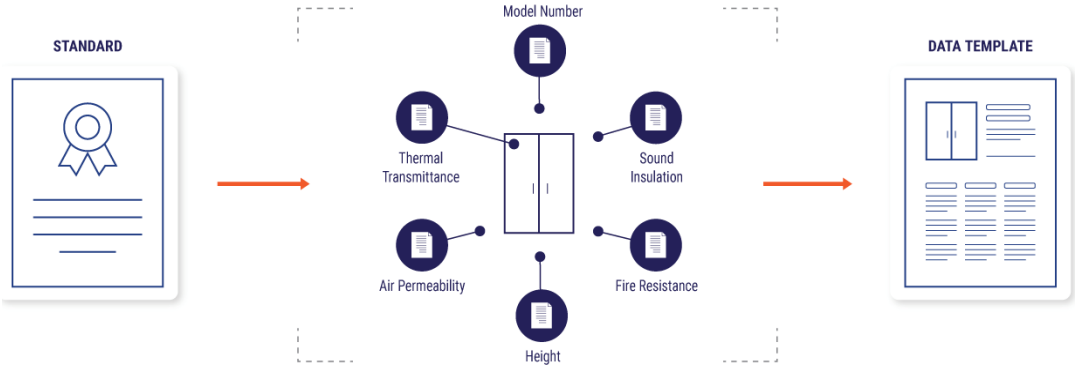
DDTs are structured and designed to incorporate universal, machine-readable properties that can cover an objects life cycle - from the point of manufacture to the end of the construction life cycle. They can be used and managed in a project context by different stakeholders. The importance of DDTs in the construction sector cannot be overstated. The Europeans acknowledge and understand this, recognising their sector is amongst one of the most significant sources of waste.[21] Given this, it is an important goal throughout the European Union, to efficiently use resources to reduce overall environmental impacts throughout a building's life cycle.

In the context of a building's life cycle, the design and construction phases are clearly essential, given the purpose is to materialise a built object that is going to be used. Throughout this phase, different products are bought to accomplish numerous performance-related goals and to produce a compliant built object. In contrast, the longest phase in the building life cycle is the 'use phase', where components are maintained, replaced and upgraded. To perform these activities successfully, specific data needs must be satisfied, and can be in a DDT.

3.2 Technical aspects of digital data templates

In summary, the key to the successful adoption and implementation of data templates relies on the ability to use construction object properties from the start, or to set an unbreakable link between the properties that use different concepts.[22] The ability to use data from the original source brings significant gains in work and productivity, but it mainly brings gains in achieving a long-term understanding of the meanings and terms within the industry. Product information management is a challenge as data sharing involves different stakeholder involvement throughout the building and construction process. Data templates help solve this issue.

Figure 2 - Digital data template overview



Broadly speaking, a DDT is a structured template that enables standards, data on the properties of an object or product (e.g., CO2 emissions per tonne), to be combined into a searchable digital template as illustrated in Figure 2 above.

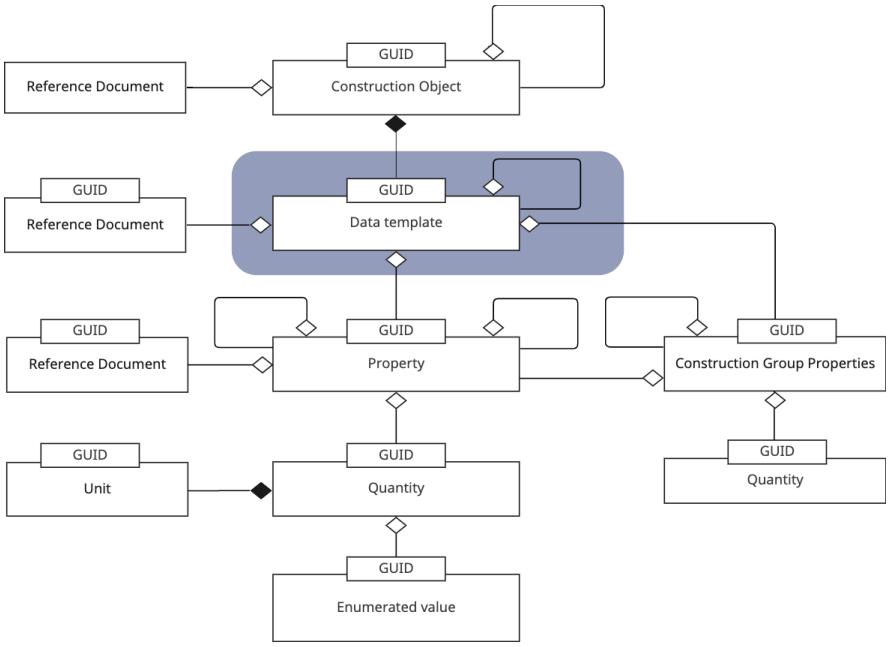
[20] https://Cobuilder.com/en/
[21] European Commission (2018).
[22] Mêda et al. (2020).

The DDT is not a static web page with data or links to PDFs as is most often used in the sector today. Figure 2 identifies links to the technical standard, and outlines object properties that can include EPD information and reusability values that are relevant for circular economy concerns.

A data template is a common data structure describing the characteristics (properties) of an object (usually a product), according to a source of information. When a data template is completed with information, the output is called a data sheet. In practice, a data sheet includes the performance and the technical characteristics of the object. With an information exchange format, data sheets can be shared and used by different IT tools or digital environments.[23]

The underlying structure of a DDT is illustrated below in Figure 3, showing the use of a Global Unique Identifier (GUID) being a central feature of the template to link together properties, reference documents and units of measure to create a template of object characteristics.

Figure 3 - EN ISO 23387 – DDT structure

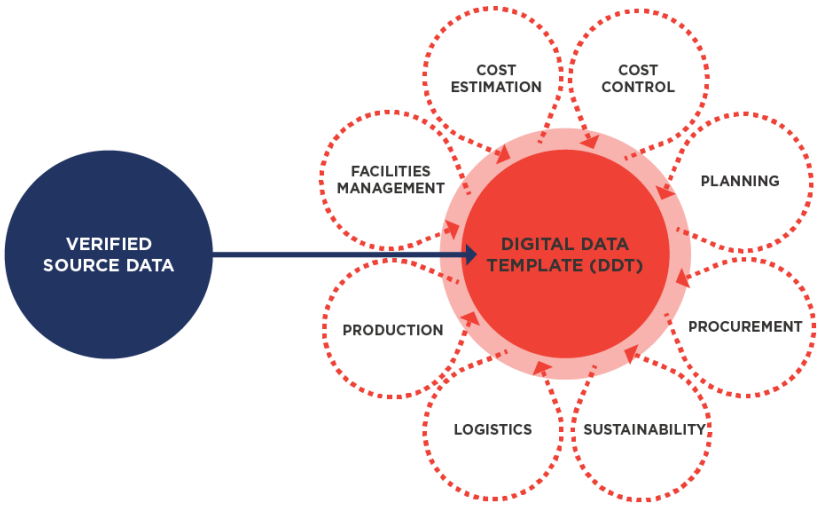


3.3 Digital data templates are persona-specific

DDTs enable product data to be entered once for sharing with many parties (data recipients) and for different uses cases. Inputting product and attribute data once can save information providers significant financial and resource costs, as it avoids having to re-enter and maintain the same or similar data in multiple trading partner/stakeholder systems.

[23] https://www.construction-products.eu/publications/digitalisation/

Figure 4 – Persona-specific use cases



DDTs can be considered as having 'persona-specific' utility (Figure 4 – *Persona-specific use cases*), in that they support different dataset requirements of multiple users, but core data elements are often common among users/recipients.

Recipient use cases typically include design processes (e.g. BIM, procurement, construction operations, seamless handover to facilities management, and proactive maintenance, among others). DDTs are extensible in that they can provide for different types of data and information that traverse multiple disciplines and life cycle phases of assets.

3.4 The Cobuilder platform used for interviews

Working with Cobuilder, we built and demonstrated a prototype DDT using two construction objects that are both imported into New Zealand, namely, a window system and a length of Norwegian-grown timber. The demonstration was in real-time using Cobuilder's online platform named *Define*. This approach was chosen to provide the interviewees with an authentic and interactive experience.[24]

The *Define Platform*:

- enables authoring, managing and sharing of DDTs using a common data dictionary framework
- has at its core a *Define Data Dictionary* that is a specific, industry-developed and managed tool (a management board comprising various construction industry actors is responsible for all decisions about the development of the tool).

Define enables organisations within the construction industry to structure their data in line with all relevant international standards for data management principles. Validated data can then flow freely between different systems and BIM-authoring tools, allowing for a universal machine-readable language. Interoperability is also ensured through connections to other data dictionaries, such as buildingSMART's Data Dictionary.[25]

Compliance with open international standards is a disciplined, characteristic approach used throughout the European building and construction sector, to enable sector-wide digitalisation of information, a topic we cover in the next section.

3.5 Window template demonstration screenshots used in interviews

We outline in the following pages, screenshots of the *Define* DDT as demonstrated in our interviews. We provide a more detailed illustration and explanation in Appendix 2.

[24] https://Cobuilder.com/en/
[25] https://Cobuilder.com/en/steering-committee-established-for-implementing-common-digital-language/

Figure 5 illustrates an example of core product data, including solar factors, thermal transmittance and the relevant reference standards used.

Figure 5 - Digital Data Template Properties Tab (window example)

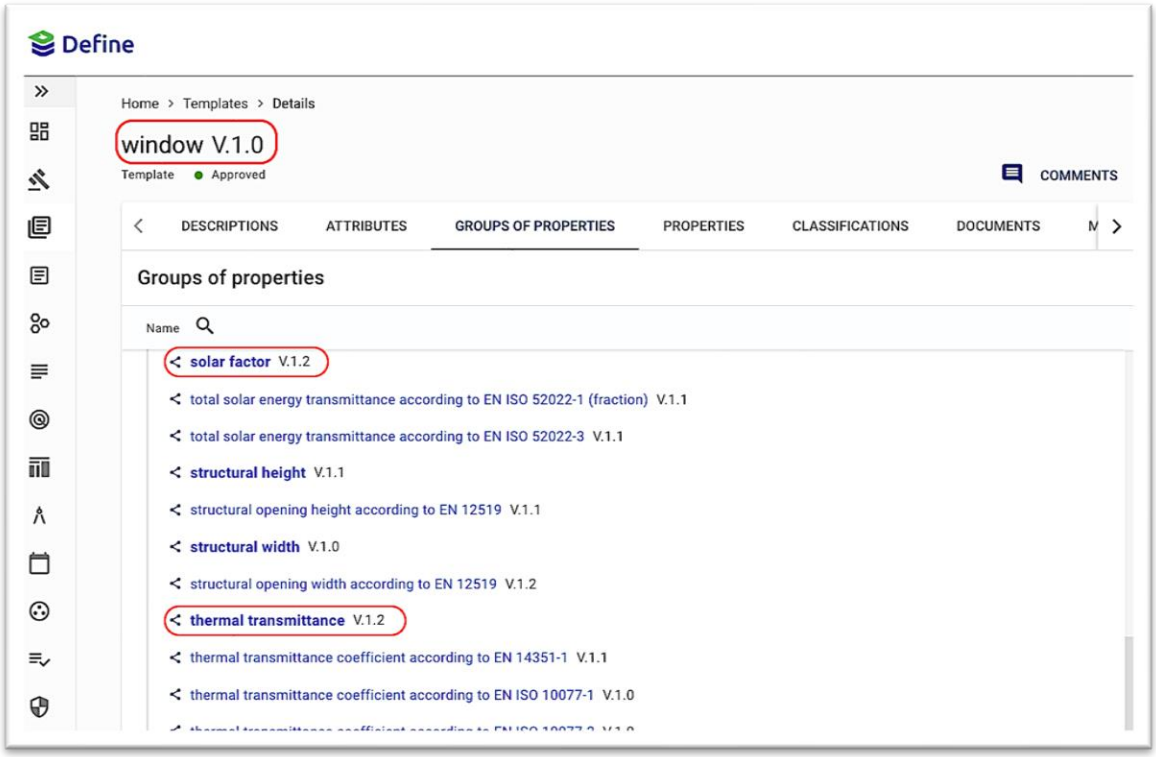
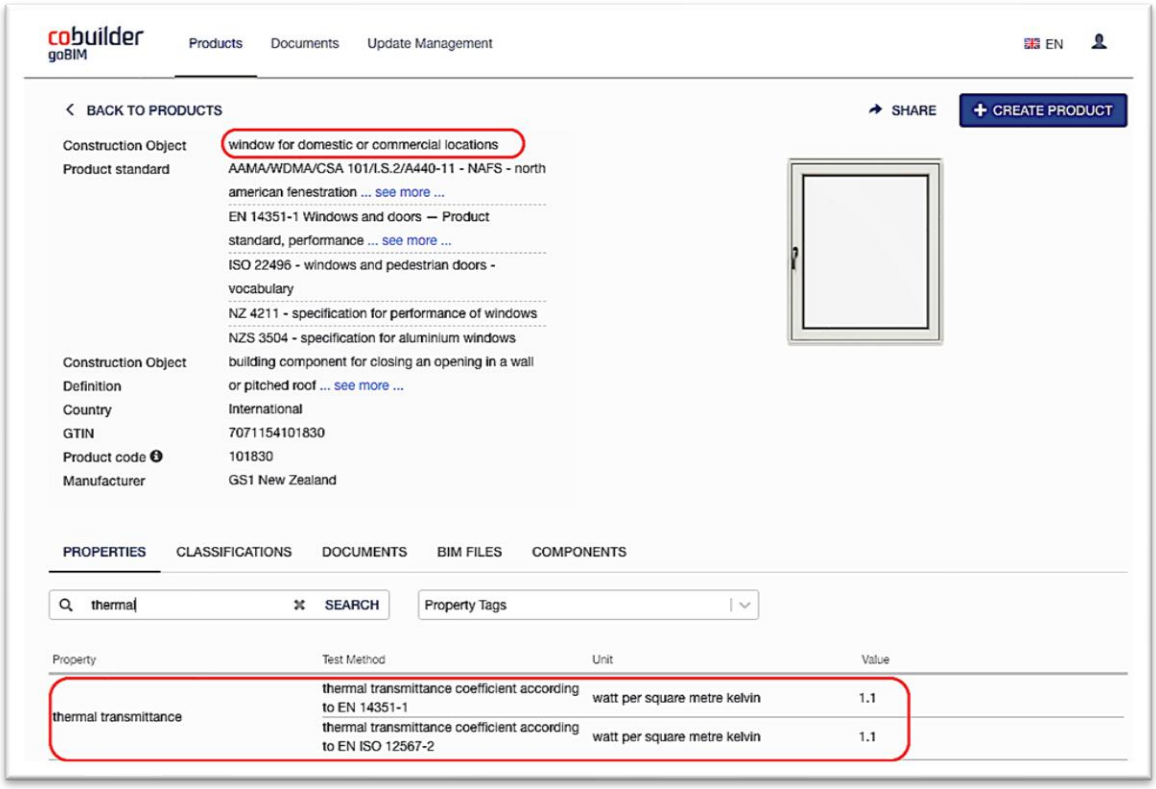


Figure 6 - Illustrates how construction object data (i.e., product data), which was originally inputted in the Define data template, both links to, and is represented in a BIM system.

Figure 6 - Construction object data represented in GoBIM environment (window example)



3.6 The ISO standards for data templates

The DDT story began with the need for data and infostructure standards. Without standards and standardisation, accurately defining building object properties and data structures, is difficult as it impedes the ability to construct interoperable systems to realise the value that DTTs provide.

The European Committee for Standardisation (CEN) and International Standards Organization (ISO) have developed a suite of standards that cover the methodology for creating data templates. Our prototype was developed based on the following standards:

- EN ISO 23386[26] - Building Information Modelling (BIM) and other digital processes used in construction - Methodology to describe, author and maintain properties in interconnected dictionaries.
- EN ISO 23387[27] - Building Information Modelling (BIM) - Data templates for construction objects used in the life cycle of any built asset - Concepts and principles.[28]

A third standard (ISO 22057:2022[29]) has recently been added to the ISO suite and details the principles and requirements that enable environmental and technical data provided in Environmental Product Declarations (EPDs).

EPDs are associated with construction products and services, construction elements and integrated technical systems for use in BIM, to assist in the assessment of the environmental performance of construction works over an asset life cycle.

As covered above, the value proposition of DDTs is that they more efficiently inform many building industry decisions. In the following section, we will outline the drive for the development of standards that underpin data and dataflow requirements in the sector that have been promulgated, in the main, by circular economy concerns and initiatives in the EU.

4 At the leading edge - digitisation and the circular economy

In understanding what leading edge digitalisation in the construction sector digitisation referred to, we reviewed emerging developments, literature and reports from the European Union. The Scandinavian countries within the EU are considered to be at the forefront of recent DDT developments and other initiatives to digitise construction.

Digitalisation is seen as a key enabler in delivering on the European Green Deal. The main objective is to move towards low-emission technologies and the sustainability of products and services to achieve climate neutrality by 2050.[30]

4.1 Targeting data-driven, circular construction in the European Union

Digitalisation impacts directly on environmental goals, such as those concerning eco-friendlier solutions, energy efficiency, products recycling and sustainability certifications. These strategies rely on data and, more precisely, digital data that is interoperable, incremental and traceable.

DDTs contribute to ‘good data’ as well as the circular industry.[31] Some industry researchers advocate to extend the need to move beyond the use of DDTs in isolation, to include digital building logbooks and digital twins in construction as

> The ability to capture, store, add and trace construction-related data will not just improve construction life cycle management, but will also support the built environment and its constituent parts at the end of life.

[26] www.iso.org/standard/75401.html
[27] www.iso.org/standard/75403.html
[28] Note this standard is currently being redeveloped and will be replaced by ISO/AWI 23387 Available at: www.iso.org/standard/85391.html
[29] https://www.iso.org/standard/72463.html
[30] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
[31] Mêda, P, et al. (2021).

joint solutions, a trifecta of elements that creates a digital, data-driven concept that enables more robust circular economy decision-making.

If a product or construction element can be reused or recycled, its information can also be. The ability to capture, store, add and trace construction-related data will not only improve construction life cycle management, but also support the built environment and its constituent parts at the end of life. Broad digital understanding will therefore foster a transformation that impacts the construction industry's overall performance and the built environment's circularity.[32] Meda et al., go as far as to describe the role of data templates in this context as a game changer.[33]

A 2019 EU analytical report into sector digitalisation outlined that standardised data templates and formats would provide a consistent approach for product manufacturers, by providing a specific format for a precise data type that can be understood and used by all actors in the value chains. The use of data templates was cited as enabling digital construction data processes (e.g., from BIM) to be automated and to have a higher degree of reliability, thus favouring the wider use of digital tools. Data standardisation will also support the delivery of sustainable construction projects by providing information in a homogeneous way, allowing both project promoters and customers to compare sustainability data more easily (e.g., energy efficiency and waste produced) from different buildings.[34]

4.2 Digitalisation policies and initiatives in the EU

In 2021, the European Construction Sector Observatory (ECSO) project published a report that described the state of play of digitalisation in the construction sector, including the main drivers and challenges.[35]

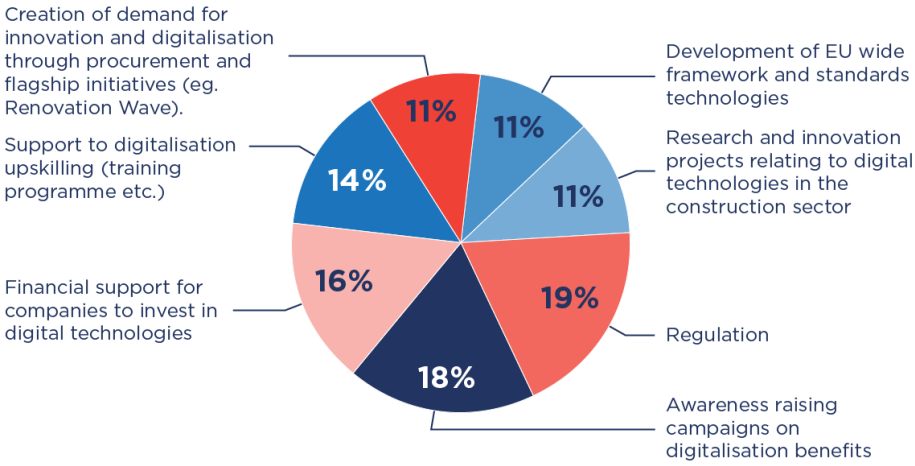
The report provided information, evidence and lessons learnt to support a wide range of stakeholders, including policy-makers who wish to support the integration of digital technologies in the construction sector.

Although gradually transforming, the EU construction sector is one of the least digitalised sectors in that economy. At the same time, the integration of digital technologies is often viewed as a key element to tackle some of the main challenges it is faced with, such as labour shortages, competitiveness, resource and energy efficiency, and low productivity growth.

The report also outlined the results of a survey undertaken in the ECSO project. Key results indicate that regulations, awareness raising, campaigns on digitalisation benefits and financial support to construction companies are the top three areas the EU should focus on to make a difference. Together, these accounted for over half of the total number of responses. These are followed by policy intervention focusing on developing digital skills, supporting research and innovation projects, incentivising digital technologies through public procurements, and finally, establishing an EU-wide framework and standards technologies. These results are reflected in the responses received from stakeholders in most EU Member States – the top three EU policy interventions deemed relevant account for more than 50% of the responses as outlined in Figure 7.[36]

[32] Ibid.
[33] Ibid.
[34] European Commission (2021b).
[35] Ibid.
[36] European Commission (2021b).

Figure 7 - Policy interventions to foster digitalisation



The report also outlined that the effective use of digital data represented the future of the digitalisation of the construction sector in Europe. The EU construction sector is making progress in the uptake of digital technologies, despite 'digital twins' being limited to a few pilot projects. However, most public and private stakeholders consulted agree that they have high potential for the future.

Government public policy support

There is strong interest among EU policy-makers in supporting the digitalisation of the construction sector. Most EU Member States have policies in place covering or specifically targeting the digitalisation of the construction sector. Policy measures in support of digitalisation are often accompanied by financial support in the form of grants, loans or equity, but also by technical assistance, such as for digital construction platforms. While platforms do not always generate strong traction, they do enable collaborations, synergies and knowledge sharing within the construction sector and between the public and the private sector.

There is a consensus in the EU that digitalisation is both inevitable and pivotal for the competitiveness and sustainability of the European construction sector.

Many national governments have BIM requirements in place for public procurement processes. This requirement is considered particularly beneficial for fostering digitalisation.[37] National and local governments also facilitate the uptake of digital technologies in the construction sector by providing e-services, such as by issuing building permits and keeping the repository of building data and geospatial information. These provide crucial information and data and could facilitate the uptake of digital technologies.

An increasing number of EU Member States have therefore adopted digital building permits systems, digital logbooks and registries of construction object properties. Overall, with recent developments at the EU level on policies, support measures, funding, etc, it can be expected that national governments will be incentivised to do more to support the digitalisation of their respective construction sectors. This will be crucial for supporting the transformation of the sector and its growth, but also to reach climate and sustainability-related objectives.[38]

There is a consensus in the EU that digitalisation is both inevitable and pivotal for the competitiveness and sustainability of the European construction sector.[39]

4.3 EU construction industry-government ecosystem

The *High Level Construction Forum* (HLCF) is an initiative that evolved from the European Commission's Construction 2020 Strategy, with the purpose to co-create the green, digital and resilient transition pathway for the EU construction industry ecosystem.[40] The HLCF's Digital Cluster Group's key themes are supporting

[37] Ibid.
[38] Ibid.
[39] Ibid.
[40] https://single-market-economy.ec.europa.eu/system/files/2021-11/HLCF_1st_DigitalClusterGroup_MeetingReport.19_0.pdf

frameworks for digital technologies, data governance and digital platforms, and the digitalisation of small-to-medium enterprises (SMEs). Digitalisation is seen not as a goal, but one of the means towards a greener and more efficient and resilient construction ecosystem in Europe.

The HLCF used the European Union Data Act 2022 as a tool to level the playing field, and improve trust, collaboration and interoperability to improve data sharing and public demand through public procurement as a level for innovation and standardisation, especially through open BIM. A key emphasis for the group is data governance and platforms to streamline accessibility, transparency and reliability, as well as the shareable and protected data provided in digital data repositories. Making public-sector data available for re-use, as well as the decentralisation of infostructure (i.e., a common, open, transparent and trusted infrastructure), are also objectives.

Other key themes that HLCF highlights are:

- **Standardisation and harmonisation** across the supply chain. These are key pillars in achieving digital transformation to produce a more efficient, productive, sustainable and safer built environment.
- **Electronic public procurement**, which although well developed in Europe due to EU requirements, still needs greater levels of interoperability in procurement tools to increase data availability and integration.
- **Common data formats and language** to create a common understanding for interoperable platforms, preferably based on open standards and systems.
- **Digitalising SMEs** where the digitalisation of the public sector will serve as an incentive for digital transformation in the private sector, especially for SMEs, where the costs can be balanced by improved efficiency and productivity gains.

Key issues identified by the HLCF community:[41]

- **Data availability and fragmentation** remains an issue, because despite data availability it is often fragmented, not easily sourced and is often non-standardised. This impedes the opportunity for product benchmarking, comparison and substitution. While EPDs are becoming more prevalent in Europe, they are often considered too difficult to understand and read, despite standardisation efforts.
- **Generic vs specific EPDs** in public procurement are being used in some European countries (e.g., Switzerland), as they are seen to create a common convention that allows for a fair and reproducible view of environment impacts. Also, having a common EPD framework is desirable to facilitate data sharing (including life cycle stages and indicators), because SMEs cannot be expected to create specific EPD's extensive product ranges.
- **A definition for structured data** is required across Europe and is a key element in the implementation of data dictionaries and data templates in the construction sector in some European countries (e.g., Czechoslovakia, Sweden, Norway). The most important activity related to this topic is the creation of a common data dictionary based on international standards.

A 2020 poll of HLCF members responding to a question of *priority use cases to address through digital platforms* showed that enhancing the digital supply chain, including product and equipment data, is a top priority.[42]

The most important activity relating to structured data is the creation of a common data dictionary based on international standards.

A recently published document by Construction Product Europe (CPE),[43] a European Association representing the interests of all construction products manufacturers throughout Europe, commented on the European Commission's Construction Products Regulations.[44] It stated that having underlying principles will enable construction manufacturers to use harmonised, machine-readable [data] formats, which will help towards the implementation of *Digital Product Passports* (DPPs) for construction products across Europe.

[41] European Commission (2022a).
[42] Ibid.
[43] www.construction-products.eu/about-us/
[44] https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr_en

Many of the HLCF themes and objectives outlined above align very closely with those outlined in Allison and Hartley (2020).[45]

4.4 Data template implementation in Europe

It is unlikely in the short term that it will be possible to have data templates for all products and construction solutions. Therefore, to ensure sector stakeholders are not overwhelmed by the scale of widespread DDT implementation, the use and adoption of data template structures should be prioritised in line with individual stakeholder requirements and objectives.

Cost is always a factor in economic activities. From a manufacturer or contractor perspective, products with higher relevance for cost (e.g., acquisition, life cycle, environmental goals) are found to be more relevant to prioritise, or to be set on a construction project using data templates (Meda et al., 2020).

Product information management is a challenge as data dealing involves different stakeholders involved throughout the building and construction process. Data templates help solve this issue.

In following European construction industry trends, it is possible to evidence that products with high contributions to the built environment efficiency at energy, CO_2 or waste levels can be at the forefront.

Many construction products still lack specifications (information or data) about environmental requirements, and therefore a minimum environmental criterion for EPDs is a priority (Meda et al., 2020). The development and adoption of data templates is reliant on having reliable sources of product information, to identify and describe products, systems and/or construction object properties. It is therefore vital for all stakeholders to understand the pivotal role that data has in the end-to-end construction process and in the correct structuring of it.

There is then a recurrent theme about the reliance on harmonised standards, regulations, environmental declarations, facility management properties and interoperability tools, such as the Industry Foundation Classes (IFC) or buildingSMART Data Dictionary (bsDD), to provide a standardised workflow, and to guarantee data quality and information consistency.[46] BIM standards and libraries are fundamental for DDT awareness and interoperability.[47]

4.5 Country-specific digitalisation initiatives in Europe

Norway

The Federation of Norwegian Construction Industries[48] (BNL) is an umbrella organisation for 15 different sectors within the construction industry, involving over 4,000 member companies. In October 2020, BNL published a digital strategy for the Norwegian construction sector named *Digital roadmap 2.0.*[49] While providing practical advice on how to approach digitalisation, the strategy underscored the importance of using common digital standards to enable machine-to-machine information exchange.

BNL's announcement followed a call to action in 2019 from the Norwegian Home Builders' Association (NHBA), asking its members to start requesting digital product data from all suppliers, to drive machine-readable information exchange.[50] The NHBA has requested suppliers to start implementing data templates by the end of 2022. The request covers all construction products, including piping, electrical and ventilation products, and paints etc. The NHBA view product data templates as the digital building blocks needed to digitise the

[45] Allison, N, Hartley, G (2020).
[46] FC is a standardised, digital description of the built asset industry. It is an open international standard (ISO 16739-1:2018) and promotes vendor-neutral, or agnostic, and usable capabilities across a wide range of hardware devices, software platforms and interfaces for many different use cases. Available at: www.building.org
[47] ISO/FDIS 23387:2020(E).
[48] www.bnl.no/in-english/
[49] www.bnl.no/siteassets/bilder/generelle-bilder/digitaltveikart_2020.pdf
[50] https://Cobuilder.com/wp-content/uploads/2019/11/2019.11.01-Byggevareleverand%C3%B8rer-m%C3%A5-levere-produktinformasjon-som-maskinlesbar-PDS-EN.pdf

construction industry and consider them to be crucial for construction product manufacturers to provide machine-readable product information.[51]

The 2020 *Digital roadmap 2.0* also proposed the establishment of a national council, with representatives from both the public and private sector to take ownership and collaborate on the development of a common framework for information management in the industry. The roadmap goes deep into the specific actions needed to create a common digital language. Direct reference is made to the importance of data templates based on the EN ISO 23386 and EN ISO 23387 Standards. The data templates are expected to be used by sector stakeholders to set requirements towards construction product properties, including environmental requirements, and to establish the basic structure for product databases.

The strategy outlines that common, interoperable, technical solutions must be developed and implemented. Common components include a *National Catalogue of Product Properties* (based on data templates), where manufacturers and other actors in the construction industry must have access to an agreed set of templates for product properties that align at both the Nordic and European levels. Open access to 'as-built information' is also required, as both private and public actors have an interest in making relevant asset information easily available. Access is enabled using a common database or a common mechanism for a distributed system.

A common system for product identification and marking (e.g., barcodes/barcoding, RFID) for project, asset and construction components is also required to ensure robust product traceability outcomes. Also proposed is the need for efficient information exchange, with relevant public services *including a register of legal entities* (i.e., similar to the New Zealand Business Number Registry – NZBN).[52]

It is widely recognised that in achieving Norway's digital transformation goals, broad sector-wide collaboration is essential, underpinned by alignment on common goals, using common frameworks.

Sweden

Sweden's *Smart Built Environment* (SBE)[53] is a government-funded national digitalisation programme that provides support to the public construction sector through research, development and innovation.

Established in 2016, SBE plays a key role in the digitalisation efforts of the Swedish construction sector, providing stakeholders with support in improving efficiency and sustainability outcomes. SBE supports several different initiatives in four key areas, including information infrastructure that focuses on a common infrastructure, standardisation in data exchange, integration and information structures for life cycle analysis, and the use of data templates to standardise information exchange across the value chain.[54]

Expected benefits include improved information flow between actors in the value chain, improved decision-making based on better product information, and enhanced digital integration that all aim to aid in reducing the impact on the environment and climate.

Luxembourg – Product circularity data sheets

In 2018, the Luxembourg Government launched an important digitalisation initiative called the *Product Circularity Data Sheet* (PCDS), which is a basic source of verifiable data that incorporates data templates as core infrastructure.[55] The PCDS is a standardised digital 'fingerprint' for sharing trusted data on the circularity characteristics of products across supply chains. It focuses on making basic circularity data widely available in a decentralised way using open-source data formats from which standardised statements can be extracted and used by other stakeholders and platforms across the supply chain.[56] The PCDS were developed by the Ministry of Economy of Luxembourg and more than 50 international organisations. The PCDS aims to promote circularity

[51] Ibid.
[52] www.nzbn.govt.nz/
[53] www.smartbuilt.se/in-english/
[54] www.smartbuilt.se/projekt/informationsinfrastruktur/data-templates/
[55] https://pcds.lu/pcds-system/
[56] https://pcds.lu/wp-content/uploads/2020/11/20200214_Light_PCDS_v3.2s_FORM.pdf

by improving data-sharing efficiencies. The goal of the project is to transform PCDS into an industry standard for sharing circularity data, and 2023 is the target date for the development of a draft ISO or CEN Standard.

The United Kingdom

In August 2022, the British Standards Institute (BSI) and Norwegian software provider, Cobuilder, signed an agreement to facilitate the digitisation of content of BSI standards and to develop purpose-built datasets (i.e., data templates) into a machine-interpretable form for the British and international built environment sector.[57]

The objective is to assist the sector strengthen collaboration in achieving carbon neutrality, and to facilitate the transition to achieving circular economy objectives. Contractors and other built environment actors will be able to use the standardised data templates in projects to improve business processes, such as cost calculations, design, purchasing, carbon footprint calculations and more.

Similar agreements exist with other standardisation bodies across Europe, including Norway, the Czech Republic and Denmark.[58]

The European timber industry digitalisation initiative

The European Confederation of Woodworking Industries (CEI-Bois)[59] represents 21 European and national organisations from 15 countries and is the body backing the interests of the whole industrial European wood sector. The Federation has an annual turnover of about Euro 152 billion. A 2020 memorandum of understanding (MoU) signed by members established a joint initiative called TIMBIM,[60] which supports continuous knowledge-sharing and collaboration between participating member states.

A 2021 pilot project aimed to help manufacturers digitise their data and make it available in a machine-readable and standardised format and involved the development of a common data dictionary and common data templates. The data templates were based on relevant harmonised product and test standards that are applied across all European countries. Sector stakeholders can gain access to the data templates through a web-based interface and API integration. Currently, Sweden, Switzerland, Austria and Finland are developing 'national' implementations.

4.6 Open standards for improving product circularity in Europe

In March 2019, the European Commission adopted a comprehensive report on the implementation of the Circular Economy Action Plan. The report sketched out future challenges in shaping the European economy and paving the way towards a climate-neutral circular economy where pressure on natural and freshwater resources, as well as ecosystems, is minimised.[61] Accelerating the green transition (i.e. The European Green Deal) is a key priority of the EU for the coming decade and achieving EGD objectives will not be possible without fundamental shifts in both global and European economic resource and data flows.

[57] https://Cobuilder.com/en/machine-interpretable-standards-information/
[58] https://molio.dk/nyheder-og-viden/nyheder/seneste-nyt/byggebranchen-far-et-faelles-digitalt-sprog
[59] www.cei-bois.org/
[60] www.cei-bois.org/_files/ugd/5b1bdc_e4c3544b8c07426da41bbd0d2440ff35.pdf
[61] https://ec.europa.eu/environment/circular-economy/first_circular_economy_action_plan.html

The concept of a *Digital Product Passport* (DPP) is proposed as a key mechanism through which EU economies will support sustainable consumption and production, resource flows and supply chain management. Under the draft EU regulations, a product passport is required with a set of data specific to a product (specified in the delegated act), to be made accessible via electronic means through a data carrier.[62]

Under the draft regulation, the DPP will ensure that actors along the value chain, including consumers, economic operators and competent national authorities, can access product information relevant to them, and include the necessary data attributes to enable tracking of all substances of concern throughout the life cycle of the products covered by the DPPs.

Under the new regulation, the Digital Product Passport will ensure that actors along the value chain, including consumers, economic operators and competent national authorities can access product information relevant to them and include the necessary data attributes to enable the tracking of all substances of concern throughout the life cycle of the products covered by the Digital Product Passport.

DPPs will be assigned to each product covered under the regulation, providing key data on the product's characteristics.[63] Further, DPPs need to be fully interoperable among themselves for the technical, semantic, as well as the organisational aspects of end-to-end communication and data transfer.

Benefits will also extend beyond fundamental supply chain utility. Structured, standardised and interoperable product master data will be required to better inform procurement and purchasing processes, as well as product substitution decision-making capabilities.

A Deloitte study into the adoption of standards for circularity in Europe,[64] commissioned by the global standards organisation GS1 in Europe, concludes that there is significant value in using existing global, structured, open data supply chain-related standards because of the data integration and data interoperability potential, among other benefits.[65]

Some of the open, global standards have significant efficacy within the context of data template use and implementation, including the GS1 Global Trade Item Number (GTIN), which is the ubiquitous identification number standard used in the global supply chains for trade items. The draft regulation makes several specific references to the use of ISO/GS1 data standards. The European Commission's intention is not to pick a particular technology (e.g. blockchain), but rather to establish the standards and foundations that enable interoperability.

4.7 New Zealand

There has been little movement in the New Zealand market towards the use of digital data standards or templates for product identification or procurement purposes. Our research suggests that the new ISO/DIS 22057 Standard for DDTs has not been implemented, apart from the prototype developed for this research.

Similar to the EU, New Zealand's construction industry is fragmented and as our respondents commented lacks the necessary cross industry and government leadership required for the levels of digital transformation evidenced in the EU. Our analysis finds that procurement decision-makers and supply chain participants cannot easily access standardised product information, especially environmental information, or use it efficiently and effectively.

Other key findings include:

- many suppliers have not rationally invested in Life Cycle Assessment (LCA) and EPD development because developing them is expensive, so they are not readily available and not widely used[66]
- LCA and EPD documents are either paper-based or in PDF and are typically complex, so are therefore not suitable for commercial e-procurement initiatives in New Zealand

[62] www.gs1.eu/news/eu-digital-product-passport-revealed-time-to-act
[63] Ibid.
[64] Deloitte (2022).
[65] Ibid.
[66] https://lcanz.org.nz/lca-guidance/lca-intro/

- different countries and organisations do not share the same product naming conventions, technical standards, spelling or abbreviations, which challenges data use and interoperability
- in some instances, the use of an EPD appears to be a marketing tool that has an entire portfolio of product range, so is therefore not product-specific or targeted to a specific audience.[67]

New building product information regulations

In June 2022, new regulations on building product information requirements (Building Product Information Requirements Regulations 2022) were introduced by the Government. The new regulations have been developed to provide building product users with information about how building products contribute to compliance with the Building Code. The regulations place obligations on New Zealand-based manufacturers, importers, retailers and distributers, and are effective from December 2023. The information requirements to be displayed online include:[68]

- the name and a description of the product (or product line from which the product is customised) and its intended use.
- a product identifier (in most circumstances)
- the legal and trading name of manufacturers and, if applicable, importers
- a statement specifying the relevant clauses of the Building Code and how the product is expected to contribute to compliance, as well as any limitations on its use
- any design, installation and maintenance requirements
- either a statement that the product is not subject to any warnings or bans, or a description of warnings or bans applicable to the product.

Product information must be kept up to date on the internet site from which the information is accessed by the public, and there are also requirements for reviewing, updating and maintaining the information. There are also further requirements governing information access and disclosure.

While this is a positive step forward for *product information disclosure*, it relies on PDFs and information embedded in websites. As a minimum requirement for the effective digitalisation and interoperability of product data, the use and implementation of a 'globally unique product identifier' (ideally referencing ISO/GS1 standards) is considered highly prudent as regulators in the EU have experienced.

Construction Sector Accord – Transformation Plan Update 2022-2025

The New Zealand Construction Sector Accord is a joint industry/government initiative that seeks to create a high-performing construction sector. Goals focus on increasing productivity, raising sector-wide skills and workforce capability, and improving overall resilience for the broad stakeholder community.[69] The Accord was recently updated in July 2022 to include a stream on digital enablement through innovation.

The Accord's Transformation Plan 2022-2025 outlines a focus on improved procurement disciplines, climate and environmental action, and data and information use.[70]

The Plan highlights systemic challenges that have historically held back the sector from achieving higher performance outcomes including:

[67] www.brandsandvalues.com/environmental-product-declaration
[68] www.building.govt.nz/building-code-compliance/product-assurance-and-certification-schemes/building-product-information-requirements/#jumpto-background
[69] www.constructionaccord.nz/transformation-plan/innovation/
[70] Construction Sector Accord (2022).

- uninformed decision-making, as the sector often makes decisions based on anecdotal evidence rather than real data. Having the right information at the right time will support leaders to make better decisions[71]
- sector-wide fragmentation and minimal collaboration
- high environmental impacts from the use of carbon-intensive building materials and processes, creating significant energy use and high waste production.

Priorities of particular interest for a digitally-enabled industry include:

- environmental and climate action – to accelerate the adoption of carbon and waste minimising materials and practices, which can be progressed with better data and digitisation
- innovation and an advanced construction ecosystem – to accelerate innovation ranging from incremental business performance improvement to disruption and value creation.

The Accord is working to develop responses to each of the priorities and have identified that public-private partnerships will be core to its responses and success. The environmental responses include the use of sustainable products and practices. It is recognised that strengthening the construction ecosystem requires a focus on the use of data. Including system performance indicators and data flows across the sector mean this work will be enhanced, as well as allow for the development of greater transparency and the availability of data.

The sector often makes decisions based on anecdotal evidence rather than real data. The right information at the right time will support leaders to make better decisions.

These challenges are not dissimilar to those being experienced globally throughout the construction sector and are highlighted repeatedly in the literature. The scale of these challenges, and the changes needed to address them, are considerable and will require industry and government to collaborate on strategies and solutions to solve them.

5 Key interview findings and insights

We interviewed construction industry stakeholders to understand how they access sourced product data to inform purchasing and other decisions and to assess whether DDTs would be a valued tool.

Stakeholders included large construction sector suppliers and merchants, who influence what is offered in the New Zealand market, as well as government construction procurement agencies, who in turn shape product demand via large procurements or have large facilities management operations.

Interviews started by demonstrating the DDT prototype we had developed, using an online tool, then answered any questions about functionality. We then asked interviewees a set of open (but structured) questions, starting with the issue of the current state, data consistency and completeness issues. Interviewee responses are summarised in this section.

5.1 Data consistency, completeness and quality

There was consensus that product information was not typically provided in standardised, machine-readable or interoperable formats, and was therefore not readily accessible to designers, builders, policy writers in government and Building Consent Authorities (BCAs). Most of the information was only available in a PDF or Microsoft Excel format, which are typically provided by product suppliers.

The information is in hard copy and locked digital formats so it cannot be used easily for side-by-side comparison purposes. Data provided in this manner generally leads to overall process inefficiency and the potential for data integration errors.

[71] Ibid.

Respondents satisfied with data had invested in data collation and bespoke applications

Some respondents were, however, satisfied with the data accessibility, format and the completeness of the information provided.

These respondents typically had teams employed to translate information into in-house templates or systems, or they asked suppliers to provide the data in a custom spreadsheet. In these situations, the data was loaded into bespoke databases held by the organisation for its own purposes.

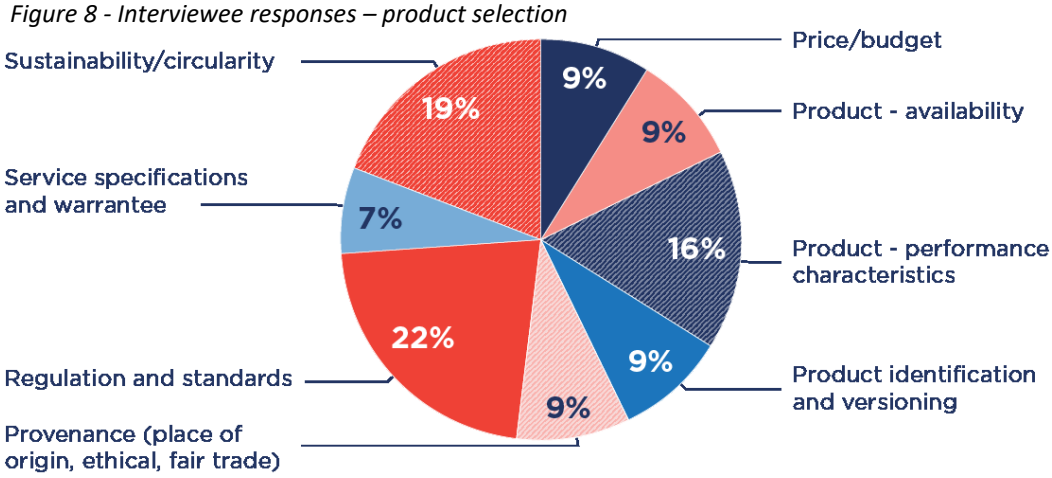
This activity creates the additional cost of doing business for the supplier as they are being asked to provide information in multiple bespoke formats for similar purposes by multiple users.

5.2 Product selection

We found that product selection was strongly influenced by the contextual situation of the respondent and related to sector group, role or position. The consensus view was that product selection was heavily influenced by designer and/or consultant specifications,[72] and/or compliance with industry regulations and/or standards.[73]

Of the considerations interviewees regarded as important for purchase decisions (refer Figure 8), three factors most frequently reported were meeting regulations and standards (22%), sustainability considerations (19%) and product performance characteristics (16%). Only 9% reported price/budget and an important caveat is that interviewees were not being faced with a real budget constraint. Therefore, results may reflect participant demands and aspirations, rather than 'real-life' practice that will reflect budget and ease of access to information.

Figure 8 - Interviewee responses – product selection



We also found that to obtain a building consent from a Building Consent Authority (BCA), sufficient evidence is required to show that the performance criteria of all relevant clauses in the Building Code will be met. This means that any industry appetite to choose new products is stifled, due to the time, cost and complexity involved in demonstrating to the BCAs that choosing a new product has benefits and utility over the 'tried and tested' product(s) currently being used in market. To add additional complexity to this, there are also timing and delivery pressures (e.g., supply chain disruption) influencing these decisions.

Product familiarity bias to the tried and tested

A key theme emerging from our interviews, in some instances, mirrored the findings outlined in the recently published Commerce Commission report into residential building supplies about the selection of like building products.[74]

[72] This group included, but was not limited to, architects, designers, structural engineers and specifiers.
[73] Includes environmental and building standards, government regulation, council consent processes and materials regulation.
[74] https://comcom.govt.nz/__data/assets/pdf_file/0028/289360/Draft-report-Residential-building-supplies-market-study-4-August-2022.pdf

Interviewees expressed frustration that the process of selecting building products is inefficient, takes too long, and is costly and unnecessarily complex. This involves reliance on providing product efficacy evidence, such as BRANZ appraisals, expert reports, proof of in-service history, calculations and proof of comparability, to compliance achieved by an Acceptable Solution or Verification Method.[75] Interviewees advised that many products are typically selected on familiarity, at the expense of a choosing new, improved and potentially more innovative products, which may offer additional flexibility and/or sustainability opportunities in the future.

5.3 Awareness of DDTs

Internationally, the adoption of new technologies is perceived as bringing considerable advantages to the construction industry in the European Community. Research from Sategna et al., identifies that adoption of digital technologies is valued by EU industry for the sharing of data.[76] However, not surprisingly, our interviews identified that there is limited awareness of digital tools, such as DDTs, with minimal evidence of use in the wider sector. Some respondents considered that a BIM was a DDT.

The development of DDTs was seen as transformational by respondents

The use and implementation of DDTs (using standards-based digitised data) for use in e-procurement processes, but also broader application, was seen to provide opportunities to drive the automation of numerous downstream processes, including BIM adoption, whole-of-life asset management and the sharing of digital information in supply chains.

> Product data in a consumable format will be a mouse click or scan away.

Although our research focused on assessing the utility of DDTs for use with EPDs, our analysis clearly identifies more broad utility for sector stakeholders (i.e., personas), such as in the design process, construction operations, consenting processes and whole-of-life building maintenance, among others.

5.4 DDT value and use cases

It was felt by all participants that there was both value and efficiencies to be gained from developing a DDT service for New Zealand. Once again, this was strongly influenced by the contextual role in the industry of the respondent (persona). The use cases Identified were numerous and represented the requirements of the stakeholder's role.

The variety of use cases identified included (Figure 9):

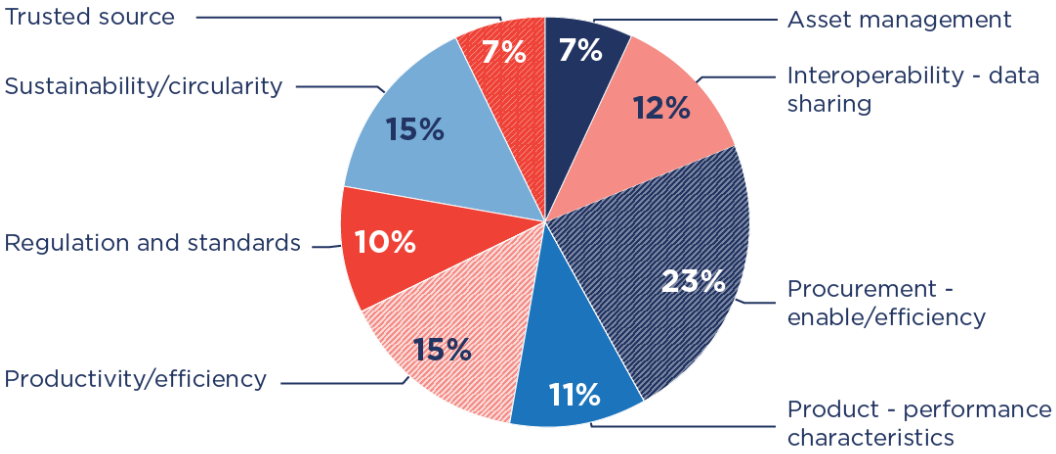
- improved, more efficient asset management
- streamlined consenting process
- streamlined building life cycle maintenance – 'Cradle to Grave' or 'Cradle to Cradle'
- more efficient and informed product procurement and selection
- enhanced design and product specification opportunities
- enhanced environmental design and reporting
- digitised, standards-based, machine-readable, interoperable product data with streamlined business processes and improved productivity
- enhanced, more informed product substitution options.

Some interviewees felt that the digital interoperability characteristics of the DDT, including the use of standardised, machine-readable data, would enable easier data transfer from trusted sources. The most

[75] MBIE 'Cabinet paper – Lifting the Efficiency and Quality of the Building System: Overview'. 11 October 2019.
[76] Sategna, LG, et al. (2019).

frequently cited value-add was in enhanced procurement processes (23%), followed by enhanced product sustainability information (15%) and more efficient asset management (15%).

Figure 9 - Interviewee frequency of response - value-adds of DDTs



A group also advised that sharing trusted data would enhance overall process efficiencies and contribute to improved productivity through the provision of standardised role-specific information. The effective use of DDTs was seen to improve access to information and provide downstream opportunities, including more informed data-driven product attributes, performance comparisons and product availability.

5.5 Barriers to industry uptake

We explored potential barriers that would impede DDT adoption and implementation in New Zealand. Recognising that constraints and barriers differ, depending on a stakeholder's role/perspective in the industry, we identified six main barriers that our interviewees talked to:

- fragmented industry structure and incentives
- limited government procurement support and regulatory leadership
- a lack of sector-wide leadership and direction
- sector-wide immaturity, coordination and alignment on data standards and data sharing, despite a recognition of the value opportunity offered
- the cost, scope and scalability of implementing DDTs to achieve efficacy
- low industry appetite for change from a 'tired' sector under stress.

5.6 Leadership and governance

Interviewees were asked what governance model would be most appropriate to lead and drive DDT adoption in New Zealand, assuming there is an appetite to do so. Governance options included using a government department, an industry association, or a public-private partnership model.

Digitisation in the sector lacks infrastructure, agreed process and governance. There is a need for rigorous governance.

The consensus was for a suitably funded (e.g., government-funded, building levy-funded) independent body. The 'arms-length' independence required of such an entity, it was suggested, would garner better sector-wide support for adoption than the other options suggested. The governing entity would be responsible for aligning and galvanising both government and industry around common strategies and objectives for successful implementation and beyond.

5.7 Conclusion

In general, survey participants' insights about product information has been extremely useful in better understanding how sector-wide interoperability, enabled by a well-defined standards-based digital template, would improve productivity and decision-making. While there is a particular struggle in accessing EPD information, the same concerns exist for other information. Responses indicated general agreement that information in the format of a DDT would allow the construction industry to improve sustainability, environmental, safety and efficiency outcomes, while improving authentication of EPDs, giving greater trust and confidence to the sector and beyond. The responses mirror EU findings that have led to a wide range of the digitisation initiatives outlined in section 4.

6 Adoption and scaling the use of DDTs in New Zealand

There are challenges in the digitisation of product and construction materials information. EPDs face additional challenges due to data availability and the perceived value of investing in them. If they cannot be easily shared, this is another obstacle to their uptake and therefore value.

Arguably the single biggest challenge is *scaling information* provision across the many millions of products used in the construction sector and keeping this data maintained and up to date. This goes well beyond the adoption of DDTs, to include incentives to invest in populating and then sharing data among stakeholders, who are often in competition with each other.

We briefly outline our ideas to move forward, starting with insights based on the EU approach, and then we turn to the recent *Commerce Commission Market Study* report that was published near the completion of this research.

6.1 The EU lessons for New Zealand construction sector digitalisation

In the context of the data and infostructure challenges outlined in the Accord's Transformation Plan, the approach taken by the European construction industry should offer credible guidance in building a roadmap for New Zealand. However, initiatives need to be anchored in the New Zealand context and culture, where tangible gains from structured, standardised and shared data are beyond the experience of most stakeholders.

The Building Innovation Partnership (BIP) recently published a position paper on the *Digitisation of the New Zealand Building Industry*, and it neatly identifies a path forward that is well aligned with our research findings.

Recommendations include:

- support for grassroots initiatives for the technology sector (e.g., MBIE funding partnerships to accelerate the development and uptake of technologies)[77]
- government use of BIM to be required in procurement
- adapting the regulatory framework to incentivise digital developments (e.g., automated consent applications)
- foundational data and process standards agreed across industry and government
- education of key industry participants (e.g., government procurement agencies, best practice technologies and standards use).

BIP's approach is similar to the EU countries where multi-pronged efforts to digitise construction industry data across the life cycle of the built environment are being deployed. This kind of approach would be necessary to spearhead the implementation of DDTs in New Zealand, and to scale product data creation and share it for reuse, including EPD data across the industry.

6.2 New Zealand Commerce Commission Market Study

In the 2020 report on 'Digital Product Data for Lifting Productivity', we investigated the infostructure that could be established to share a limited set of product data. This occurred in the context of several industry participants promoting the need for a national product library as part the Government's product regulation changes.

The product 'library' idea has been put back on the Government's agenda with the Commerce Commission draft findings in the *Building Materials Market Study* (August 2022).[78] The study recommends the establishment of a *centralised* digital national key products registry.

The Commission's preliminary view is that there is benefit in introducing some form of centrally-operated national products register. Such a register would act as the primary reference source for information about building products, including the information that will be required to be disclosed because of the building law

[77] Jones, D, Amor, R, Bellamy, L (2020).

[78] https://comcom.govt.nz/__data/assets/pdf_file/0028/289360/Draft-report-Residential-building-supplies-market-study-4-August-2022.pdf

reforms. This could make it easier for designers, builders and BCAs to find and share information about available building products, potentially reducing the barriers to use of different products.

In principle, a database of this nature could be useful for sharing product data, and therefore aid in driving the broader adoption of DDTs.

However, there are numerous difficulties in implementing a *centralised,* government-run system, in the context of the millions of building products in the market, including:

- Deciding what constitutes 'key products', i.e., what is the scope and coverage of product data? Also, what product data would need to be in the registry? These are not easy ex-ante issues to resolve in establishing a government-run database.
- It may be difficult for the Government to ring-fence any *perceived guarantee* of data quality and accuracy. Government agencies risk legal claims, and potential damages, where there is reliance on the quality, accuracy and completeness of product data. Best practice would typically assign the responsibility and liability for providing and maintaining accurate product data and assurance claims onto product suppliers.
- Resource demands placed on a government agency that would be required to populate, maintain and continuously update data would likely limit the availability of products in market. This is likely to impact on the use, utility and value of the database.
- The business *incentives* to participate in a centralised database may be considered weak, because without regulation participants may not trust the efficacy of the data.

More generally, a centralised approach is not in keeping with the best practice emerging in the EU, as we have outlined in this report. The EU model uses industry agreed, digital standards to facilitate the exchange of data between trading partners and relies on a more *decentralised* model that harnesses commercial incentives.

6.3 A decentralised approach to product data creation and sharing

Once data is structured and standardised to industry agreed requirements, it can be shared throughout an industry ecosystem. In this context, the term '*infostructure*' describes the soft infrastructure of information interoperability and data exchange. Support for building this common infostructure is, arguably, a role for government, as it would assist markets function more efficiently and effectively in exchanging data.

The main challenges in establishing a decentralised approach are:

1. **Reaching government and industry agreement on the choice of, and commitment to, the use of open international standards**, which would facilitate competition for *data enrichment services*, rather than locking in local or proprietary solutions.
2. **Building in strong commercial incentives for product suppliers to be able to participate,** to populate product data in systems, and keep it continuously up to date. This would allow for the scalability of the volume of product that is available in the marketplace.
3. **Reaching government and industry agreement on a governance model as well as data access and use rules**. As an example, there are currently several product data service providers in New Zealand, including GS1 New Zealand. Service providers might offer a more open competitive market environment.

The Government could play an important role in building consensus and supporting the 'start-up' phase of a public-private partnership.

Updating our previously distributed product data model to incorporate DDTs

In a GS1 2020 report,[79] a data model describing how a product data infostructure might function was outlined (as illustrated in Figure 10). In the report, GS1 recommended the establishment of a not-for-profit, cross-industry governance group, to oversee the required infostructure, rather than have a Product Data Repository (PDR) operate as a business unit within a government agency.

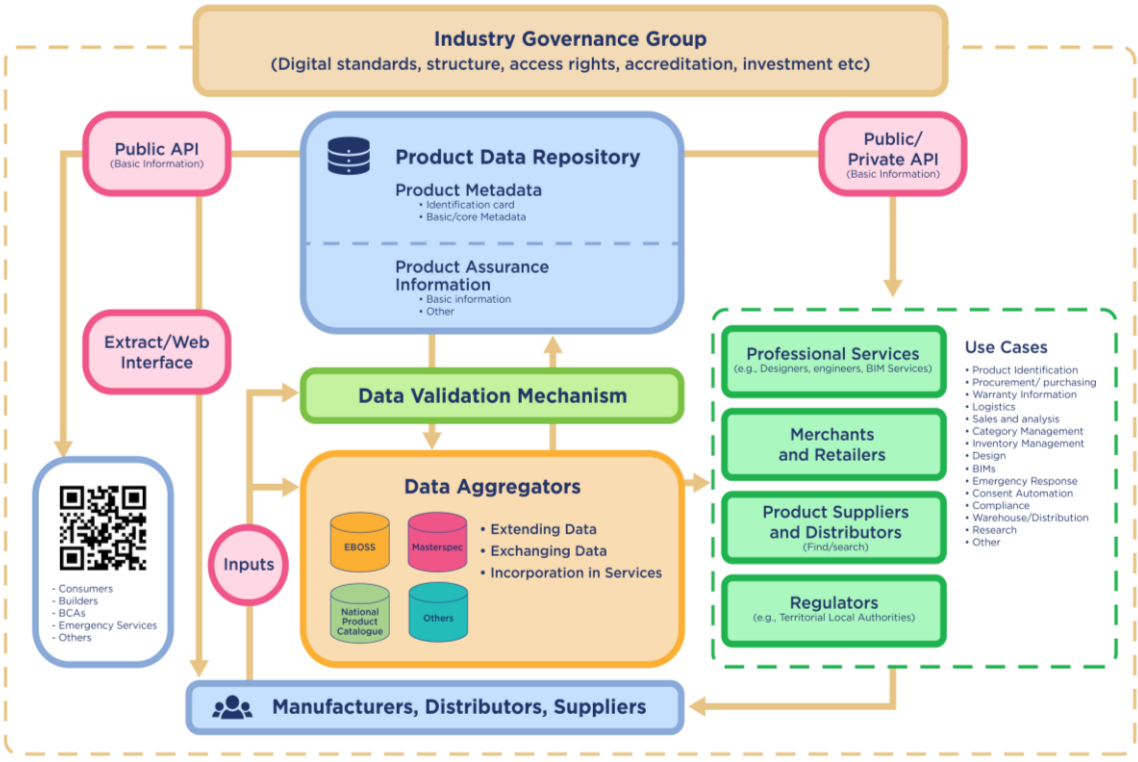
It was recommended that the infostructure operate based on the following principles:

[79] Allison, N, Hartley, G 2020.

- use of open-source international product standards, wherever possible
- provide public visibility of basic product data, including the identity of the data provider
- be market neutral in data provision, and pro-competitive, to enable a competitive data integration service that supports innovation in many forms
- be the agreed source of truth for product data, with robust data validation, to ensure integrity, trust and confidence
- enable one-to-many and many-to-one interoperable data exchanges, designed to mitigate data and system error, while supporting systems scalability and feature enhancements.

Also recommended was a one-to-many data exchange model, where metadata was kept to a minimum, it rarely changed, and it supported agreed data maintenance protocols to ensure data was current and accurate.

Figure 10 – Product data infostructure system



Data aggregators – commercial incentives to use DDTs

To ensure the proposed infostructure is scaled appropriately, a data validation mechanism was recommended that outlined how manufacturers and others could load product data into the system. A repository of this nature is also referred to as a 'data lake',[80] where data is structured and compliant with agreed formats and standards, to ensure data interoperability requirements. This is consistent with the recently published ISO standards on DDTs that were issued after the GS1 report was published.[81] The infostructure also allows for product data to be made widely available to industry, including basic product data, via a public API.[82]

Pre-qualified data aggregators,[83] or intermediaries, working with manufacturers could load enriched, validated product information, or expand existing product data into the system. Figure 10 illustrates three examples of existing data aggregators. Examples of aggregators who may have a future interest in aggregating and enriching product data include:

[80] https://en.wikipedia.org/wiki/Data_lake
[81] Allison, N, Hartley, G 2020.
[82] Application Programming Interface (API)
[83] Aggregators include industry associations, government procurement agencies and BCAs etc.

Materials, products and trades associations

- Association of Wall and Ceiling Industries of New Zealand Inc
- Building Enclosure Council New Zealand
- Cement & Concrete Association of NZ
- Climate Control Companies Association
- Frame and Truss Manufacturers Association
- Insulation Association of New Zealand Inc.
- National Association of Steel-Framed Housing
- National Flooring Association
- NZ Home Heating Association
- NZ Metal Roofing Manufacturers Association
- NZ Ready Mixed Concrete Association
- Window Association of NZ

Government agencies

- Energy Efficiency & Conservation Authority
- Health New Zealand
- Kāinga Ora
- Ministry of Business, Innovation and Employment
- Ministry of Education
- Waka Kotahi.

DDT deployment would facilitate growth in the amount of product data available, as well as the number of data aggregators enabled through providing a *ready-made* means of sharing data. What is emerging in the EU is leadership from sector-based industry associations with their members in making data readily available in a DDT. The incentive for manufacturers, suppliers and others is to publish data once, so it can be shared with multiple data recipients, allowing for products to be marketed widely in a competitive marketplace. Incentives to populate data would also depend on the policies set around participation in the ecosystem. Incentives could include providing data suppliers with compensation for making data available while instilling confidence throughout the community, by having a well-designed and functioning governance model.

Galvanising government to use open global standards, such as DDTs, is not a small task. Government leadership is pivotal in supporting the development of DDTs, and to facilitate the digitalisation of the construction sector. A key finding in our interviews with government agencies, especially those involved in procurement and facilities management, is that they curate their own building materials and product information, and usually for one-off use cases. Data is also managed using in-house non-interoperable spreadsheets. Government agencies do not have commercial incentives to manage information in interoperable standardised formats. Agencies also do not appear to have any understanding of how a DDT environment could function. Government policy would be needed to mandate any process and behavioural change.

6.4 Recommendations

It is recommended that:

1. The New Zealand construction sector, including government agencies, take the lead from their European counterparts (and others) and initiate collaboration initiatives to drive a product digitisation agenda, including the use of DDTs to share data.
2. Establish a private-public, not-for-profit, cross-industry governance-group model, to drive materials and product digitisation, rather than having the PDR operate as a centralised business unit of MBIE.
3. Government agencies that are involved in procurement and facilities management should be required to coordinate around product data sharing protocols.

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Appendix 1

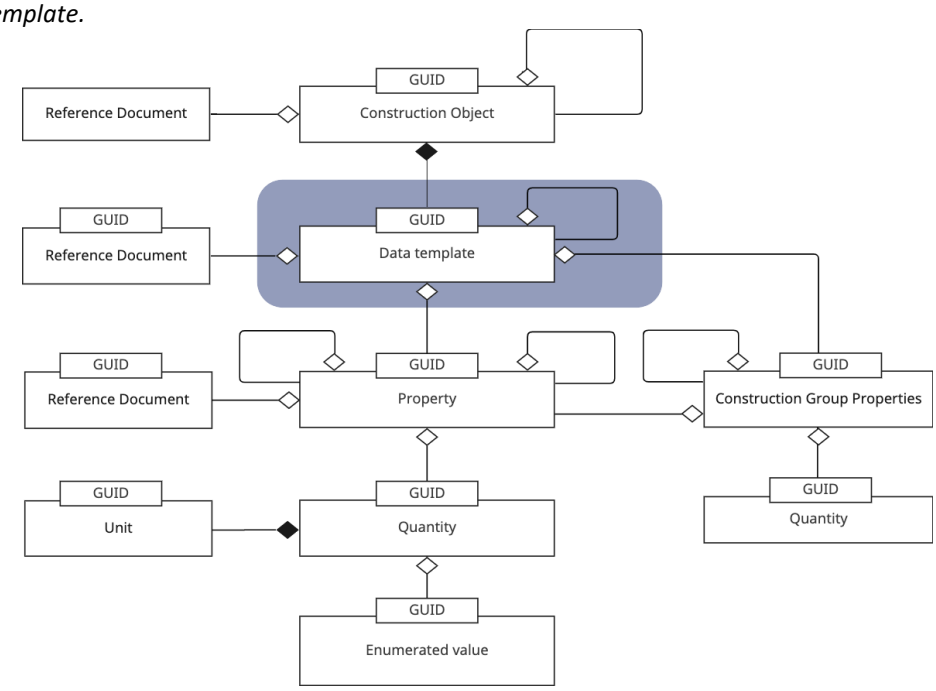
Data Template Demonstration

What is DEFINE

- *Define* is software for authoring, managing and sharing Data Templates within a common data dictionary framework. It supports the standardising of data management practices and defining what product data to exchange to meet the increasing demand for data throughout the value chain.
- *Define* is a data dictionary that enables users to author, manage and share Data Templates.
- *Define Data Dictionary* is a solution for the construction industry managed by the industry itself. A management board comprising various construction industry actors is responsible for all decisions about the development of the tool.
- *Cobuilder* is the operator of the *Define* environment. Cobuilder integrates the technical requirements and the international standards and they were responsible for working with the requested data templates for this project.

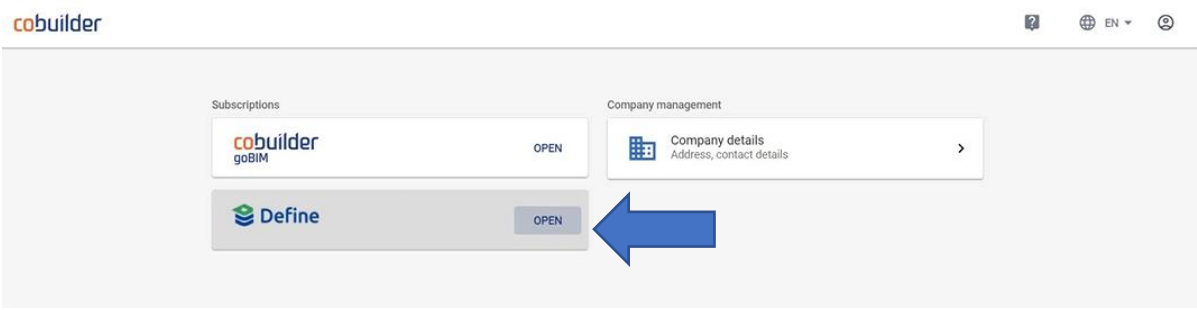
Data template demonstration

The figure below outlines the structure of a Digital Data Template according to *EN ISO 23387*: *The Structure of the Data Template.*



- The data template is a dictionary item representing the collection of items for a construction property.
- A data template is composed of several building blocks such as a *Construction Object*, *A Property,* which can be grouped into a *Group of Properties* for user management.
- *The Property* itself has unique attributes, such as quantity, as well as Enumerated Values, *Reference Documents* and a *Global Unique Identification Code* (or GUID) that makes the Data Template machine-readable.

The system



In this system, there are three (3) main *DEFINE* users:

- A *BASIC* or *Contributor* can create concepts in the system,
- An *EXPERT* can create concepts but also approve different kinds of concepts in the system, and finally,
- *An ADMIN* can create, approve and share different kinds of concepts in the system.

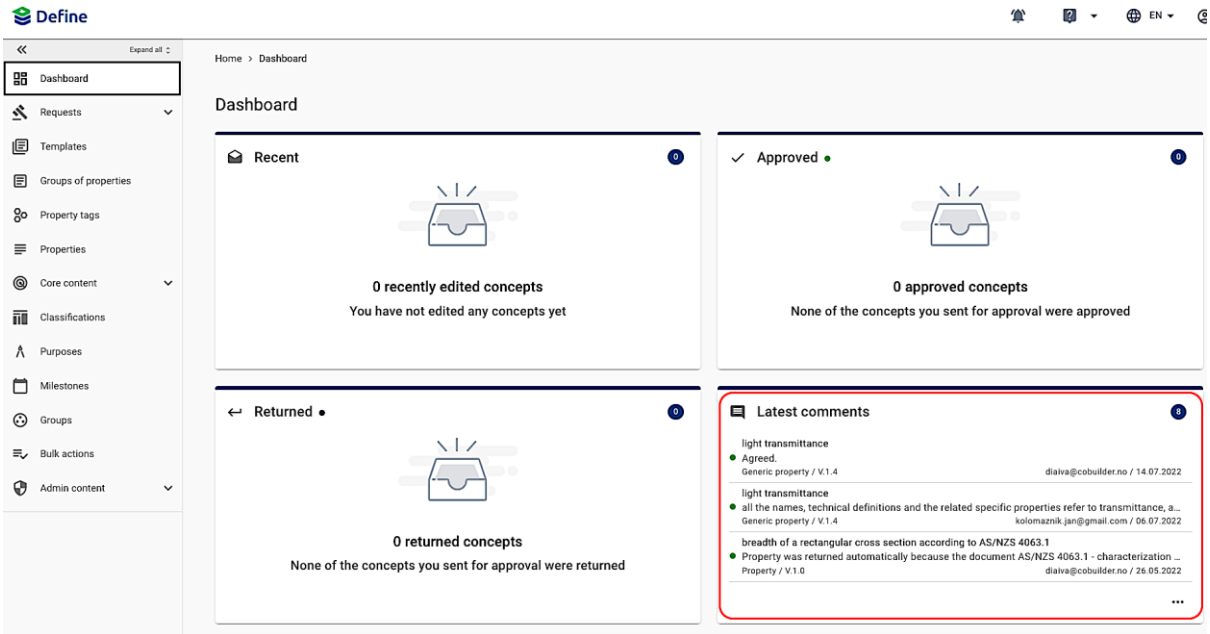
The dashboard

Logging into the *DEFINE* system, the first thing that we see is the DASHBOARD.

The **dashboard** is the landing page for all users. It provides a high-level view of the development of templates and the addition of new standards or supporting documentation (highlighted below).

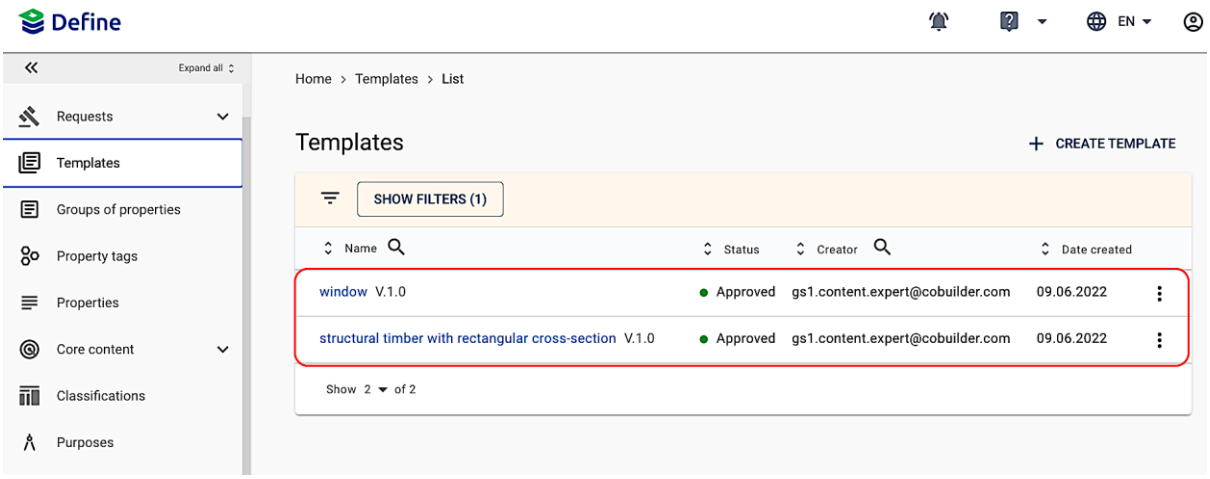
The dashboard gives an overview for any *Recent work*, what has been *Approved* or *Returned,* as well as *Latest comments,* which are tracked and include the dialogue around the addition of standards to the template.

These four elements are part of the *GOVERNANCE* process, which ensures that the data is kept up to date and there are no duplicates created in the system.



The data template

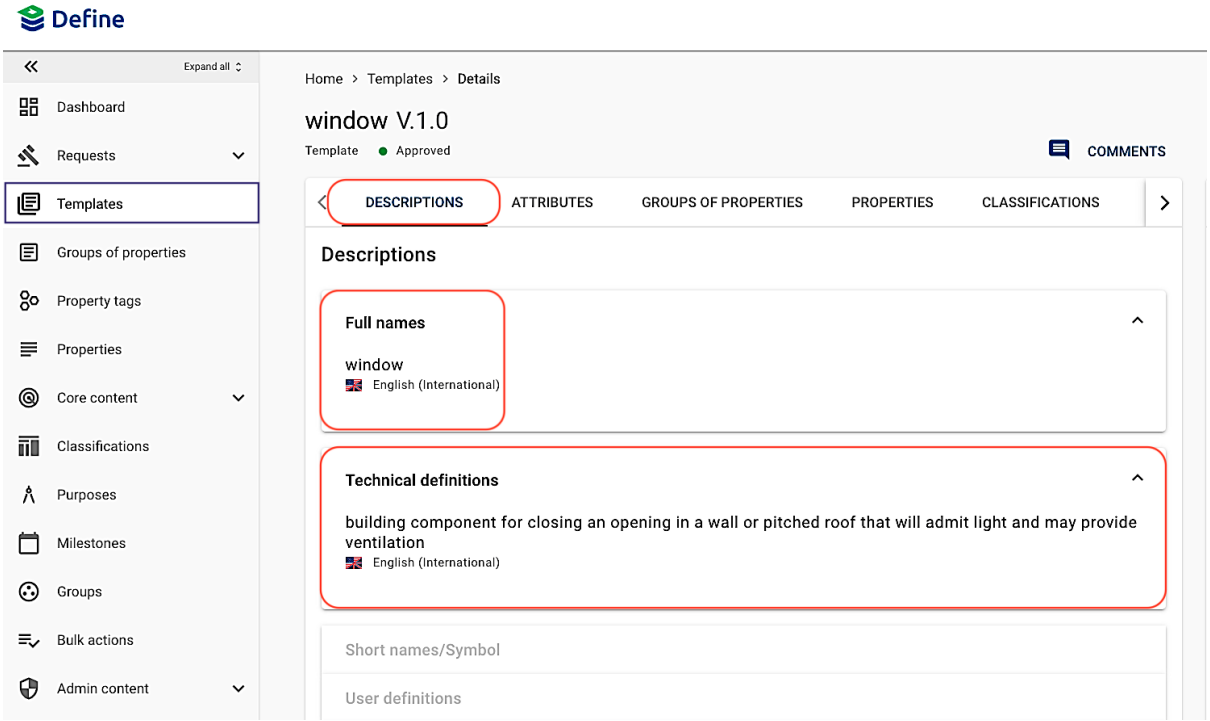
A full list of developed templates is available to the user in the *Templates* window. This view can be filtered and searched by the user. For the demonstration, we developed two construction object templates as highlighted below.



Descriptions tab

When the template for *window V1.0* is selected from the template list, the first tab available is *Descriptions*. The *Descriptions* tab provides the *full name* and the *technical definition* with all the translations; *technical definitions* and *full name* are always taken from the associated standard.

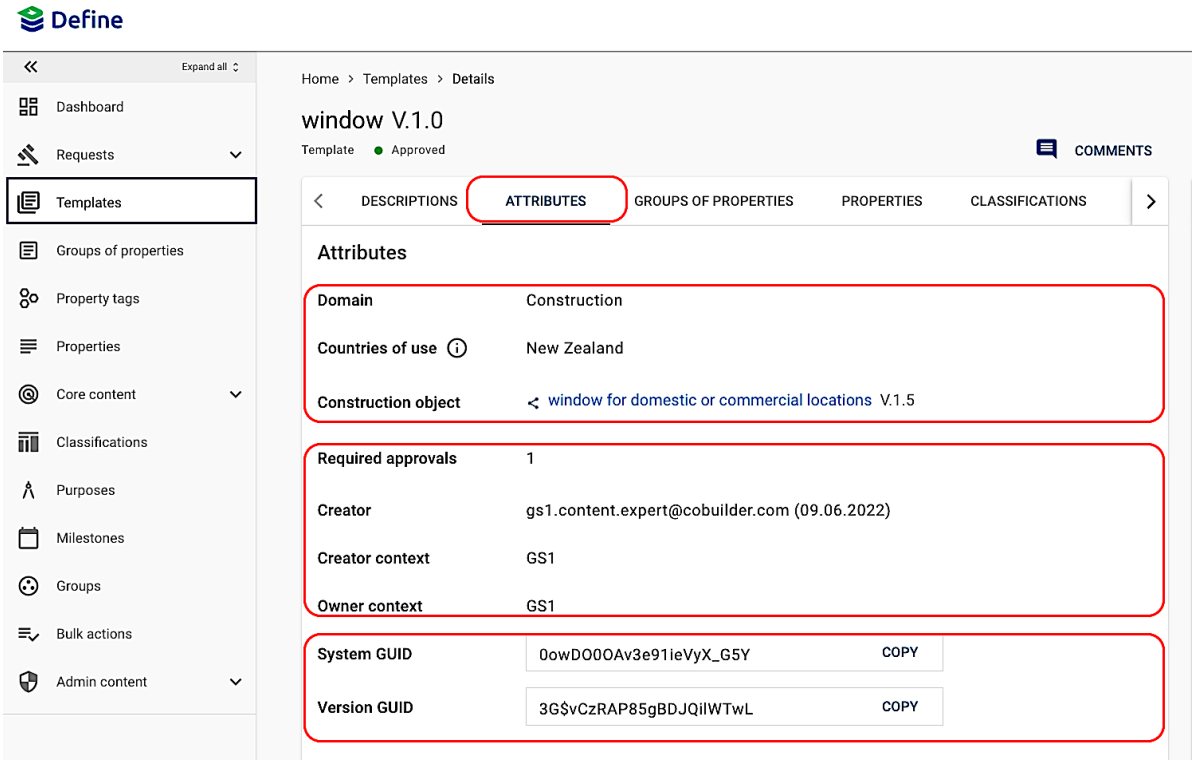
Sometimes, the *description* and *full name* are not well understood by industry, so there is an opportunity to add content, such as a *short name* or a *user definition,* to provide more clarity about the template.



Attributes tab

A template contains a list of attributes that define the product in the template. Attributes fall into three areas, which are highlighted below the figure:

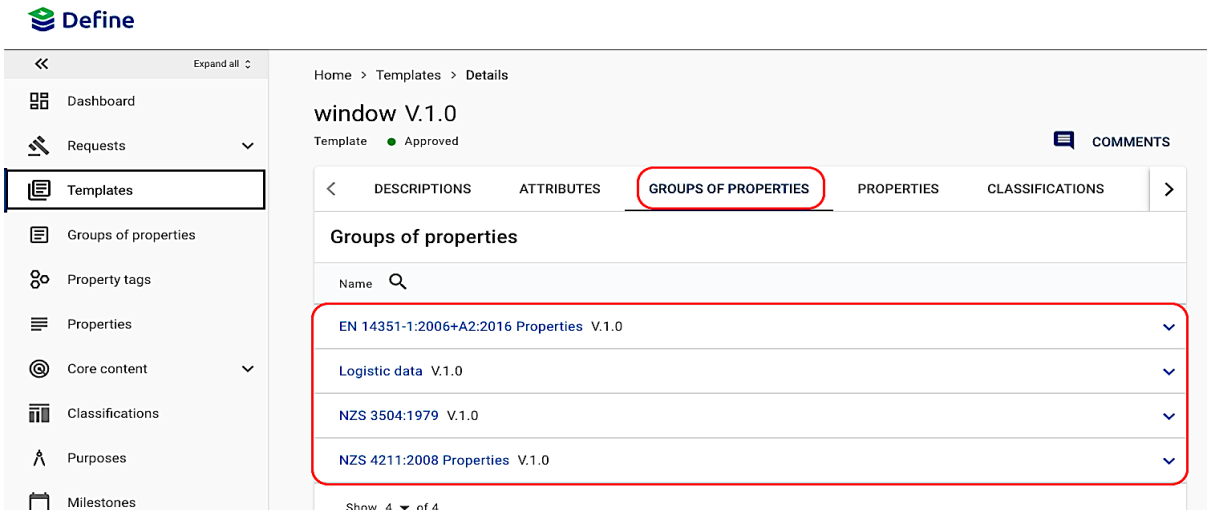
- The first set of attributes contains *Domains* that are used to define which *Authority* has the relevant knowledge to create or approve content in *Define*. In the view below, we can see that the *Domain* is Construction, the country for this domain is New Zealand, and the linked *Construction Object* is *window V1.5*.
- The second set of attributes is part of the *Governance process,* and in this case identifies at least one expert approver who is necessary to evaluate the concept change before it is accepted in the data dictionary. Also identified is the creator of the concept, and where and who owns the concept.
- The final attribute set is the GUID (Global Unique Identifier), which relates to the system and versioning of the template record. This assists with the audit and tracking of a template through its life cycle and makes the concept machine-readable.



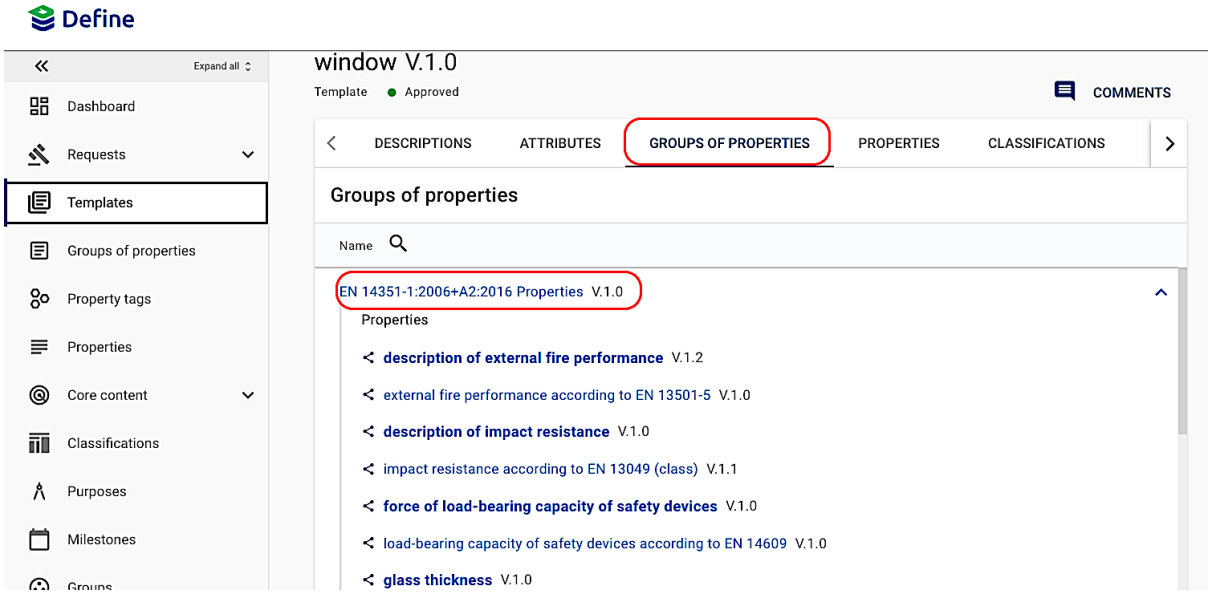
Groups of Properties tab

In this example there are four different kinds of groupings based on the harmonised international standard, the New Zealand Standard and some logistics data.

The groupings (i.e. EN ISO Standard 14351-1) can be expanded to show the associated properties that are included in them.



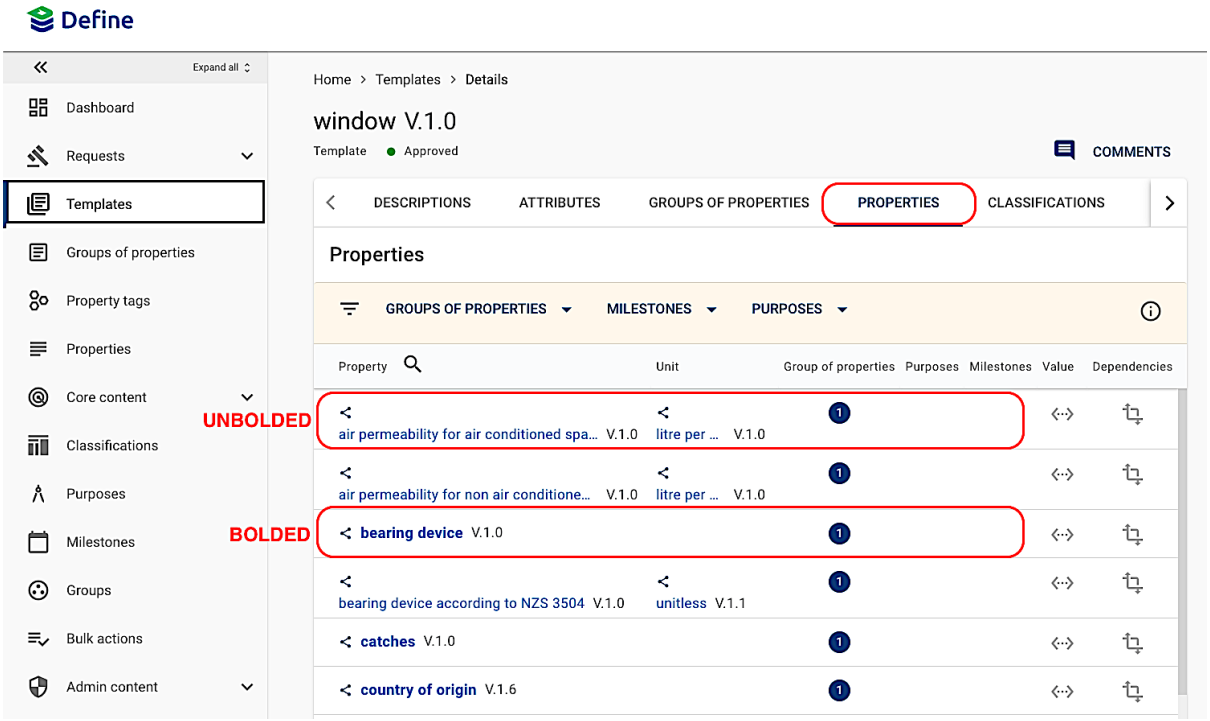
The G*roups of Properties* (i.e. EN ISO Standard 14351-1) can be 'opened' to see the construction object's full name, its technical definitions and its individual properties.



Properties tab

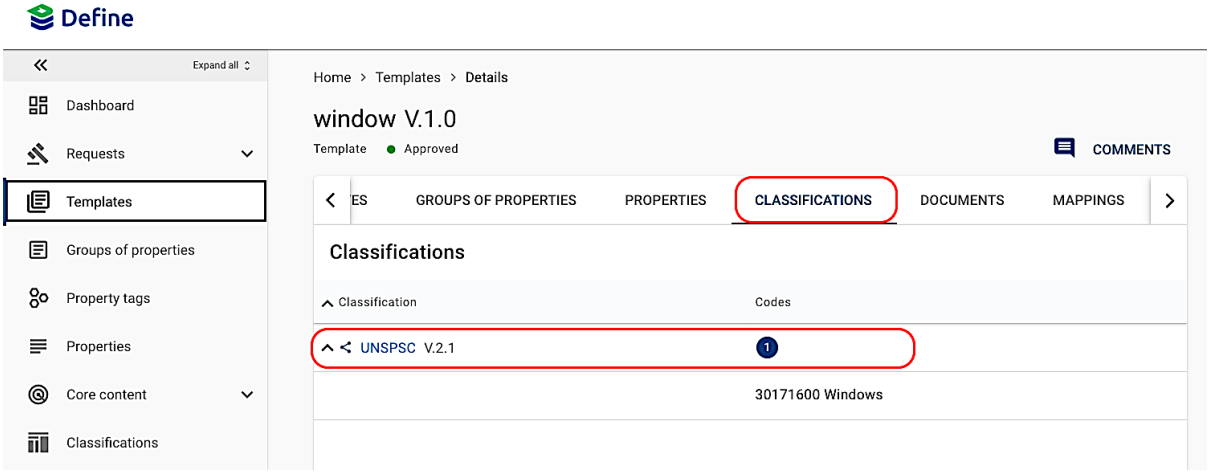
PROPERTIES are a representation of the characteristics describing the *construction object*. *Properties* describe assets such as the measurements used to describe the property such as time, mass and length.

On the *PROPERTIES* tab there is a deeper more detailed view of the *property attributes* that can be filtered for different kinds of groupings. There properties are in **dark BOLD** and light BOLD text. The **dark BOLD** are inherent, for example: length, sound reduction index (properties). The light BOLDED are called *SPECIFIC PROPERTIES* that define a specific test method, for example: length according to EN 12058, and the sound reduction index according to ISO 10140-4 (specific properties).



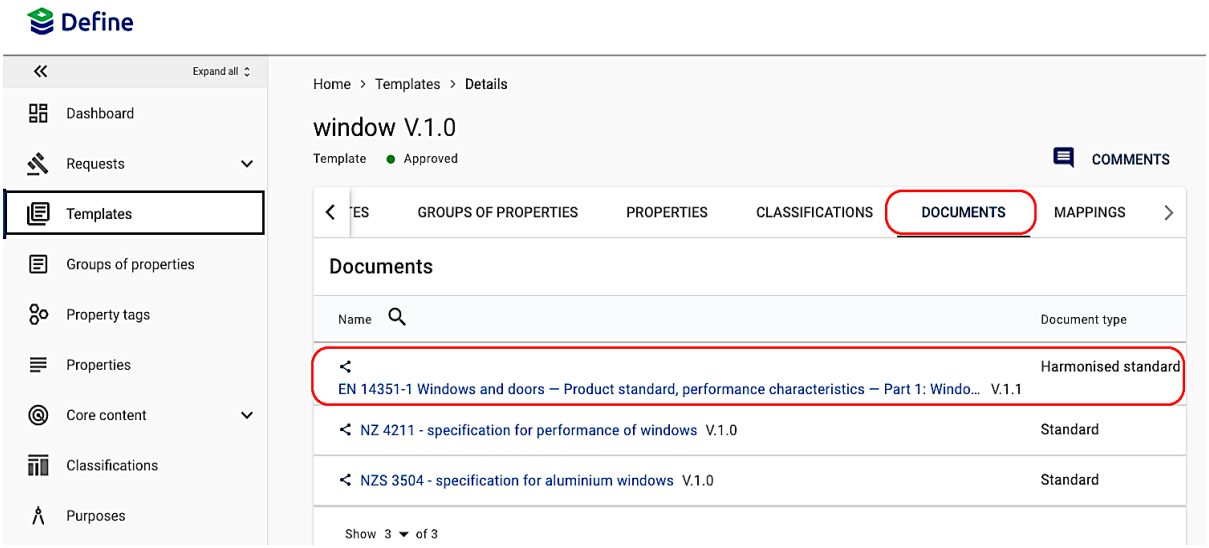
Classifications tab

Product *classifications* are often used in industry. The *Classifications* tab allows users make the template part of any other classification system, such as Uniclass 2015, NS 3451, TFM etc. This is the way to link construction objects to other classifications. In this example, the classification is UNSPSC as highlighted below.



Documents tab

In the *Documents* tab, users can select the documents used to define the template and its properties. These are only representations of these documents (e.g. standards) and are not PDFs or .xls files and are not the standards documents. The documents applied to the template may include test methods and the reference table in the standard.



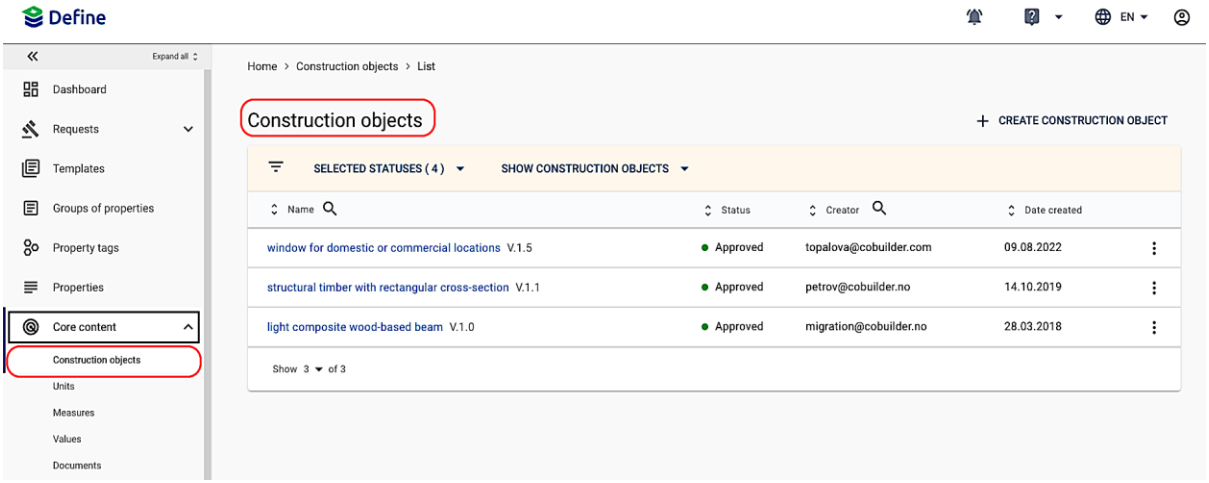
Template core content

There is a set of core content that is essential to the template construction. The core content is essential to accurately identifying the construction object and developing the data dictionary associated with templates.

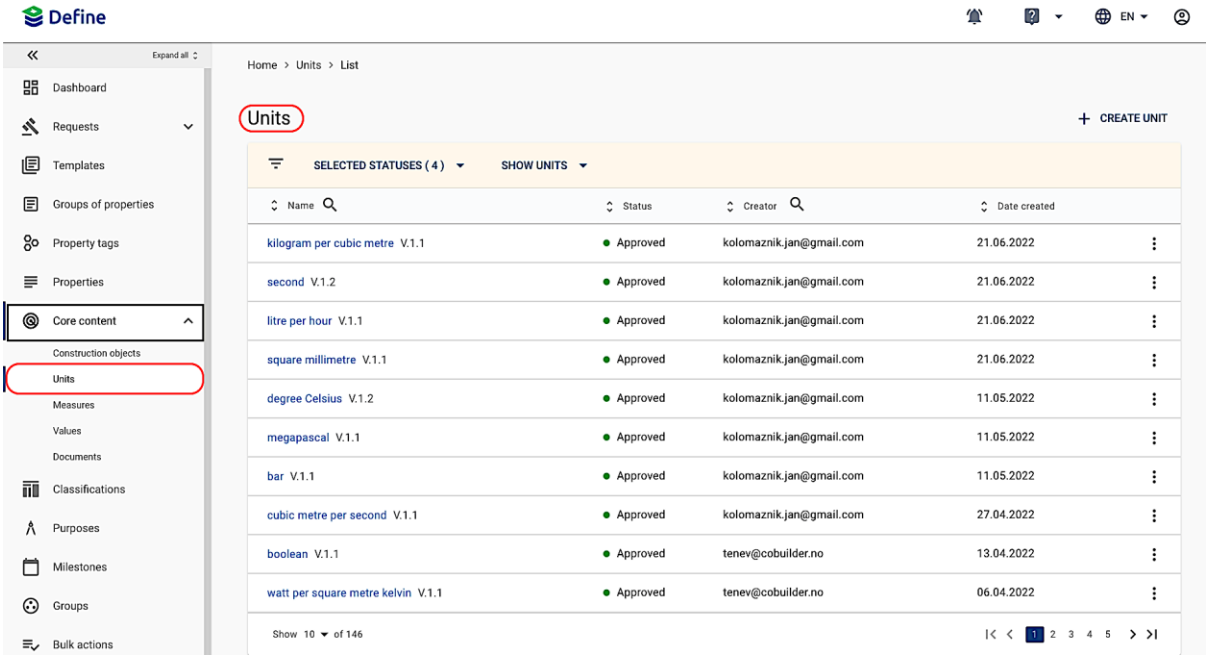
CONSTRUCTION OBJECT – is an item representing a physical asset of any construction product or system used in the construction process.

Example 1: The construction object 'window' is a type of system.

Example 2: The construction object 'piece of structural timber' is a type of product.



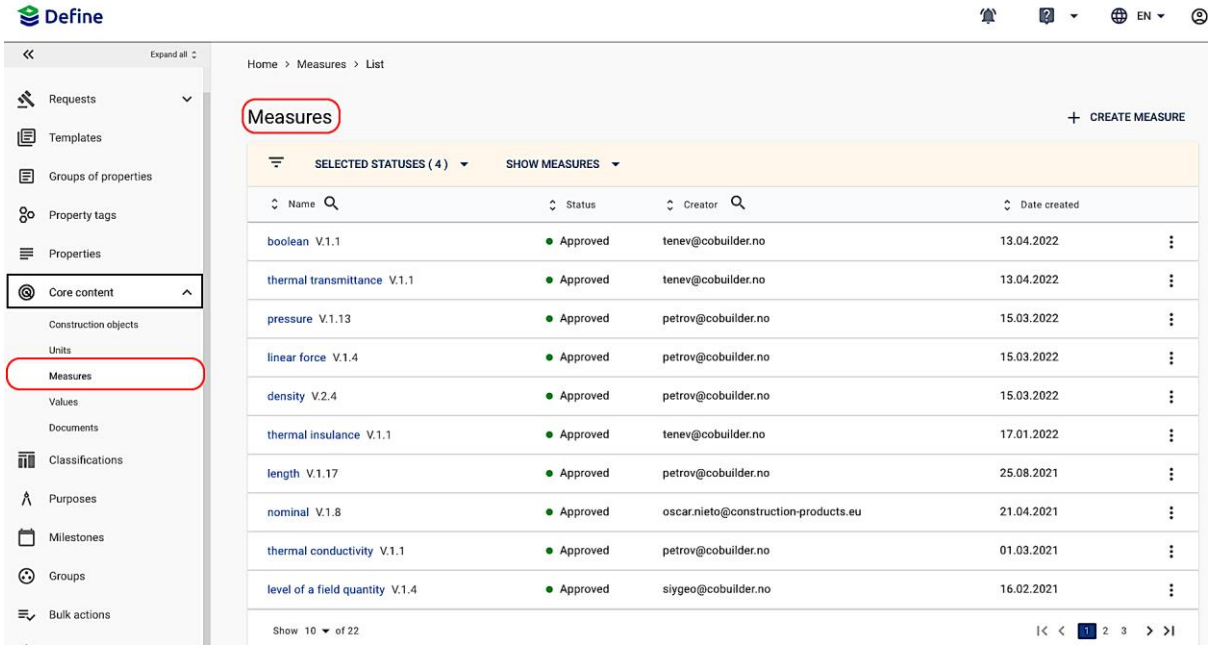
UNITS – is a representation of how the *property* is measured, such as millimetre or metre. A unit is a measurement unit that gives scale to a property's value (e.g. m^2, kg CO_2 eq., cm, etc).



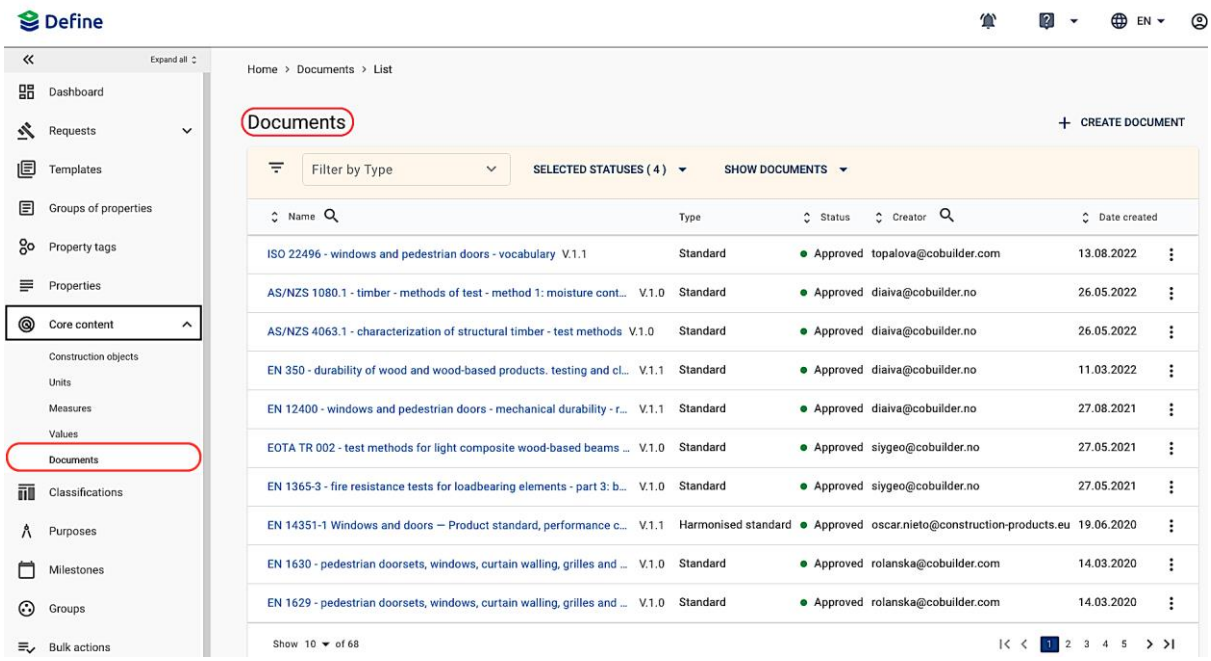
MEASURES – measure is referred to as '*quantity*'; a measure is a representation of a *property's* physical nature that can be measured and expressed numerically (e.g. pressure, time, mass, etc).

Example 1: Length, mass, electric current (ISQ base quantities).

Example 2: Plane angle, force, power (derived quantities).

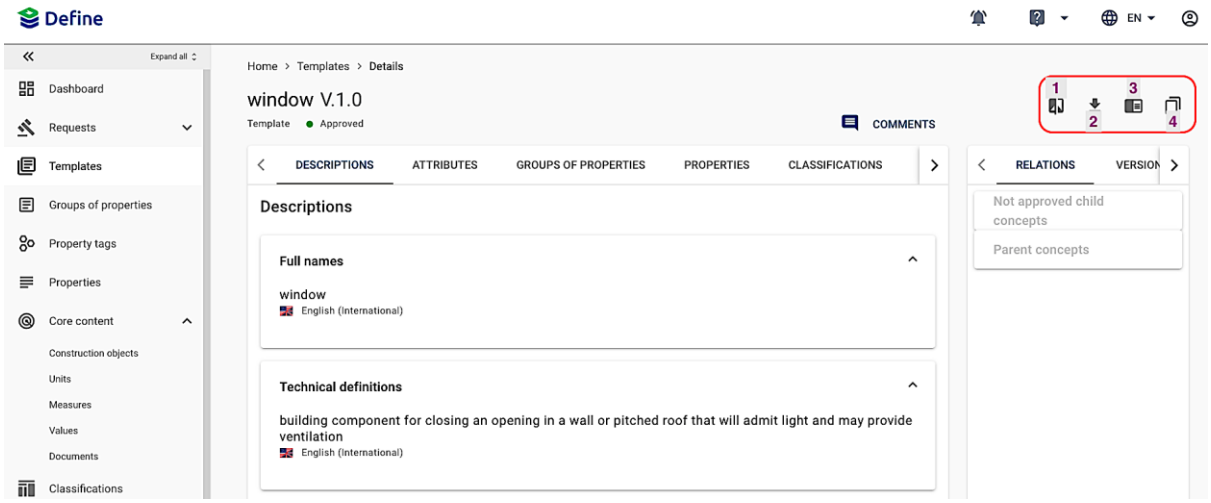


DOCUMENTS – are reference materials, such as linked standards or testing results.



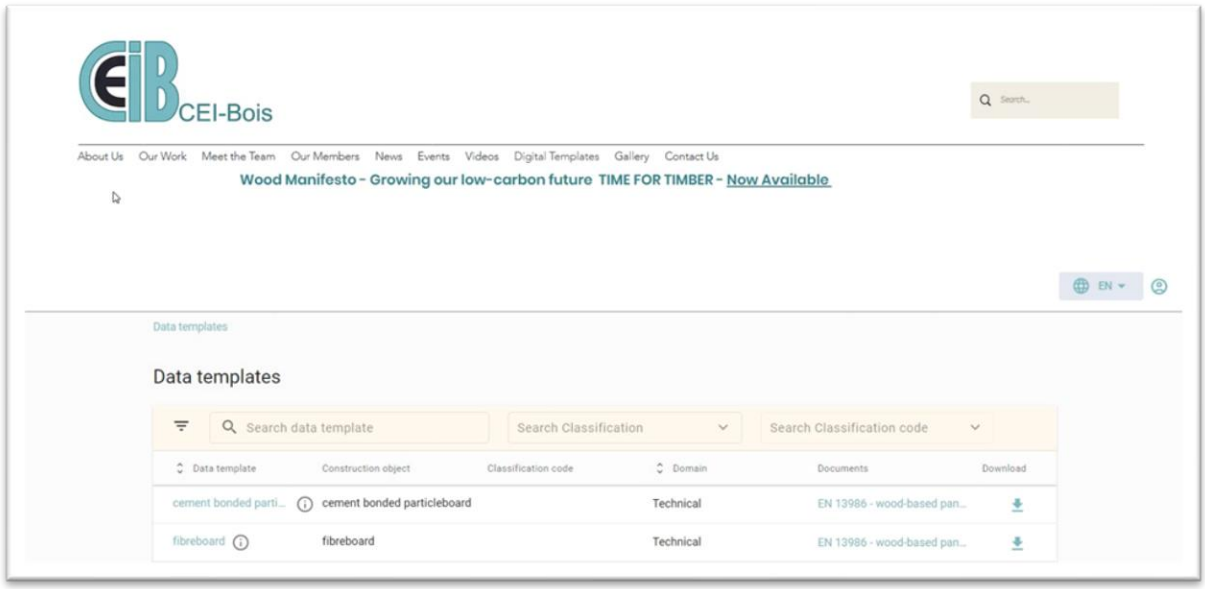
Tools within the interface

- **1st Icon** – allows comparison with another temple already built or another version of a template. In this example, this is *window V1.0*. Concepts that can be tracked in the system to see what has been changed in the system over time, and who has made the change, when and why.
- **2nd Icon** – is the export function, which allows exporting the template to another parting, using .xls in an email, for example.
- **3rd Icon** – the system allows for the creation of a new version of the template.
- **4th Icon** – allows changing some information (under the Governance rules), or the creation of a copy of the template, which is useful when minor changes are required in an existing template.



What can be done with the finished template

1. Export the document via email using the EXPORT ICON, or
2. Implement the template in a business's webpage (e.g. CEI-Bois) as a public view, to show what requirements are necessary to comply with local or international standards or regulations as outlined below.



3. Use an API that can be used to integrate template data into internal or external systems such as BIM as outlined in the figure below. As an example, a product data sheet that has been created – **ND NTech One Sidehinged**.

This is a window based on the window data template created in DEFINE such as the CONSTRUCTION OBJECT, what STANDARDS the object is complying to, CONSTRUCTION OBJECT DEFINITIONS, COUNTRY, the GTIN, PRODUCT CODE, and the manufacturer. The template data has been transferred into a BIM environment, in this case, using an API.