Picture credits: Ruukki Construction

2017-2020
PROGRESS
PROVISIONS FOR GREATER REUSE OF STEEL STRUCTURES

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# BIM for Circular economy, deconstructing, reuse and recycling

## PROGRESS webinar 2

14 May 2020

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VTT Technical Research Centre of Finland

# BIM: information for design - build - operate - renovation- demolition

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In project level BIM process and data flow is defined in **Modelling Guidelines for each BIM use case.**

Building information **standard CEN TC 422** is are forming the foundation.




European Commission

# BIM for life cycle of buildings

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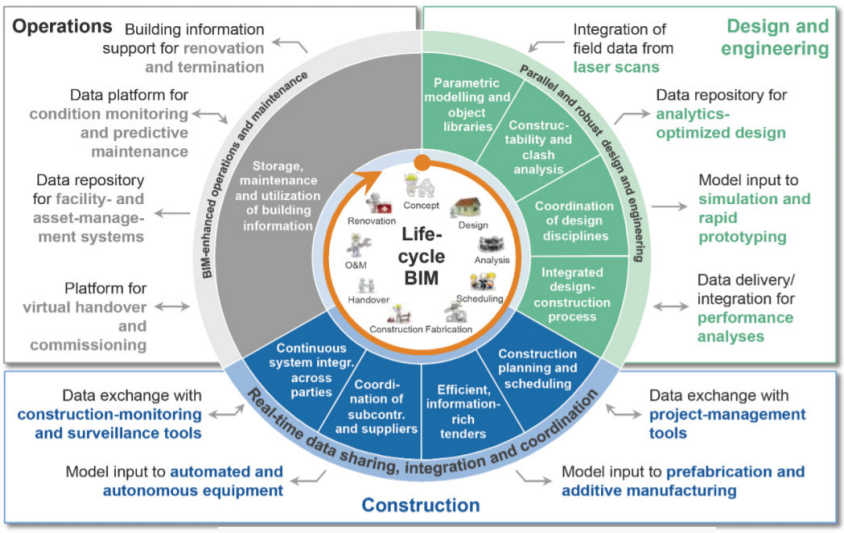
Design and engineering: **parallel and robust** design and engineering.

Construction: **real-time data sharing, integration and coordination.**

Operations: BIM – enhanced operations and maintenance.




Use of BIM along the engineering and construction value chain (Source: Shaping the Future of Construction)



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# End of life phase/ steel

Cost and CO2 estimations

Visualisation and data of Demolition plan and Circular economy plan

Preliminary evaluation of re-use

Call for tenders for demolition and re-use (with re-use model)

Analyses of product data and properties

Pre demolition audit

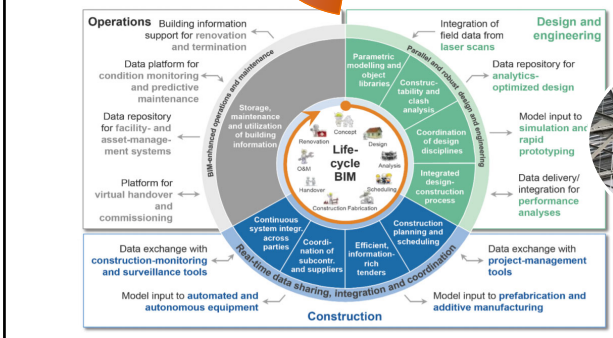
Execution plan of demolition

**Inital data model** for re-use (product data and geometry)

Reuse BIM model

Demolition survey → Demolition work → Sorting

Assessment of re-use and detailed circular economy planning



Reuse on site

Reuse in buildings
- in another building
- in another project

Recycling
Manufacturing of new steel
- for building industry
- for other industries

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| | Level 0 | | Level 1 | Level 2 | Level 3 | | Level 4 |
|---|---|---|---|---|---|---|---|
| Content | Pencil and ink lines and text | Digital lines, text, blocks and symbols in 2D | Simple 3D objects | 3D building objects with unspecified information | 3D building objects with requirements to objects, properties and ID | Manufacturer's 3D objects & properties for operation / FM | All project, operational documentation and history are linked to objects in the model |
| Digitization | Drawings on transparent paper on a drawing table Paper copies | Drawings made with 2D CAD in a computer Paper copies | Drawings made with 3D CAD/BIM Paper prints | Data hosted in the Common Data Environment (CDE) | Drawings / views from BIM streamed to mobile devices. Limited paper use | Open BIM with dimensioning streamed to mobile devices | Open BIM with all operational information and history streamed to mobile |
| Interoperability | Drawing on plastic film copy of other disciplines drawings | Work on 2D DWG or DXF background from other disciplines | Work on 3D DWG background from other disciplines | File based sharing of open BIM (IFC), aggregated models | Serverbased sharing of open BIM (IFC), continuous validation of model. | Serverbased communi-cation & issue handling, all issues related to objects in BIM | Sensors enriches model. Direct communication between the model and functional systems |
| Collaboration | Coordination in design meetings and onsite meetings | Systematic interdisciplinary controls with digital workflows | 3D visualization, visual controls in modeling tools | Systematic model coordination, clash detection, quantity take off | Interface handling in BIM. Advanced simulations. Integrated Project Delivery (IDP) | Model carry all inform-ation for construction and operation. Model driven producton and assembly | Model used by operations, employees and users and the public |

Enterprise BIM

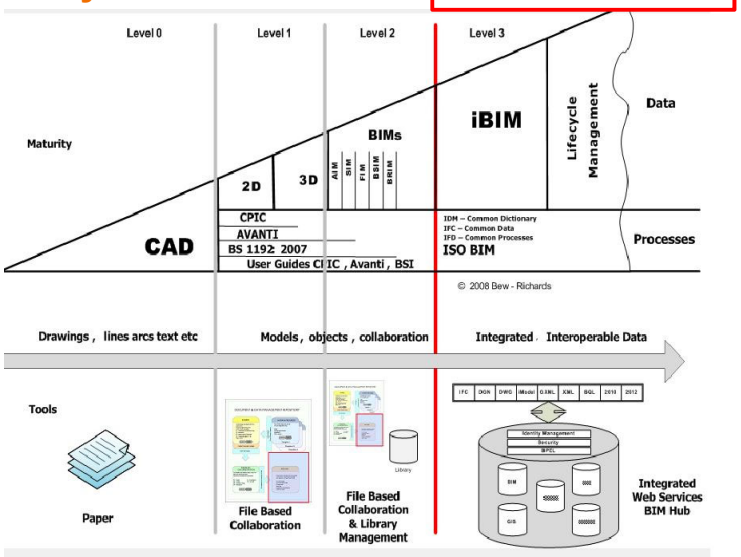
BIM maturity levels (level 0…level 4) and **four aspect of maturity**: the content of models, the digitalization level, the interoperability and the collaboration.



# BIM Technical maturity

General BIM maturity target in EU: Level 2

**From file based collaboration towards integrated web/cloud- based services.**




European BIM Framework for digital transformation and process re-engineering

# ”BIM is a moving train”
# New technologies are integrated to support the core

Virtul models (VR)
Augmented reality (AR)

Data driven

Digital twin

Gaming models

Blockchain

Integrated Design and Delivery Solutions (IDDS)

Linked data
Semantic web technology

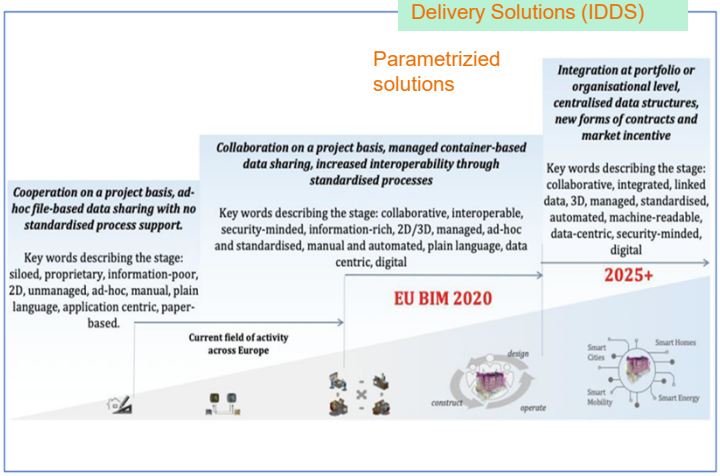
Open data Platforms

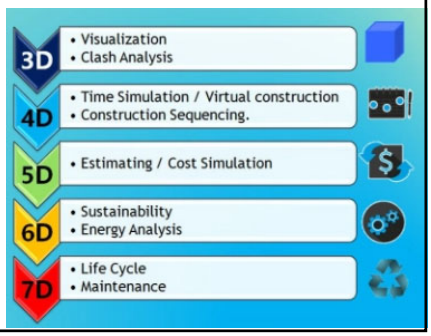
Parametrizied solutions

Generative design

Internet of Things
IoT –solutions

AI, Artificial intelligence (AI)
Algorithms



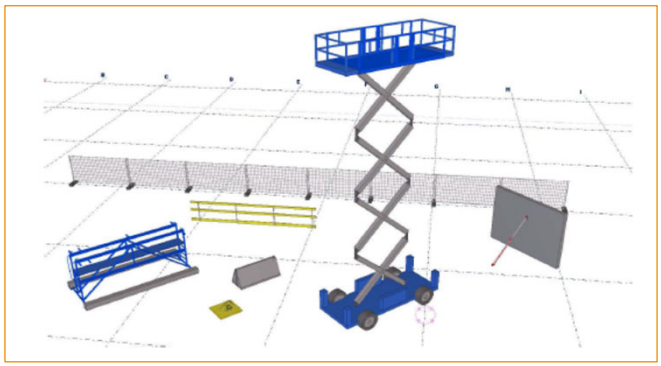

05/13/2020

# Existing BIM use cases

The use of **4D-BIM in planning of on-site operations** can result in improved occupational safety during building construction

The same concept can be adapted for the deconstruction work with the 4D model or higher (utilizing also the information collected during the operation and maintenance of the building).

Similarly to the construction (assembly) process, model parts have to be linked to the corresponding stages of deconstruction (disassembly) creating suitable visualization rules.



Examples of on-site planning objects created in TurvaBIM (top) and BIM Safety (bottom)

# ”BIM cube”
# Little BIM – Closed BIM
# BIG BIM Open BIM

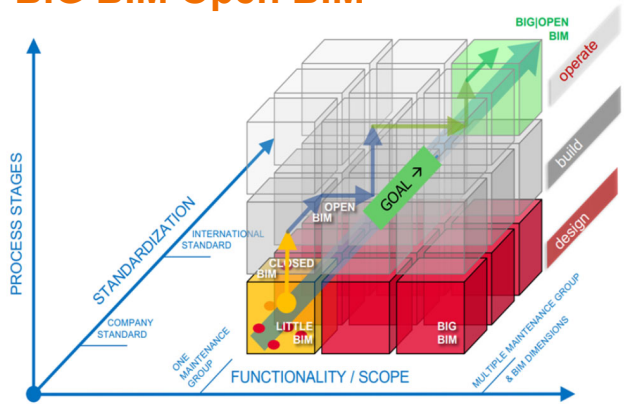



*Figure 1 From “Little” BIM towards “Big” BIM (Source: BuildingSMART International)*

When the first steps with BIM are taken, it usually starts with “Little or Closed” BIM.

**“Little and Closed” BIM** means today company-specific standards/ guidelines and implementation in one area, for example design, and one user group.

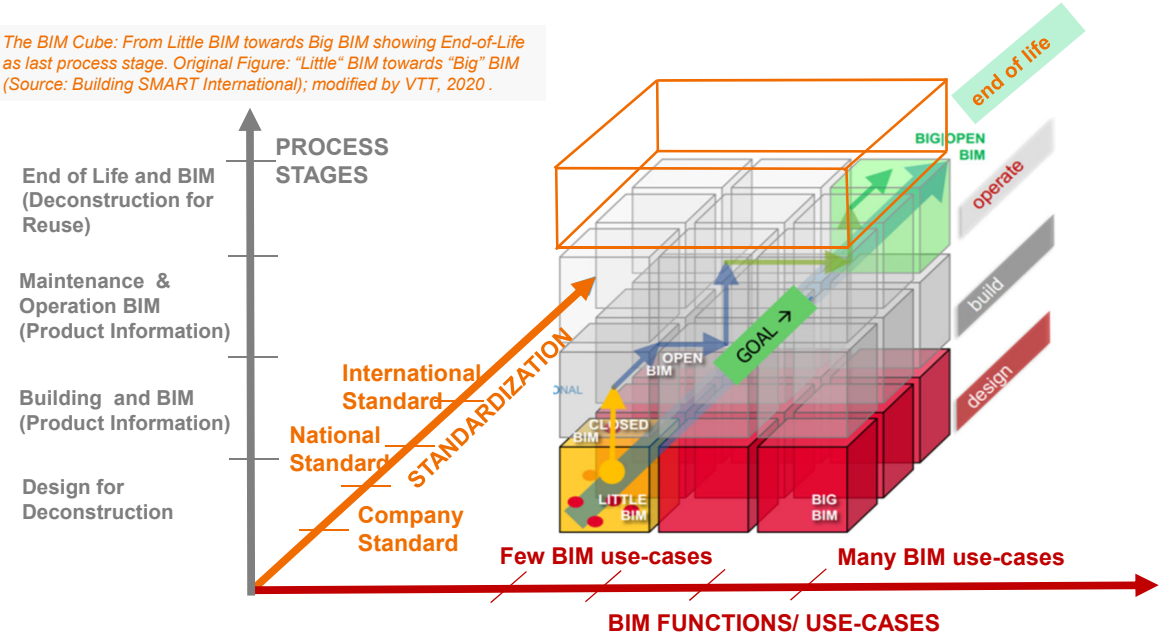
The full benefits will only be reached when striving for **“Big and Open” BIM**, which operates according to international standards, covers the whole life cycle process, and involves all parties. “Big and Open” BIM requires a vision, a lot of systematic commitment and work.

Chancing focus **from investment project to lifecycle and use** is an interest of the forerunner companies, but **end of life phase is less developed.**

In The Cube this means adding another 4th level describing BIM for deconstruction, reuse and recycle processes.

13.5.2020 VTT – beyond the obvious 9

*The BIM Cube: From Little BIM towards Big BIM showing End-of-Life as last process stage. Original Figure: “Little“ BIM towards “Big” BIM (Source: Building SMART International); modified by VTT, 2020 .*



Existing DfD tools and their features.

| Nos Tools | BIM compliant | Embodied energy estimation | Carbon footprinting | End-of-life impact estimation | Estimation of building deconstructability | Deconstruction process simulation | Deconstruction plan generation | Material recovery assessment | Lifecycle costing | Whole-life environmental impact assessment | Optimisation of material selection |
|---|---|---|---|---|---|---|---|---|---|---|---|

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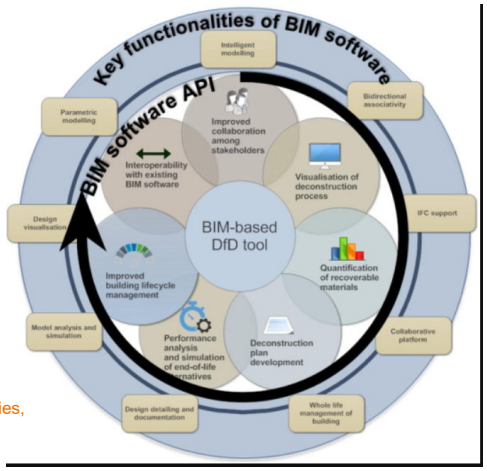
## BIM based Design for Deconstruction applications?

Seven key functionalities of BIM-based DfD tools:

- improved collaboration among stakeholders
- visualisation of deconstruction process
- identification of recoverable materials
- deconstruction plan development
- performance analysis and simulation of end-of-life alternatives
- improved building lifecycle management
- interoperability with existing BIM software.




Akinade et al (2017), BIM-based deconstruction tool: Towards essential functionalities, International Journal of Sustainable Built Environment



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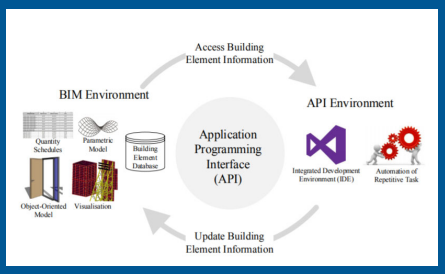
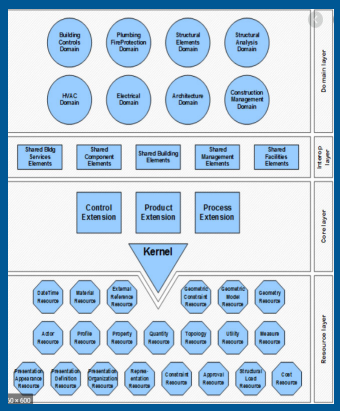
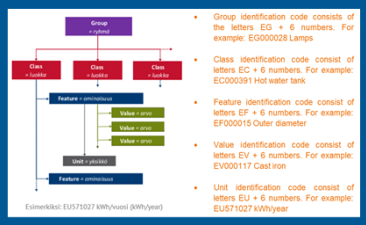
## Product data

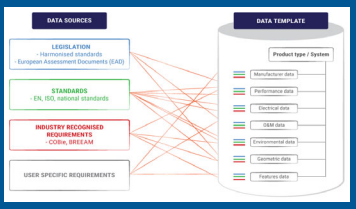
## Little BIM - Big BIM
## Closed BIM - Open BIM – Deep BIM

- BIM use cases for deconstruction, reuse and recycling **need detailed information** on property levels about products and building components of the building. 4 approaches:



# Approaches for management of product information

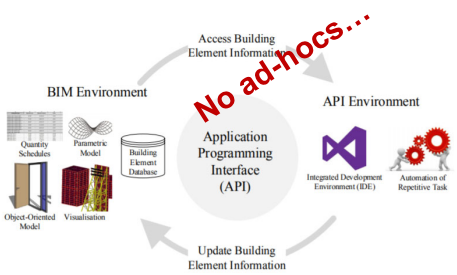
DeepBIM is a term used for more detailed information applied in analyses, calculations, simulations and performance assessment. BIM use cases for deconstruction, reuse and recycling need detailed information on products and building components of a building. We have identified four methods for a carrier of detailed information/ property level information of a product or building component, in data transfer or data drop actions:

(1) **API interfaces which software vendors develop ad-hoc between systems and tools to meet needs for information content or transfer.**

(2) **OpenBIM based approach is based on defining the IFC-file content for the needed data/ information transfer actions.**

(3) **BIM classification and for instance ETIM- structure**

(4) **OpenIFD based approach**




(3) and (4) are still **emerging approaches** and available to business only after enriched with data, adapted to the processes and implemented to information services and software.

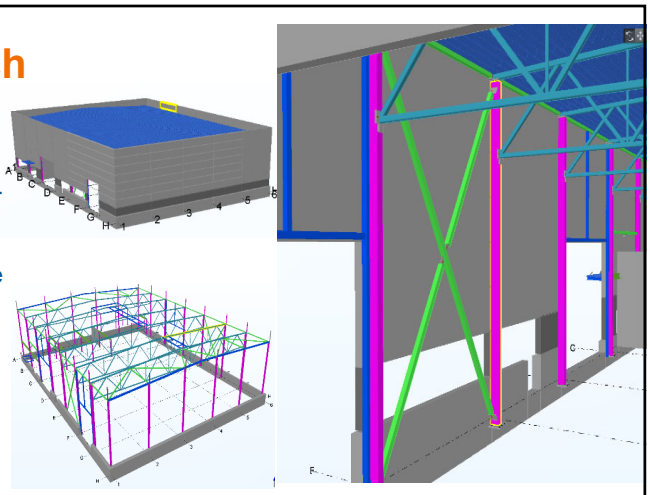
# (1) OpenBIM based approach defining the IFC-file content

For the PROGRESS test case: OpenIFC and IFC-file approach is used.

The product in the case example is steelwork, one column. Integration of BIM model data, Smart CE data and Smart EPD data is defined on property levels.

The selected Column is part of the structural assembly designed in Tekla Structures and stored in IFC format. The model contains material grade (S420MH), but no explicit information about the material properties and manufacturer.

=> This may be insufficient in the case of reuse when the conformity of the products to the harmonized has to be verified.



*Single storey steel hall (top left), its steelwork (bottom left) and the selected column for the case study highlighted by the yellow outline (right).*

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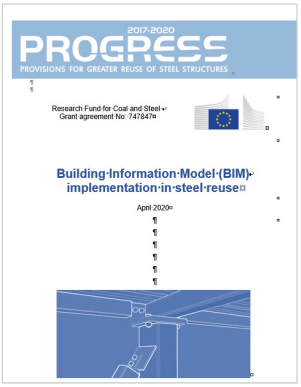
*6.2 → Information stored in the existing BIM model*

The selected *Column* is part of the structural assembly designed in Tekla Structures and stored in IFC format. The model contains material grade (S420MH), but no explicit information about the material properties and manufacturer. This may be insufficient in the case of reuse when the conformity of the products to the harmonized has to be verified.

The BIM model contains the information that the *Column* named 'COLUMN':

- has the following explicit attributes
  - Global ID: → 1DXmk9000gz34pC30tDZat
  - Owner history: → *OwnerHistory*
  - Name: → 'COLUMN'
  - Description: → 'CFRHS300X200X8'
  - Object type: → 'CFRHS300X200X8'
  - Object placement: → *LocalPlacement*
  - Representation: → RectangleHollowProfileDef
    - Profile type: → .AREA.
    - Profile name: → 'CFRHS300X200X8'
    - Position: → Axis2Placement2D
    - X dimension: → **200 mm**
    - Y dimension: → **300 mm**
    - Wall thickness: → **8 mm**
    - Inner fillet radius: → **12 mm**
    - Outer fillet radius: **20 mm**
  - TAG: → '1CP-43'
- is decomposed by: → *ElementAssembly* 'Steel Assembly'
- is definded by: → *PropertySet* 'Tekla Quantity'
  - Weight: → **544 kg**
  - Width: → **200 mm**
  - Height: → **300 mm**
  - Length: → **9211 mm**
  - Volume: → **0.1 m³**
  - Gross footprint area: → **0 m²**
  - Net surface area: → **9.2 m²**
  - Area per tons: → **16.5 m²/t**
- is definded by: → *PropertySet* 'Pset_ColumnCommon'
  - LoadBearing: → **True**
  - Reference: → **'1CP-43'**
- is defined by: → *ElementQuantity* 'BaseQuantities'
  - Length: → 9211.01267240892 mm
  - Outer surface area: → **8.89783843037278 m²**

## (1) OpenBIM based: defining the IFC-file content




PROGRESS report D3.2

## (1) OpenBIM based approach: Smart CE-mark and Smart EPDs

| PARAMETER | UNIT | PRODUCT STAGE TOTAL A1 - A3 RAW MATERIAL SUPPLY AND MANUFACTURE OF STEEL PRODUCT | BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY D RE-USE, RECOVERY, RECYCLING POTENTIAL |
|---|---|---|---|
| PARAMETERS DESCRIBING ENVIRONMENTAL IMPACTS | | | |
| GWP Global warming potential | kg $CO_2$ equiv. | 2.47 | -1.36 |
| ODP Depletion potential of the stratospheric ozone layer | kg CFC-11 equiv | $1.04 \times 10^{-06}$ | $4.31 \times 10^{-08}$ |
| AP Acidification potential of soil and water sources | kg $SO_2$ equiv | $4.96 \times 10^{-03}$ | $-2.10 \times 10^{-03}$ |
| EP Eutrophication potential | kg $(PO_4)^{3-}$ equiv | $5.09 \times 10^{-04}$ | $-9.20 \times 10^{-05}$ |
| POCP Formation potential of tropospheric ozone | kg ethene equiv | $4.03 \times 10^{-04}$ | $-6.75 \times 10^{-04}$ |
| ADP-elements Abiotic depletion potential | kg Sb equiv | $2.56 \times 10^{-05}$ | $-1.37 \times 10^{-05}$ |
| ADP-fossil fuels Abiotic depletion potential | MJ, net calorific value | 24.67 | -14.37 |
| PARAMETERS DESCRIBING RESOURCE USE AND PRIMARY ENERGY | | | |
| Use of renewable primary energy used as energy carrier | MJ, net calorific value | 0.72 | 0.79 |
| Use of renewable primary energy resources used as raw material | MJ, net calorific value | 0.00 | 0.00 |
| Total use of renewable primary energy resources | MJ, net calorific value | 0.72 | 0.79 |
| Use of non-renewable primary energy used as energy carrier | MJ, net calorific value | 13.8 | -1.1 |
| Use of non-renewable primary energy used as raw material | MJ, net calorific value | 12.01 | -11.7 |
| Total use of non-renewable primary energy resources | MJ, net calorific value | 25.8 | -12.8 |
| Use of secondary material | kg | – | – |
| Use of renewable secondary fuels | MJ, net calorific value | – | – |
| Use of non-renewable secondary fuels | MJ, net calorific value | – | – |
| Net use of fresh water | $m^3$ | 0.03 | $-3.53 \times 10^{-03}$ |
| OTHER ENVIRONMENTAL INFORMATION DESCRIBING WASTE CATEGORIES | | | |
| Hazardous waste disposed | kg | 0.08 | 0.01 |
| Non-hazardous waste disposed | kg | $1.91 \times 10^{-01}$ | $3.69 \times 10^{-02}$ |
| Radioactive waste disposed | kg | $5.34 \times 10^{-03}$ | $4.61 \times 10^{-04}$ |
| OTHER ENVIRONMENTAL INFORMATION DESCRIBING OUTPUT FLOWS | | | |
| Parameter | Unit | Product stage total | |
| Components for re-use | kg | – | |
| Materials for recycling | kg | – | |
| Materials for energy recovery | kg | – | |
| Exported energy | MJ per energy carrier | 0.04 | |

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*6.4 → Smart EPD proposal*

Based on the diagrams illustrated in **Error! Reference source not found.** and **Error! Reference source not found.**, we propose to include the essential information related to the studied column as:

*Column* 'COLUMN'

- is defined by:
  - Product(s): → 'Cold-formed tube products, steel sections and piles'
  - Standard: → 'EN 15804:2012'
- contains:
  - Number of the EPD: → -
  - Type of the EPD: → 'Cradle to grave with option'
  - Manufacturer: → *PropertySet* 'Manufacturer'
  - Verifier: → *PropertySet* 'Third party verifier'
  - Declared unit: → '1 kg tube products'
  - Ref. service life: → -
  - Documentation: → -
  - Validity: → 28.11.2019
  - Date: → 28.11.2014
  - Signatory: → 'Thomas Andersson'
  - Signature: → ElectronicSignature
- contains:
  - Declared characteristics: → *PropertySet* 'Declared characteristics'
- 

*PropertySet* 'Declared characteristics' contains:

- Input and output flows: → *DeclaredCharacteristic*
  - is defined by: → *Property* **'Product stage (A1-3)'**
    - requires: → *Property* 'Components for re-use'
      - from: → *Declaration* **value 0%**
    - requires: → *Property* 'Materials for recycling'
      - from: → *Declaration* **value 20%**
    - requires: → *Property* **'Exported energy'**
      - from: → *Declaration* **value 0.04 MJ**
  - is defined by: → *Property* 'Impact beyond the system boundary (D)'
    - requires: → *Property* 'Components for re-use'
      - from: → *Declaration* **value 0%**
    - requires: → *Property* 'Materials for recycling'
      - from: → *Declaration* **value -90%**
    - requires: → *Property* **'Exported energy'**
      - from: → *Declaration* **value 0 MJ**
- 
- Environmental impacts: → *DeclaredCharacteristic*
  - is defined by: → *Property* **'Product stage (A1-3)'**

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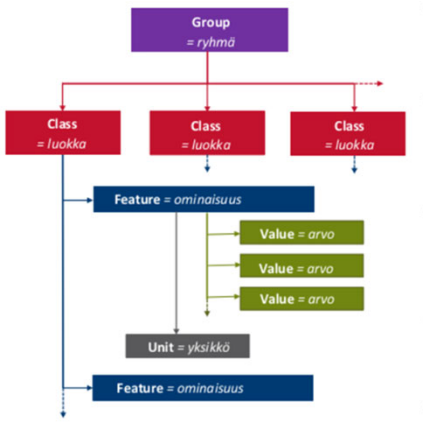
# (3) BIM classification and for instance ETIM- structure

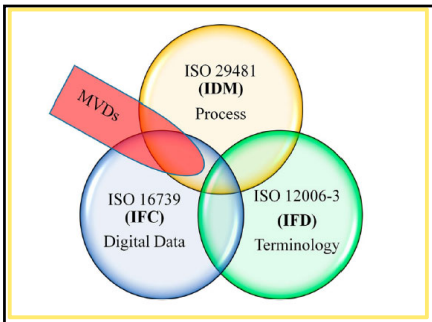
Classification are foundation for the every day business needs for delivering product information in project level.

These approaches are usually supported in national tools and information registers and databases of product information.




Esimerkiksi: EU571027 kWh/vuosi (kWh/year)

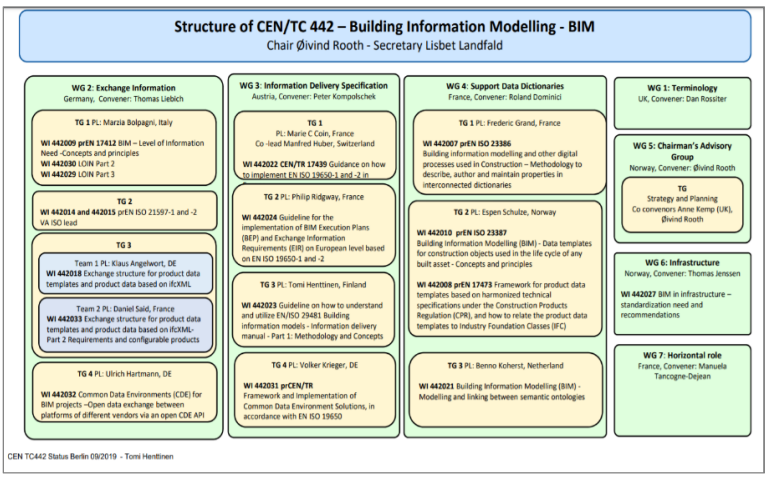
- Group identification code consists of the letters EG + 6 numbers. For example: EG000028 Lamps
- Class identification code consist of letters EC + 6 numbers. For example: EC000391 Hot water tank
- Feature identification code consist of letters EF + 6 numbers. For example: EF000015 Outer diameter
- Value identification code consist of letters EV + 6 numbers. For example: EV000117 Cast iron
- Unit identification code consist of letters EU + 6 numbers. For example: EU571027 kWh/year




*Four main areas of information exchange standardization in building SMART international:*

- *IDM (information delivery manual); IFC (industry foundation classes)*
- *IFD Library (International Framework for Dictionaries, nowadays also expressed as DD, Data Dictionary) and*
- *MVD (Model View Definition).*

# BIM standards




Working group structure of the **CEN/ TC 442 committee** - Building Information Modelling - BIM. WG4 is especially interesting from the perspective of product data management.

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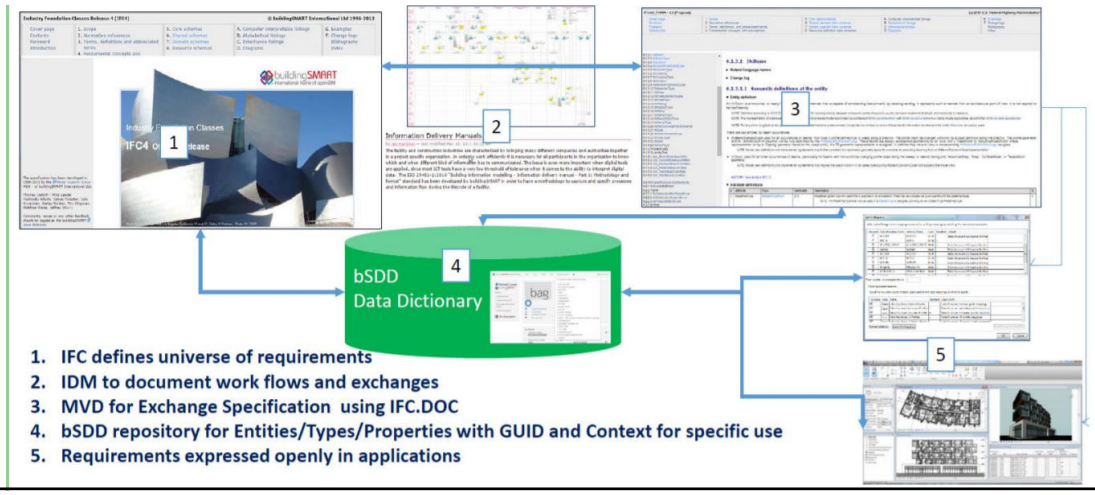
## (4) OpenIFD based approach

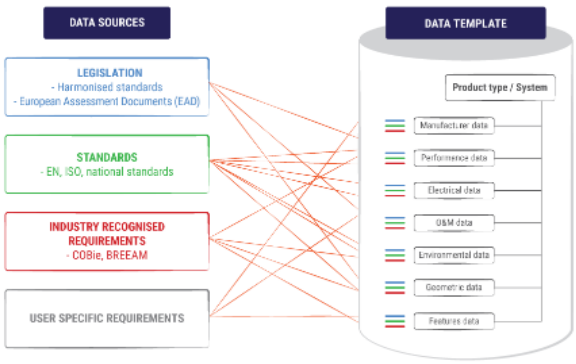
OpenIFD is evolving approach for managing product information, with 4 standards to support adoption and implementation.

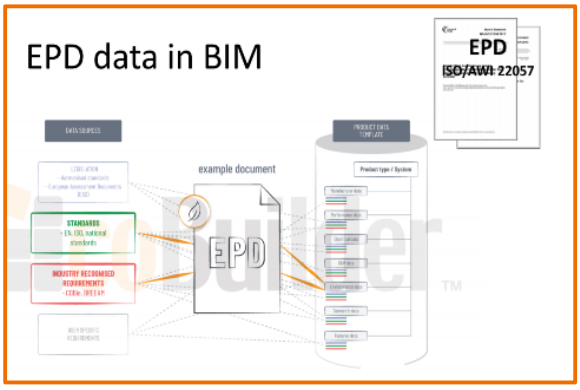



## (4) Product Data Templates

are created to serve as a common framework for anyone to use in order to manage construction product related data.

A Product Data Template is a **common data structure** defining the 'properties' that describe any type of product in a way that can be traced to a credible source. Such credible sources are product standards declaring the performance characteristics of products and the methods they should be tested against.




Product data sources are used to define Data Template (DT). On right a general graph how to create EPD data in BIM using Data Templates.

# BIM is not about technology

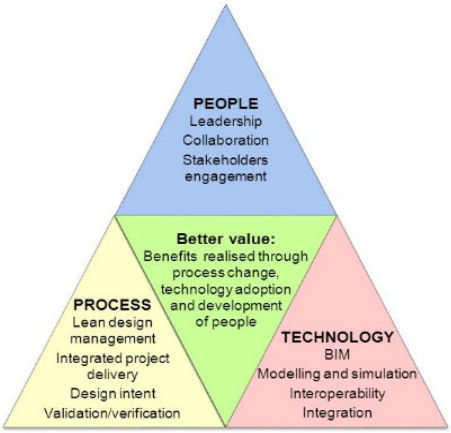
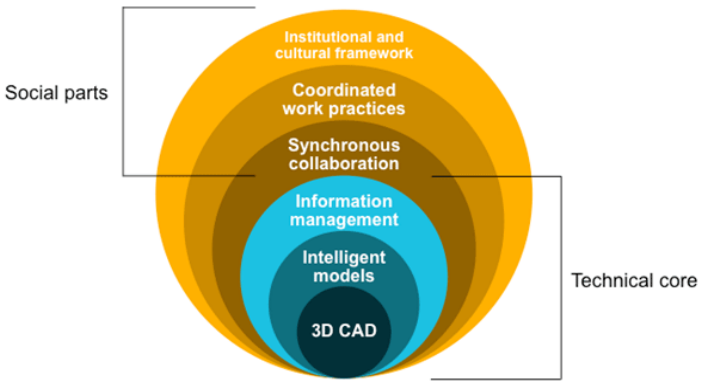



Figure by Arto Kiviniemi

## BIM as Sociotecnical System




*BIM viewed as a sociotechnical system with a technological base and layers of social components*



# BIM guidelines

Common BIM Requirement 2012, COBIM, is based on the BIM Requirements published by Senate Properties in 2007. The update project was funded by Senate Properties in addition to several other real estate owners and developers, construction companies and software vendors. BuildingSMART Finland participated also in the financing of the project. As a result, the updated Series 1-9 and new Series 10-13 were released in Finnish on March 27th 2012.

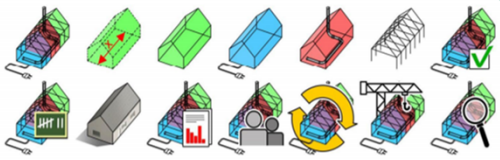
Series 1: General part
Series 2: Modeling of the starting situation
Series 3: Architectural design
Series 4: MEP design
Series 5: Structural design
Series 6: Quality assurance
Series 7: Quantity take-off
Series 8: Use of models for visualization
Series 9: Use of models in MEP analyses
Series 10: Energy analysis
Series 11: Management of a BIM project
Series 12: Use of models in facility management
Series 13: Use of models in construction

Additional BIM guidelines and appendix (Available only in Finnish, YTV):
Series 14: Use of models in building permit process
Appendix:
- Architecture model Guideline fro the client
- Structural model, Guideline for the client
- HVAC model: Guide for quantity-take-of
- HVAC modelling requirements

**Missing BIM Guidelines:**

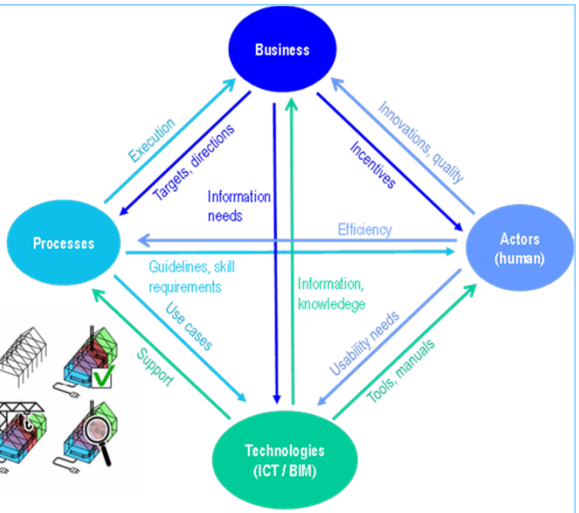
- **Use of models in LCA and Environmental Data Management**
- **Use of models for Sustainability Assessment**
- **BIM for Reuse and Recycling**
  - **Circular Economy process**
  - **Building Component data**
  - **Product data and properties**

https://buildingsmart.fi/en/common-bim-requirements-2012/
https://buildingsmart.fi/yleiset-tietomallivaatimukset-ytv/



National BIM Requirements, COBIM 2012

# BIM as methodology

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