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Guidelines for Implementing Common Information Model in Electricity Retail Market Information Exchange

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The information exchanges between the participant companies of the Finnish electricity retail market are changing. A new centralized information exchange model will be introduced in a couple of years. Additionally there are efforts for harmonizing these exchanges on European and Nordic levels.

This Master's thesis focuses on one of the options for this harmonization, the usage of the International Electrotechnical Commission's (IEC) Common Information Model (CIM) standard for modeling the data exchanged in the processes of the electricity retail market. The goal of the thesis was to provide guidelines for Fingrid Datahub, the operator of the centralized information exchange system, for the preparation and implementation of the IEC CIM based exchanges. The study also provides information about the standard and the contributing organizations to electricity retail market harmonization in Europe, and can be considered as training material for Fingrid Datahub.

The information provided in this thesis will help Fingrid Datahub to prepare for, and identify requirements for the harmonization with the usage of CIM if it is required at some later stage.

As part of the thesis, a message currently specified for the Datahub was modelled with IEC CIM. This new data model was then compared to the information in the original message and the gaps and differences were analyzed.

The model creation exercise and the analysis shows that CIM can be used to model the Datahub message exchanges used in the process of meter data reporting. One of the key findings and recommendations of this thesis is that further analysis and similar exercises should be done for the other Datahub processes that were beyond the scope of this study.

Additionally the thesis recommends participation in various work groups and organizations and involvement in the development work of the IEC CIM standard.

Keywords	Electricity retail market information exchange, datahub, IEC CIM, harmonization

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List of Abbreviations

ABIE	Aggregated Business Information Entity
ACC	Aggregated Core Component
ACER	Agency for the Cooperation of Energy Regulators
API	Application Program Interface
B2B	Business to Business
BIM	Business Information Model
BRS	Business Requirement Specification
CEN	European Committee for Standardization
CGMES	Common Grid Model Exchange Standard
CIM	Common Information Model
CIM EG	CIM Expert Group
DER	Distributed Electricity Resources
DSO	Distribution System Operator
EA	Sparx Systems Enterprise Architect software
EBG	ebIX Business Group
ebIX	European forum for energy Business Information eXchange
EDI	Electronic Data Interchange
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EFET	European Federation of Energy Traders
EG	Expert Group
EMS	Energy Management System
ENTSO-E	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute
eSett	A company providing imbalance settlement services to electricity market participants in Finland, Norway and Sweden
ESMP	European style market profile
ETC	ebIX Technical Committee
ETSI	European Telecommunication Standards Institute
GENELEC	European Committee for Electrotechnical Standardization
GWAC	GridWise Architecture Council
HNR	Harmonized Nordic Retail Market
HRM	Harmonized Role Model
IEC	International Electrotechnical Commission

IoT	Internet of Things
IS	International Standard
ISO	The International Organization for Standardization
ITU	International Telecommunication Union
MBIE	Message Assembly Model
MoU	Memorandum of Understanding
MT	Maintenance Team
NC	National Committee
NMEG	Nordic Market Expert Group
NWIP	New Work Item Proposal
OCL	Object Constraint Language
PT	Project Team
RDF	Resource Description Framework
RDFS	RDF Schema
SC	Subcommittee
SCADA	Supervisory Control and Data Acquisition
SFTP	Secure File Transfer Protocol
SGAM	Smart Grid Architecture Model
SGTF	Smart Grid Task Force
SIDM	System Interfaces for Distribution Management
SMB	Standardization Management Board
SOAP	Simple Object Access Protocol
TC	Technical Committees
TS	Technical Specification
TSO	Transmission System Operator
TYNDP	Ten Year Network Deployment Plan
UML	Universal Modelling Language
UMM-2	UN/CEFACT Modelling Methodology 2.0
UN	United Nations
UNECE	United Nations Economic Commission for Europe
URI	Universal Resource Identifier
W3C	World Wide Web Consortium
WG	Working Group
VPN	Virtual Private Network
XML	Extensible Markup Language
XSD	XML Schema Definition

1 Introduction

The Finnish electricity retail market is undertaking significant changes in the coming years. With the introduction of the Datahub in the spring of 2022, all retail market communication will move from a decentralized model to a centralized information exchange system. In addition to the change within the data exchange in the Finnish market, there are efforts to harmonize or converge the market communication between the EU member states. These changes will affect the way market information is exchanged between the electricity retail market participants. This study will focus on the anticipated effects that the convergence of the data exchanges in the Nordic and European member states will have on the Finnish electricity market and especially Fingrid Datahub. The study will concentrate on the likely introduction of the Common Information Model (CIM) based information exchange.

This study is conducted for Fingrid Datahub Oy, which is a subsidiary of the Finnish transmission system operator (TSO) – Fingrid Oyj. Fingrid is a public limited liability company, which was established on November 1996. Fingrid's main responsibility is the electricity transmission in the high-voltage transmission system in Finland. This nationwide transmission grid is the high-voltage trunk network that covers the entire Finland and connects major power plants, industrial plants and regional distribution networks. [1]

In addition to the planning and operating the Finnish electricity transmission system, Fingrid has other tasks, such as developing the exchange of information required for electricity trade and imbalance settlement. This is set out in the Electricity Market Act [2]. Based on a study performed in 2014 [3], the Finnish Ministry of Employment and the Economy asked Fingrid to implement a centralized information exchange system, datahub. Fingrid Datahub Oy was established to take care of the operational tasks of the datahub.

In today's electricity retail market, information is exchanged constantly between various market participants. These parties are mainly the regional grid operators, also known as distribution system operators (DSO), and electricity retailers. The market participants exchange information for example in relation to customer agreements, information collection, and when consumers move or switch retailers. This information is transmitted between the market participants' IT systems.

In order for the market participants to be able to exchange information between each other, there has to be an agreed way to communicate and send messages. The format of the data exchanged between the market participants will change with the introduction of the Datahub, and will most likely change again if conformity between the Nordic and EU countries needs to be achieved. One of the proposed options to model the data in multiple different markets is to use International Electrotechnical Commission's (IEC) Common Information Model (CIM) based data model. In order for Fingrid Datahub to be able to anticipate the requirements and understand the changes needed in the future, investigation into how to adopt the IEC CIM based information model in the future needs to be done.

This thesis highlights the drivers for the possible change towards IEC CIM based retail market data exchanges and tries to identify the benefits and any other alternatives. The thesis also tries to give guidance on how and when the change towards CIM based is likely to be needed, and what steps should be considered in order to achieve the best outcome for Fingrid Datahub. The thesis will also compare the data model introduced as part of the Datahub introduction, and one created using IEC CIM. Additionally the thesis will work as training material for Fingrid Datahub in information exchange harmonization and IEC CIM.

The thesis is divided in to 6 chapters. The following chapter gives a more detailed explanation of the current data exchange methodology in the electricity retail market information exchange, followed by the methodology used after the introduction of the Datahub. The drivers and workgroups related to the development of the information exchange in Europe are explained in chapter 3. Chapter 4 will concentrate on the IEC CIM standard, how it is used currently, and how it will most likely be used in the electricity retail market. In chapter 5, the steps required to build an information model for the Finnish electricity retail market based on the IEC CIM are detailed. Part of the model is then compared to the model used in the first introduction of the Datahub. The last chapter will consist of analysis and discussion of the differences found in chapter 5, their implications and tries to give guidance on how Fingrid Datahub should approach the IEC CIM model in the retail market.

2 Current State Analysis

This chapter describes the existing method of information exchange currently used in the Finnish electricity retail market. The chapter also explains the changes introduced by the centralized information exchange model that will be adopted as part of the Datahub introduction.

2.1 Electricity Retail Market Information Exchange in General

In the electricity retail markets, an electricity supplier sells electricity to the end user. A well operating energy market requires co-operation of the market participants. A participant cannot operate on the market without sending and receiving information between other market participants. For this reason, electricity suppliers are required to participate in the information exchange by for example informing about a start or end of a supply agreement. The suppliers do not handle the distribution and measurement of the energy, that part is operated by the distribution system operators (DSOs), also called grid operators.

In order for the electricity retail market to operate well, the information exchange or data exchange between these market participants needs to work efficiently. The purpose of the information exchange is to enable, support and enhance the business processes in the market. In these processes, information is exchanged between the market participants in relation to for example customer move, change of supplier, imbalance settlement and measurement data. [3] [4]

The main participants in the retail market information exchange are the grid operators (DSOs), electricity suppliers, balance responsible parties, and the imbalance settlement responsible (eSett). Most of the market process related information is exchanged between these parties however, measurement data is also sent as market messages to companies, or if authorized by the customer, to third parties, such as energy consultants. [3]

Currently there are about 80 grid operators (DSOs) in Finland, operating roughly 3,7 million accounting points. The number of electricity retailers is over 90.

The message exchange and procedural instructions are defined by Finnish Energy (Energiateollisuus ry) [5]. The procedural instructions are based on the Electricity Market Act [2], Government decree on the settlement and metering of electricity deliveries [6] and the Decree of the Ministry of Employment and the Economy on the exchange of information in electricity trade and the settlement of electricity supplies [7].

The transmission system operator, Fingrid, is responsible for maintaining instructions describing the technical implementation of information exchange used in the retail market. Additionally, Fingrid is responsible for the development of procedures and standards related to information exchanges, and to participate in international development work. As the TSO, Fingrid is also responsible for the promotion of the compatibility of the information systems and the validity of the information exchanges within the industry. The responsibilities also include proposing changes in procedures or standards to the Ministry and the communication, training and counsel in relation to the information exchanges. [2]

2.2 Existing Electricity Market Information Exchange in Finland

The information exchange in the Finnish electricity retail market is highly automated. Manual operation is sparsely needed and email and other communication methods are rarely required.

The retail market information exchange is based on a decentralized model, illustrated in Figure 1, where the market participants can exchange required information directly between two parties if so desired. In practice however, the data is generally exchanged in partly centralized fashion where the messages are routed by message exchange operators. The market participants are responsible of providing the routing information for the messages, and the operators will then relay the messages either to another operator, or directly to the receiving market participant. [3]

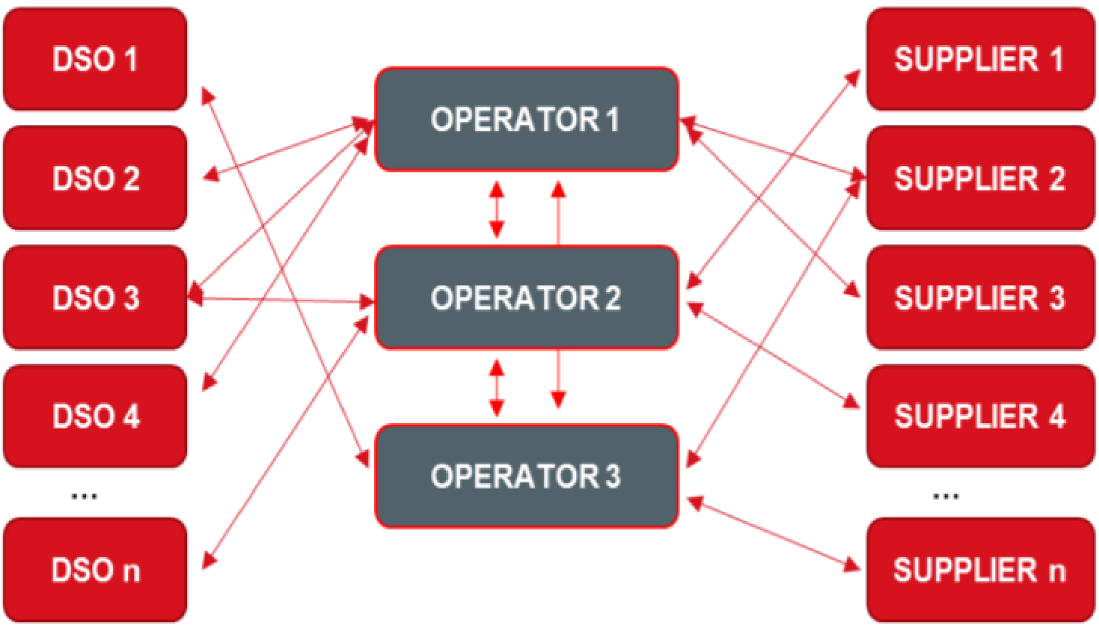

Figure 1: Current Information Exchange model in the Finnish electricity retail market

The message files are generally transferred via Secure File Transfer Protocol (SFTP) in Virtual Private Networks (VPN).

2.3 Ediel Messages

The message types used in the electricity retail market in Finland are based on the Ediel specification developed by the Nordic Ediel Forum for the Nordic electricity markets.

The Ediel Forum was formed in by the Nordic TSOs 1995 to deal with the increased need for the exchange of information between different parties in the power industry. The scope of the Forum was to standardize the use of EDI (Electronic Data Interchange) based on the UN/EDIFACT (the United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport) standard in the Nordic power industry. [8]

UN/EDIFACT is a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data. This structure is displayed in Figure 2. UN/EDIFACT rules are approved and published by UNECE (United Nations Economic

Commission for Europe). Besides the electricity sector, the EDIFACT messages are widely used in the trade and logistic industries among others. [9]

```
An interchange consists of:
        Service String Advice    UNA   Conditional
    ____ Interchange Header      UNB   Mandatory
   | ___ Functional Group Header  UNG   Conditional
   | | _ Message Header          UNH   Mandatory
   | | |  User Data Segments           As required
   | | |_ Message Trailer         UNT   Mandatory
   | |___ Functional Group Trailer UNE  Conditional
   |_____ Interchange Trailer     UNZ   Mandatory
```

Figure 2: UN/EDIFACT message interchange structure [10]

The messages based on the Ediel specification are used to send customer, contract and measurement information. Separate acknowledgement messages are used to relay information about the message reception.

There are several types of Ediel messages for different purposes. Customer and contract information is send as PRODAT-messages and measurement information as MSCONS-messages. APERAK- and CONTRL-messages are used for acknowledgement purposes. In addition, DELFOR-messages are used for sending delivery schedule information. Other message types are used for lesser extent. An example of a PRODAT-message is displayed in Figure 3. [8]

```
UNA:+.? '
UNB+UNOC:3+HKE:SLY:MTK+HKE:SLY+060518:0930+HKEXCSR'
UNH+1+PRODAT:D:97A:UN:E2FI01'
BGM+Z05+PROZ03000002+9+AB'
DTM+137:200605180915:203'
DTM+ZZZ:3:805'
NAD+FR+HKE000:160:SLY'
CTA+MS+:052345678'
NAD+C1+HKE:160:SLY'
NAD+DO+HKE:160:SLY'
NAD+C2+HKE:160:SLY'
LIN+1+14+FI_HKE000_83625:::SLY'
DTM+93:200608150000:203'
RFF+VC:100256'
RFF+AIV:2006092112345'
NAD+IV++++Matinkuja 2+MATTILA++01234'
UNT+15+1'
UNZ+1+HKEXCSR'
```

Figure 3: Example Ediel PRODAT-message containing a notification of the customer's moving out to current supplier. Lines breaks are used for presentation purposes. [11]

As can be seen in Figure 3, the Ediel messages consist of segments identified by three letter codes. Each interchange starts from the UNB segment, and ends in UNZ. An interchange can consist of multiple messages, but only from one sender to one market participant. However combining multiple messages to one interchange is not recommended. Multiple messages of the same type, from segments UNH to UNT can be combined. Maximum size of each interchange is 2 MB. Ediel messages are sent without line breaks.

2.4 Centralized Information Exchange with Datahub

Since the adoption of the Ediel messaging the volumes of exchanged information have increased significantly. This is partly due to the hourly meter readings made possible by the introduction of remotely readable electricity meters, and also due to the introduction of hourly imbalance settlement. The importance of the quality and the time criticality of the information exchange has also increased. This is driven by the need for new electricity products priced by the hour, increased requirements of electricity consumption and the need for the market participants to automate their processes. In the future new drivers, such as the increased need to support demand side flexibility are likely to affect the information exchange requirements. [12]

The responsibility to develop the information exchange in the Finnish electricity retail market is defined in the Electricity Market Act, as belonging to Fingrid [2]. Based on that responsibility Fingrid commissioned a study, with co-operation with the players in the energy industry, on the future of information exchange solutions in the electricity retail market. The final report of that study was released in December of 2014, and in the report Fingrid proposed a datahub as the future information exchange solution. [12]

The project to develop the Datahub started in 2015. Datahub is currently planned to be introduced to the market in 2022. The Datahub will be a centralized information exchange system for the market, and will contain information from about 3,7 million electricity metering points in Finland. Figure 4, illustrates the new information exchange model introduced by the Datahub.

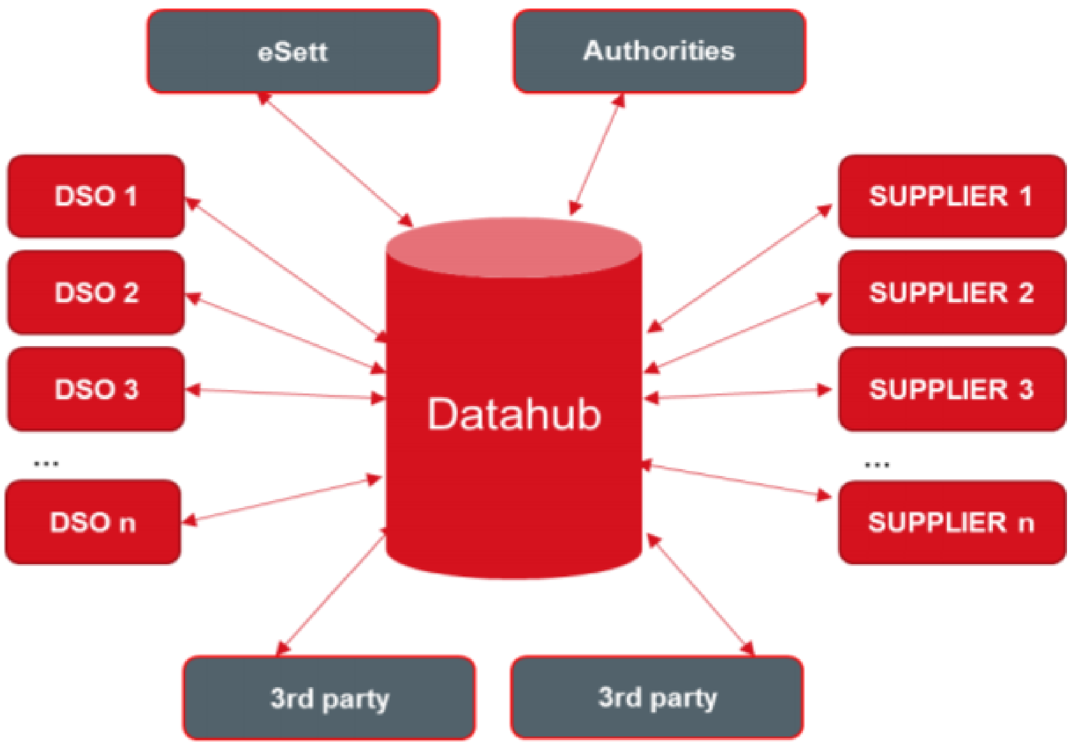

Figure 4: Information Exchange model after Datahub introduction

As can be seen, instead of the de-centralized model illustrated in Figure 1, the Datahub will act as the central point of information exchanged in the electricity retail market. All communications will go through the data hub and all the market related data will be stored and accessed from the Datahub.

After the introduction of the Datahub, when a customer changes electricity supplier, the information will be sent to the relevant parties via the Datahub. In addition to the implementation of the market processes Datahub will have multiple other responsibilities, such as storage of the metering data and metering point information, and handling of the imbalance settlement by the distribution network owners.

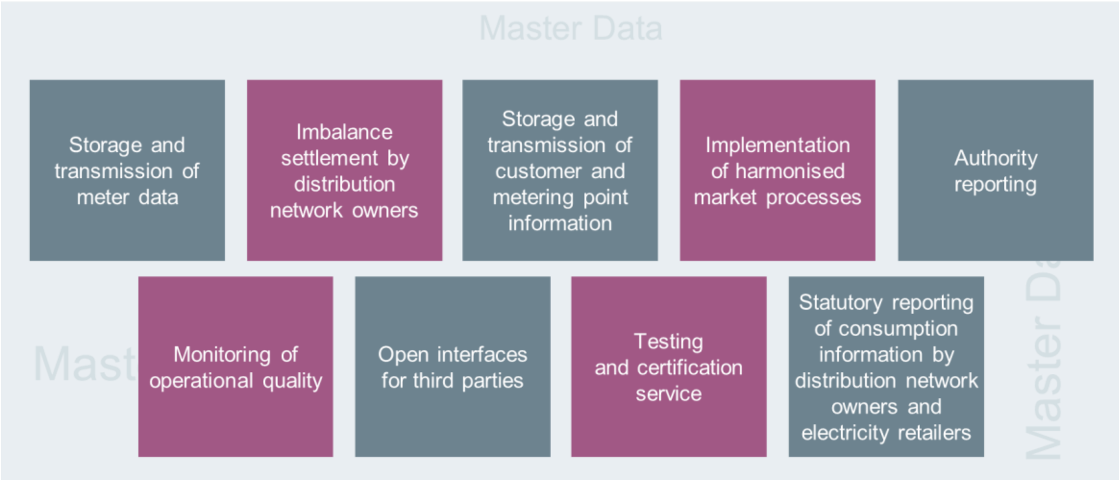

Figure 5: Datahub main functionalities

As can be seen from Figure 5, after the introduction of Datahub, most of the retail market related activities will be handled though the Datahub.

2.5 Datahub Processes, Events and Messages

The introduction of the Datahub, will also introduce completely new message format for the information exchange. The current EDIFACT-format messages will not be used with the Datahub. They will be replaced with XML-messages based on an information model developed by the European forum for energy Business Information eXchange (ebIX). The "ebIX-based" information exchange has also been used as part of the Harmonized Nordic Retail Market (HNR) project and the Norwegian datahub project, Elhub. The specifications and documentations from those projects were also used as starting point for the Finnish Datahub. However since the functionality of the Finnish Datahub significantly differs from both the above mentioned projects, and the processes defined by ebIX, direct utilization of those existing specifications is limited. Besides the Norwegian Elhub the ebIX-based information model has been used as basis for example in the Danish Datahub. [13]

The ebIX organisation, ebIX model and the efforts done by the various ebIX work groups is further explained in chapter 3.

As stated above, the ebIX model has been used as a starting point for the information exchanges defined for the Datahub. The final exchanges and are based on processes defined in co-operation within the industry. The definition work has been done in workgroups with representatives appointed by the Finnish Electricity Industry. The processes are documented in [14]. These processes can include several Datahub events.

The flow of information to and from the Datahub can be broken into several stages. These stages are displayed in Figure 6.

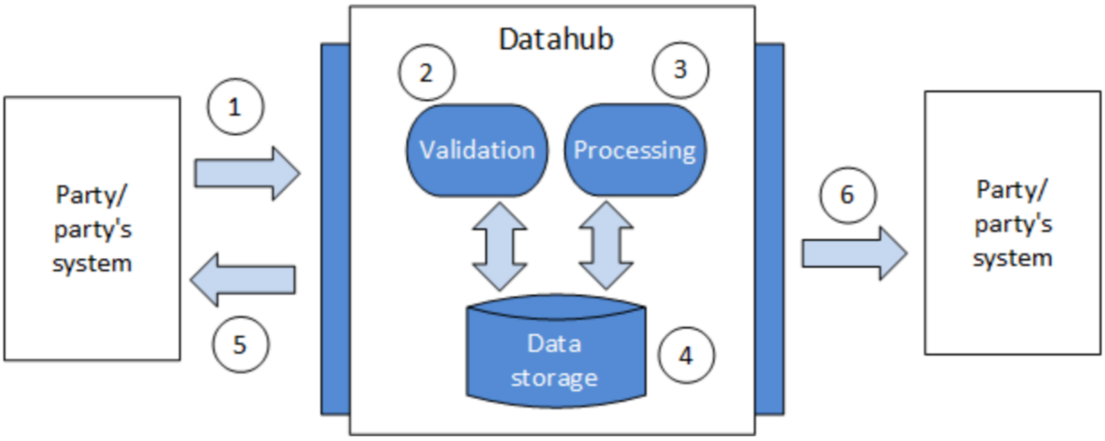

Figure 6: Description of a Datahub event

As can be seen from Figure 6 an event is a single interaction between the market parties and Datahub. This interaction is usually a request, notification or data update event. In the Figure, the market party's system sends message towards the Datahub (1), which is then validated (2), processed (3) and stored in the data storage (4). Datahub then replies the sending party with an acknowledgement (5). Depending on the process in question additional parties may be notified of the change by a message from the Datahub (6).

The information included the messages is specified in the “Datahub Events” –document [13], and the requirements for the information that information exchanged in the messages are based on the processes described in the “Electricity retail market business processes in Datahub” –document [14].

The data included a Datahub event is separately described for each event in the “Datahub Events” –document [13]. The required information is displayed in a class diagram (Figure 7) and a table.

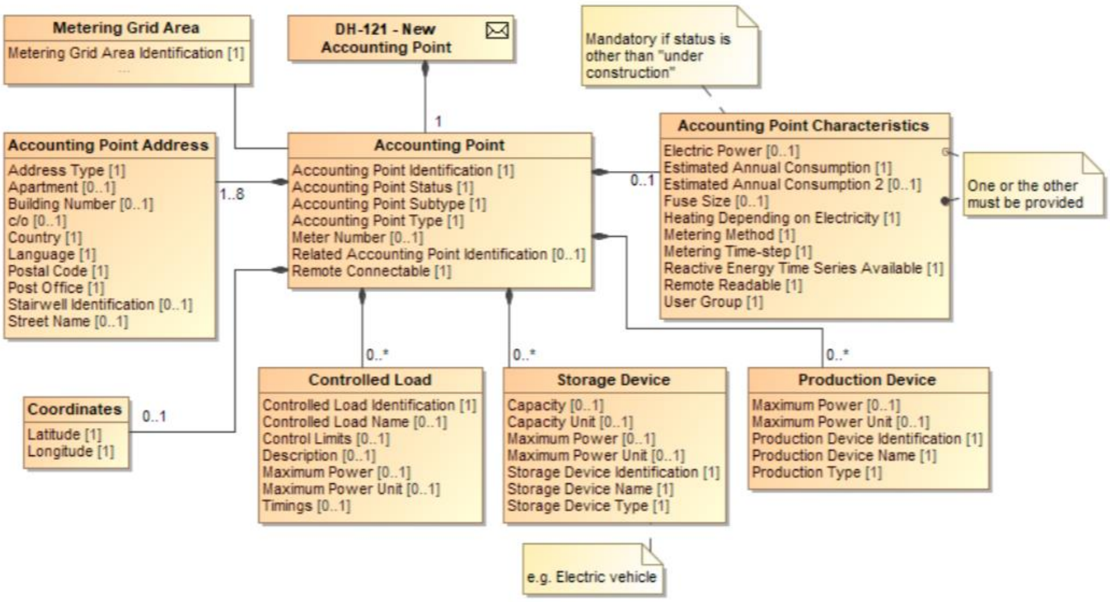

Figure 7: Class diagram, information required for the creation of an accounting point

The class diagram in displays the information required for the creation of a new accounting point in Datahub. Different classes, relevant to different aspects of the accounting point can be seen in the diagram. Each class then as attributes belonging to it describing the accounting point in more detail. Depending on the cardinalities, not all classes or attributes are mandatory. The class diagram represents relevant data required to describe an accounting point in the Datahub.

The business-to-business (B2B) channel used to for the exchange of the market messages between the market parties and Datahub is achieved through a single web service using XML representation of one or more transactions in a Simple Object Access Protocol (SOAP) envelope. The web service and the Datahub B2B channel is further described in the document External Interface Specification [15].

Inside the SOAP envelope, the XML-structure of the message consists of an operation specific MessageRequest element, a MessageContainer element, and the message Payload element. Within the payload element the event specific market message is carried. The contents of the payload are described in the Datahub Events document [13]. The payload contains the following XML elements:

- Message header data
- Process data
- Payload / transaction

The header and process data elements have the same requirements for each event type. The header contains information such as message type, sender and recipient. The process data element contains data related to the process, such as the process ID and the process role of the sending party. The contents of the payload or transaction element are event-specific and are based on the requirements of the event data. An example of a Datahub message can be seen in Figure 8.

SOAP Envelope, Message request and Message container

Message Payload

Market Message Header

Process Data

Event Payload


```xml
<soapenv:Envelope xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope" xmlns:urn="urn:cms:b2b:v01"
xmlns:urn2="urn:fi:Datahub:mif:common:HDR_Header:elements:v1" xmlns:urn3="urn:fi:Datahub:mif:common:PEC_ProcessEnergyContext:elements:v1"
xmlns:urn7="urn:fi:Datahub:mif:masterdata:E58_MasterDataMPEvent:v1"
xmlns:urn8="urn:fi:Datahub:mif:masterdata:E58_MasterDataMPEvent:elements:v1">
  <soapenv:Header/>
  <soapenv:Body>
    <urn:ProcessMessageRequest>
      <urn:MessageContainer>
        <urn:Payload>
          <urn7:MasterDataMPEventMessage>
            <urn7:MasterDataMPEvent>
              <urn7:Header>
                <urn2:Identification>100311fa72daf46e43a78a0b0093bf539cc7</urn2:Identification>
                <urn2:DocumentType>E58</urn2:DocumentType>
                <urn2:Creation>2019-04-12T09:28:19Z</urn2:Creation>
                <urn2:PhysicalSenderEnergyParty>
                  <urn2:Identification schemeAgencyIdentifier="9">6429020100004</urn2:Identification>
                </urn2:PhysicalSenderEnergyParty>
                <urn2:JuridicalSenderEnergyParty>
                  <urn2:Identification schemeAgencyIdentifier="9">6429020100004</urn2:Identification>
                </urn2:JuridicalSenderEnergyParty>
                <urn2:JuridicalRecipientEnergyParty>
                  <urn2:Identification schemeAgencyIdentifier="9">6410000000001</urn2:Identification>
                </urn2:JuridicalRecipientEnergyParty>
                <urn2:PhysicalRecipientEnergyParty>
                  <urn2:Identification schemeAgencyIdentifier="9">6410000000001</urn2:Identification>
                </urn2:PhysicalRecipientEnergyParty>
              </urn7:Header>
              <urn7:ProcessEnergyContext>
                <urn3:EnergyBusinessProcess>DH-121</urn3:EnergyBusinessProcess>
                <urn3:EnergyBusinessProcessRole>DDZ</urn3:EnergyBusinessProcessRole>
                <urn3:EnergyIndustryClassification>23</urn3:EnergyIndustryClassification>
              </urn7:ProcessEnergyContext>
              <urn7:Transaction>
                <urn8:StartOfOccurrence>2019-04-08T21:00:00Z</urn8:StartOfOccurrence>
                <urn8:MeteringPointUsedDomainLocation>
                  <urn8:Identification schemeAgencyIdentifier="9">642902010696677098</urn8:Identification>
                  <urn8:PhysicalStatusType listAgencyIdentifier="NFI">AE01</urn8:PhysicalStatusType>
                  <urn8:MeteringPointType listAgencyIdentifier="NFI">AG01</urn8:MeteringPointType>
                  <urn8:MeteringPointSubType listAgencyIdentifier="NFI">AQ01</urn8:MeteringPointSubType>
                  <urn8:RemoteConnectable>0</urn8:RemoteConnectable>
                  <urn8:MeterIdentification>112345</urn8:MeterIdentification>
                  <urn8:MeteringGridAreaUsedDomainLocation>
                    <urn8:Identification schemeAgencyIdentifier="305">6429020100000000</urn8:Identification>
                  </urn8:MeteringGridAreaUsedDomainLocation>
                  <urn8:MeteringPointAddress>
                    <urn8:Type listAgencyIdentifier="NFI">AF01</urn8:Type>
                    <urn8:StreetName>Streetname</urn8:StreetName>
                    <urn8:Postcode>00510</urn8:Postcode>
                    <urn8:CityName>Helsinki</urn8:CityName>
                    <urn8:CountryCode schemeAgencyIdentifier="5">FI</urn8:CountryCode>
                    <urn8:Language schemeAgencyIdentifier="5">fi</urn8:Language>
                  </urn8:MeteringPointAddress>
                  <urn8:MPDetailMeteringPointCharacteristic>
                    <urn8:RemoteReadable>0</urn8:RemoteReadable>
                    <urn8:MeteringMethod>E13</urn8:MeteringMethod>
                    <urn8:UserGroup>BE01</urn8:UserGroup>
                    <urn8:HeatingMethodType>0</urn8:HeatingMethodType>
                    <urn8:FuseSize>2x3x63</urn8:FuseSize>
                    <urn8:EstimatedMetrics>
                      <urn8:MeterTimeFrame>E11</urn8:MeterTimeFrame>
                      <urn8:Total>50000</urn8:Total>
                    </urn8:EstimatedMetrics>
                  </urn8:MPDetailMeteringPointCharacteristic>
                </urn8:MeteringPointUsedDomainLocation>
              </urn7:Transaction>
            </urn7:MasterDataMPEvent>
          </urn7:MasterDataMPEventMessage>
        </urn:Payload>
      </urn:MessageContainer>
    </urn:ProcessMessageRequest>
  </soapenv:Body>
</soapenv:Envelope>
```


Figure 8: Example of a Datahub message

The elements described in the previous paragraphs are highlighted in the figure above. The message is used in Datahub process DH-121 in which a DSO sends a message from its system to the Datahub in order to create a new Accounting Point. The relevant information required for the payload in this message is defined by the data model illustrated in the class diagram in Figure 7. The example message contains the minimum required information needed for Accounting Point creation. Additional attributes, according to the event specifications, can be included.

As described, the contents of a Datahub message are defined by the market process the message is related to. On the other hand the Datahub B2B channel where the message is sent on brings its own requirements to the message content. The flow of information contributing to the message structure is displayed in Figure 9.

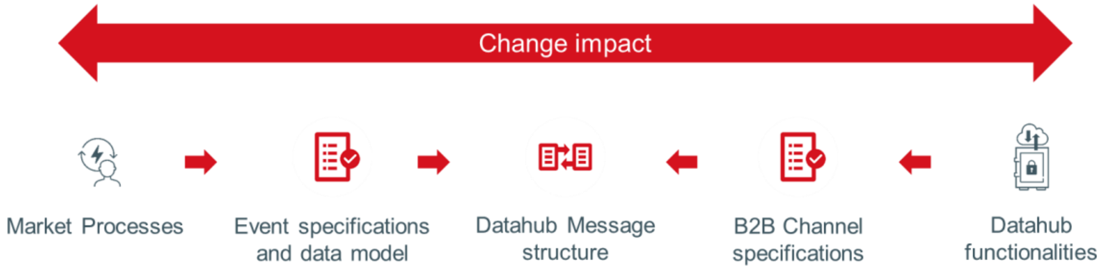

Figure 9: Contributors to Datahub message format

As illustrated in Figure 9, the market processes define the events that are carried out between the market participants and Datahub. This also results in the data model used as part of the information exchange in each event and eventually the contents of the messages sent to and from the Datahub. On the other hand the Datahub system functionalities dictate requirements for the B2B channel that also contributes to the structure of the messages.

This leads to the fact that changes in either end of the chain might affect the other. Meaning, a change in the business processes, for example a new business requirement brought by a change in legislation, could bring on the need for new events, changes in the data model and eventually bring new requirements for Datahub functionalities. Conversely, a Datahub functionalities, or restrictions in functionalities, could affect the messages and events and eventually the business processes conducted in the Finnish electricity retail market.

3 Drivers and stakeholders for the change to usage of CIM

This chapter will further explain the drivers and various stakeholders that are contributing to the adoption of CIM based information exchange in the Finnish electricity retail market. The chapter will also describe how the different stakeholders are contributing to the development of the information exchange in the electricity sector.

3.1 Background

During the recent years has been a growing need for interoperability of energy services across EU member states. One of the key facilitator of this interoperability is the convergence or alignment of the data access and data exchange procedures within the retail energy markets of the member states. A study [16] conducted by the Asset Project, and funded by the European Commission summarized that this interoperability will not only improve the customer processes but will also render the energy markets more competitive:

- *"it should become easier for energy suppliers to become active in other Member States, through compatibility of national data access and exchange practices as well as data management models (lower market barriers).*
- *customers are given tools and options to get empowered and actively participate in the energy market (flexibility and energy services).* [16]*"*

One of the ways to improve this interoperability for the data exchanges is to start aligning and harmonizing the information models used in the retail market data exchanges in the EU member states. As the Common Information Model (CIM) is already used in the industry as part of exchanges of grid models as used for example in the Energy Management Systems (EMS), and also in the exchanges of market information in the wholesale sector within Europe, the adoption of the CIM would be a natural choice also for the retail market information exchanges.

3.1.1 European Directives

The ambition to increase the interoperability between the EU member countries is also highlighted in the European directives. The recast Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU [17] states the following:

> *Article 24*
>
> **Interoperability requirements and procedures for access to data**
>
> *1. In order to promote competition in the retail market and to avoid excessive administrative costs for the eligible parties, Member States shall facilitate the full interoperability of energy services within the Union.*
>
> *2. The Commission shall adopt, by means of implementing acts, interoperability requirements and non-discriminatory and transparent procedures for access to data referred to in Article 23(1). Those implementing acts shall be adopted in accordance with the advisory procedure referred to in Article 68(2).*
>
> *3. Member States shall ensure that electricity undertakings apply the interoperability requirements and procedures for access to data referred to in paragraph 2. Those requirements and procedures shall be based on existing national practices.*

The original Commission proposal for the Article 24 was referring to a "a common European data format and non-discriminatory and transparent procedures", but this then evolved, after discussions with the Council and European Parliament, into “interoperability requirements and non-discriminatory and transparent procedures”. Therefore, instead of defining a common data format, requirements for the interoperability are set in the directive. [18]

3.1.2 Smart Grid Task Force

In 2009 the European Commission set up a Smart Grid Task Force (SGTF) [19] in order to advice on issues related to smart grid deployment and developments. The task force consist of five Expert Groups (EG) focusing on specific areas. The work of the EGs is helps to shape EU smart grid policies.

The five Expert Groups and their areas are:

Expert Group 1	Smart Grid standards
Expert Group 2	Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment
Expert Group 3	Regulatory recommendations for smart grid deployment
Expert Group 4	Smart grid infrastructure deployment
Expert Group 5	Implementation of smart grid industrial policy

Table 1: List of Smart Grid Task Force Expert Groups

The Expert Group most relevant for the implementation of the CIM standard in the retail market is EG1. Most recently during the period of 2017-2018, SGTF EG1, more specifically Working Group on Data Format and Procedures, worked on procedures for data access and exchange in both gas and electricity and investigated the way towards interoperability within EU. The result of the work was a Final Report [18] published March 2019.

The report [18] states that *"throughout the investigation, it was made apparent that, on the way to interoperability of the respective national practices, what is to be sought is ultimately a reference core process model where national practices could largely fit in, while measures should be taken to allow for national or regional specificities and customisation. Such a 'framework' that can serve as the basis for developing interoperability would include a core process model using an information model (information and semantics) along with a role model, and would determine a number of transition pathways to interoperability building on existing national set-ups and practices."*

The report goes on to list several more detailed recommendations, including*: "To facilitate interoperability adopt and use a common information model for semantics, for example consider building on the available IEC CIM model."*

3.2 Organizations and Workgroups

The development and adoption of CIM is conducted with the help of various organizations and workgroups. The following subchapters will detail some relevant organization and their role concerning CIM, with the focus towards the electricity retail market.

3.2.1 The International Electrotechnical Commission (IEC)

The International Electrotechnical Commission prepares and publishes international standards for electrical, electronic and related technologies. IEC cooperates with the International Organization for Standardization (ISO) and the International Telecommunication Union (ITU) to ensure that the international standards fit together and complement each other. [20]

IEC international standards are consensus-based. Each member country has one vote and a say in what goes into a standard. The development of the standards is carried out through Technical Committees (TC) and Subcommittees (SC) dealing with particular subjects. The structure of the IEC organization is illustrated in Figure 10. The committees consist of representatives of National Committees (NC). The Finnish national committee in IEC is represented by SESKO [21]. [20]

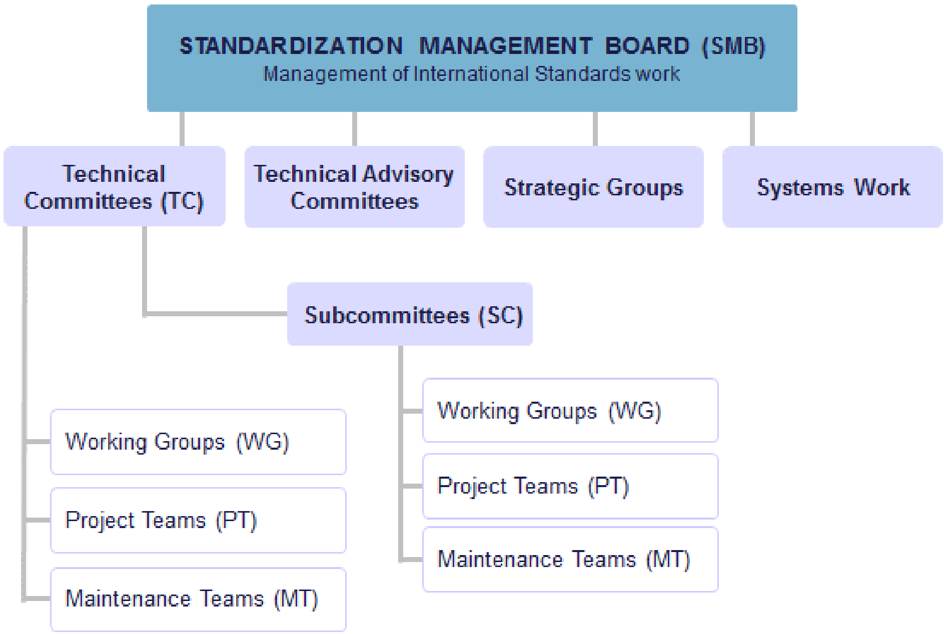

Figure 10: IEC Management Structure [20]

As illustrated, the various IEC Technical Committees are further divided in to Working groups (WG), Project Teams (PT) and Maintenance Teams (MT), each dealing with a certain subject matter. The TCs are created and disbanded by the Standardization Management Board (SMB). SMB is also responsible of appointing a chairperson and secretariat for the TC. [20]

IEC TCs and SCs prepare technical documents on specific subjects within their respective scopes. These documents are submitted to the Full Member NCs for vote and approval as International Standards. [20]

The IEC National Committees are free to take part in the work done in the TCs. The NCs can join a TC either as a P-member (Participating member) or as an O-member (Observer member). The P-members have the obligation to contribute in the meeting and vote at all stages of the standardization process. O-members can submit comments, attend the meetings and receive committee documents. [20]

The IEC Technical Committee responsible of managing the CIM standard is TC 57 - Power systems management and associated information exchange. Furthermore, the CIM work is divided in to domains handled in three Working Groups:

- WG13 - Energy management system application program interface (EMS - API)
- WG14 - System interfaces for distribution management (SIDM)
- WG16 - Deregulated energy market communications

Each working group is focusing their work towards a set of CIM standards. These standards are further explained in Chapter 4.4.

The primary duty of a technical committee or subcommittee is the development and maintenance of International Standards. Figure 11 below illustrates the project stages and documents associated to the development of the standards.

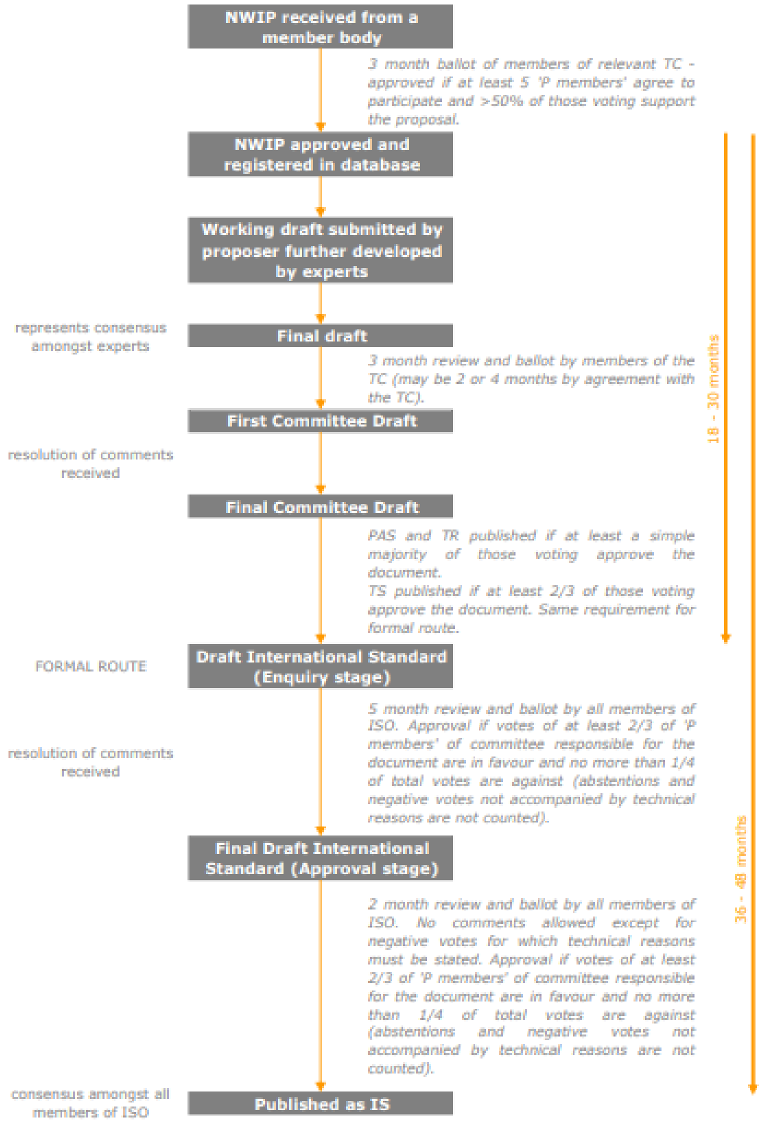

Figure 11: ISO/EIC International Standard development process [22].

As can be seen from the figure above, the time required for building an International Standard (IS) from a New Work Item Proposal (NWIP) is significant, and this should be taken into account when new needs for standards are identified and required.

3.2.2 European Network of Transmission System Operators for Electricity (ENTSO-E)

The European Network of Transmission System Operators for Electricity (ENTSO-E) was established and mandated by the EU in 2009. It represents the electricity transmission system operators (TSOs) across member European countries. [23]

The objectives of ENTSO-E are to set up the internal energy market and maintain its functioning, and supporting the European energy and climate agenda. These objectives are achieved by for example:

- Drafting and implementing network codes – a set of rules created in order to facilitate the harmonization, integration and efficiency of the European electricity market. The network codes are drafted with the guidance of the Agency for the Cooperation of Energy Regulators (ACER)
- The development of long-term pan-European network plans (TYNDPs) - Ten year network deployment plans that offer views on how the networks should evolve in order to meet the European climate objectives.
- Technical cooperation between TSOs – for example development of European operational standards. [23]

In order to ensure that the IEC CIM standards are developed in line with the needs of the European TSOs, ENTSO-E is participating in both TC57 work groups 13 and 16 as a liaison member. The organization is also working in cooperation with various user groups in order to exchange information within the CIM community. [23]

In order to speed up the IEC standardization work, and to meet the aggregated requirements of all member TSOs, ENTSO-E is leading the development of IEC Technical Specifications (TS) that will be the basis for future International Standards. [23]

The ENTSO-E CIM Expert Group (CIM EG) consist of subject matter experts from the member TSOs. The group meets regularly and its objective is to work in cooperation with other ENTSO-E bodies in order to develop the data exchange formats for market, system operation and system development processes. CIM EG also promotes the use of technical specifications and standards approved by ENTSO-E, IEC International standards or CENELEC European norms, or other CIM related recommendations. The group also encourages vendors to develop off-the-self products using CIM based standards and technical specifications. ENTSO-E was also participating in the investigation done by the SGTF EG1 Working Group on Data Format & Procedures [18]. [24]

Fingrid is a member of ENTSO-E and is also participating in the CIM Expert Group. However the work in the CIM Expert Group is mainly focused towards the Common Grid Model Exchange Standard (CGMES) and the wholesale market. Retail market data exchanges are seldom discussed, so besides the work towards the IEC standards and the Harmonized Role Model (HRM), the relevance for Datahub can be trivial.

3.2.3 European Forum for Energy Business Information Exchange (ebIX)

Where ENTSO-E is more focused in TSO-TSO communication and the wholesale market, the European Forum for Energy Business Information Exchange (ebIX) covers the needs for the retail market (downstream) and the interface towards the wholesale market (upstream). The ebIX organization aims to provide standardised and harmonised processes for the liberalised downstream electricity and gas markets with the focus on information exchange, following EU rules and allowing national customisation. [25]

The ebIX tasks include adopting and publishing a methodology describing processes and exchanges in the European energy market, developing and maintaining ebIX business procedures, which describe the procedures in the energy market for interchange of data, and recommending standards for communication in the energy market. The organization also co-operates with other standardization bodies within the industry. Currently ebIX is the only European organization where downstream gas and electricity information exchange is modelled. [26] [27]

The membership for ebIX is open for European countries. Each country can have two member organizations participating. Typically they are TSOs, or national energy associations. As of summer 2019 there are nine full member countries and four observer member countries in ebIX. [27] [26]

The presiding body of ebIX is the ebIX Forum. The forum meets twice per year and acts as the decision-taking meeting where products, project plans and budgets are approved. Besides the Forum, there are two permanent working groups in ebIX; the ebIX Business Group (EBG) and the ebIX Technical Committee (ETC). The organization also has several Memorandums of Understanding (MoU) and Liaison agreements with various other organizations and workgroups.

As can be seen from Figure 12, both ETC and EBG report to the ebIX Forum. EBG is also responsible of defining and guiding new business oriented projects within ebIX.

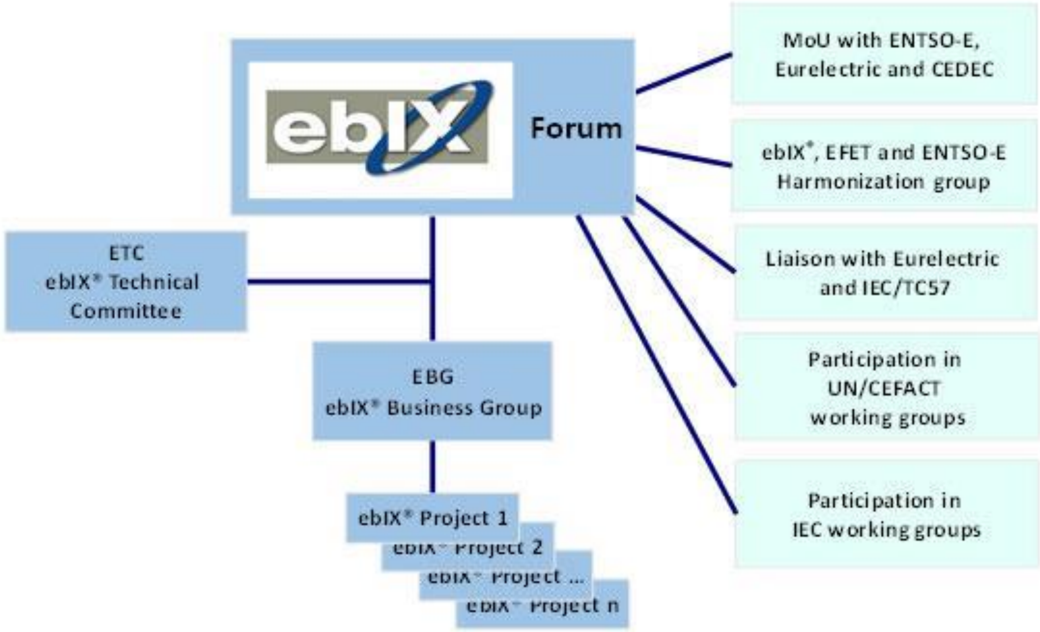

Figure 12: ebIX organization chart

One of the main tasks of the EBG is to develop and maintain the ebIX business documents. The ebIX model business requirements are detailed in Business Requirement Specifications (BRSs) and EBG is responsible of updating existing and creating new BRSs when required. [28]

The ebIX Technical Committee is responsible for the technical part of the ebIX work. ETC maintains the ebIX technical documents, the Business Information Models (BIMs), which documents the technical implementation of the BRSs created by the EBG or other project groups. ETC also harmonizes information exchange principles with other standardization bodies such as ENTSO-E, and participates in international standardization organizations. [29].

The organization also participated in the work done by SGTF EG1 and the Final Report of Working Group Data Format & Procedures [18].

3.2.3.1 The ebIX Model

The BRSs and BIMs created by the project groups, EBG and ETC aim to describe the harmonized data exchange in the European energy market. These documents help to provide a general understanding of how the exchange of data in the European energy market works. The BRSs and BIMs consist of the following 3 main parts that are in line with the UN/CEFACT Modelling Methodology version 2.0 (UMM-2):

- Business Requirements View
- Business Choreography View
- Business Information View [30]

The UN/CEFACT Modelling Methodology used by ebIX aims to provide global choreography of inter-organizational business processes and their information exchange. The UMM models are platform independent and are notated using the Universal Modelling Language (UML) syntax. [31]

The Business Requirements View of the UMM-2 methodology included in the ebIX BRSs. The Business Choreography and Business Information Views are detailed as Modelled Processes, and Modelled Information of the ebIX BIMs. [30]

The models defined by ebIX consist of modes for the exchange of metered data between parties in the European energy market, such as Measure Collected Data, Measure fore Imbalance Settlement and Settle Reconciliation. Besides the measurement models, ebIX also defines models for customer facing processes such as Change of Supplier,
Customer Move and End of Supply. [25]

3.2.3.2 The ebIX BRSs

The BRSs defined by the project groups and EBG consist of a definition of BusinessProcessUseCase, BusinessProcess, and a BusinessDataView containing all the elements needed to describe the conceptual assembly of the business entity. A business entity is a set of real world data exchanged between business partners in a business process (eg. Metering Point characteristics). The BRS also includes state diagrams describing the life cycle of each business entity. The main business process use case described by the BRS may include several sub-processes each detailed in the same BRS using stereotypes defined in UML. [30]

Following figures are examples of BusinessProcessUseCase, BusinessProcess and BusinessDataView as part of a BRS.

The business process use case illustrated in Figure 13 defines the use case where a new Balance Supplier Requests the Metering Point Administrator for change of supplier.

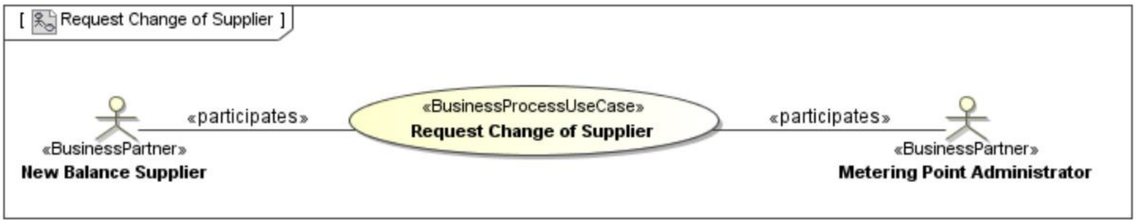

Figure 13: Request Change of Supplier (Business Process Use Case) [32]

This use case is part of a higher-level use case "Change of Supplier" that is triggered when a customer initiates a new contract with an energy supplier. The use case illustrated has two participants, the New Balance Supplier and the Metering Point Administrator. [32]

Figure 14 shows the business process for the use case Request Change of Supplier. It lists the actions required from each participant in order to complete the process into either a success or a failure state. [32]

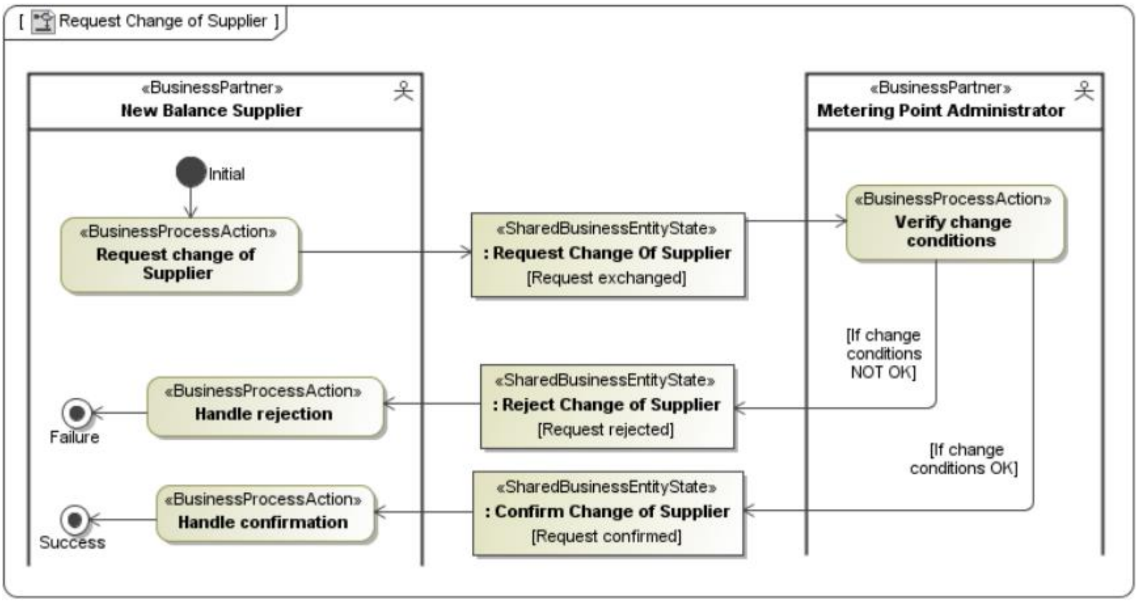

Figure 14: Request Change of Supplier (Business Process) [32]

As displayed in the process diagram, some of the actions are specific to one of the actors in the process and some actions are shared.

The diagram in Figure 15 lists the information elements required for the Request Change of Supplier use case. The optional a-synchronous web service information is displayed in green color. [32]

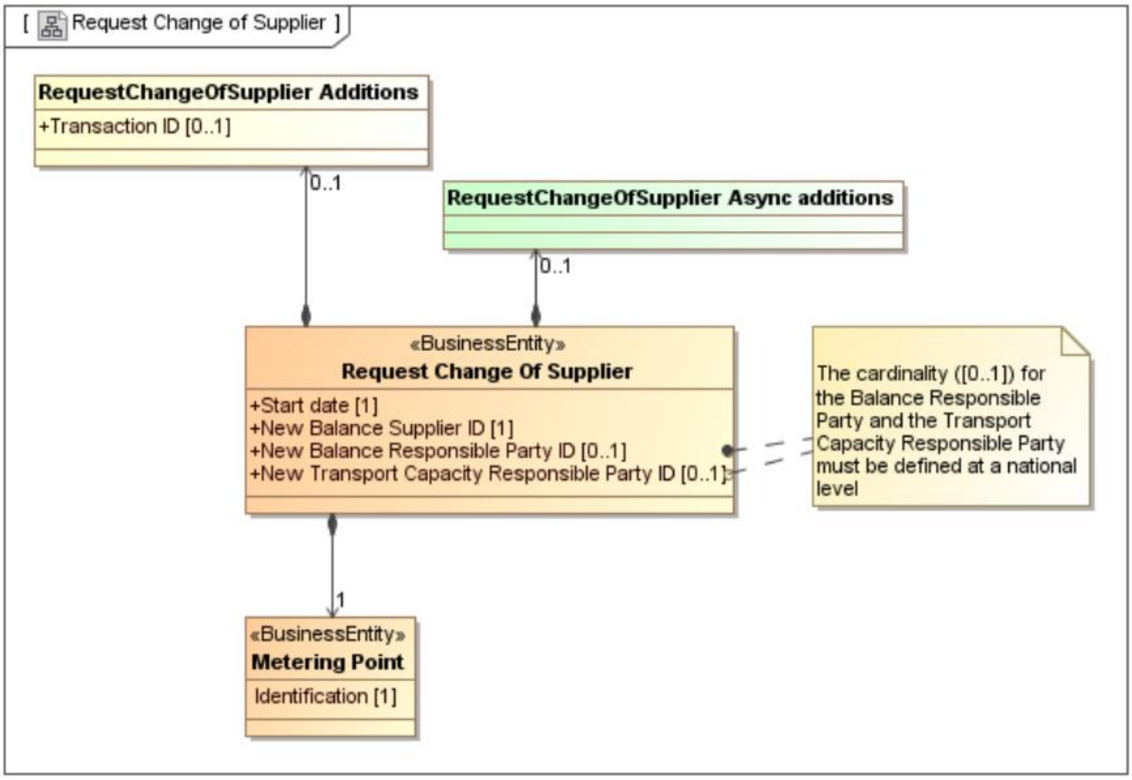

Figure 15: Request Change of Supplier (Business Data View) [32]

As can be seen from the figure, the request consist of two main classes of information, the “Request Change of Supplier” which defines the information about the New Supplier and Start Date, and the “Metering Point” which specifies the metering point identification of the metering point in question.

Finally, the BRS illustrates the state diagram for the exchange of information. An example of this can be seen in Figure 16.

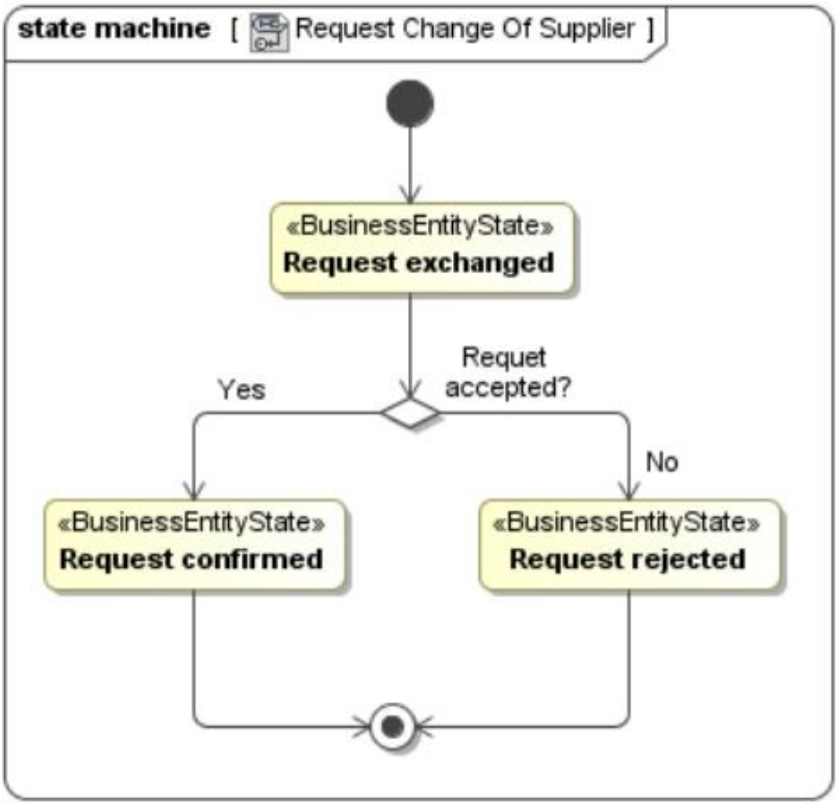

Figure 16: Request Change of Supplier (State Diagram) [32]

As displayed in the diagram, once the request has been exchanged it will either be confirmed or rejected, which will lead to the end of the exchange.

Besides the Request Change of Supplier use case, the overall BRS for Change of Supplier includes various other sub-processes that will happen before and after the process listed in the above figures. [32]

The target audience for the BRSs are business people. The more technical details are described in the BIMs.

3.2.3.3 The ebIX BIMs

Once the business requirements are defined, the ebIX Technical Committee creates a modelled version of them into the ebix Business Information Model (BIM) document.

First, the business processes are modelled in the Business Choreography View. This includes modelling the business transactions between the parties in a Business Transaction View. An example of a Business Transaction is illustrated in Figure 17.

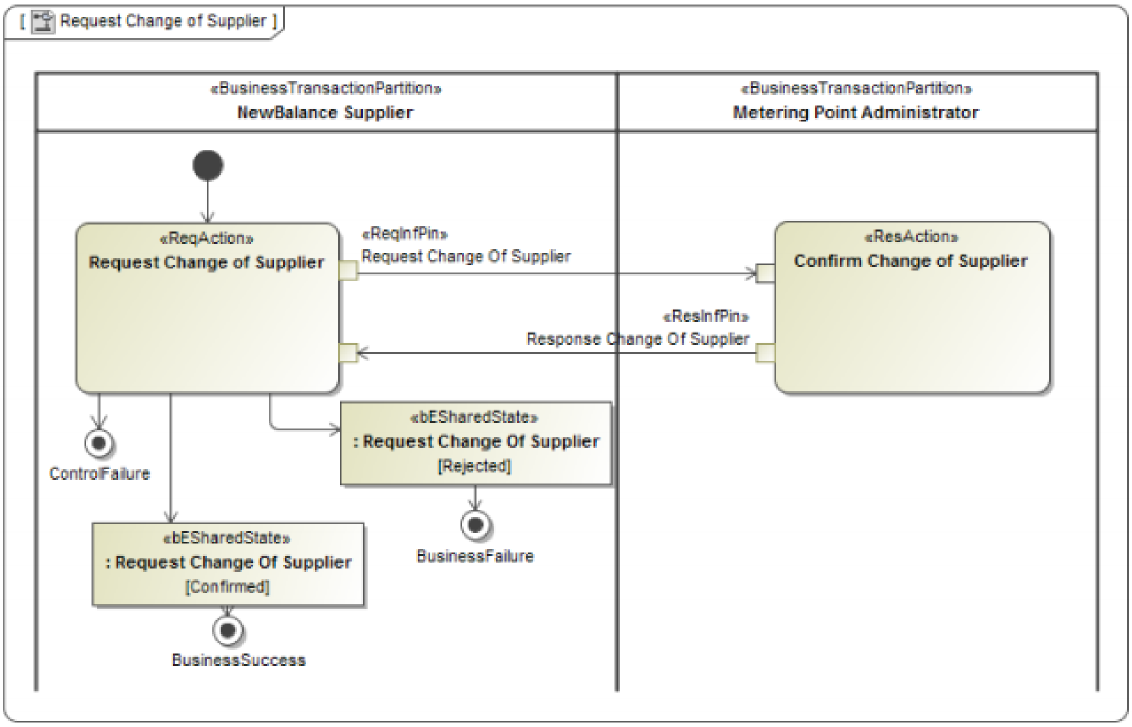

Figure 17: Request Change of Supplier (Business Transaction) [33]

As can be seen in the figure, the Business Transaction view identifies the procedures of each party responsible of sending and receiving business information related to the use case.

The Business Choreography view also details the requirements on the collaboration between the parties involved, and the different realizations of the collaborations into business realization use cases.

Finally, the Business Requirements are “translated into modeled information to be exchanged between parties. This is done by constructing the data into standard reusable Core Components and Aggregated Business Information Entities (ABIEs).

The ABIEs, as can be seen in the example in Figure 18, specify the structure of an information payload, the context of the information exchange and the header of the exchanged document.

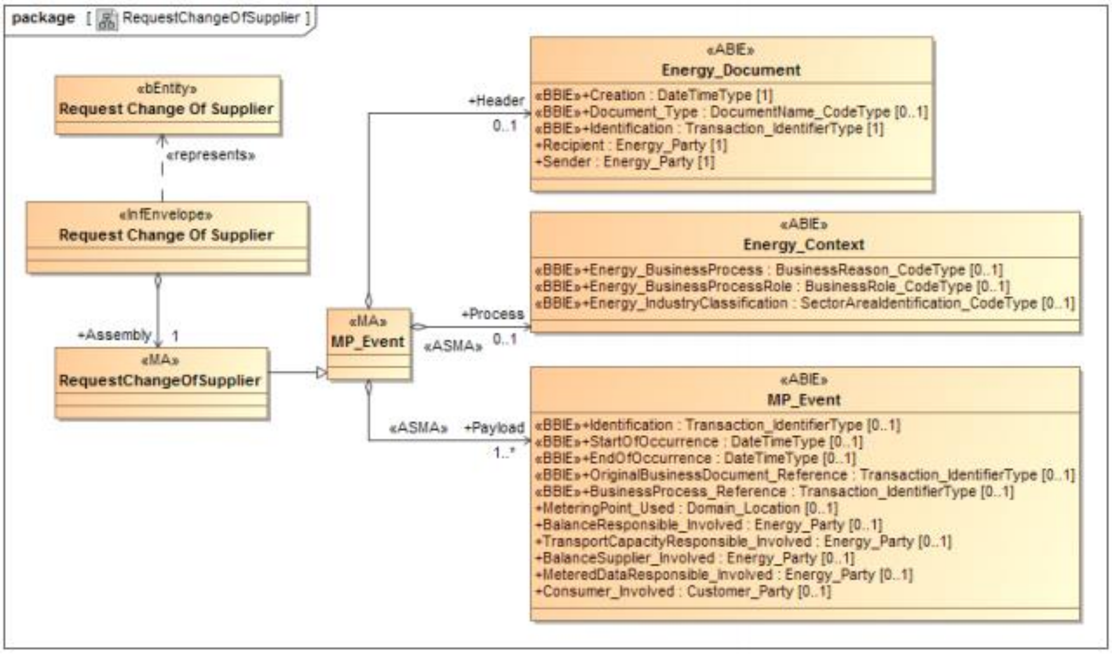

Figure 18: Request Change of Supplier (Business Information View) [33]

As the ABIEs have to cater to a broad set of requirements the content represents a wider range than what is needed in an individual use of ABIE. For that reason the ABIE is narrowed down for each application with the help of Object Constraint Language (OCL) Statements. [30] [31]

One of the key aspects of ebIX modelling is technology or independence. The Business Information View consists of these syntax independent models. Base on the business needs syntax specific modes, such as XML schemas can be created from the UML. The UML models and XML schemas are also available on the ebIX website. [30]

Figure 19 displays the steps into creating syntax specific ebIX exchange formats from business requirements.

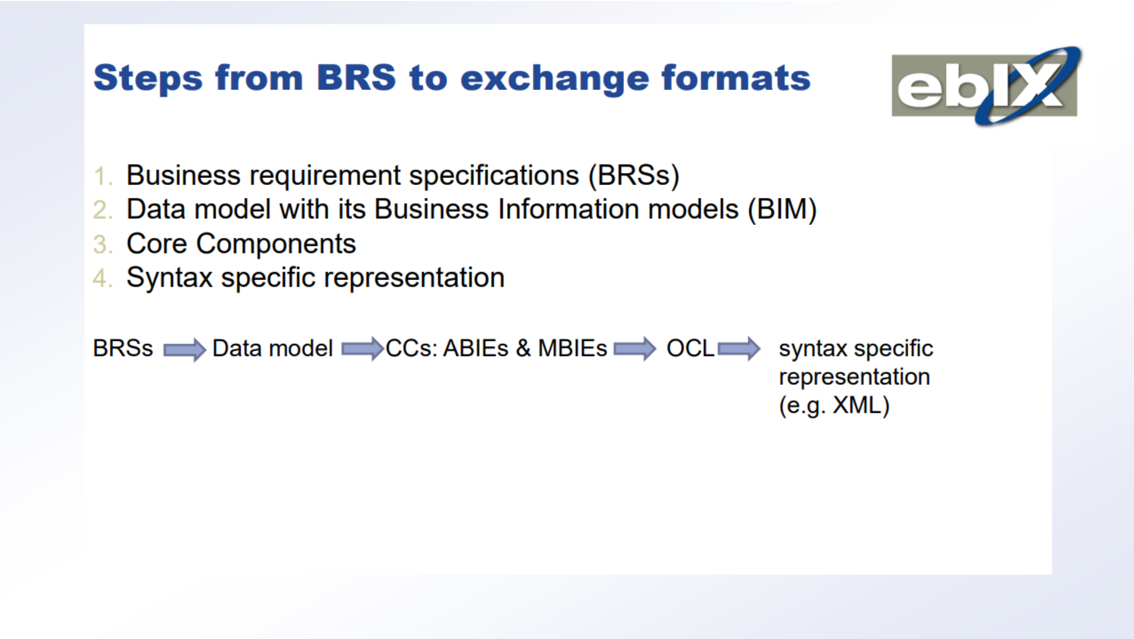

Figure 19: Steps from ebIX BRS to exchange formats [27]

The Business Information View in the BIM document also includes a graph, which displays the links between the business requirements listed in the BRS document and the data resulting data in the Information View of the BIM. [30]

3.2.3.4 Harmonized Role Model (HRM)

ENTSO-E, ebIX and the European Federation of Energy Traders (EFET) have together developed the Harmonized Electricity Market Role Model (HRM) [34]. The aim of the role model is to provide market participants from different countries with a single name for each role and domain present in the electricity market. The role model provides the formal means of identifying these roles and domains that are used in the information exchange. The key idea of the HMR is to provide common terminology for the IT supported information exchange The HRM covers both the wholesale and retail market. [23]

In the HRM a market party can play many different roles depending on the information exchange process. For example a TSO might act as a System Operator, LFC Operator or an Imbalance Settlement Responsible role defined in the HRM. However, since the electricity markets in Europe differ from one another, these roles might be played by some other actors as well. [34]

Besides the roles, the HRM also identifies different objects present in the electricity market information exchange. These include domains, points, resources, CIM objects and accounts.

As can be seen in Figure 20, the role model uses UML class diagramming and UML symbols to represent the roles and objects.

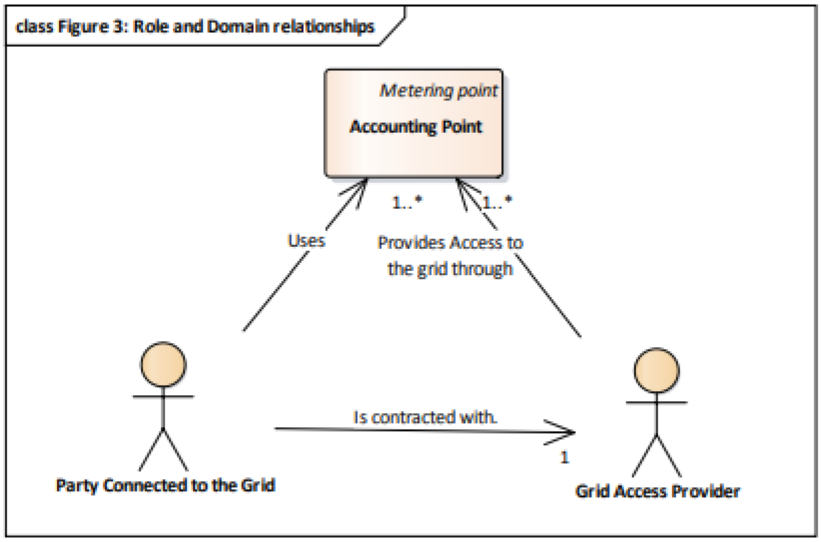

Figure 20: HRM Role and Domain relationships [34]

As can be seen from the subset of HRM in Figure 20, the relationships between the roles and classes in the HRM are shown by the arrows drawn between them.

In the context of the retail market, all parties present in the processes defined by ebIX are mapped to the HRM. By using HRM roles instead of market actors, the ebIX processes can be generalized to cover multiple different retail markets in Europe.

The HRM is constantly updated as various roles and domains are identified and required. The retail market part of the role model is constantly reviewed by ebIX, and new roles are requested in the form of HRM maintenance requests.

The use of the Harmonized Role Model was also recommended in the Final Report of the SGTF EG1 Working Group on Data Format & Procedures [18].

3.2.3.5 ebIX and CIM

In 2014 ebIX started active cooperation with IEC in order to link the ebIX model to IEC CIM, and updating the IEC CIM to fit the specifications in ebIX [27]. This resulted in an IEC Technical Report IEC TR 62325-103 [35].

In the report, the business requirements described in the ebIX BRS documents are mapped to the IEC CIM, especially to the IEC 62325 series of standards. The report compares the definition of the classes described in the BRSs and tries to locate similar artefacts in CIM. If the class in question exists an association between the ebIX class and the CIM class is created. The same mapping is done for the relations between classes and for the attributes inside the classes. In case the classes, associations or attributes cannot be located in CIM, the report identifies and highlights them. [35]

The outcome of the investigation in the Technical Report was that most of the classes, associations and attributes needed can be found within CIM. However, in order to cover all the needed exchanges of information in the deregulated European retail energy market, some updates to CIM were identified. Some of the required updates are already implemented in later versions of the CIM standard. [35]

As can be seen from the outcome of the IEC Technical Report, ebIX is mostly compatible with IEC CIM. Full mapping to CIM is yet to be done, but the work towards updating the CIM standard to accommodate the ebIX requirements is ongoing.

3.2.4 Nordic Market Expert Group (NMEG)

The Nordic TSOs and market actors both in the retail and wholesale sector, exchange information in various different formats and standards. These include EDIFACT and several different variants of XML, including documents based in ebIX and IEC CIM. Additionally there are several Nordic projects ongoing, such as the introduction of datahubs, hence there is a significant need to harmonize the data exchanges. [36]

The Nordic Market Expert Group, which consists of two expert from each Nordic TSO, continues the work stared by the Nordic Ediel Forum in 1995. NMEG is responsible for the development and maintenance of the Nordic Ediel standards and documented Nordic business processes for data exchange in the energy industry. The documents created by NMEG are mainly based on existing international standards from ebIX, ENTSO-E and IEC. There is a strategic decision by NMEG, and the Nordic TSOs towards the use of IEC CIM based XMLs.

NMGE also actively participates in relevant European and worldwide organizations for data standardization, in order discuss and promote positions in a common Nordic voice. These organizations include ebIX, ENTSO-E and IEC.

4 Common Information Model (CIM)

This chapter first introduces the concept of interoperability in the scope of smart grids and the Smart Grid Architecture Model Framework. Subsequently the chapter introduces the Common Information Model (CIM) standard in general. The background of CIM and current standards of CIM are detailed, followed by a look into how CIM is currently used in the electricity retail market in Europe.

4.1 About Interoperability and Smart Grids

In general, the definition of the smart grid is the concept of modernizing the electrical grid, comprising of everything between the point of creation to the point of consumption. With the addition of new smart grid technologies, the electricity network can intelligently integrate the actions of all users connected to it, in order to efficiently deliver sustainable, economic and secure electricity supplies. [37]

The IEC Smart Grid Standardization Roadmap [38] defines the smart grid as “a term which embraces enhancements to the power grid to accommodate the immediate challenges of the near future and provides a vision for a future power system in the long term.

By employing innovative products and services and emerging technologies smart grids are for example able to increase the role of consumers, facilitate better connections, reduce the impact on environment and deliver enhanced level of reliability and security of electricity supply. [37]

Key aspect of a smart grid is interoperability. In the context of smart grids, interoperability is described as the ability of two or more devices from the same vendor, or different vendors, to exchange information and use that information for correct cooperation. This concept of interoperability is illustrated in Figure 21. [39].

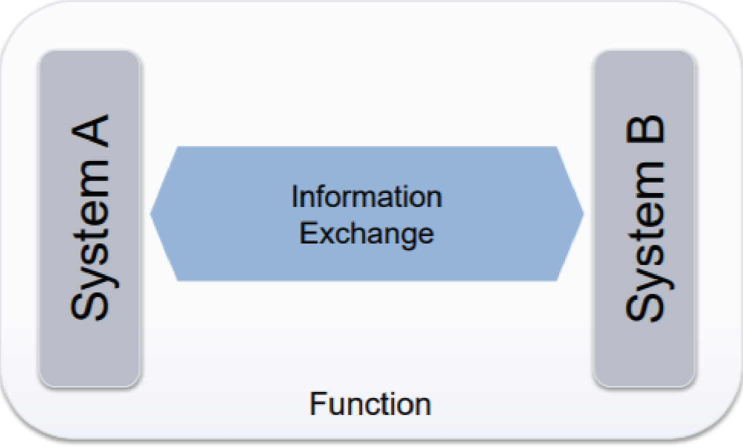

Figure 21: The definition of interoperability

By the definition, two or more systems (devices or components) are interoperable, if the two or more systems are able to perform cooperatively a specific function by using information which is exchanged [40].

The requirements for the interoperability in a smart grid, as defined by the GridWise Architecture Council (GWAC), can be divided into three layers: technical, informational organizational. These in turn can be further divided into seven subcategories as displayed in Figure 22. [41]

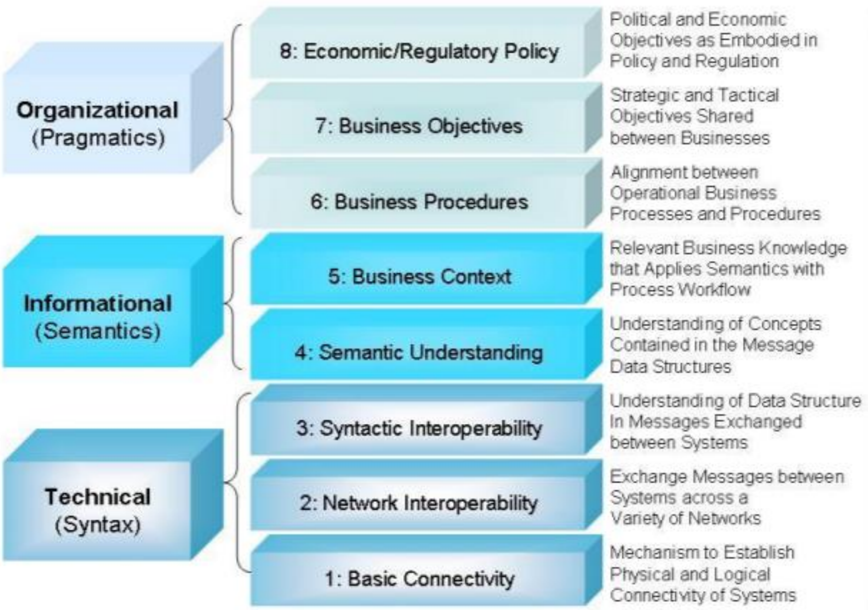

Figure 22: Interoperability categories according to GWAC [41]

The interoperability categories can be considered as requirements in order to be able to achieve interoperability between system or components. All of the eight categories have to be covered, by means of standards or specifications. [40]

The European standardization organisations - the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (GENELEC) and European Telecommunication Standards Institute (ETSI) – have further defined the architecture framework and requirements for interoperability in the smart grids. The Smart Grid Architecture Model (SGAM) Framework created by CEN-CENELEC-ETSI aggregates the interoperability categories in to five abstract layers. These layers and their link to the categories defined by GWAC are illustrated in Figure 23.

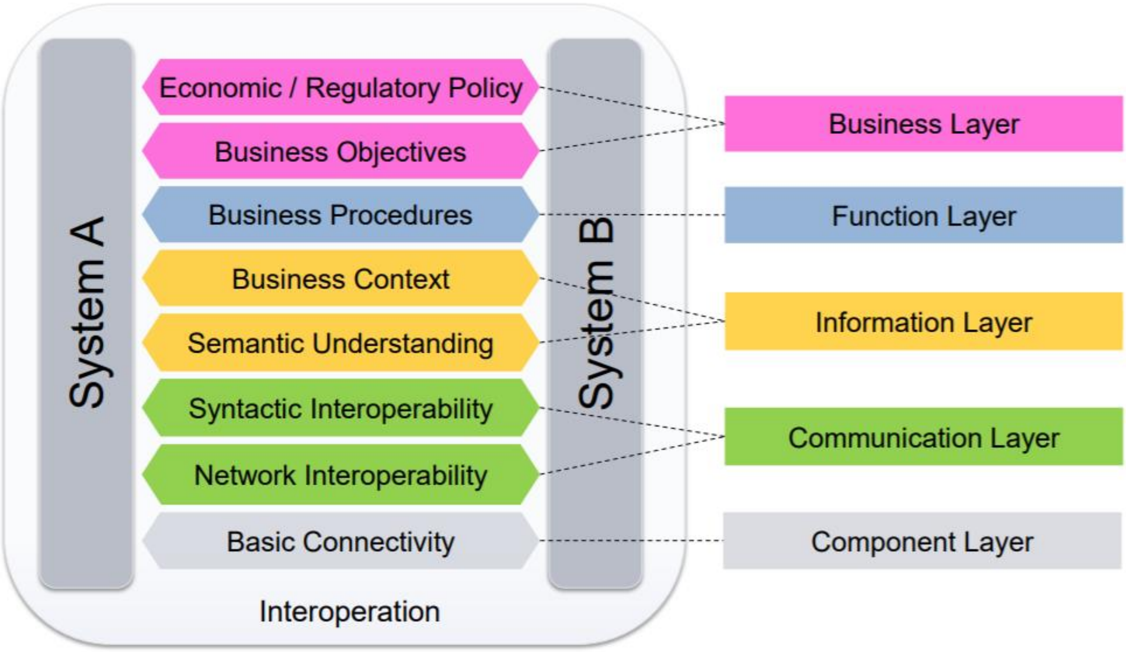

Figure 23: Grouping of interoperability categories into layers [40]

As can be seen above, he SGAM interoperability layers are:

- Business Layer, representing the business view of the information exchange. For example, regulatory and economic structures and policies, business models and portfolios of the participants can be mapped to this layer.
- Function layer, describing the functions and services and their relationships. These functions are derived from use cases and are independent of actors.

- Information layer, describing the information being exchanged between the functions, services and components.
- Communication layer, identifying the protocols and mechanisms used to exchange the information.
- Component layer, representing the physical distribution of participating components in the smart grid context. [40]

In addition to the interoperability layers, the SGAM also defines the Smart Grid Plane, which represents where interactions related to power system management take place. The SGAM Smart Grid Plane is displayed in Figure 24. [40]

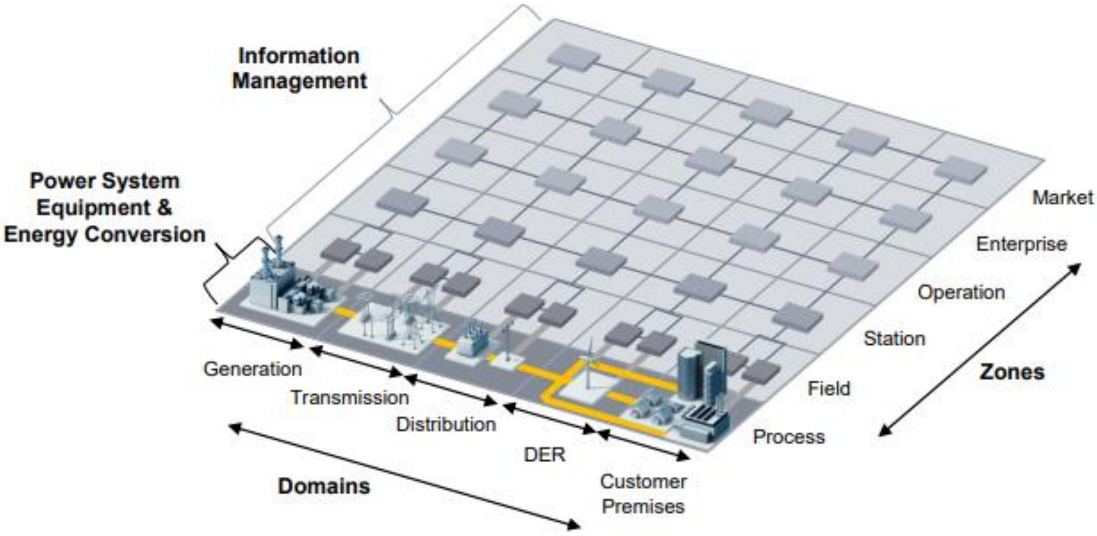

Figure 24: SGAM Smart Grid Plane [40]

As can be seen from the illustration, the Smart Grid Plane is divided in to domains and zones. The domains cover the complete electrical energy conversion chain from generation to the customer premises. The zones represent the hierarchical levels of power system management and cover the areas from the process, representing the physical elements directly involved, to market, representing the market operation along the energy conversion chain. The market zone also includes the retail market sector. [40]

Combining the Interoperability layers displayed in Figure 23 and the Smart Grid Plane in Figure 24 results in the SGAM Framework. This framework displayed below, spans over three layers: Domain, Interoperability, and Zones as displayed in Figure 25. [40]

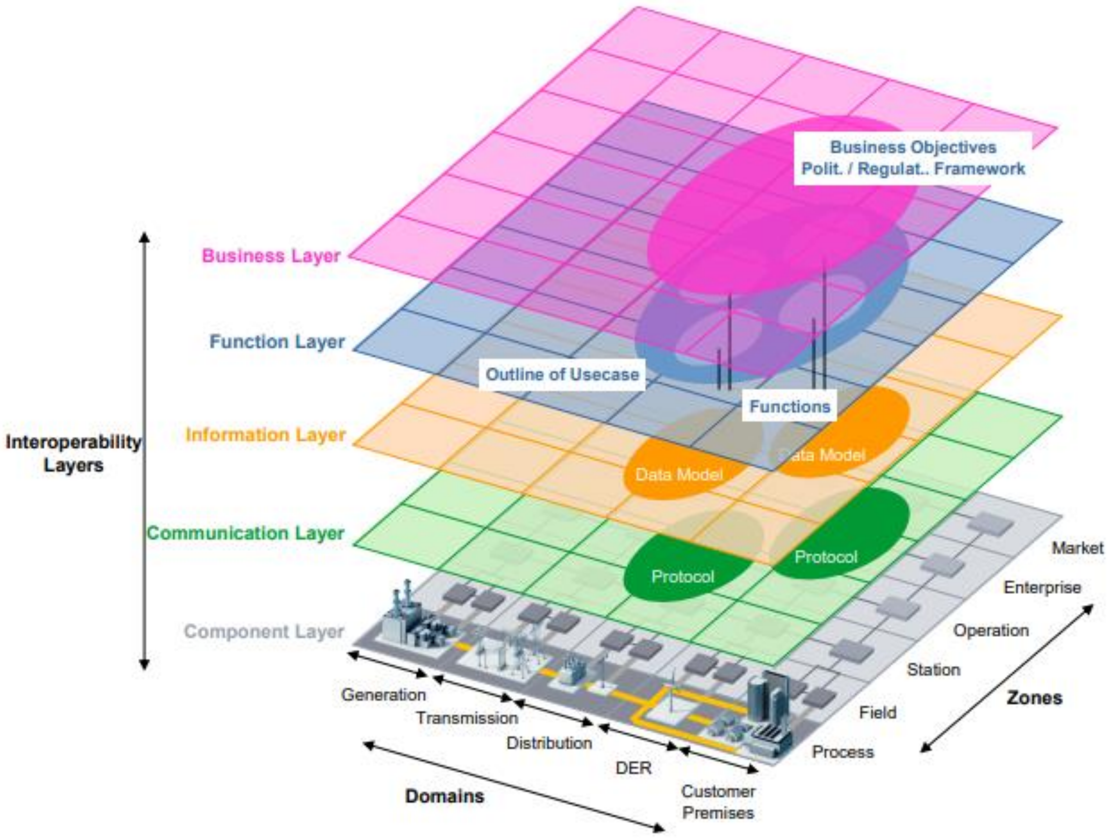

Figure 25: SGAM Framework [40]

As described by the GEN-CENELEC-ETSI Smart Grid Coordination Group in [40], the SGAM Framework, illustrated in Figure 25 allows the representation of entities and their relationships in the context of smart grid domains, information management hierarchies and in consideration of interoperability aspects. [40]

As previously described, information exchanges in the smart grid happen in a many interfaces and interoperability is a fundamental requirement for the smart grid functionality. The following sub-chapters will introduce the Common Information Model and explain how it fits to the SGAM Framework and how interoperability can be achieved with the help of CIM.

4.2 CIM Background

The Common Information Model (CIM) was originally developed in the 1990s by the Electric Power Research Institute (EPRI) in North America with the fist aim of defining a common definition on the components in power systems for use of the Energy Management Systems (EMS) Application Programming Interfaces (APIs). The aim was first to develop an internal database model for EMS and Supervisory Control and Data Acquisition (SCADA) systems and to prevent vendor lock-in caused by proprietary models used by the EMS vendors. As the benefit of having a common definition of the data transferred between applications became more apparent, CIM soon evolved into an approach to model objects and relations of electrical distribution, transmission and generation transferred as part of information exchange between systems. [42] [43]

In order to promote the usage of CIM not only by the utilities, but also by the vendors, the model was adopted as an international standard by the IEC, which the established the Technical Committee 57 and the Working Groups 13, 14 and 16 to further develop and maintain the CIM standards. [42]

4.3 CIM in General

As mentioned, CIM started as a way to allow the EMS systems to import and export network models. However, within a short period it became clear that the model could be used to exchange power system data used in network analysis. Parts of the full model were being used for the exchange of information such as power flows, topology information and state estimations. These subsets of the CIM model used for various purposes are known as profiles. [44]

Later on, as the needs of the utility sector grew, the original CIM model started to expand and support data exchanges with various enterprise systems. The expanding model started to support exchanges of information related to distribution management, outage management and meter data management, to name a few. As the markets became more and more deregulated the model also grew to support market management systems and the information exchanged between them. [44]

Currently CIM is a core standard for IEC and is considered as a backbone of the future Smart Grid. It covers many aspects of the SGAM Grid Plane as illustrated in Figure 26.

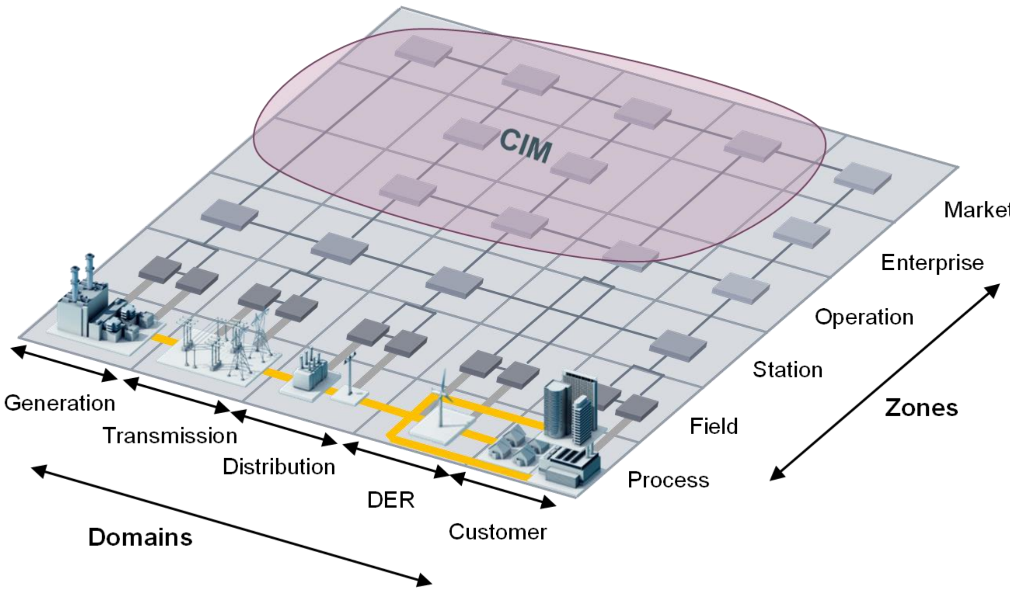

Figure 26: CIM and the Smart Grid Plane

As can be seen from above, CIM expands over the SGAM domains between generation and the distributed electricity resources (DER) directly connected to the public grid and covers the Zones between Operations and Market. The remaining gaps seen in the grid for example in the station and field zones are covered by other IEC standards such as the IEC 61850: Communication Networks for and systems for power system utility automation. The customer domain on the other hand is covered by many emerging automation and Internet of Things (IoT) technologies and standards such as KNX, BackNet and Profibus.

CIM resides in the information and communication layers of the SGAM interoperability layers. Sematic and business context interoperability is offered by the CIM UML model and the contextual profiles. Syntactic interoperability on the communication layer is offered in the form of the syntactic models and schemas.

4.3.1 The CIM UML Model

The canonical CIM UML model, sometimes also called contextual or public model, is an abstract model that represents all the major objects in an electrical utility enterprise. The information is defined in UML as classes. The class characteristics are defined

with attributes and each class also have associations defining the relations to other classes.
The canonical model consist of three parts. The first part, IEC 61970, represents the power system model and the data types, classes and attributes used to model electrical characteristics necessary for network analysis. The second part, IEC 61968, contains classes and attributes for distribution systems, and the third part, IEC 62325, contains classes and attributes related to electricity markets. [42] [44]

Each of the parts, or packages, contain classes that represent real world objects or concepts. The power system model contains classes such as ACLineSegment, Switch and TapChanger, the distribution model classes such as WorkTask and Outage, and the market model classes called MarketEvaluationPoint, Price and Quantity. These classes, their attributes and associations are then represented as part of the packages and can be viewed with an UML editor, such as Sparx Systems Enterprise Architect (EA). An example of a CIM UML from the power system model containing the ACLineSegment class is illustrated in Figure 27. [42]

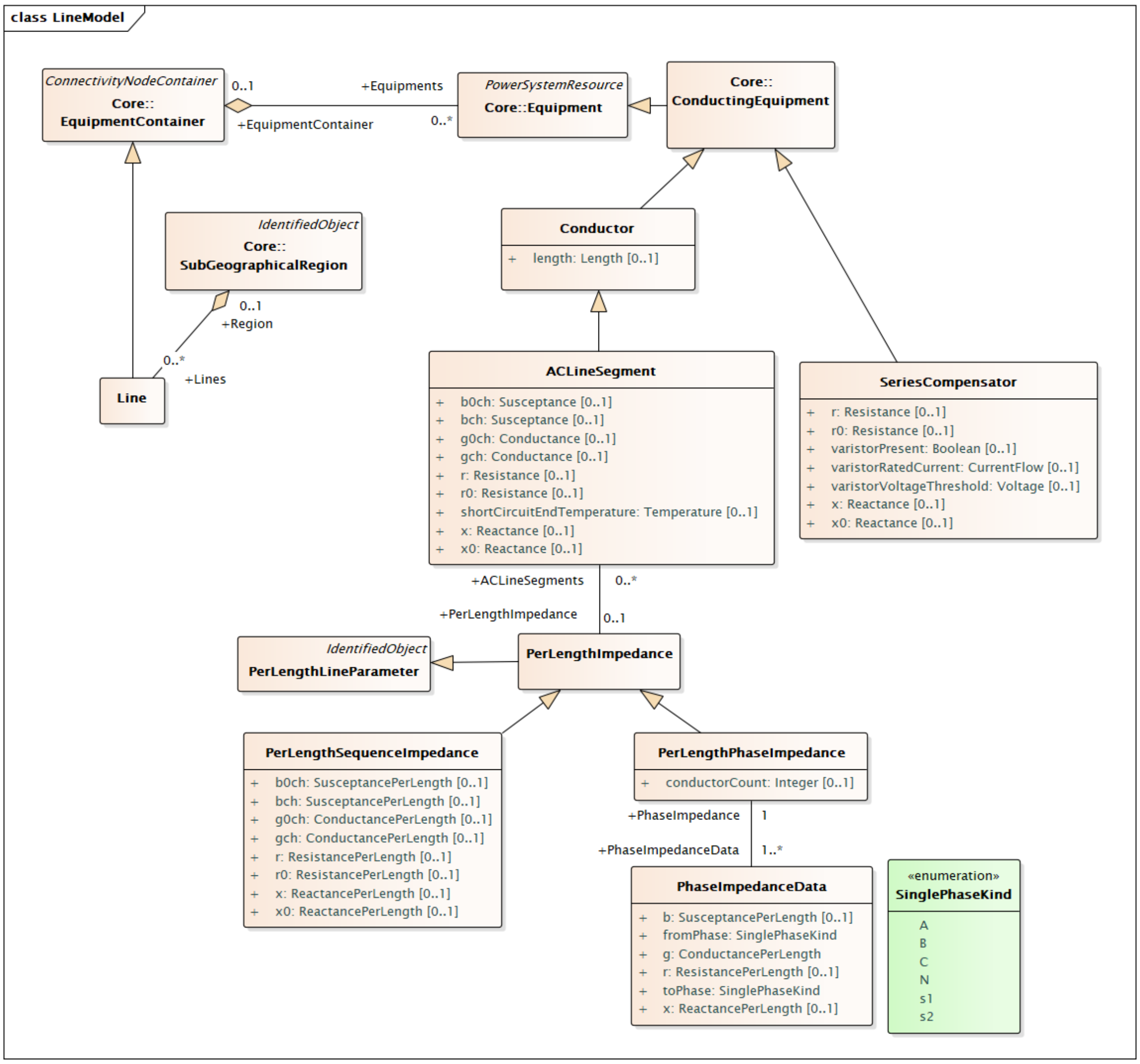

Figure 27: CIM UML example, IEC 61970 LineModel

In the figure above some classes form the IEC 61970 UML model can be seen. The classes, such as ACLineSegment and PhaseImpedanceData are displayed with the attributes the describe the class. The arrows between the classes represent the inheritance or specialization of the classes. In the example, the ACLineSegment can be considered as a type of Conductor, thus it inherits the attributes and the associations of the Conductor class and any class above the Conductor in the lineage. Lines with no arrow at either end illustrate simple associations. Each association has a role name and a multiplicity. In the figure above, the association between PerLenghtPhaseImpedance and PhaseImpedanceData is displayed as “1” on the PerLenghtPhaseImpedance side and “1..*” on the PhaseImpedanceData side. This means that each PerLenghtPhase-Impedance can have one or many PhaseImpedanceData and each PhaseImpedance-Data is associated to exactly one PerLenghtPhaseImpedance. [44]

4.3.2 CIM Profiles

The CIM UML model is constantly evolving and growing. The original canonical model has been expanded with distribution application exchanges and market information and the new additions are done when new requirements are identified in information exchanges. As new implementations of CIM are conducted, issues with the model can appear and corrections to the existing model are done if required. [44]

The evolution has led to the fact that currently there are over 2000 classes in the canonical CIM model. The relations are generalized to “one to many” or “none to many”, and all attributes are optional. This leads to the fact that the full model can be too complex or impractical to use as is. Also the data can be expressed in multiple incompatible ways. For this reason, in the actual data exchanges, a subset of the model is used. These subsets or selections of the full model are called profiles. [43]

The profiles are collections of classes, attributes and relations derived from the canonical CIM. They also set additional restrictions such as mandatory attributes and restriction of the cardinalities of the associations between the classes. [43]

By contextualizing the CIM model to a profile, the model can be restricted to define the data exchanges required for a use case or interface. The profile defined for an exchange and the further be used to derive an implementation model for the serialization of the data. This process of generating the implementation model, such as and XSD schema from the canonical CIM is illustrated in Figure 28. [43]

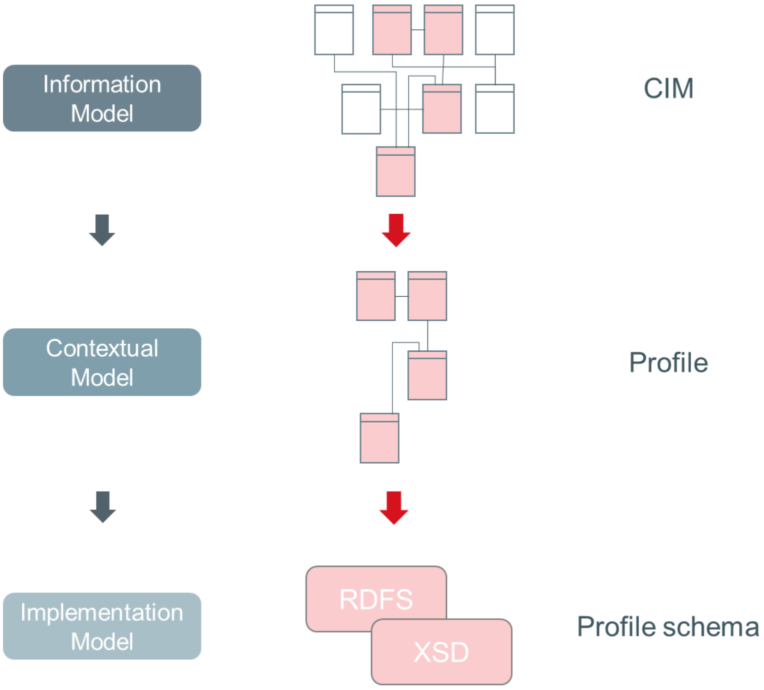

Figure 28: How profile schemas are created from canonical CIM

As can be seen from the figure above, the contextual model, or profiles used in a given exchange are based on the information model, CIM. The profiles only contain the classes, attributes and relations needed to define the data relevant to the exchange. From the profiles, implementation models, such as Resource Description Framework (RDF) Schemas or XML Schema Definitions (XSDs) can be created to define the structure of the serialized data. This is further explained in the next sub-chapter.

4.3.3 CIM Payload Serialization

Like described, the profiles define the data relevant to the information exchange use case. The data is represented in an UML class diagram, so in order to be able to use it as part of an information exchange a syntax for the data needs to be selected. Currently there are two alternatives for the definition of the syntax RDFS or XSD. Both alternatives are based on XML, developed by the World Wide Web Consortium (W3C).

The original format of syntax chosen for the CIM was defined with RDFS. This flavor of XML relies on the usage of RDF identifiers to define the data and does not support nesting. RDFS based profiles are widely used in network model exchanges supporting bot full models or model increments. The reduced W3C RDF Schema used in CIM model exchanges is defined in IEC standard 61970-501. The instance data or the payload serialization version of the reduced RDFS schema is called CIM RDF XML or CIMXML.

The RDF XML format allows the possibility denote relationships between two elements that are not parent and child. The format uses Universal Resource Identifiers (URIs) to identify elements and provides the possibility to refer to elements using these URIs. An example of a CIM RDF XML can be seen in Figure 29.

```
<cim:VoltageLevel rdf:ID="_951eb339-290c-4619-a050-eb90ef07b003">
    <cim:IdentifiedObject.name>543</cim:IdentifiedObject.name>
    <cim:VoltageLevel.BaseVoltage rdf:resource="#_4bd4e54c530445289e31df0770d1c939"/>
    <cim:VoltageLevel.Substation rdf:resource="#_1234ad43-5d3c-4c50-1290-4d5cad3667ba"/>
</cim:VoltageLevel>
<cim:ConnectivityNode rdf: ID="_c8318d70-953a-4dec-a0b6-e3c1d81a3b05">
    <cim:Identifiedobject.name>XYZ</cim:IdentifiedObject.name>
    <cim:ConnectivityNode.ConnectivityNodeContainer rdf:resource="#_951eb339-290c-4619-a050-eb90ef07b003"/>
</cim:ConnectivityNode>
<cim:Terminal rdf:ID:"_2394eac3-87c9-4ed0-b51e-d9851dce79c7">
    <cim:Terminal.ConductingEquipment rdf:resource="#_e793c6dd-7bfa-4b6a-992f-a8c2fc426dbf"/>
    <cim:Terminal.ConnectivityNode rdf:resource="#_c8318d70-953a-4dec-a0b6-e3c1d81a3b05"/>
</cim:Terminal>
```

Figure 29: Example of a CIM RDF File

In the example above, the `ConnectivityNode` with name `"XYZ"` is identified with `rdf:ID="_c8318d70-953a-4dec-a0b6-e3c1d81a3b05"`. This `ConnectivityNode` is connected to a `ConnectivityContainer` identified with the `rdf:resource="#_951eb339-290c-4619-a050-eb90ef07b003"`. This ID refers to the `VoltageLevel` with name `"543"` defined in the above element. With the help of these identifiers, the relationships between power system components can be defined in XML format.

As the need for the data exchanges outside of network models grew in the utility sector the second variation of the syntax emerged. A natural choice for the new syntax was to validate the XML against W3C XSD. This type of XML syntax is widely used in many integrations and there are a number of tools supporting it. The XSD based XMLs are used in CIM when only parent-child relationships are needed. An example of an XSD based CIM XML file is displayed in Figure 30. [44]

```xml
<TimeSeries>
    <mRID>string</mRID>
    <businessType>B63</businessType>
    <product>8716867000016</product>
    <in_Domain.mRID codingScheme="NNN">string</in_Domain.mRID>
    <out_Domain.mRID codingScheme="A01">string</out_Domain.mRID>
    <measure_Unit.name>WTT</measure_Unit.name>
    <auction.mRID>string</auction.mRID>
    <Period>
        <timeInterval>
            <start>5591-09-06T03:16Z</start>
            <end>6125-01-25T12:34Z</end>
        </timeInterval>
        <resolution>P2Y6M29DT8H21M16.76S</resolution>
        <Point>
            <position>2551</position>
            <quantity>2512620.2349058</quantity>
        </Point>
    </Period>
    <Period>
        <timeInterval>
            <start>4395-07-30T06:49Z</start>
            <end>5601-10-01T22:19Z</end>
        </timeInterval>
        <resolution>P3Y4M16DT10H37M47.96S</resolution>
        <Point>
            <position>9686</position>
            <quantity>2948590.2349058</quantity>
        </Point>
    </Period>
</TimeSeries>
```

Figure 30: Example of a CIM XML file based on XSD

As can be seen in the example, this format of expression has the possibility nesting, meaning allowing elements to belong within one another. In the example, the `TimeSeries` element contains other elements such as `mRID` and `BusinessType`. The format also allows multiple instances of the same element type to be nested within the parent element. In the case of the example, there are multiple `Period` elements within the `TimeSeries` element. This makes the format suitable for example in the exchange of meter values.

To summarize, the CIM RDF XML format is best suited when there are links needed between elements of the same level, thus it is better suited for network model definitions, and used for example in the grid model exchanges of the IEC 61970 standard. The XML syntax defined by XSD is used by the IEC 61968 and 62325 standards and is mode suitable for the transmission of data such as meter readings, capacity allocations and schedules. [45]

4.4 Existing Standards and Profiles

As mentioned earlier, the Common Information Model is currently standardized in to three high main categories of standards, the IEC 61970 containing the power system model, IEC 61968 which models the utility and distribution side, and IEC 62325 which contains the classes relevant for the market systems. These standards are further elaborated in the sub-sections below. As the market information exchanges are the main topic of this thesis, the IEC 62325 standards are covered in more detail.

4.4.1 IEC 61970 - Energy Management System Application Program Interface

The IEC 61970 series of standards contains the required information needed to model electrical characteristics for network analysis. The core canonical CIM power system model, the CIM base, is defined in the International Standard IEC 610970-301. The edition 6 of 610970-301 was standardized in 2016. This model is extended with information related to dynamics in IEC 61970-302 released in 2018. The IEC 61970 standard is maintained by the IEC TC 57 WG13.

For the European transmission system operators, one of the main applications of this standard is the Common Grid Model Exchange Specification (CGMES). The common grid model (CGM) is a data set agreed together with the European TSOs describing the main characteristics of the power system. The CGM is based on Individual Grid Models (IGM) of the TSOs. The IGMs contain information such as generation, load and grid topology. The IGMs are merged to form the CGM. The Common Grid Model Exchange Standard has been developed by ENTSO-E in close co-operation with the member TSOs and is adopted as an IEC Technical Specification. The structure and rules of the CGMES are defined in IEC TS 61970-600-1 and the CIM profiles related to CGMES are defined in 61970-600-2.

Besides the TSs defining the CGMES there are several other standards and technical specifications related to IEC 61970. An overview of the related standards and specifications is displayed in Table 2. [44]

Type of standard	Standard	Description
CIM canonical model	IEC 61970-301	Base power system model
Profile standards	IEC 61970-4xx	Profiles based on use cases
CGMES	IEC TS 61970-600-1 IEC TS 61970-600-2	Common Grid Model Exchange Specification rules and profiles
IT Schema	IEC 61970-501	W3C RDF reduced schema description
Instance data	IEC 61970-552	Description of how the RDF XML is produced

Table 2: IEC 61970 standard

4.4.2 IEC 61968 - Application Integration at Electric Utilities - System Interfaces for Distribution Management

The IEC 61968 standard extends the 61970 model with classes relevant to distribution companies. The extended model also includes support for Asset Management, Work Management, Geographical and Meter Data among others. [43]

The main standards relevant to IEC 61968 are displayed in Table 3 below. The IEC 61968 standard is maintained by IEC TC57 WG14. [44]

Type of standard	Standard	Description
CIM canonical model	IEC 61968-11	Base distribution operations model
Profile standards	IEC 61968-3 to IEC 61968-14	Profiles based on use cases
IT Schema	W3C XSD IEC 62361-100	W3C XSD standard describes how the XSD is produced and used. IEC62361-100 companion standard describes the XSD to XML mapping that is required for the CIMXML message payload
Instance data	W3C XML	Describes the XML format

Table 3: IEC 61968 standard

4.4.3 IEC 62325 - Framework for Energy Market Communications

The IEC 62325 extends the IEC 61970 and 61968 base models with market related classes. The additional packages define the data exchanged between market participants. Contrary to the earlier described standards, the IEC 62325 does not model the market, it is specifically designed to define the data exchanged by entities involved in the market operation. These markets include day-ahead and real time markets and settlement, among others. [43] [44]

The canonical model for the market communications is standardized in IEC 62325-301. As the markets in North America and Europe are significantly different, regional contextual profiles are generated from the canonical model for each style of market. The European style market profile (ESMP), IEC 62325-351, contains the necessary core components required for the European information exchange. These components are also known as aggregated core components (ACCs). [46]

Based on needs of the specific use case, a document contextual model is created from the regional contextual model. In this stage of the profiling process the ACCs of the regional model are contextualized to form aggregated business information entities (ABIEs), which in essence are the classes, attributes and relations required to model the information outlined in the business requirement specifications. Once the document contextual model is finalized a message assembly model (MBIE) can be automatically created from it. The XML schemas defining the syntactic model can be automatically created from the message assembly model. The IEC 62325 profiling methodology is illustrated in Figure 31. [46]

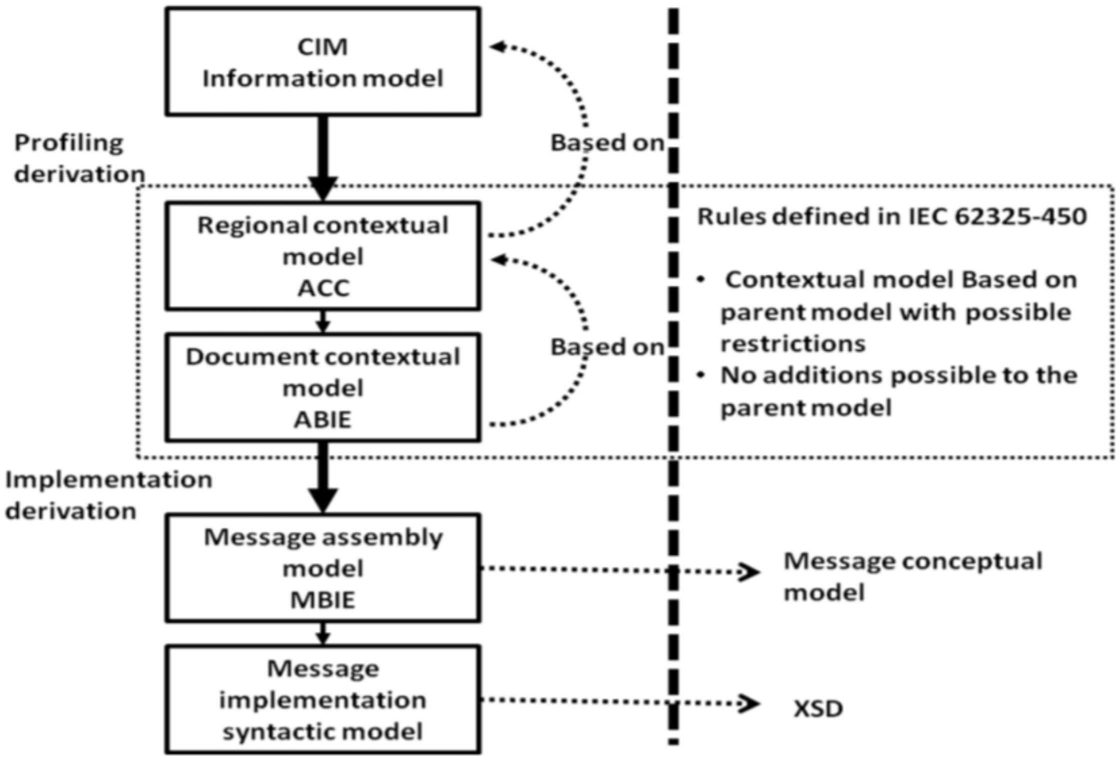

Figure 31: IEC 62325 modelling framework [46]

As can be seen from the illustration, the regional contextual model, for example ESMP, is based on the canonical CIM. The document contextual model then further specifies the regional model. Each step reduces the scope of the model and cannot add to the parent model. The process illustrated in Figure 31 can be considered similar to the steps illustrated Figure 28, with additional profiling steps reducing the scope of the model. The rules for the IEC 62325 profiling process are standardized in IEC 62325-450.

There are several document contextual models standardized for the European market. These models, based on the ESMP, are standardized as the IEC 62325-451 series. Each profile is linked to a specific use case and a specific information exchange. Similarly to the ebIX BRSs and BIMs described earlier, the documentations of the 62325-451 series contain, in addition to the profile and data exchange format descriptions, the business processes they are linked to. The 62325-451 series profiles currently define the information related to business processes in the wholesale, or upstream, market in Europe.

IEC TC 57 Working group 16 maintains the standards of the IEC 62325. The key parts of the series of standards, in relation to European market communication, are listed below in Table 4.

Type of standard	Standard	Description
CIM canonical model	IEC 62325-301	Base market model
Profile and context modelling rules	IEC 62325-450	Defines how to create a profile
ESMP	IEC 62325-351	European Style Market Profile
ESMP Profiles	62325-451-x	ESMP profiles based on use case
IT Schema	W3C XSD IEC 62361-100	W3C XSD standard describes how the XSD is produced and used. IEC62361-100 companion standard describes the XSD to XML mapping that is required for the CIMXML message payload
Instance data	W3C XML	Describes the XML format

Table 4: IEC 62325 standard

4.5 Usage of CIM in the Retail Market Sector

The CIM standard is widely used on European level in the electricity transmission systems and wholesale market communications today. However, the usage in the retail market communications is currently limited. The following sub-chapters aim to give an understanding on what drives the introduction of CIM in to the retail sector in Europe, and to what level it is currently used.

4.5.1 Key Drivers

As mentioned in chapter 3.1 one of main drivers for the usage of CIM on the retail market sector, is the high-level ambition to harmonize, or converge, the information exchanges in the retail markets in Europe. The ambition is highlighted in the European directives as stated in chapter 3.1.1. The study done by the Smart Grid Task Force EG1

[18], highlighted an important pre-requisite for harmonization is to achieve comparability through the use of reference models. The study also recommended the adoption of CIM to for semantics in order to facilitate interoperability.

Since CIM is already in use in the electricity sector in other areas, such as network analysis and upstream market information exchanges, it would be a natural choice to select as the reference model for the retail market exchanges as well. The wholesale and retail markets are becoming more and more co-dependant and overlapping on each other. As CIM is already used in the European wholesale markets, adopting the same model for the retail markets would enable better interoperability and semantical understanding.

Due to the fact that the retail markets in Europe are not currently aligned to any specific information model, as highlighted in the chapter below, there is no clear other pre-existing candidate, other than CIM, that could be selected as a reference model

4.5.2 Current Usage in Europe

The European retail markets operate differently between states. There are different procedures and processes implemented in between the countries, for example due to variances in the legislations. The differences are also visible on the data management and information exchanges between the market participants in the European countries. The Asset project study [16], conducted in 2018, found that the information standards available for the communication between stakeholders in the markets. The EDIFACT standard is the most implemented, as at the time of the study it was in use in Belgium, Germany, Finland, Luxembourg and Sweden. However EDIFACT only offers interoperability on syntactic level, but not on semantical level, so it does not offer a common vocabulary. It was also highlighted that even if two countries use EDIFACT-based messaging, it does not mean that the communications are compatible.

Besides the EDIFACT standard, most countries still use national-specific, often XML based, formats for communication. And no change to this was highlighted as for future considerations, as at the time of the study CIM was considered as a future alterative only by Finland.

5 CIM for the Datahub

In this chapter a CIM based model from a part of the Datahub information model is built using the Sparx Enterprise Architect (EA) software. The result is then analyzed and compared model used the Datahub. The results will give an example of the requirements that need to be put towards the CIM in order to be able to model the Datahub information exchange using the Common Information Model. The chapter will also describe the process of defining a CIM profile using the Sparx EA software.

5.1 Process for Custom CIM Profile Creation

When defining a custom CIM profile the requirements for the information exchange have to be identified first. This means that the data defined by the model is based on the requirements of the process in question. Similar approach has been used when the data model for the Finnish Datahub has been defined. As the requirements are already defined in the Datahub documentation, these will be used as the source for the requirements of the CIM profile.

Since the data used by the Datahub is market data, the European Style Market Profile will be used as the source of the model, and the IEC 62325 modelling framework, described in chapter 4.4.3, will be used in the profiling process. ESMP will be used as the regional contextual model (ACC), and the custom profile will be based on the classes included in the ESMP model. The process steps for creating a custom profile are displayed in Figure 32.

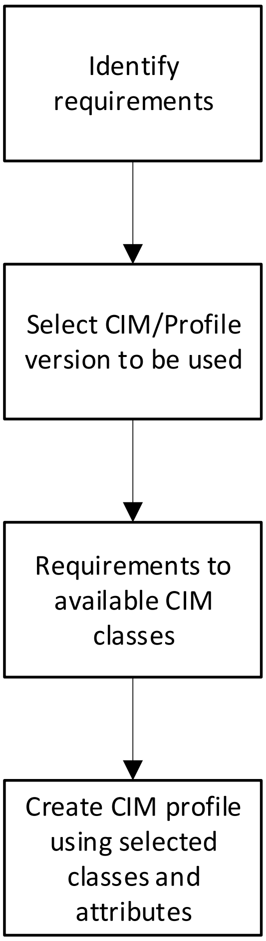

Figure 32: Process for custom profile creation

First step of the profile creation is identify the data requirements that the profile should contain. Following the data selection, a combined CIM model version or an existing profile is selected as the source for the profile creation. Once the version is selected, relevant the relevant classes in the source are identified by mapping them to the data requirements. Once the class and attribute requirements are clear, a custom profile can be created. The way to develop UML models based on IEC 62325-450 methodology in the context of the European style market profile is described in [46].

5.1.1 Selection of data exchange for profile creation

The chosen information exchange for which the profile is created is the exchange of meter data between the DSO and the Datahub. The process for the exchange of data is described in [13], and illustrated in Figure 33 below.

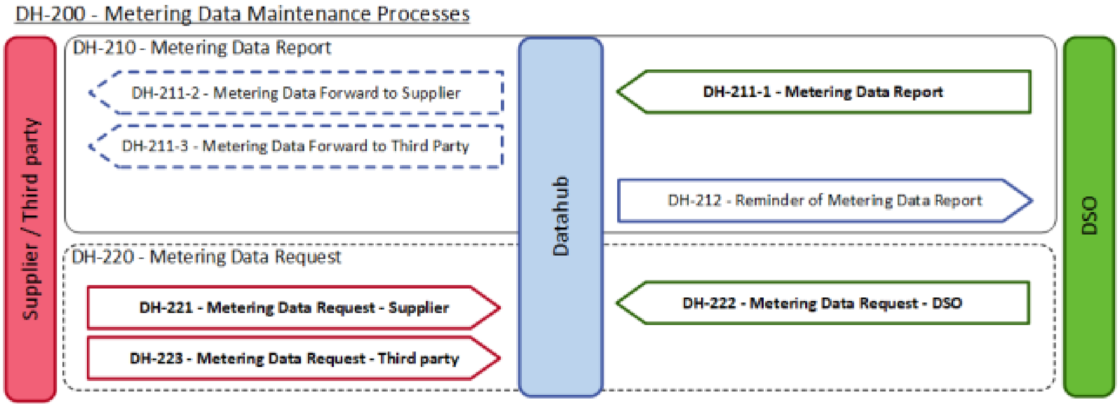

Figure 33: Datahub metering events [13]

The event where the DSO sends the metering data report to the Datahub is identified as DH-211-1 and belongs to the overall metering data maintenance processes (DH-200) in the Datahub. The DH-211-1 can trigger two additional events, or data exchanges: when the DSO reports the meter values, the Datahub sends a Metering Data Forward to the Supplier, and possibly to a Third Party.

The information that is exchanged as part of this event is described in the Datahub Events document [13]. The data fields requirements for the information provided by the DSO in the metering data report message is displayed in Table 5.

Information Field	Level	Cardinality
Header data	**1**	**1..1**
Message indentification	2	1..1
Message type	2	1..1
Message creation time	2	1..1
Technical Sender of message	2	1..1
Juridical sender of message	2	1..1
Technical recipient of message	2	1..1
Juridical recipient of message	2	1..1
Sender's routing data	2	0..1
Process	**1**	**1..1**
Process Information	2	1..1
Information exchange role	2	1..1
Industry	2	1..1
Payload	**1**	**1..n**
Unique transaction ID	2	1..1
Metering time series identification	2	0..1
Reporting period	2	1..1

Time step	3	0..1
Start time	3	1..1
End time	3	1..1
Metering type	2	1..1
Metering time series type	3	1..1
Unit	3	1..1
Metering characteristics	2	1..1
Metering point type	3	1..1
Metering point	2	1..1
Metering point identification	3	1..1
Area information	2	0..1
Metering grid area identification	3	1..1
Input area	2	0..1
Metering grid area identification	3	1..1
Output area	2	0..1
Metering grid area identification	3	1..1
Time series values	2	1..n
Position	3	1..1
Values	3	1..1
Value	4	1..1
Status	4	0..1
Value missing	4	1..1

Table 5: DH 211 -message data fields

As can be seen from the table, the main point of the report is the time series data related to the metering values collected by the DSO listed in the bottom of the table. In addition to the payload information, the message specific information is carried out in the header and process data parts of the messages. These can be seen in the top of the table.

The DH-211-1 event was selected as for analysis in this thesis as metering data and the time series related to meter data management can be expected to be quite well covered by the CIM standard at this point as similar exchanges are conducted within processes between for example the TSOs and ENTSO-E. As highlighted in the IEC TR 62625-103 [35], the ebIX defined exchanges related to measurement data are covered to quite large extent by the CIM model, so it can be expect that the model used by the Finnish Datahub project is also covered to large degree.

5.1.2 Required Tools for the Profiling Process

The UML modelling tool used for the profiling process of CIM is Enterprise Architect (EA) by Sparx Systems. In addition, two plugins are required for the modelling process. The details of the software used to create the CIM profile in this chapter are displayed in Table 6 below.

Software	Developer	Version
Enterprise Architect	Sparx Systems	14.1.1429
CIMContextor	ZAMIREN	2.8.27
CIMSyntaxGen	ZAMIREN	2.3.25

Table 6: Software used for CIM profile creation

The CimContextor and CIMSyntaxGen are required in order to be able to use the profiling methodology of the European Style Market Profile. They are installed as plugins to the EA software and are available for download on the ENTSO-E website.

5.1.3 Selection of CIM Version

For this thesis, the following CIM UML model file has been used:
20191018_ESMPv4_iec61970cim17v34_iec61968cim13v12_iec62325cim04v04.eap

This corresponds to the ESMP and canonical CIM model versions listed in Table 7.

Standard	Major Release Version	Minor Release Version
ESMP	4	
IEC 61970	17	34
IEC 61968	13	12
IEC 62325	04	04

Table 7: Standards versions used in the profiling process

ESMP is based on the three IEC standards and contains relevant classes suitable for the purposes of the profile creation based on the selected information requirements.

5.1.4 Identifying Relevant Components Based on Requirements

Following the process described in Figure 32, the requirements are mapped to available classes, attributes and associations in the selected CIM model. The requirements selected are based on the tables defining the data contents of the DH-211-1 message and are available in [13].

As part of the process, each data field is individually identified, and a corresponding class or attribute is located in the ESMP model. The full mapping table between the requirements and the selected CIM source is listed in Appendix 1.

In order to be able to map the whole message contents, in addition to the payload part, the header and process data are also considered as part of the requirements.

5.2 Profile Creation Process with EA

Based on the previous step of identifying the relevant classes and attributes, the profile creation can be started using the Enterprise Architect software.

First, a new package is created for the new profile, including a package diagram and to additional packages, one for the contextual model and one for the assembly model. This created package layout can be seen in Figure 34.

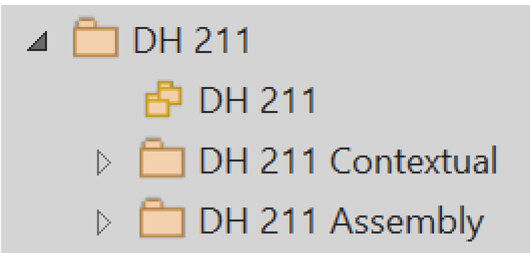

Figure 34: New profile package layout in EA

Within the new package diagram an “isBasedOn” dependency is created between the ESMP and the new Contextual package. This relationship is illustrated in Figure 35.

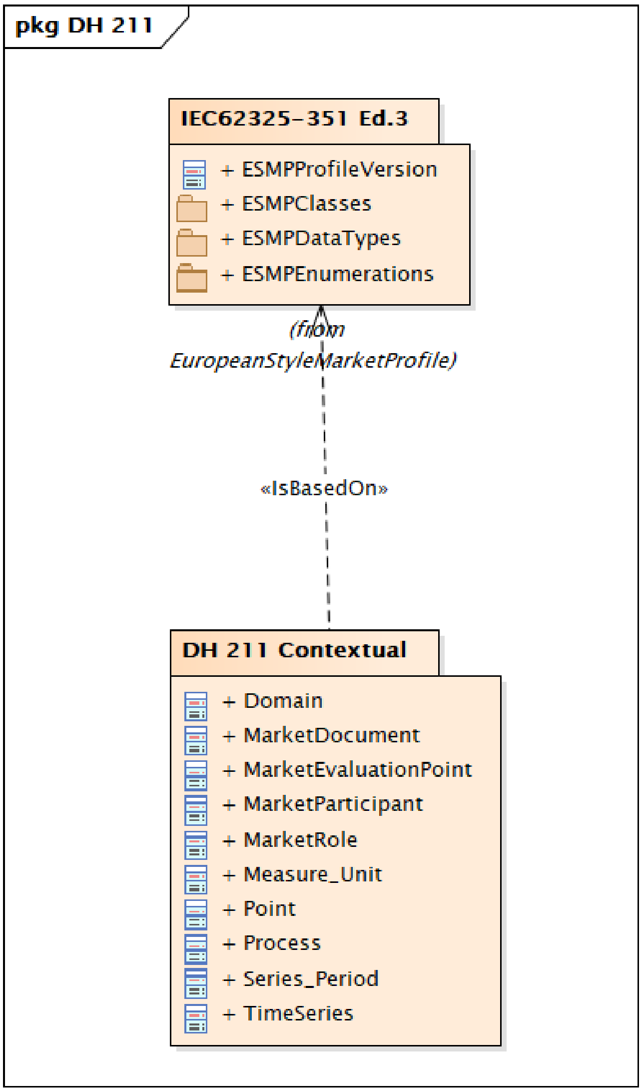

Figure 35: Package dependency between new contextual model and ESMP

This dependency declares that the created contextual model package will use classes, attributes and associations available in the package it has the “isBasedOn” dependency, in this case the ESMP and its sub-packages.

Following this, a new class diagram is created under the contextual package. Into this diagram the required classes with their attributes are selected from the ESMP model. This defines the contextual model for the profile, illustrated in Figure 36.

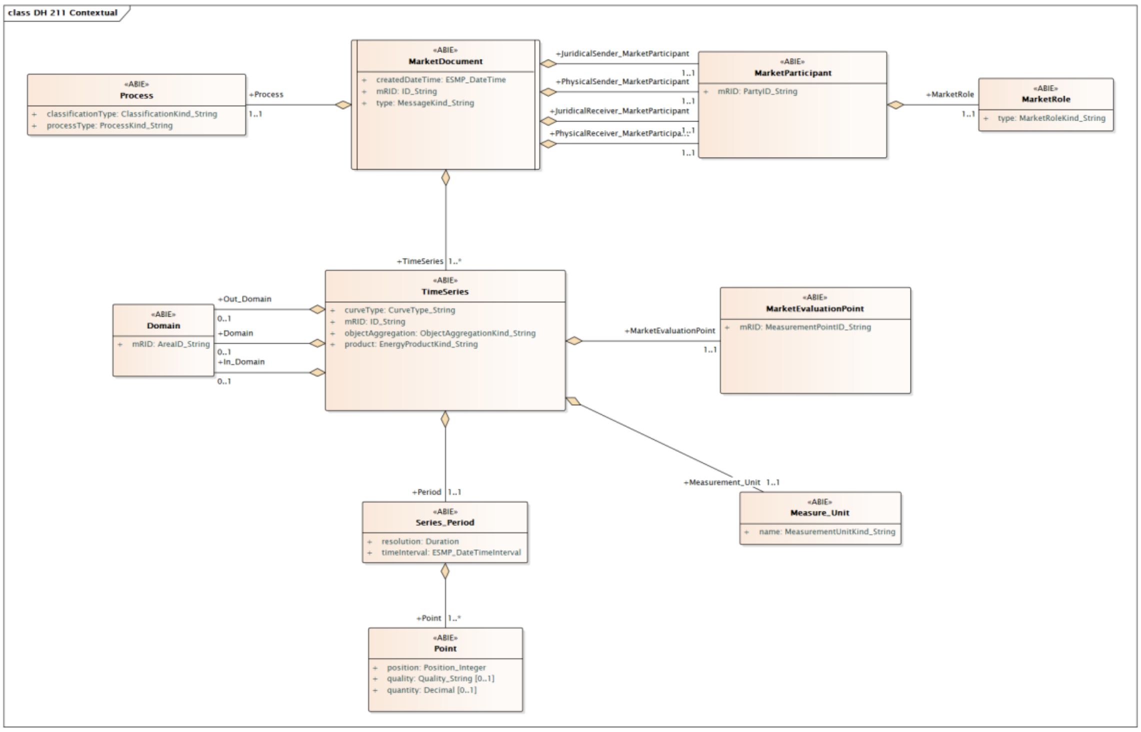

Figure 36: Contextual model for DH 211-1

In the contextual model, all the classes and attributes that were identified in the data mapping stage can be seen with the dependencies. In this view the cardinalities of the classes and attributes are also visible.

Based on the contextual model, assembly model can be created. This is done using the CimContextor plugin of EA. As described earlier, this reduces and simplifies the model structure. The assembly model for DH 211-1 can be seen in Figure 37.

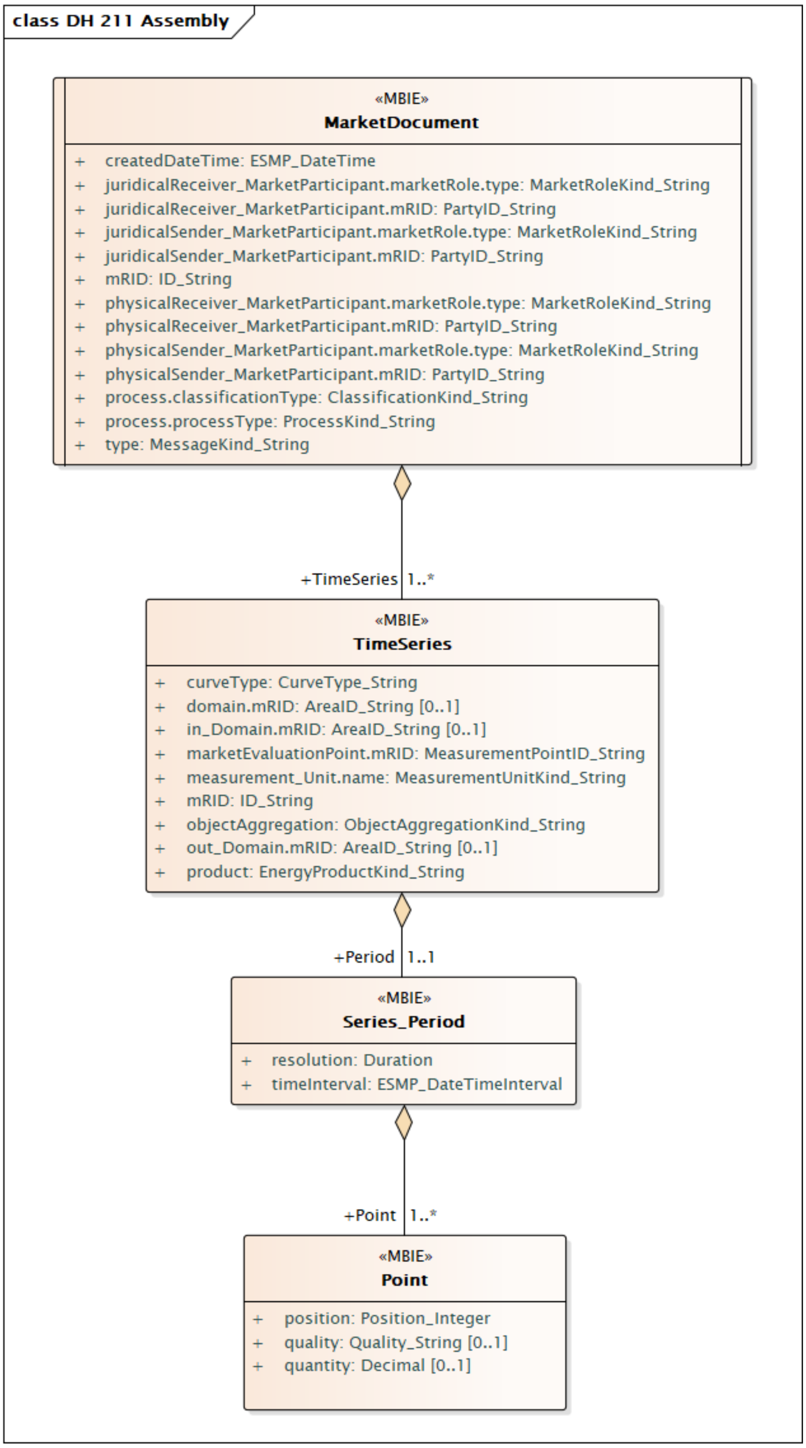

Figure 37: Assembly model for DH 211-1

As can be seen the assembly model consists of four main parts, MarketDocument, TimeSeries, Series_Period and Point. The MarketDocument consists of information mainly available in the Header and Process fields of the DH 211-1 message. The

TimeSeries consists of most of the Payload information, with exemption to the information about the series time period and the actual meter values which are located in the Series_Period and Point classes.

Finally, based on the Contextual model, an XSD describing the structure for the XML message to be used in the information exchange can be created. This is done using the CimSyntaxGen plugin of EA.

The detailed steps for the profile creation are listed in Appendix 2.

5.3 Comparison of the Profile to the Datahub Event

When mapping the data requirements to the event data specifications for DH 211-1 message, it was seen that most of the requirements can be met with ESMP classes and parameters. This sub-chapter lists the main points of differences between the models.

5.3.1 Process and Market Participant Association

In the Datahub events specifications the market participants Information Exchange Role is an attribute of the Process element, and the role information exists only once in the message, defining the sender role. However, in ESMP, there is no association between the Process class and the MarketParticipant class, only between the Procees and MarketDocument and between MarketParticipant and MarketDocument classes.

This leads to the fact that, as the MarketParticipant class is needed to define sender's and receiver's juridical and physical identification, the role is also required for all four instances. This can be seen in the Figure 37, as the MarketParticipant.MarketRole.type is listed four times, once for each participant.

5.3.2 Definition of Missing Values

In DH 211-1 event there is a choice when defining the meter values. If the values exists, they will be listed in the "Value" -field, but for the timestamps where the values do not exists a separate field, "Value Missing", will be used with the value "1" stating that the values is missing. [13] In the ESMP model, there is no attribute in the Point class defining if the value is missing for this point of time. In order to accommodate for the missing values, the quantity attribute has been left as optional, so if a value is missing it will not be reported as part of the time series.

5.3.3 Time Period Resolution and Time Interval

In the DH 211-1 event the data field “Time Step” defining the measurement resolution is mandatory, and the “Start Time” and “End Time” of the time series is defined in separate mandatory fields. In ESMP, the “resolution” attribute is available in the “Series_Period” class where both “resolution” and “timeInterval” are mandatory attributes. However in the timeInterval, both the start and end time are defined in one field. For this reason, the start time and end time from the Datahub event are combined to the timeInterval field.

5.3.4 Missing Attributes

The corresponding attributes for the following DH 211-1 event message data fields could not be located in the ESMP profile:

- Metering Time Series Identification
  This field is optional and is meant to be used in case the reporting system needs to add a separate identification code for the time series for example for error handling. There is no similar field in ESMP, the TimeSeries description attribute could be used for this purpose
- Sender Routing Data
  This field is an optional part of the Header section of the message. It can be utilised in the routing of the received acknowledgement to the system sending the original message. There is no available field for similar information in ESMP associated to the MarketDocument class.
- Metering Point Type
  This field is mandatory and defines the type of metering point in question. The metering point can be an Accounting Point, Production Unit or Connection Point. In ESMP there is no type attribute for the MarketEvaluation class. However, the objectAggregation in the TimeSeries class has similar options, and has been used for this purpose in the profile.

6 Discussions, Conclusions and Recommendations

This chapter will further discuss the creation of the new profile done in chapter 5 and give recommendations on further analysis. The chapter will also detail similar efforts done as part of projects in other countries or organizations, and how they will affect the introduction of CIM-based messaging in Finland.

6.1 Determining the Need to Move to CIM

As detailed in Chapter 4.5, the current usage of CIM in the European downstream markets is very limited. The retail markets and market models are different between the countries and the data models used for the information exchanges are most often nationally specific.

The latest European directives [17], and the study done by the Smart Grid Task Force EG1 [18], talk about facilitation of interoperability, using a common information model for semantics and convergence over time instead of a common European data model. Based on this it can be assumed that the need for the Finnish Datahub to move to CIM will not come from European legislation in the very near future.

On a Nordic level harmonization of the retail markets, and interoperability of the Nordic datahubs might be relevant in closer time frame. A study done by THEMA Consulting Group [47] and funded by the Nordic Council of Ministries stated that the Nordic ministries and regulators aim to harmonize the electricity markets. With the help of these harmonized market rules retailers from one Nordic country would be able to start operating in another country without difficulties. This would result in improved customer choice and reduced cost. The harmonization of information exchanges in the markets would reduce the cost of IT system development for the retailers, as they could be developed for all Nordic countries instead of each country individually. [47]

The harmonization of processes and information exchanges would also help third parties, such as energy service companies, to provide services around, for example, meter data management more efficiently to all Nordic countries.

The study by THEMA Consulting Group concluded with two recommendations. First, in order to address differences between the datahubs, to develop a common data model and to analyse the existing processes, a technical working group should be formed. Secondly, once all the datahubs are operational, interoperability between the hubs should be enabled. For this purpose, a common data model is needed as well. [47] The IEC CIM would be a natural option for the data model.

Regardless of the origin, the drive towards the usage of CIM in the Finnish Datahub is likely to come from an overall goal of harmonization. As the Finnish retail market is currently in process of changing the information exchanges to fit the centralized model of the Datahub, it is unlikely that a need to change the information model again would arise internally.

However, in anticipation of the possible future efforts in harmonization, it would benefit Fingrid Datahub to participate in working groups and organizations where these tasks are discussed and addressed. Being in the forefront of the development of CIM for the retail market data exchanges would be beneficial since it would enable the possibility affect the information model to suit the Finnish and Nordic requirements. Participating and contributing to the model development would ease the possible move towards the usage of CIM at some stage, as the model would already suit the current requirements, rather than having to conform to a standard that is not suited for the Finnish market.

6.2 Readiness of CIM for Finnish Electricity Retail Market

As the profile creation exercise done in the previous chapter showed, creating a CIM profile with the data requirements of the Finnish Datahub can be done. However, finding the suitable classes, attributes and relationships might not be as easy for other events as for the one selected for this thesis.

The study comparing the ebIX model to IEC CIM done in IEC TR 62325-103 [35], highlighted that in most elements the information exchanged as part of the ebIX processes can be modelled with IEC CIM. However, there were several attributes and associations that were listed as suggested updates to the CIM model. The missing attribute for Metering Point Type, mentioned in the previous chapter, was also listed as a possible addition to CIM in the study done in the IEC TR.

Many of the required additions to CIM are related to the master data part of the information exchanges. Meaning the information exchanged for example as part of contract agreements, customer information update, or metering point information update. Additionally, the possibility to refer to a request, meaning the possibility to point to a previous message that was requesting the metering data report, was found missing in CIM.

In order to fully determine the readiness of CIM for the Finnish Datahub, and the Finnish electricity retail market messaging, similar exercises as done in Chapter 5 should be done. Each specified exchange should be inspected individually in order to be able to see if the information exchange requirements can be covered with CIM.

6.3 Contributing to the CIM standard

As recommended in the previous two sub-chapters, it would benefit Fingrid Datahub to analyse the current state of CIM, and to contribute to the CIM development in order to facilitate easier adoption of CIM based information exchange in the future. The best way to contribute to the standard would be to do it through an organization or a workgroup.

The main groups and organizations contributing to CIM for electricity retail markets have been previously discussed in chapter 3. Currently there is parallel work ongoing to adapt and contribute to the CIM model through these groups and their projects.

The ebIX organization is continuing the work based on the study done in IEC TR 62325-103. New change request are being put towards the IEC in order to adapt the CIM model to the business requirements defined by ebIX for the European retail markets.

The NMEG group has identified CIM to be one of the main areas of work for the recent years. The intention for the near future is to create a set of CIM based documents for the downstream market for the overall goal of making a “Nordic CIM Model”. NMEG also foresees that the prepared CIM based documents can be used in future implementation projects in the Nordics, and as an input to European and international standardization work. The Danish TSO Energinet, has also indicated the hope of introducing IEC CIM based documents in the data exchanges in the next major version of the Danish datahub. NMEG has also proposed that eSett, the company providing imbalance settlement services to the Nordic countries should gradually start to change the messages to CIM based formats. Members of the NMEG are also participating in other workgroups and organization involved with CIM development, such as ebIX, ENTSO-E CIM EG, IEC TC57 working groups and “My Energy Data” –project, for which the objective is to define standards related to the download of electrical energy data.

As highlighted in chapter 3.2.1, the IEC standardization process is consensus based and each member country has a single vote in the approval of changes to the standards. For this reason, the best option for Fingrid Datahub is to affect the CIM standard through the work of these other organizations rather than requesting changes directly in the IEC. Some of the relationships between the different organizations relevant for Fingrid Datahub that are contributing to the development of CIM for the downstream markets can be seen in Figure 38.

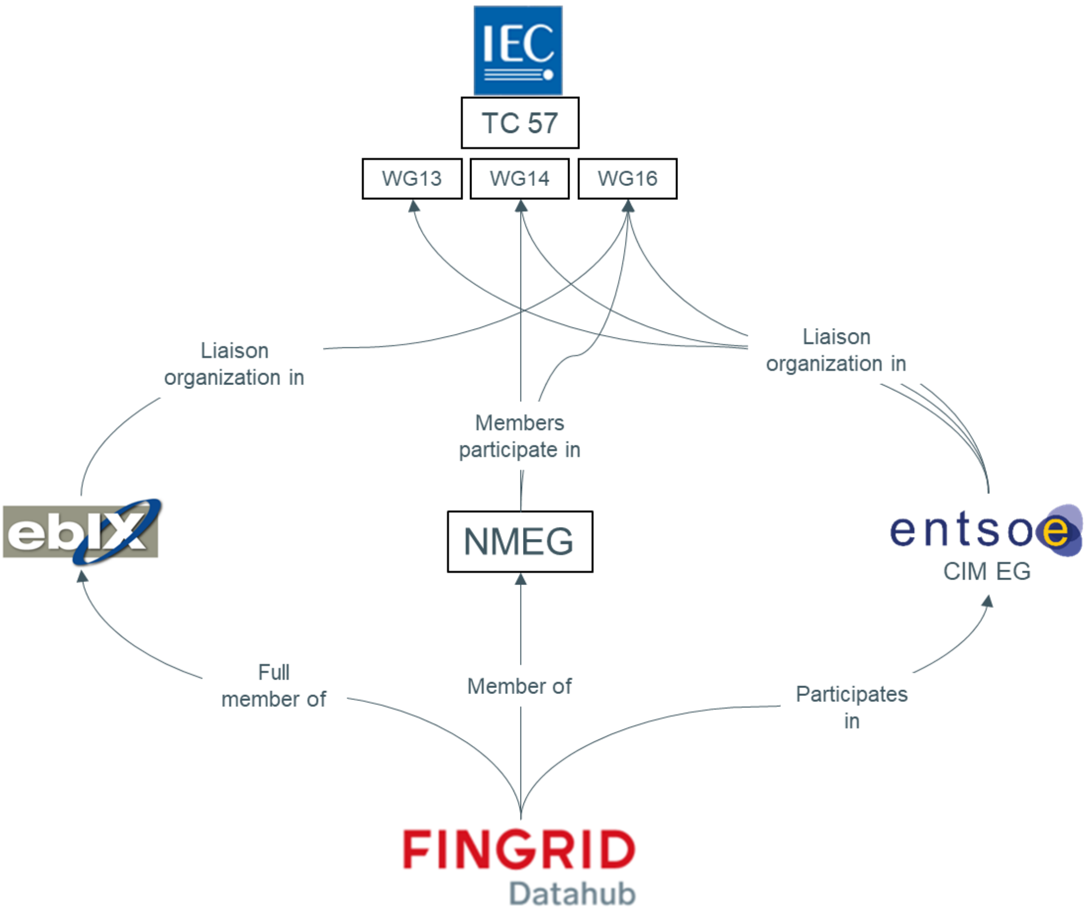

Figure 38: Relationships between various organizations and Fingrid Datahub

As displayed in the figure above, Fingrid Datahub does not have direct representation in the IEC working groups responsible of the CIM standard. However, ebIX and ENTSO-E are liaison members of these groups. In addition, some members of the Nordic Market Expert Group are also members of either WG14 or WG16. Even though ENTSO-E does not actively participate in the downstream market side, they are maintaining the ESMP model, which could be extended to cover also the downstream side in addition to the upstream market.

The NMEG group can be considered central in Fingrid Datahub's CIM development efforts as the group often presents a common Nordic voice towards both ENTSO-E and ebIX.

6.4 Recommended next steps for Fingrid Datahub

Based on the findings and information presented in this thesis some recommendations can be given for Fingrid Datahub in the near future. These recommendations are listed in the following paragraphs.

The implementing acts mentioned in Article 24 of the European Directive for common rules for the internal market for electricity [17] are likely to be written during the next couple of years. The progress of this task should be monitored in order to be able to make plans for the future in advance.

The work done in CIM development by other groups and projects such as "My Energy Data", TDX-Assist [48] and INTERRFACE [49] should be monitored in order to be able to re-use assets and best practices. Additionally, participation to any new groups and projects related to downstream market information exchanges and their standards should be reviewed case by case. This includes any projects related to TSO-DSO market data exchanges and exchanges between datahubs.

The first interface relevant for CIM for the Fingrid Datahub is likely to be towards the eSett, where Datahub sends imbalance settlement related information. The plan for eSett is to start gradually supporting CIM based messaging, and if possible, the option to use CIM based messages starting from the "go-live" date of the Datahub should be investigated. This way additional changes right after the Datahub introduction would not be required as the current message formats are likely to be phased out at some point.

Investigation for the possible introduction of new type of messaging with the Datahub should be started at an early stage. One possible option would be to investigate the possibility to support two types of messaging with the Datahub at the same time. This would allow the market participants to move towards CIM based messages during their normal system upgrade cycle or when changing system vendors. Having a “big bang” type of change towards the new messaging type would introduce additional risk and require a lot of coordination. As the Danish TSO, Energinet, plans to move towards CIM based messages within the next few years, best practices from that project should be utilized where ever applicable.

Existing and new Datahub processes should be considered with the Harmonized Role Model in mind, and harmonized roles should be used where ever possible. This task will help if and when the processes need to be mapped towards a core process model at some later stage.

As discussed earlier, mapping the existing Datahub business requirements and message data to CIM should be continued in a similar way as done in Chapter 5. This would allow the gaps to between the models to be investigated and requirements towards updating the CIM model can be put forward. This should be done in parallel with, and aligned to, the work done in the ebIX and NMEG groups. Participation, especially to in the NMEG work, should be considered important, as it would allow the possibility to be in the forefront of the CIM work for the retail market, and allow for a common Nordic voice towards the CIM development.

The suitable time for adopting CIM based messaging with Fingrid Datahub is difficult to recommend at this stage. As the introduction of the Datahub in February of 2022 is a significant change for the electricity retail market in Finland, time has to be reserved for the market to fully conform to operating with a centralized information exchange and synchronous processing of the messages. Expanding the CIM standard to fully support retail market specific information will also take time. The gaps have to first be identified and change request towards the standard have to be put forward. As discussed in earlier, the time from a new work item proposal to an IEC standard can potentially be measured in years.

Eventually, the move towards CIM should be based on some actual business requirement. So, for example, if the Nordic market clearly starts to move towards harmonization, the time frame for introduction CIM for Fingrid Datahub should be estimated again. Finally, the introduction of new message types for the Datahub is tied to version upgrades of the Datahub system. When planning for the scope of the upcoming versions of the Datahub, the possible introduction of CIM based messages has to be evaluated. Potentially a new study has to be done in order to see if the status of, and requirements towards, harmonization and the status of the CIM model presented in this thesis have significantly changed.

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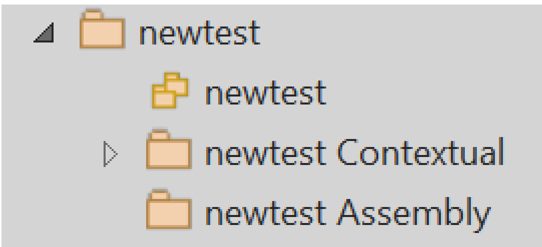
Appendix 1: Mapping table from DH-211 message requirements to CIM Classes

DH-211 Event elements and parameters					ESMP equivalent Class:attribute
Header	**1..1**				
	Message Identification	1..1			MarketDocument:mRID
	Message Type	1..1			MarketDocument:type
	Message Creation Time	1..1			MarketDocument:createdDateTime
	Technical Sender of Message	1..1			SenderTechnical_MarketParticipant:mRID
	Juridical Sender of Message	1..1			SenderJuridical_MarketParticipant:mRID
	Technical Receiver of Message	1..1			ReceiverTechnical_MarketParticipant:mRID
	Juridical Receiver of Message	1..1			ReceiverJuridical_MarketParticipant:mRID
	Sender Routing Data	0..1			?
Process	**1..1**				
	Process Identification	1..1			Process:processType
	Information Exchange role	1..1			MarketRole:marketRoleKind
	Industry	1..1			Process:classificationType
Payload	**1..n**	1			
	Unique transaction ID	1..1			TimeSeries:mRID
	Metering time series identification	0..1			?
	Reporting period	**1..1**			
		Time step	1..1		SeriesPeriod.Resolution
		Start time	1..1		SeriesPeriod.timeInterval
		End time	1..1		
	Metering type	**1..1**			
		Metering time series type	1..1		TimeSeries:product
		Unit	1..1		MeasureUnit:name
	Metering characteristics	**1..1**			
		Metering point type	1..1		TimeSeries.objectAggregation
	Metering point	**1..1**			
		Metering point identification	1..1		MarketEvaluationPoint:mRID
	Area information	**0..1**			
		Metering grid area identification	1..1		Domain:mRID
	Input area	**0..1**			
		Metering grid area identification	1..1		in_Domain:mRID
	Output area	**0..1**			
		Metering grid area identification	1..1		out_Domain:mRID
	Time series values	**1..n**			
		Position	1..1		Point:position
		Values	**1..1**		
			Value	1..1	Point.quantity
			Status	0..1	Point.quality
			Value missing	1..1	No value in Point

Appendix 2: Detailed steps for CIM profile creation with Enterprise Architect

Following steps are required when creating a new profile with the Enterprise Architect software using the IEC CIM 62325 modelling framework and CimConteXtor and CimSyntaxGen plugins. More information can be found in ENTSO-E CIM European style market profile User Guide.

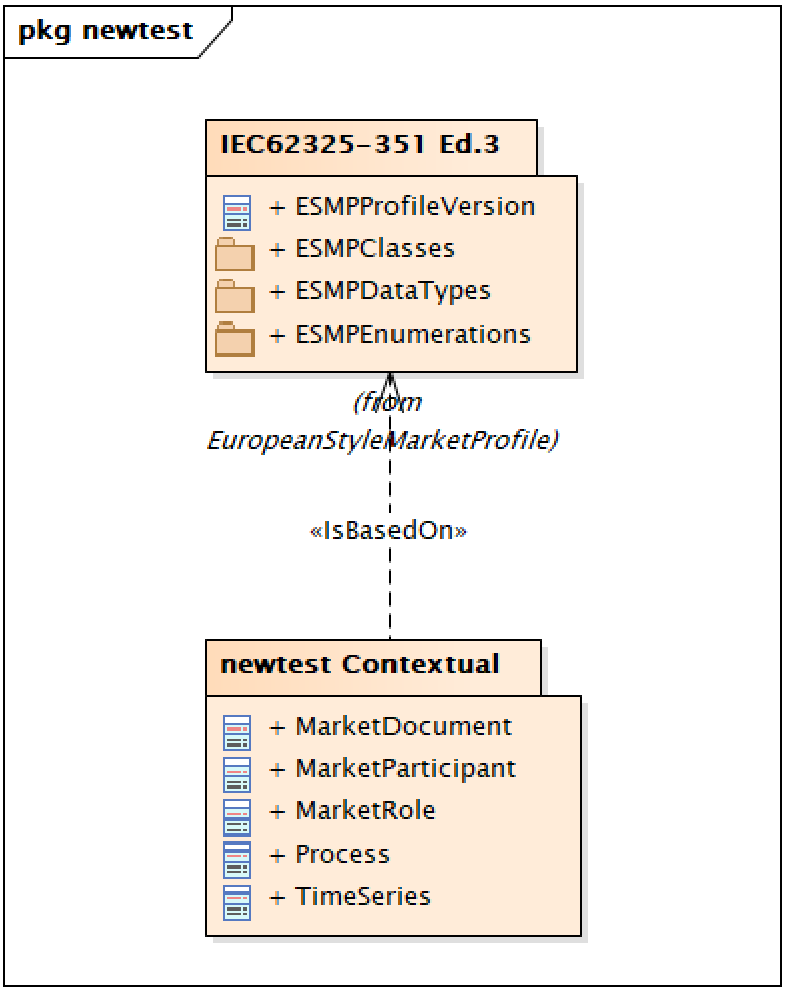
1) Open the EA application and a project file containing the required models. (eg: 20191018_ESMPv4_iec61970cim17v34_iec61968cim13v12_iec62325cim04v04.eap)
2) Within inside the Project Browser, navigate to a package where the new profile will be created (eg. ENTSO-E packages)
3) Inside the package create two additional packages (<profilename> Contextual and <profilename> Assembly) and one package diagram:
   Right-click → Add package. Select package only.
   And Right-click → Add diagram. Select package diagram type.
4) Move the Contextual package above the Assembly package using the arrows in the Project Browser 



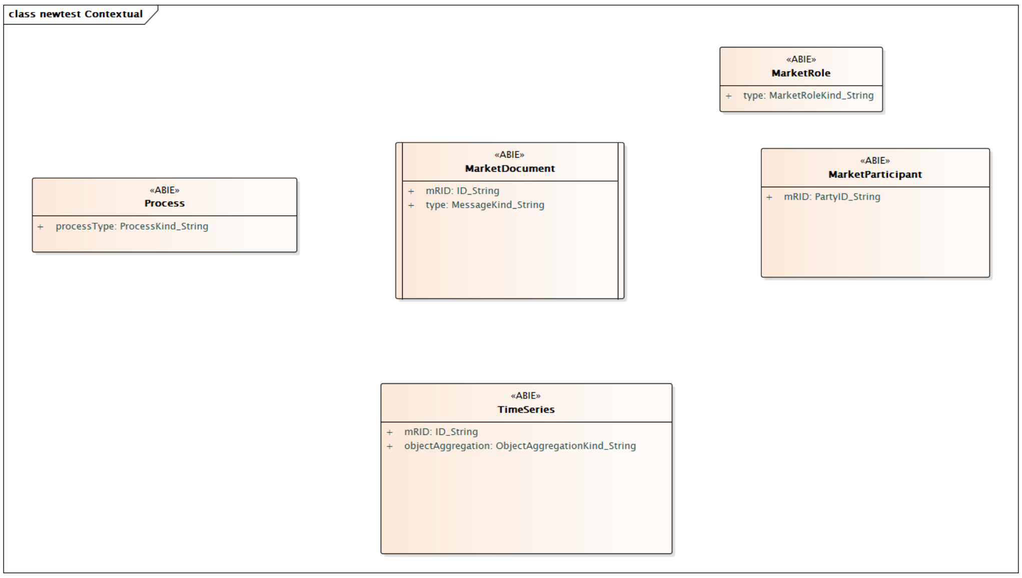
5) Open the newly created package diagram with double click.
6) In the Project Browser, navigate to the package where the profile will be based on (eg. ESMP IEC62325-351 Ed.3) and drag-and-drop it to the package diagram. Select “Package Element” in the dialogue.

7) Drag-and-drop the <profilename> Contextual package to the package diagram. Select “Package Element” in the dialogue.
8) Select the Contextual package in the diagram and click the small arrow and drag to the other package creating a relationship. Select Dependency in the dialogue.
9) Double-click the arrow representing the new dependency. In the new window select “isBasedOn” as the stereotype:

Save the diagram with ctrl+S.

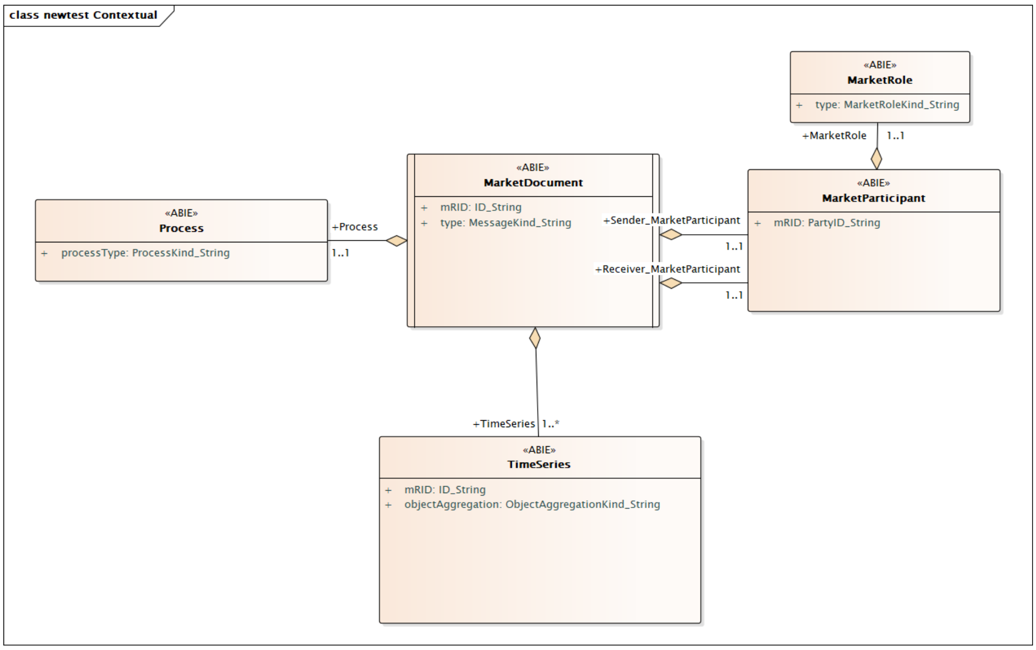


10) Right-click the contextual package in the Project Browser select: Add diagram. Select class diagram type.
11) Into the contextual model diagram drag and drop a class that is required from the profile from which the new profile is based on. (eg. <<ACC>> MarketDocument from ESMP). When prompted by CimConteXtor for isBasedOn, click OK.
12) In the new dialogue, de-select all the attributes that are not required for the profile, and edit each attributes cardinalities accordingly by selecting the attribute and “Edit cardinality”
13) De-select “Copy parent’s stereotype and edit class’s stereotype as “ABIE”.
14) If the class is the first level class (often MarketDocument) select “is root (active)”
15) Select “execute isBasedOn”
16) Do steps 11, 12, 13 and 15 for all the other classes required for the profile.

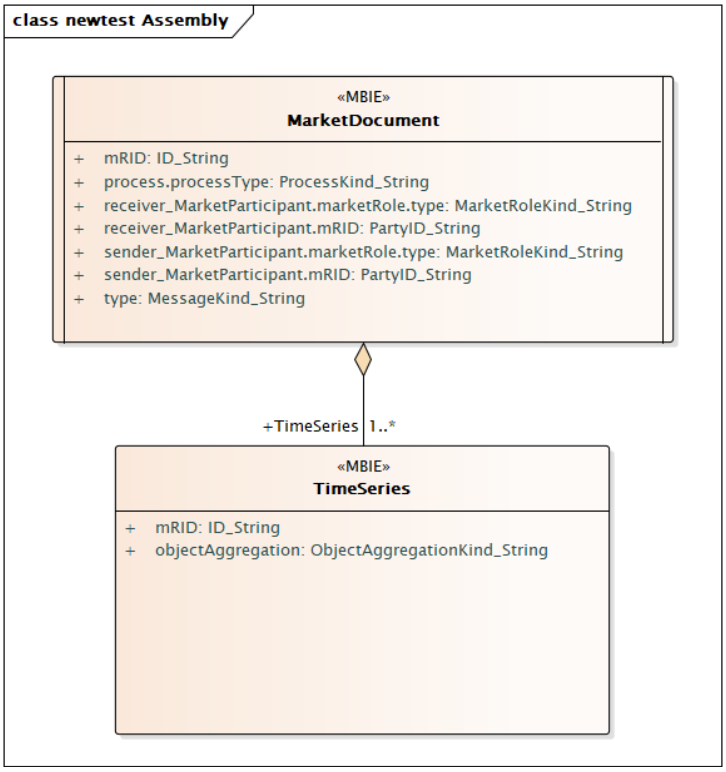


17) In order to create associations between the classes, right click the class and select Specialize→CimConteXtor→Edit hierarchical connectors.
18) In the new window select the required association and “Modify selected association”.

19) Edit the cardinality if required, and add a qualifier to the association if required. Click Save. Add additional associations between the classes if required. Click Save.
20) Do steps 17-19 for all the associations required for the profile. If two associations are created between the same classes, they will appear on top of each other in the diagram but can be dragged to other locations.



21) For each class in the profile, right-click → Specialize → CimConteXtor → "AttributeOrder". Edit the order so that 1..1 attributes are on top, 0..1 second and 1..* next. This step has to be done to all classes even if there is only one attribute.
22) Select the Assembly package in the Profile Browser, right-click → Specialize → CimConteXtor → PropertyGrouping. Select the Contextual package in the new window. Click OK when prompted.
23) Arrange the classes suitably in the Assembly model diagram.



24) Re-order the Contextual and Assembly package so that Contextual is above Assembly.
25) Generate the XSD file: right-click the Assembly package → Specialize → CimSyntaxGen → XSD →XSD WG16.
26) Select a name for the file and fill in other parameters as required. Click OK. XSD is generated.