# Full Prototype of the module for Measurement Data Processing and EUP

## AmI-MoSES Project

### Ambient-Intelligent Interactive Monitoring System for Energy Use Optimisation in Manufacturing SMEs

### FP7-ICT-224250

## Public Project Report

| | | |
|---|---|---|
| **Project Facts:** | **Duration:** | **36 Months (September 2008 – August 2011)** |
| | **Programme:** | **FP7 – ICT** |
| | **Website:** | **http://www.ami-moses.eu** |

The AmI-MoSES Project is co-funded by the European Commission under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme (2007-2013)

This publication was completed with the support of the European Commission under the 7th Framework Programme. The contents of this publication do not necessarily reflect the Commission's own position.

# *Authors and AmI-MoSES Project Partners*

| | |
|---|---|
| **ATB**<br>**Institut für angewandte Systemtechnik Bremen GmbH**<br>**http://www.atb-bremen.de** | **Bremen**<br>**Germany** |
| **TECNALIA**<br>**http://www.tecnalia.com** | **Derio**<br>**Spain** |
| **RIFOX – Hans Richter GmbH Spezialarmaturen**<br>**http://www.rifox.de** | **Bremen**<br>**Germany** |
| **Vicinay Cadenas Sociedad Anonima**<br>**http://www.vicinaycadenas.com** | **Bilbao**<br>**Spain** |
| **MB Air Systems Limited**<br>**http://www.mbairsystems.co.uk** | **Wishaw**<br>**United Kingdom** |
| **Reimesch Kommunikationssysteme GmbH**<br>**http://www.reimesch.de** | **Bergisch-Gladbach**<br>**Germany** |
| **Disseny I Subministres Tecnics, S.A.**<br>**http://www.distec.org** | **Girona**<br>**Spain** |
| **Solvera Lynx d.d.**<br>**http://www.solvera-lynx.com** | **Ljubljana**<br>**Slovenia** |
| **Valtion Teknillinen Tutkimuskeskus**<br>**http://www.vtt.fi** | **Espoo**<br>**Finland** |

# Summary

The AmI-MoSES project is about realising an innovative, beyond the state-of-the-art solution for Energy Efficiency optimisation in manufacturing companies. The solution is based on a novel approach to energy consumption monitoring by introduction of so-called Ambient Intelligence parameters and on the combination of so extended data set with Knowledge Management technologies to realise a decision support system as an innovative extended Energy Management Systems. Viability of the AmI-MoSES system functionalities is to be proved in three typical manufacturing companies, within three business cases (BC) defined as a baseline for the project realisation.

This document presents a short description of the implemented full prototype of one AmI-MoSES subsystem – subsystem for “Measurement Data Processing and Energy Use Parameters Definition, Monitoring and Advisory”. Measurement Data comprise standard Energy Consumption Data and additional, ambience based parameter measurements, whereas Energy Use Parameters are parameters derived from the measurement data, used for Energy Efficiency monitoring.

The full prototype is developed according to the specification, refined and completed based on the early prototype testing and on the comments from the AmI-MoSES project reviewers. Testing and justification of the system concepts are running, facilitating gathering of additional requirements and ideas for the ICT system improvement.

This document comprises an introductory chapter 1 with short description of the document purpose and structure. Chapter 2 gives an overall description of the system, technical details on the platform architecture and used software tools. Chapter 3 presents the system functionalities for Measurement Data Processing and EUP Definition, Monitoring and Advisory – illustrated by screen shots of the implemented functionalities. Chapter 4 is dedicated to the concluding remarks.

The full prototype of the module for Measurement Data Processing and EUP, briefly presented here is currently being tested and assessed in the three demonstrators, both as a separate part (AmI-MoSES subsystem) and within the integrated full prototype of the AmI-MoSES ICT system.

*Table of Contents*

**1 Introduction ........ 11**
1.1 Objectives of the document ........ 11
1.2 Document Structure ........ 11
**2 Overall Sub-System Description ........ 12**
2.1 Implementation Tools and Deployment ........ 12
2.2 Software Architecture ........ 13
**3 Sub-System Functionality ........ 14**
3.1 Login and Sub-system selection ........ 14
3.2 Measurement Data Processing ........ 15
3.2.1 Connection between data sources and Data Collectors ........ 16
3.2.2 Connection between Data Collector and Data Concentrator ........ 16
3.2.3 Connection between Data Concentrator and AmI-MoSES platform ........ 16
3.2.4 AmI-MoSES Data Submission Web Service ........ 16
3.2.5 Measuring Device Definition ........ 19
3.2.6 ECD and AmI Data Processing ........ 21
3.3 EUP Model definition ........ 21
3.4 EUP Monitoring and Advisory ........ 25
**4 Conclusions ........ 29**

## *Abbreviations*

| | |
|---|---|
| AmI | Ambient Intelligence |
| API | Application Programming Interface |
| BC | Business Case |
| BIRT | Business Intelligence and Reporting Tools |
| CSV | Comma-separated values |
| ECD | Energy Consumption Data |
| etc. | et cetera |
| EU | European Union |
| EUP | Energy Use Parameters |
| GSM | Global System for Mobile Communications |
| GUI | Graphical User Interface |
| HTTP | Hypertext Transfer Protocol |
| HW | Hardware |
| $I^2C$ | Inter-Integrated Circuit |
| ICT | Information and Communication Technology |
| i.e. | id est = that is to say |
| JDBC | Java Database Connectivity |
| JSF | Java Server Faces |
| M-Bus | Meter-Bus |
| MCU | Microcontroller Unit |
| PDF | Portable Document Format |
| PI | Performance Indicator |
| RFID | Radio-frequency identification |
| SOAP | Simple Object Access Protocol |
| SPI | System Packet Interface |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| UML | Unified Modelling Language |
| UMTS | Universal Mobile Telecommunications System |
| XML | Extensible Markup Language |
| WLAN | Wireless Local Area Network |
| WSDL | Web Services Description Language |

# 1 Introduction

This document is a part of the AmI-MoSES deliverable D3.4 and presents a short description of the software implemented as the full prototype of the Measurement Data Processing and Energy Use Parameters (EUP) Management sub-system. The main part of the deliverable D3.4 is the implemented software itself.

It should be kept in mind that the module for Energy Consumption Data processing and Energy Use Parameters management described in the following is not a standalone system but part of an integrated system comprising this module and the AmI-MoSES Service Platform and belonging Services, which are described in deliverable D4.4 – Full Prototype of the AmI-MoSES Service Platform. The document D5.3 – AmI-MoSES Full Prototype presents in detail the Energy Efficiency Services as a top functionality coming out of the subsystems described in D3.4 and D4.4.

The full prototype of Measurement Data Processing and EUP, briefly presented here was implemented based on the "Specification of Measurement Data Processing and EUP" and results of the testing of the early prototype, described in the deliverables "Early prototype of the module for Measurement Data Processing and EUP" (D7.5) and Early prototype Assessment. It will be tested and assessed as a separate part (AmI-MoSES subsystem) as well as within the integrated full prototype of the AmI-MoSES ICT system. Results of the testing and assessment are believed to provide valuable feedback for further developing the prototype into a viable commercial solution.

The examples described in the following are applications of the AmI-MoSES platform in the Business Cases of the company Vicinay, manufacturer of mooring chains, and in the company RIFOX, manufacturer of steam traps. Vicinay has rather energy intensive manufacturing processes and a variety of parameters, which can significantly contribute to a more intelligent monitoring and creation of a high resolution picture of energy consumption. On the other hand RIFOX steam traps are, when out of order, very serious origin of energy loss in different user's plants. The additional, ambiance stemming, parameters are currently not used for energy consumption monitoring and their inclusion – through use of the AmI-MoSES platform – allows for an innovative, knowledge based, approach in the Energy Efficiency optimisation.

The document presents the current status of the AmI-MoSES full prototype system development, and does not represent documentation of the software developed or to be developed in the scope of the project.

## 1.1 Objectives of the document

The objective of this document is to provide basic technical facts about the full prototype and an overview of its functionalities. Its purpose is to support the understanding of the structure and usage of the prototype system, to support the prototype testers either as end users or independent testers and to facilitate collection of feedback from the testers.

## 1.2 Document Structure

This document is divided into two main parts, the first one (Chapter 2) provides an overall description of the system, whereas the second one (Chapter 3) documents the system's functionality regarding Measurement Data Processing, EUP Definition and EUP Monitoring and Advisory.

Chapter 4 presents short conclusions about the implemented system prototype.

# 2 Overall Sub-System Description

The AmI-MoSES Measurement Data Processing and EUP Management sub-system has three main parts:

- The *Measurement Data Processing* module provides a web service interface for importing measurement data from Energy Consumption Data and AmI parameter measurement devices or other data sources into the AmI-MoSES platform. This module processes the incoming data to build context out of and around the measured data to allow for a high-resolution picture of current energy use.
- The *EUP Definition* module provides a user interface for configuring Energy Use Parameters (EUP) and Energy Consumption Data (ECD) / AmI Data variables.
- The *EUP Monitoring and Advisory* module provides a user interface for monitoring EUP and measurement data values, for producing report documents and for exporting the data to spreadsheet tools. In addition, this module contains components for extrapolation of EUP value development to allow for prognosis when an EUP might leave the predefined value range, i.e. to advise users on possible incoming problems.

The measurement data manager implements a web service interface that allows client software or intelligent devices to post measurement data into the AmI-MoSES platform. The measurement data is stored into the database and all dependent EUPs are re-evaluated. An event is sent to notify the energy efficiency services of the presence of new data, which is then checked for any warning conditions or other causes for action.

The EUP Definition module is used for configuring the handling of both measured data and the corresponding EUPs. This module is typically used in the initial set-up phase before the measurements are started, but changes to the configuration can be made also on a running system.

The EUP monitoring and advisory module is used for gathering data of energy usage. It allows the user to gain a quick overview of the current state of the system, and provides numeric and graphical output of the history of the data. Reports can be generated in various document formats or previewed online as web pages. The raw data can be exported into Excel or CSV files for further analysis in external tools.

## 2.1 Implementation Tools and Deployment

The AmI-MoSES platform and the measurement data processing and EUP management module are implemented using standard Java Enterprise Edition technologies. The prototype system runs on top of the JBoss Application Server, but can be deployed to other server technologies as well as long as they are Java EE 5 compliant.

All user interfaces of the system are accessed through a web-based interface. No special software is needed to install on user workstations. The user interfaces are implemented using Java Server Faces technology, and they utilize advanced user interface components from the JBoss RichFaces project. These technologies enable provision of a responsive and dynamic interface to the system by utilizing the full potential of the latest web technologies.

The data storage needs of the AmI-MoSES platform are handled through Java Persistence API on top of the Java Database Connectivity API, which allows the flexible use of many different database management systems. The prototype implementation uses MySQL, but any other JDBC- and Hibernate-compatible database management system can be used. This leaves the users free to leverage their existing data management systems.

The JBoss Seam framework (version 2) is used for integration of the system using context and dependency injection, which minimizes dependencies between the system components and allows fine-grained maintenance of the system.

## 2.2 Software Architecture

The AmI-MoSES platform has three-tiered software architecture (see Figure 1). The system is divided into three layers: presentation (or user interface), service (or business logic) and persistence (or data management). The user interface layer is built from JSF pages served through servlets on the web server. Calls to code in the business logic layer are delivered though the Seam framework. The calls are handled by Seam components that are implemented as either plain Java objects or Enterprise Java Beans, depending on the needs of the functionality.

Data from the data management layer is transferred to the upper layers as entity objects and stored in a relational database through the standard Java Persistence API interface provided by the JBoss Hibernate library. The entity object code is created automatically from a graphical UML diagram design by using the AndroMDA framework for model driven architecture.

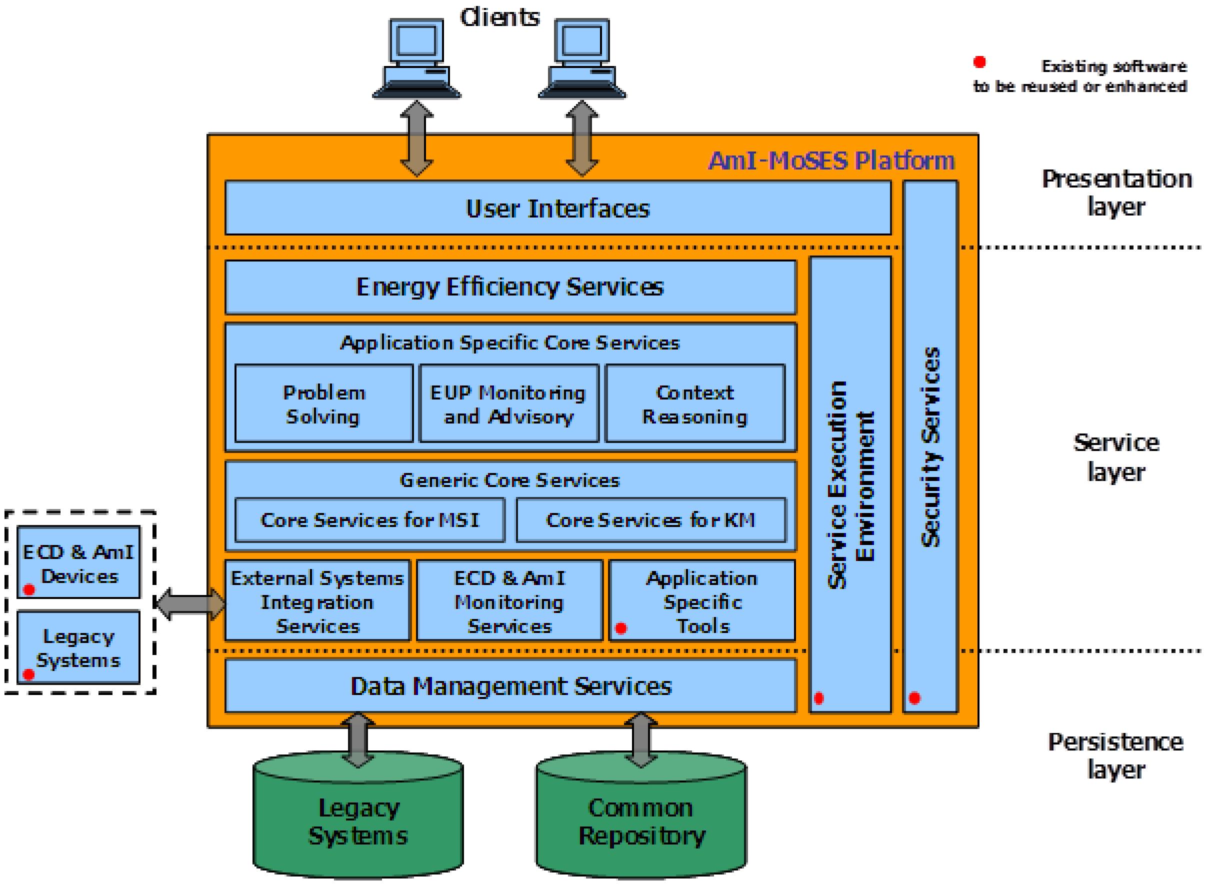


Figure 1: AmI-MoSES Full Prototype Implementation Architecture

# 3 Sub-System Functionality

Functionality of this sub-system is presented starting from the general system GUIs for Login and selection of the corresponding functionalities and followed by the sub-system particular functionalities.

## 3.1 Login and Sub-system selection

Figure 2 below shows the initial login screen of the AmI-MoSES system. A role is defined for each user. This role determines the functions of the system that the user can access. All the screens in this document show the main menu as it would be shown to an administrator of the system, which has full access rights to all features.

Figure 3 shows the main welcome screen of the AmI-MoSES system. The left hand part of the view shows a global menu of the different modules of the AmI-MoSES system. The contents of this menu depend on the access rights of the user. The top-most part of the view below the banner is a location that is used for showing possible messages to the user.

The welcome screen shows an overview of the state of the system, and especially informs the user of the presence of any possible alert conditions that have been triggered and that require action by the user.

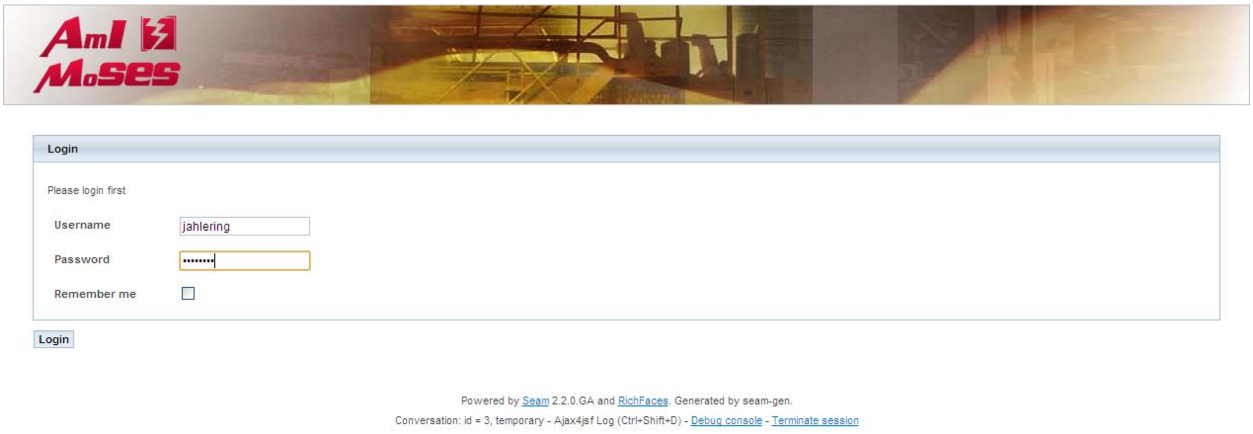


Figure 2: The login screen

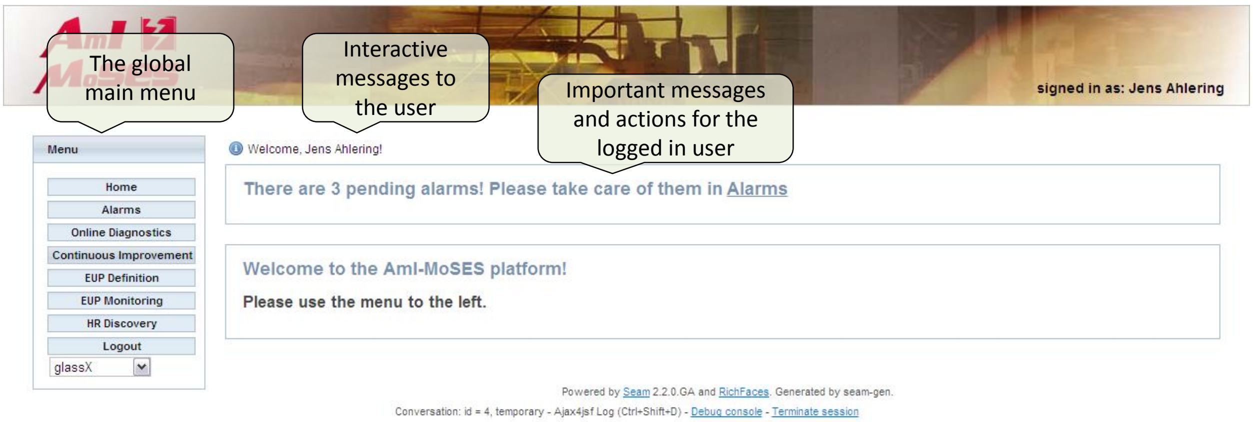


Figure 3: The main welcome screen of the AmI-MoSES system

## 3.2 Measurement Data Processing

The hardware unit used for ECD and AmI-data gathering envisages two types of devices: Data Concentrator and Data Collector. Figure 5 shows the concept of Data Collector/Concentrator focusing on the dataflow and interfaces from ECD and AmI data sources up to the AmI-MoSES platform. The Data Concentrator hardware unit is depicted in Figure 4.


Figure 4: Prototype of Data Concentrator hardware unit and wireless AmI Data sources (temperature sensors)

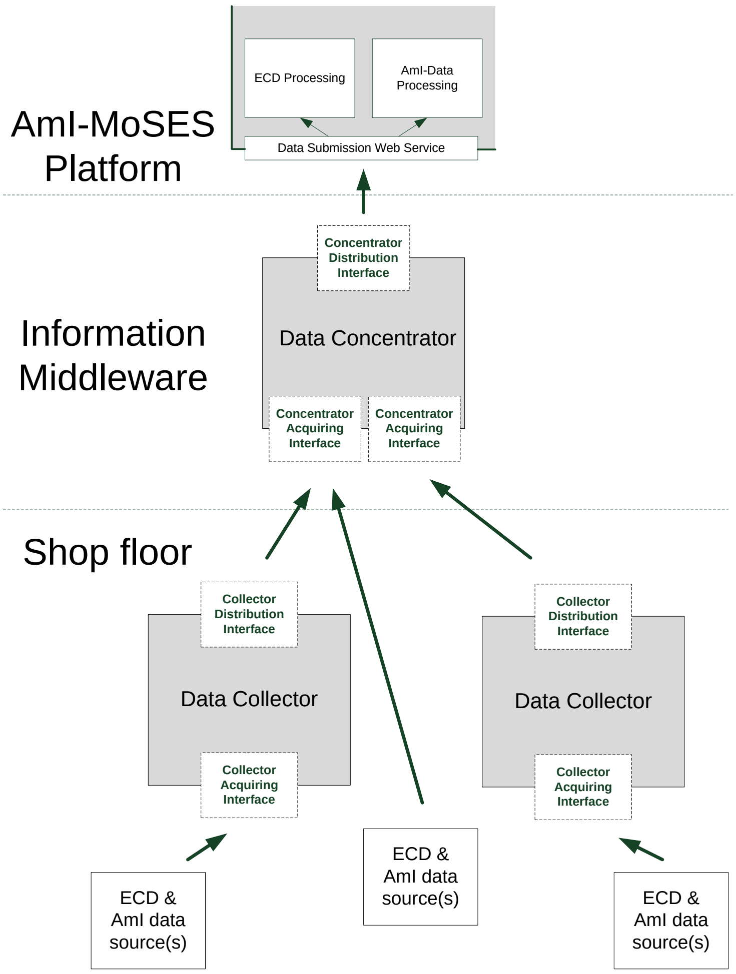


Figure 5: ECD and AmI data integration via Data Collector and Data Concentrator

The data collected in shop floor is transmitted to the AmI-MoSES platform via Data Concentrator (Information middleware level). A Data Collector collects data from one or more data sources, which can be sensors/meters or other sources (like RFID-reader providing event data). In a second step the Data Concentrator forwards data to the AmI-MoSES platform.

### 3.2.1 Connection between data sources and Data Collectors

The existing metering infrastructure of individual processes/plants can be reused as much as possible whereby different communication standards can be expected (e.g. RS232/485 (different protocols possible on RS485), S0-interface (impulse counting), different data busses, etc.) and corresponding support is provided.

One Data Collector can interface n data sources whereby n depends on the used standard. Both the Collector Acquiring and Distribution Interface limit the possible number of nodes. This limit results from electrical specification, available bandwidth (and thus frequency of measurement) or duty cycle restrictions of radio communication. As far as possible, measurement data from smart meters/devices will be directly received by the Data Concentrator Acquiring Interface, bypassing Data Collector, or even directly fed to the Service platform in the case of smaller number of data sources.

### 3.2.2 Connection between Data Collector and Data Concentrator

The Data Collector pushes forward data to information middleware level. Data Concentrators and Collectors can support different communication interfaces and protocols. A specific Data Collector's Distribution Interface has to be combined with a matching concentrator-side acquiring interface, according to the local conditions of a particular business case. Main criteria are the range needed, existing wiring (power and interfaces), and number of data sources to attach or possible disturbances for radio communication. Depending on these criteria different wired or wireless communication interfaces are of interest, including e.g. RS232/485 (especially for direct connection from data source to Data Concentrator), M-Bus (wired), WM-Bus (wireless), ZigBee, etc.

In order to fit actual and future requirements the Concentrator Acquiring Interfaces will be modular attachable to the Data Concentrator via peripheral bus like $I^2C$ or SPI. Each Acquiring Interface has a MCU which handles the data received from the Collector Distribution Interface and presents the data to the Concentrator in a common way which will be equally among every Concentrator Acquiring Interfaces. Thus Data Concentrator will support beside the above listed an arbitrary number of common and future communication interfaces and protocols.

### 3.2.3 Connection between Data Concentrator and AmI-MoSES platform

The communication between Data Concentrator and AmI-MoSES platform – ECD and AmI data processing module will be done by sending SOAP messages to a Data Submission web service. Any TCP/IP capable HW interface is suitable for this task and Data Concentrator has support for the following wired and wireless interfaces:

- Ethernet (10Base-T/100Base-TX)
- WLAN
- GSM/UMTS Modem

The Data Concentrator supports at least two Distribution interfaces at the same time, whereas Ethernet is the preferred interface due to bandwidth, reliability and cost factors.

### 3.2.4 AmI-MoSES Data Submission Web Service

The web service, which receives collected measurement data, has been implemented as part of the External Systems Integration Services (see Figure 1) on the AmI-MoSES platform side and is deliberately kept as simple and flexible as possible. Therefore, it offers a single entry point in form of a SOAP-XML based web service to submit measured data to the AmI-MoSES platform. As described above (see section 3.2.3) this entry point can be accessed using standard internet protocols (SOAP over HTTP) and thus allows for a wide range of possible clients to connect to the web service – and is not limited to the use of Data Concentrator described above (see sections 3.2.1 through 3.2.3).

Furthermore, the required data to be passed to the web service is kept at a minimal level; specifically only three parameters are required:

- measurementDeviceExternalId – the sending measuring device's identifier
- timestamp – timestamp in Milliseconds (standard UNIX format) when the data was measured
- value – the actual measured value (as a decimal number)

The only requirement on the side of the AmI-MoSES platform is that the sending measuring device is modelled in the Knowledge Repository with the same identifier that is transmitted to the data submission web service. All additional information about the measurement data, like type and unit, is being taken from the Knowledge Repository (see also section 3.2.5) to avoid redundant transmission.

The data submission web service's WSDL file is displayed below:

```
<definitions name='measurementDataManagerService' target-
Namespace='http://ami.ws.amimoses.eu/' xmlns='http://schemas.xmlsoap.org/wsdl/'
xmlns:soap='http://schemas.xmlsoap.org/wsdl/soap/'
xmlns:tns='http://ami.ws.amimoses.eu/' xmlns:xsd='http://www.w3.org/2001/XMLSchema'>

 <types>

  <xs:schema targetNamespace='http://ami.ws.amimoses.eu/' version='1.0'
xmlns:tns='http://ami.ws.amimoses.eu/' xmlns:xs='http://www.w3.org/2001/XMLSchema'>

   <xs:element name='MeasurementDeviceNotFoundException'
type='tns:MeasurementDeviceNotFoundException'/>

   <xs:element name='storeMeasurementData' type='tns:storeMeasurementData'/>

   <xs:element name='storeMeasurementDataResponse'
type='tns:storeMeasurementDataResponse'/>

   <xs:complexType name='storeMeasurementData'>

    <xs:sequence>

     <xs:element minOccurs='0' name='arg0' type='xs:string'/>

     <xs:element minOccurs='0' name='arg1' type='xs:long'/>

     <xs:element minOccurs='0' name='arg2' type='xs:double'/>

    </xs:sequence>

   </xs:complexType>

   <xs:complexType name='storeMeasurementDataResponse'>

    <xs:sequence/>

   </xs:complexType>

   <xs:complexType name='MeasurementDeviceNotFoundException'>

    <xs:sequence>

     <xs:element minOccurs='0' name='message' type='xs:string'/>

    </xs:sequence>

   </xs:complexType>

  </xs:schema>

 </types>

 <message name='measurementDataManagerService_storeMeasurementData'>
```

```
  <part element='tns:storeMeasurementData' name='storeMeasurementData'></part>
 </message>
 <message name='measurementDataManagerService_storeMeasurementDataResponse'>
  <part element='tns:storeMeasurementDataResponse'
name='storeMeasurementDataResponse'></part>
 </message>
 <message name='MeasurementDeviceNotFoundException'>
  <part element='tns:MeasurementDeviceNotFoundException'
name='MeasurementDeviceNotFoundException'></part>
 </message>
 <portType name='measurementDataManagerService'>
  <operation name='storeMeasurementData' parameterOrder='storeMeasurementData'>
   <input message='tns:measurementDataManagerService_storeMeasurementData'></input>
   <output mes-
sage='tns:measurementDataManagerService_storeMeasurementDataResponse'></output>
   <fault message='tns:MeasurementDeviceNotFoundException'
name='MeasurementDeviceNotFoundException'></fault>
  </operation>
 </portType>
 <binding name='measurementDataManagerServiceBinding'
type='tns:measurementDataManagerService'>
  <soap:binding style='document' transport='http://schemas.xmlsoap.org/soap/http'/>
  <operation name='storeMeasurementData'>
   <soap:operation soapAction=''/>
   <input>
    <soap:body use='literal'/>
   </input>
   <output>
    <soap:body use='literal'/>
   </output>
   <fault name='MeasurementDeviceNotFoundException'>
    <soap:fault name='MeasurementDeviceNotFoundException' use='literal'/>
   </fault>
  </operation>
 </binding>
 <service name='measurementDataManagerService'>
  <port binding='tns:measurementDataManagerServiceBinding'
name='measurementDataManagerServicePort'>
   <soap:address location='http://www.ami-moses.eu/amimoses-
amimoses/MeasurementDataManagerWSBean'/>
  </port>
 </service>
</definitions>
```

### 3.2.5 Measuring Device Definition

The AmI-MoSES platform provides a GUI for introducing measuring devices into the Common Knowledge Repository. This step is necessary to enable the AmI-MoSES platform to determine which device – and eventually EUP – incoming measurement data is to be related to. Thus, when installing new ECD/AmI Data measuring devices or (re)-configuring existing ones a user has to make these changes known to the AmI-MoSES platform. Via the menu entry “EUP Definition” a user with the appropriate rights is able to see the list of already defined measuring devices (see Figure 6).

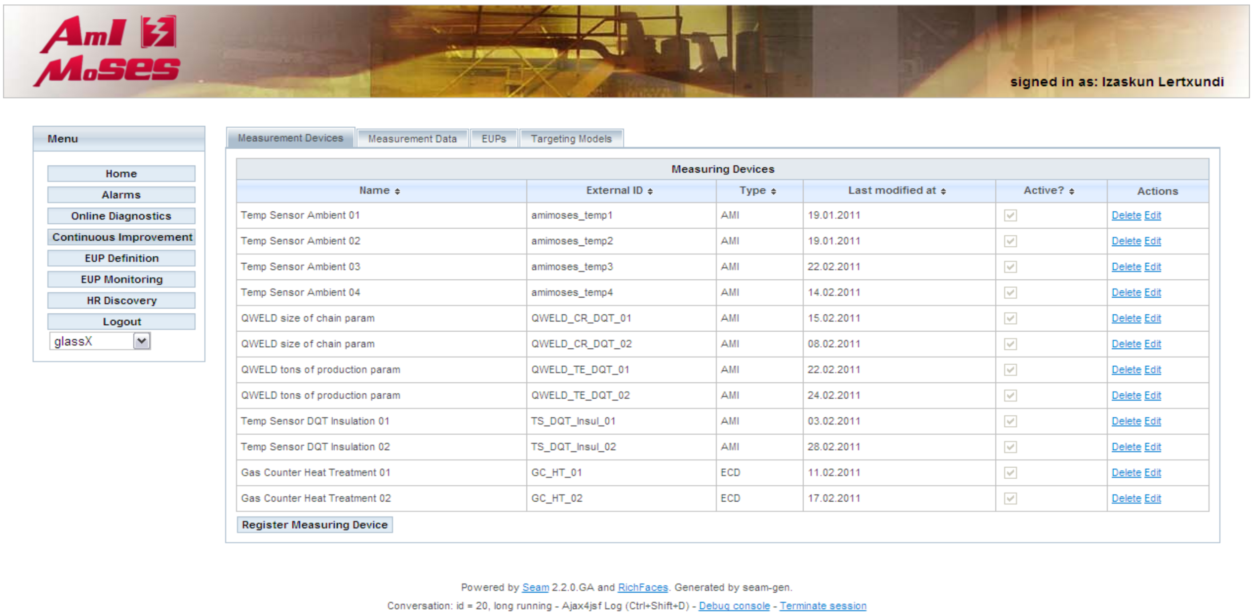


Figure 6: EUP definition module, Measuring Devices tab

In this GUI a user may edit existing measuring devices – using the “Edit” link – or even remove those devices altogether – using the “Delete” link. In case the user tries to delete a measuring device, which is still used within an active EUP, i.e. its measuring data is still needed, the action is prohibited and a corresponding warning message is displayed (see Figure 7), which is an illustration of the system robustness against unauthorised and/or erroneous activities.

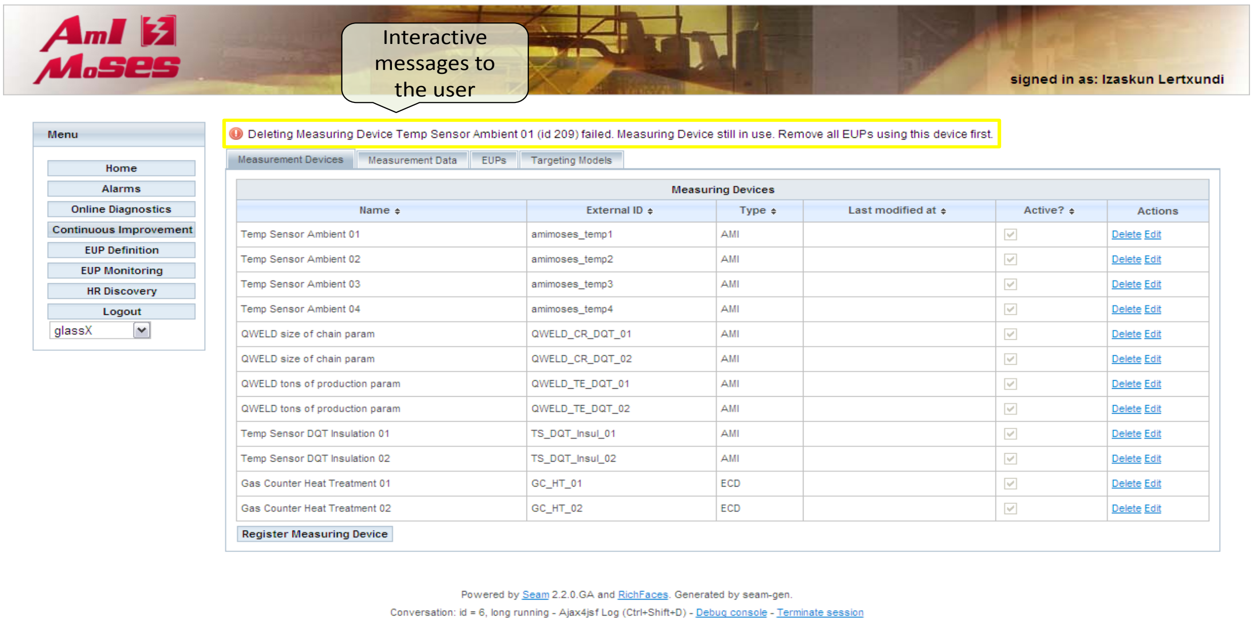


Figure 7: Deleting a measuring device that is still in use

Clicking the "Register Measuring Device" button allows a user to introduce a new measuring device into the Knowledge Repository – see Figure 8 for a VICINAY example and Figure 9 for a RIFOX example).

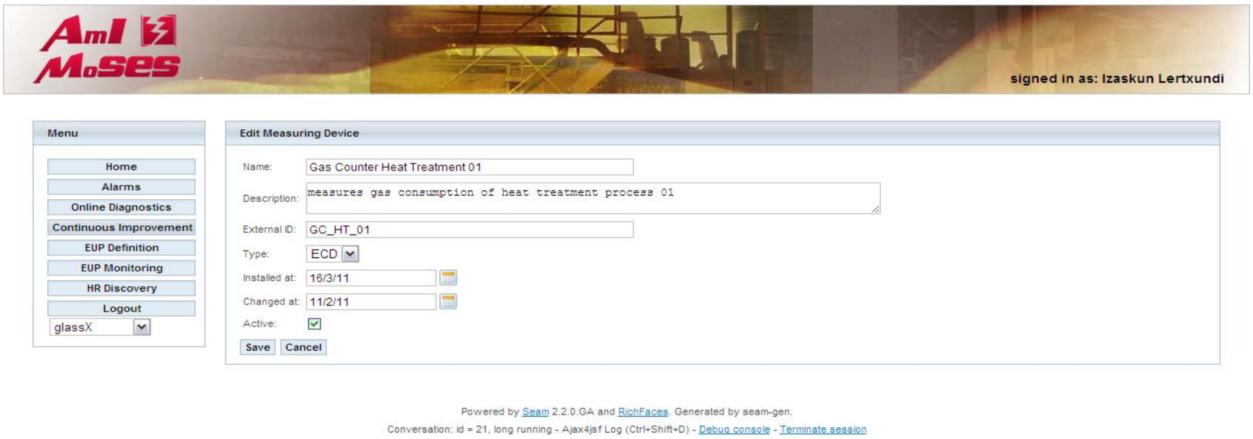


Figure 8: Registering a new measuring device

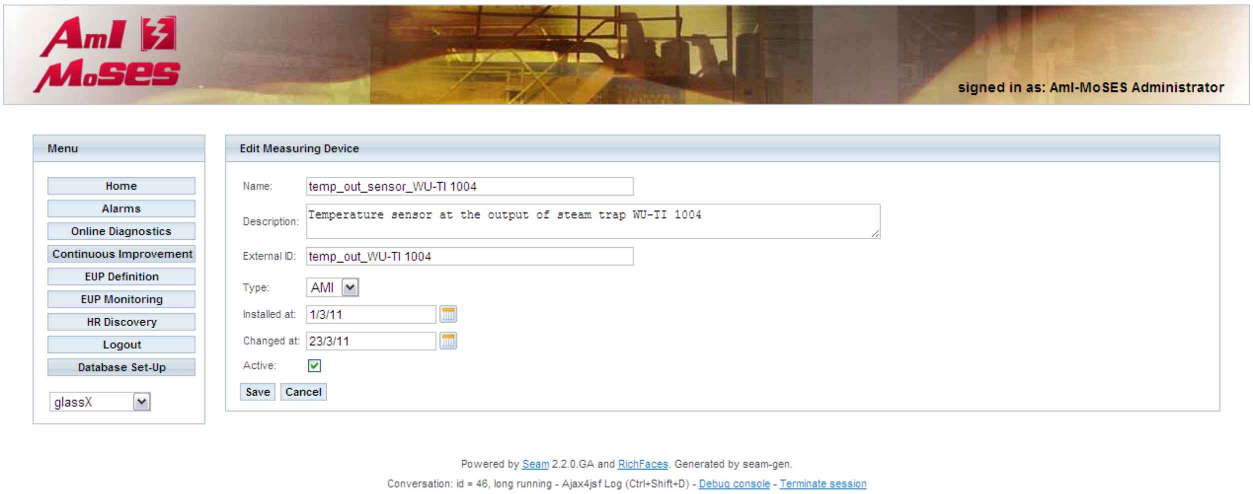


Figure 9: Registering a new measuring device (BC RIFOX)

It is crucial to define an appropriate "External ID" to enable the data submission web service (see section 3.2.4) to identify which measuring device incoming data must be referenced with – based on the transmitted "External ID". If however the External ID field is left empty, creation of the new measuring device is denied and an appropriate error message displayed (Figure 10).

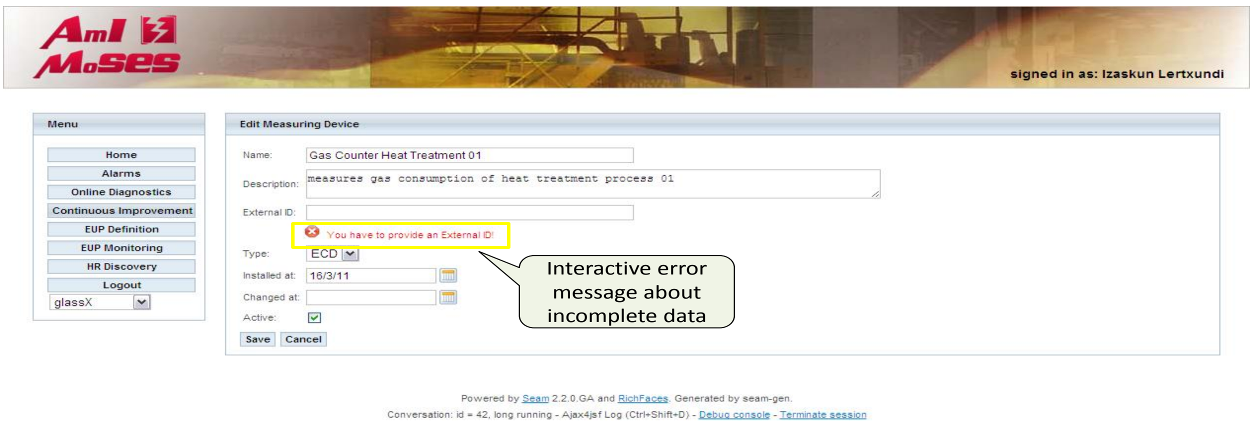


Figure 10: Incomplete data for measuring device

### 3.2.6 ECD and AmI Data Processing

The ECD and AmI Data Processing components allow the AmI-MoSES platform to handle incoming ECD and AmI data that has been measured by different ECD and AmI devices and transferred to the platform via data collectors and concentrators. AmI data are used to build a contextual model, which will be used with ECD for EUP calculation. The process is as follows:

Based on the ECD/AmI devices' ID (passed to the Data Submission Web Service) the received data is associated to the corresponding device in the Knowledge Repository. If necessary, the data values' data format is transformed to the one used in the Knowledge Repository. All EUPs for which the received data are relevant (i.e. EUPs that use the corresponding ECD and AmI data in their calculations) are retrieved from the Knowledge Repository. If an EUP's calculation tact differs from the ECD's sending tact, the available data are appropriately aggregated (e.g. by creating a mean value) to fit the EUP calculation tact. Data received in the past might be retrieved from the Knowledge Repository as well for aggregation purposes if necessary. The transformed ECD data is then stored in the Knowledge Repository, whereas AmI data is going through an additional enhancement step. This enhancement step incorporates the following procedure: all EUPs, for which the received AmI data is relevant, and their related context data are gathered from the Knowledge Repository. Relationships between new AmI data and retrieved context data are then established and the new AmI data is inserted into the current context. Afterwards the enhanced context data is stored in the Knowledge Repository.

## 3.3 EUP Model definition

The EUP Model definition module is activated by clicking on the "EUP Definition" button in the main menu. The initial view of the module is shown in Figure 11. This view is divided into four tabs that are used for the definition of measuring devices (see section 3.2.5), measurements (ECD and AmI Data), energy use parameters (EUP) and targeting models. Each of these tabs contains a list of existing entries and a command button for creating new entries. The links for each existing entry on the right hand side of the table allow the user to edit or delete the existing entries. The screenshots in the text to follow are mostly depicting examples from BC VICINAY. The screenshots depicting examples from BC RIFOX are explicitly labelled with (BC RIFOX).

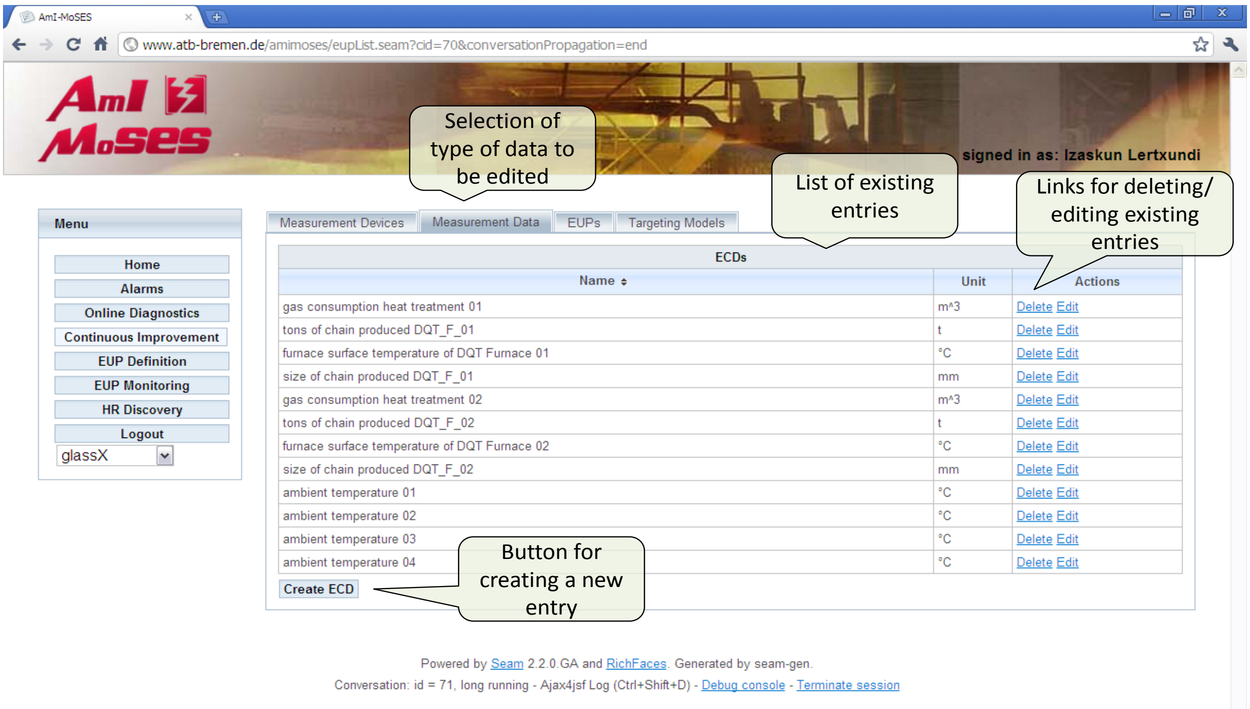


Figure 11: Main view of the EUP definition module, Measurement Data tab

Measurement data are data streams that are produced by a measurement device connected to the system. The editing view (Figure 12, Vicinay and Figure 13, RIFOX) for measurement data allows the user to give the variables a context by selecting a production unit, a process step and / or a product part to which the variable is related.

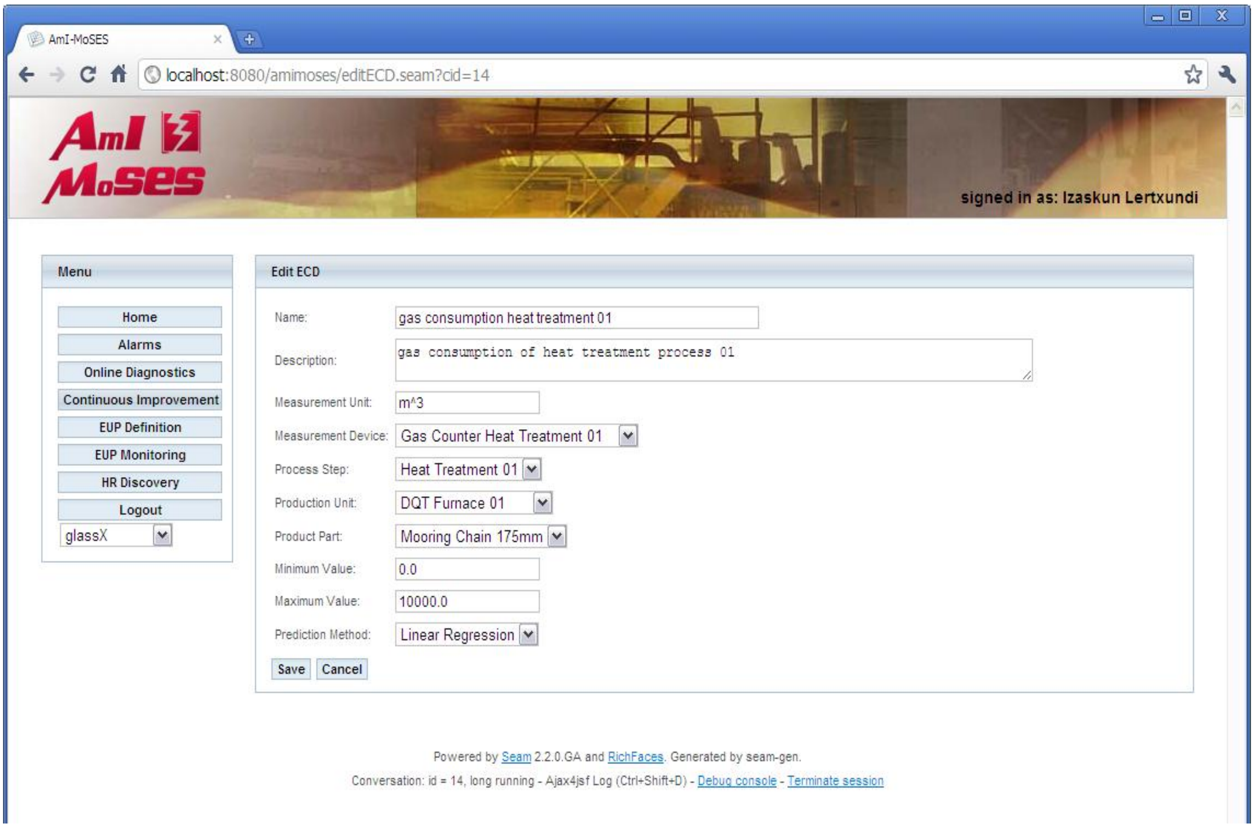


Figure 12: Measurement data editor view

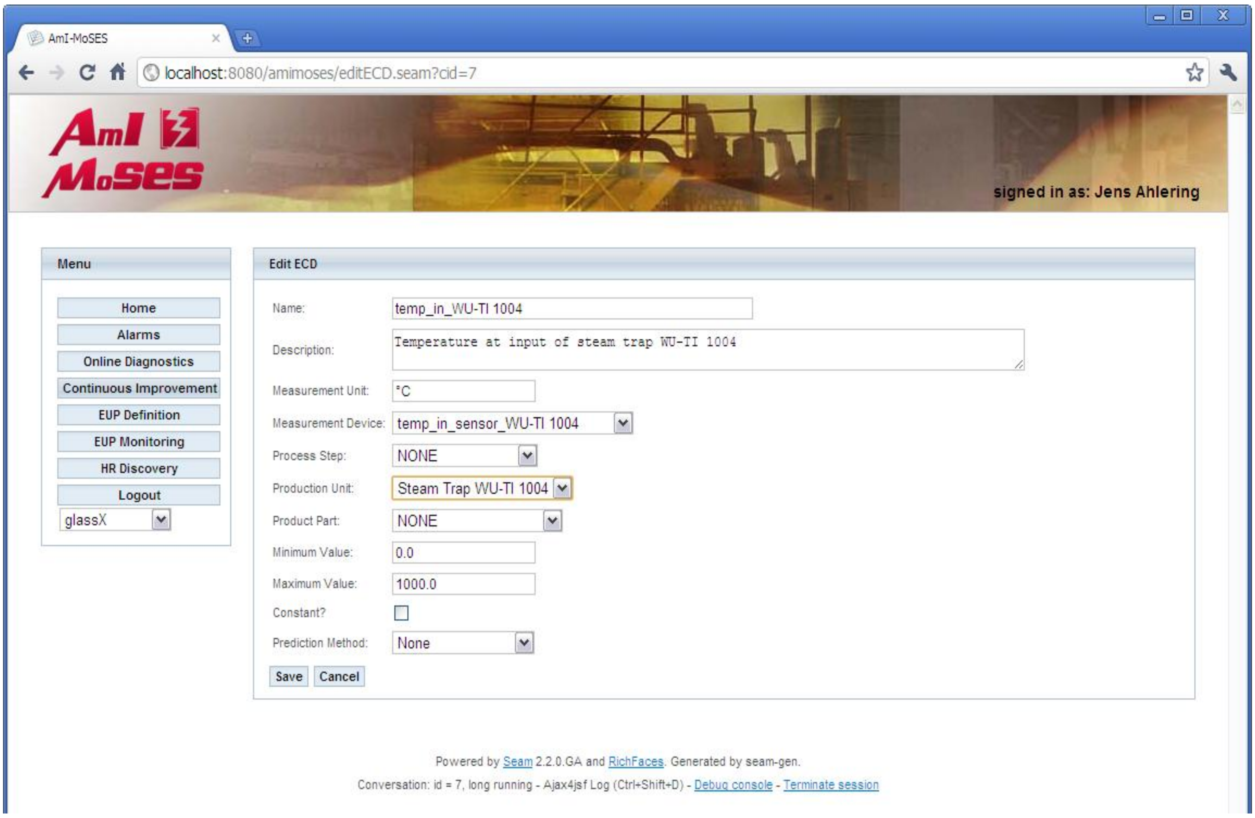


Figure 13: Measurement data editor view (BC RIFOX)

New EUP variables can be created by applying a mathematical operation to existing variables or constant values (Figure 14 Vicinay and Figure 15 RIFOX). Constants can be created directly in the EUP editor view.

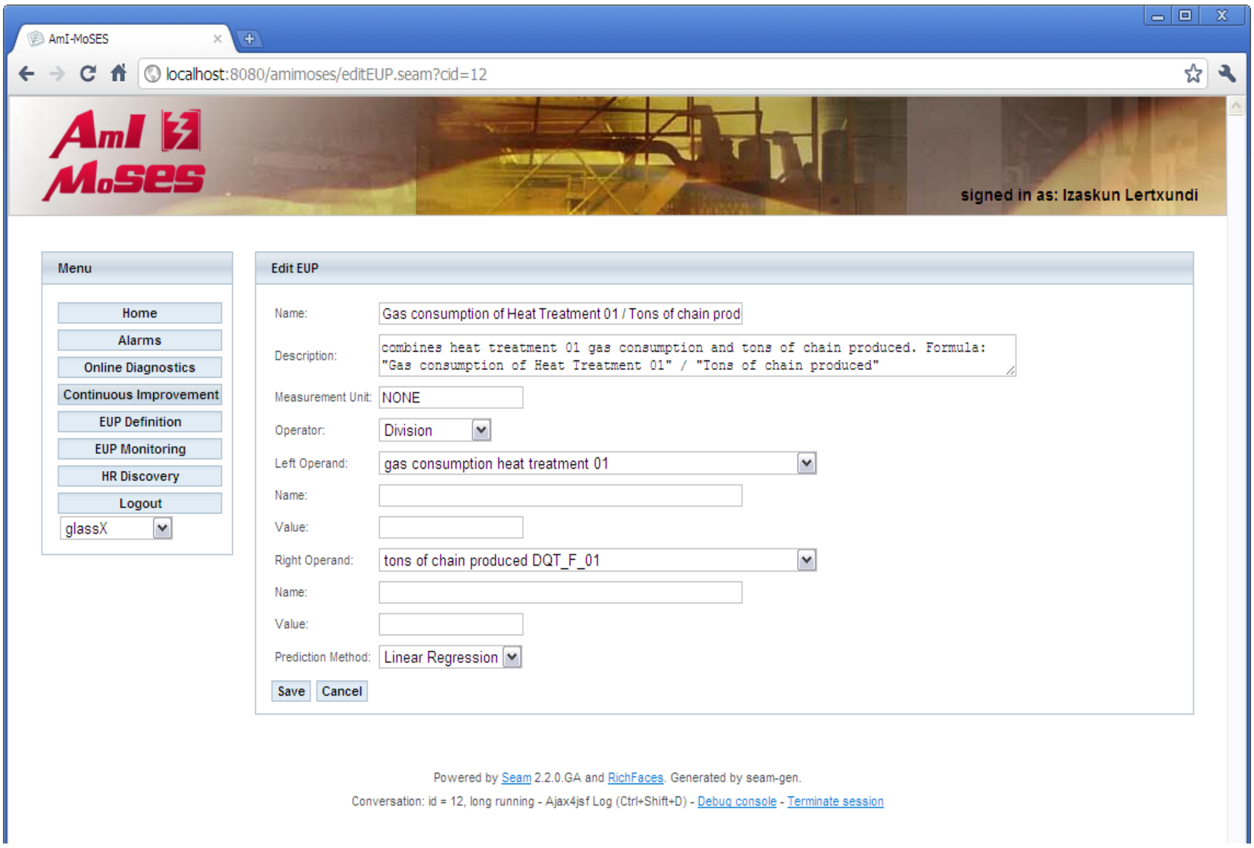

Figure 14: Composite EUP editor view

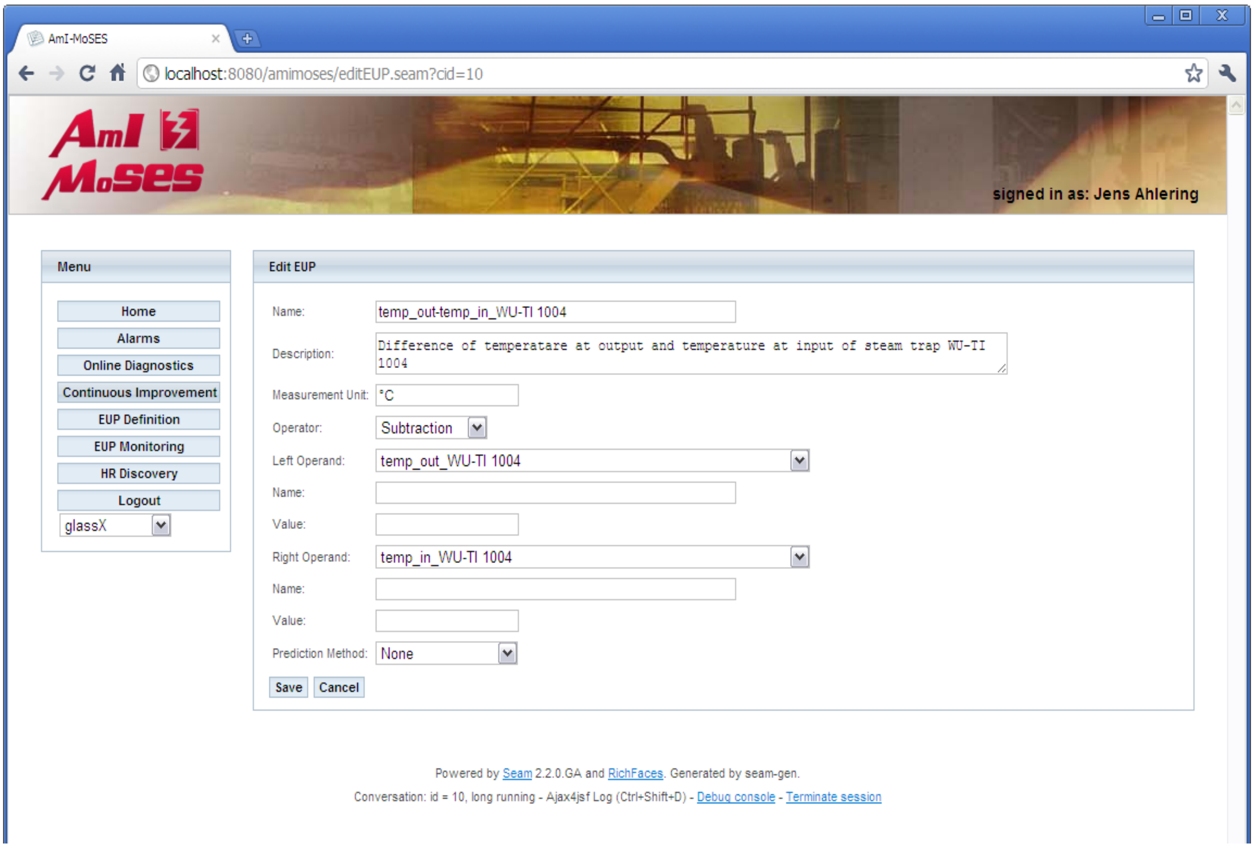

Figure 15: Composite EUP editor view (BC RIFOX)

Targeting models are used for setting conditions for the variables. These conditions are checked by the monitoring module and any violations of conditions are indicated to the user. The targeting models have a set of conditions that determine when the model is to be applied (context) and a set of conditions that determine the value ranges that trigger the condition (Figure 16). The first set of conditions defines the context under which the target model is to be evaluated, e.g. for which product part the model is defined or which ambient data measurements are to be taken into account during model evaluation, whereas the second set of conditions determines which value ranges are tolerable for the selected EUPs under the context defined by the first set of conditions.

For both measurement data and EUPs one can select a so-called “Prediction Method”, which is intended to forecast the development of values into the future using mathematical methods. The forecasted values for measurement data and EUPs can also be evaluated by the targeting models to determine excessive energy use before it actually occurs.

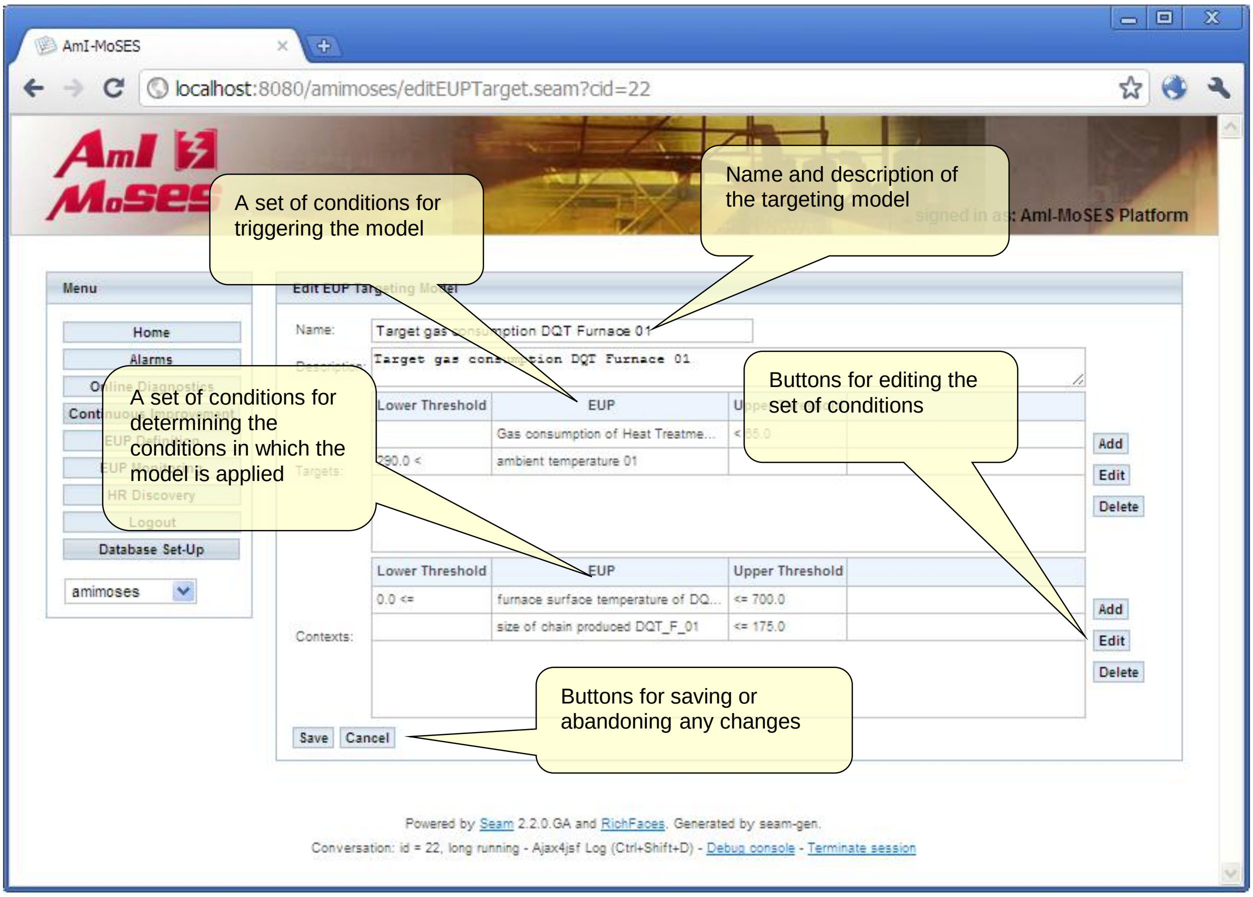


Figure 16: Targeting model editor view

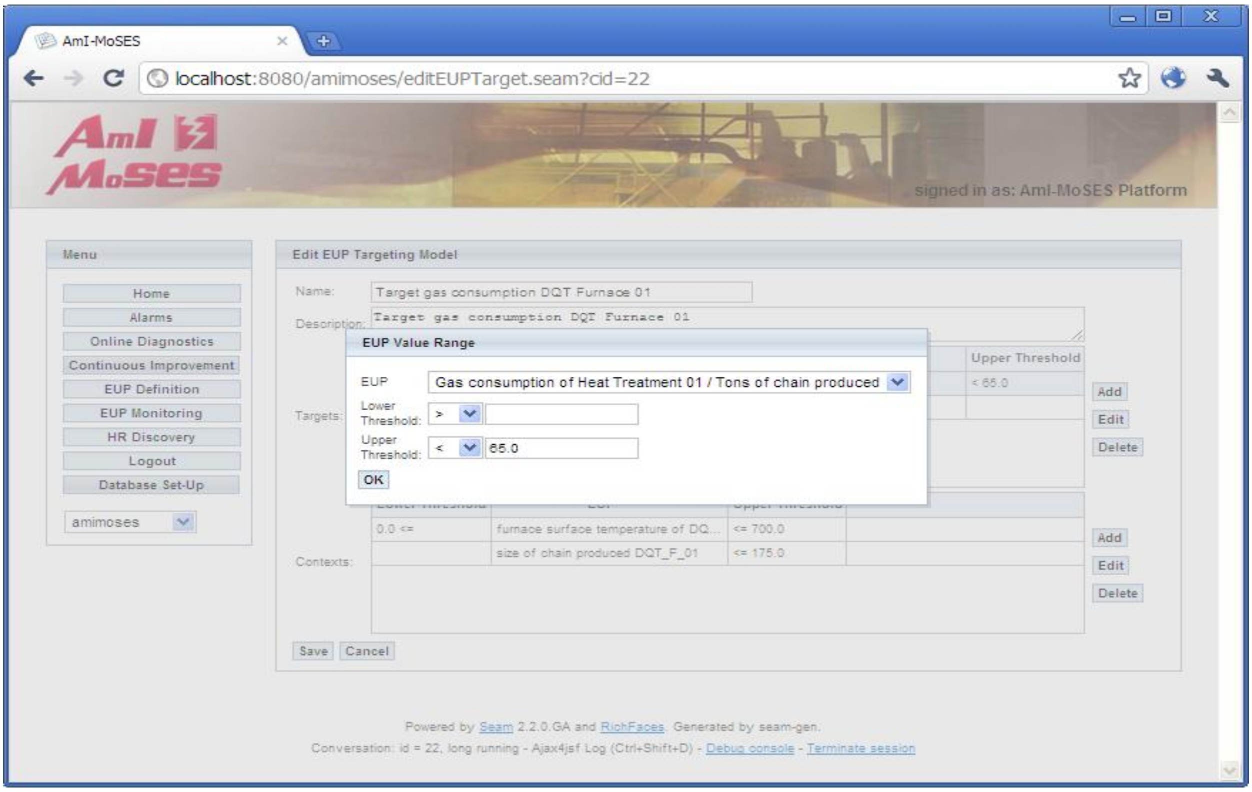


Figure 17: Targeting model condition dialog

## 3.4 EUP Monitoring and Advisory

The EUP Monitoring and advisory functionality is accessed through the "EUP Monitoring" button on the main menu. Clicking this button takes the user to the screen shown in Figure 18. This screen contains a list of active measurements and EUPs with their last values. The list of variables can be filtered by selecting items from lists of process steps, production units, product parts or business units. Only the values that are associated with each selected item are shown. EUPs are associated with these items indirectly by the variables that are used for calculating them.

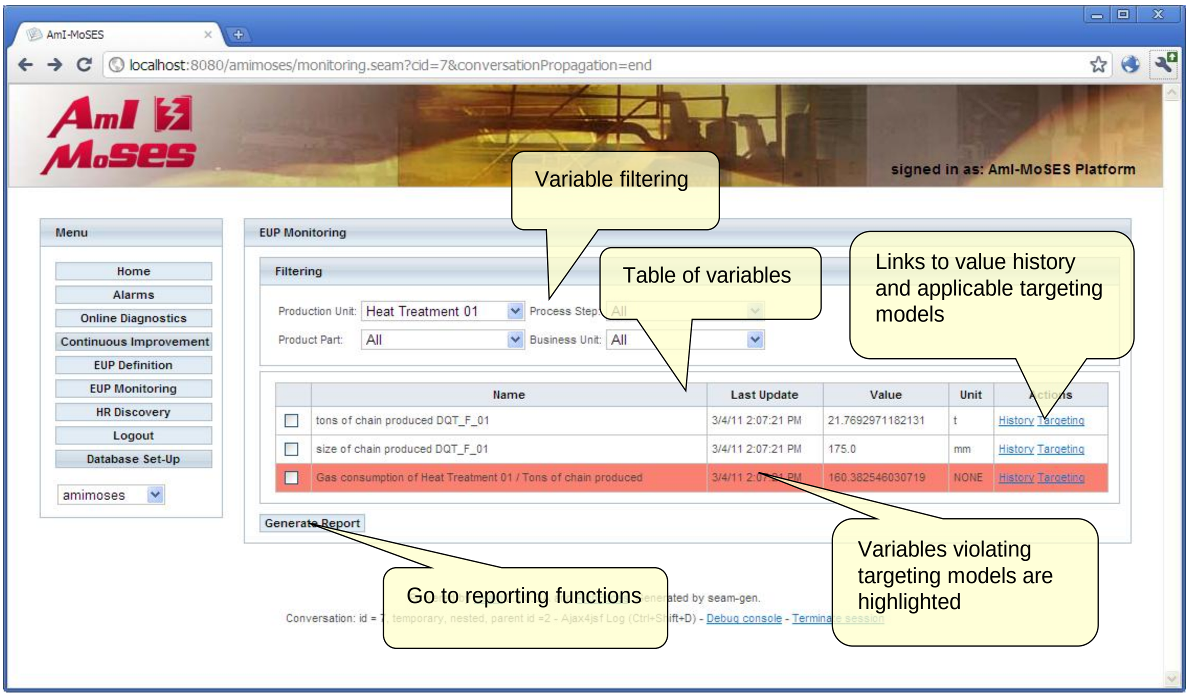


Figure 18: Main view of the EUP Monitoring module

Any values that are currently violating the conditions of an active targeting model are highlighted in a red colour. The targeting models that are applied to the variables can be shown by clicking on the “Targeting” link in the rightmost column of the table. This takes the user to the view shown in Figure 19.

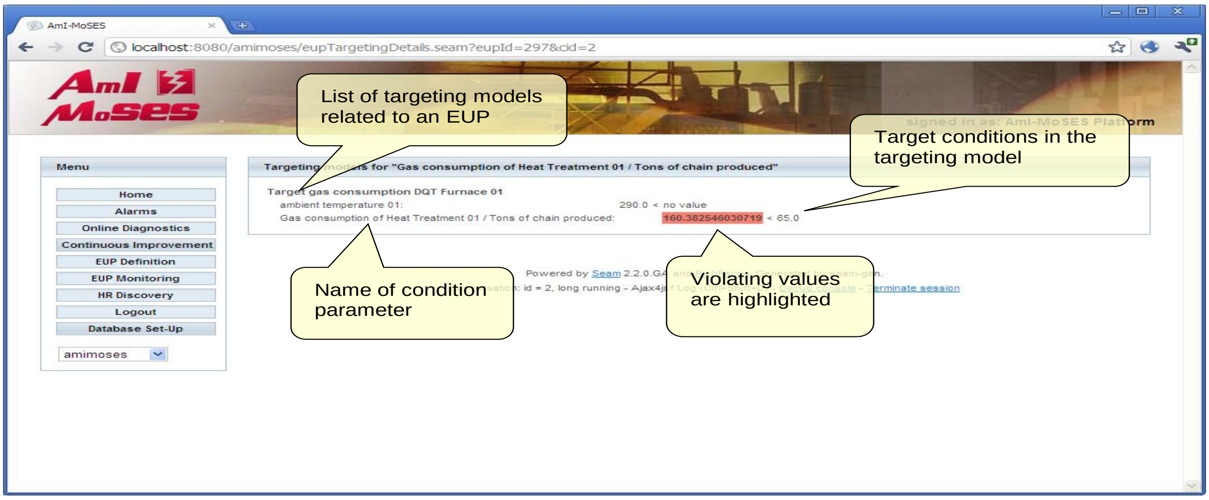


Figure 19: EUP Monitoring, targeting model view

The user can open a view of the past values of any variable by clicking on the “History” link in the rightmost column. This link opens the view in Figure 20, which lists all updates for the value of the variable. The time period for which updates are shown can be limited by selecting starting and ending dates using the controls in the upper part of the view. There are three buttons for quickly selecting standard periods (week, month, year), from the current date backwards.

The data in the table can be exported to an Excel file or a CSV (comma-separated values) file for further processing by clicking on the two buttons below the table.

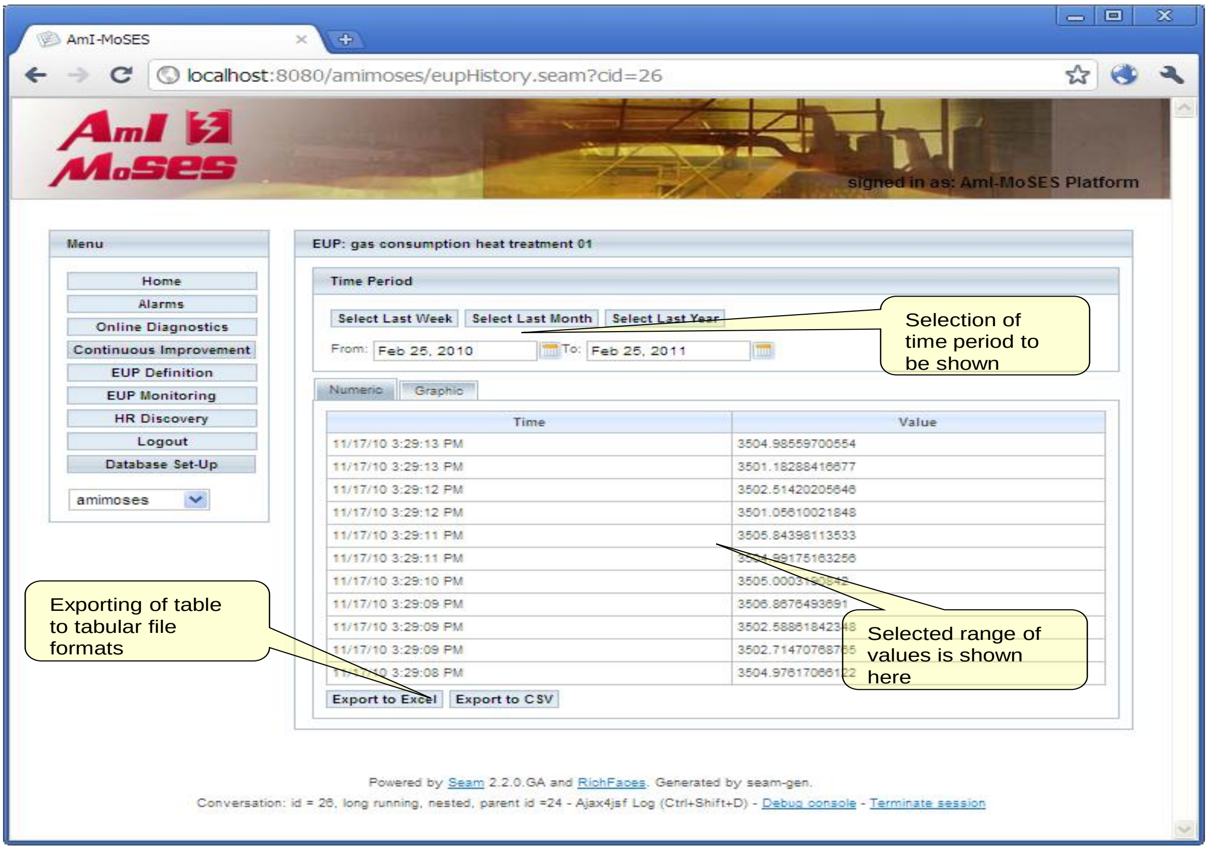


Figure 20: EUP value history view, numeric output

Clicking the "Graphical" tab switches the numeric table presentation to a graphical chart of the values. Figure 21 shows such a graphical chart.


Figure 21: EUP value history view, graphical output

There is a "Generate Report" button at the bottom of the main monitoring view (Figure 22),

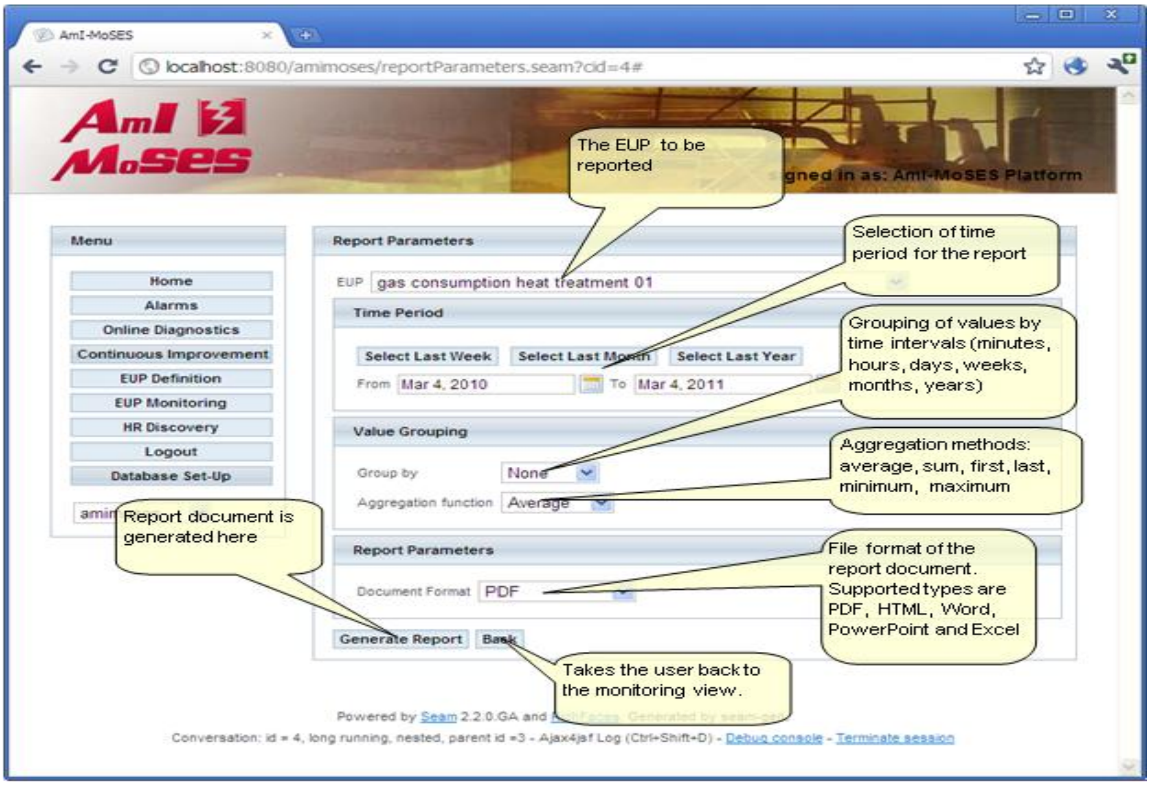


Figure 22: Report generation view

It allows the user to generate report documents of the variables and takes the user to a view where a time period can be selected, like in the history view. Additionally, the user can specify a grouping method for the data. When grouping is selected, the data is for example averaged over time periods, which can be anything from seconds to years. The report can be generated in various file formats, and contains both graphical and numeric details of the values of the variable. Figure 23 shows part of a produced PDF document in Adobe Acrobat Reader. The reporting engine is BIRT, which provides a report design editor that can be used to flexibly customize the reports according to the specific needs of the user organization.

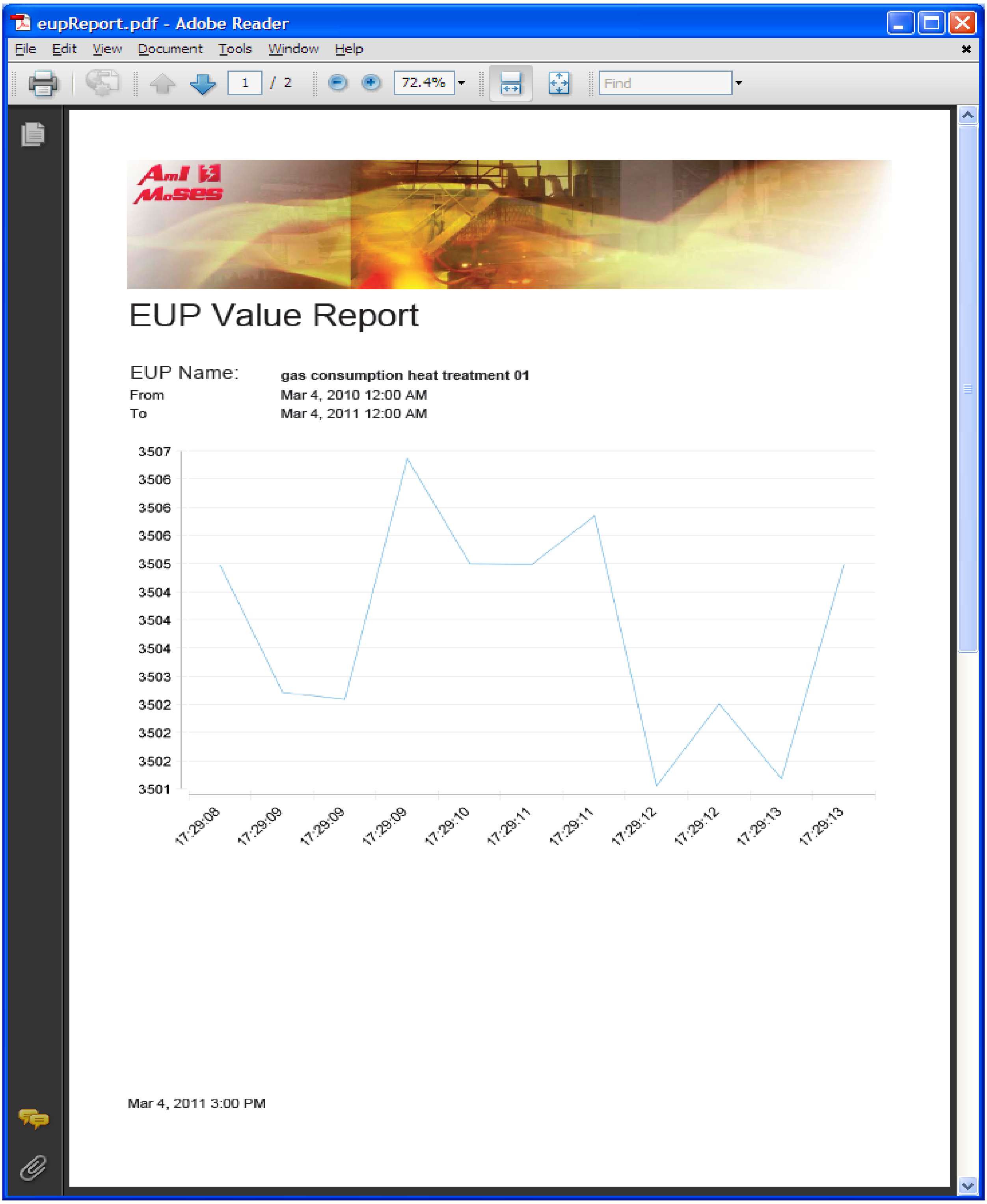


Figure 23: Generated report document (PDF)

# 4 Conclusions

The full prototype of the AmI-MoSES subsystem for Measurement Data Processing and Energy Use Parameters management, described here was implemented following an iterative process based on the module/subsystem specification and early prototype development, testing and assessment. Along the whole FP development comments and suggestions of the project reviewers and end users were analysed and implemented to a possible extent. The whole iterative development process resulted in a final prototype very much adapted to the user needs, meaning at the same time that the usability of the product resulting from the additional prototype commercialisation can be very high.

Functionalities presented here are crucial in differentiating the AmI-MoSES system from classical Energy Management Systems in terms of defining completely new, highly intelligent energy use monitoring approach by taking into account ambiance – environment and process – parameters not used so far in the energy optimisation elaboration.

The prototype presented here is rather promising also in terms of integration ability for realisation of a system for energy efficiency optimisation, enabling an easy combination of the energy consumption data and ambiance originating data into “high resolution” innovative figures of energy efficiency.

From testing of the functionalities presented herein it is possible to conclude that a wide variety of different applications in addition to the original one for Energy Efficiency optimisation can be expected. A number of other Performance Indicators (PI) can be deduced based on the process parameters monitoring. Further application of so derived PIs can be also free defined in terms of either stand-alone usage for simple monitoring and creation of reports to management or subsequent processing in different services like the Energy Efficiency services, which are a target of the AmI-MoSES project.