MOEEBIUS

Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability

D4.1 Wireless Sensor/Actuator Network Specification for Accurate, Complete and Non-Intrusive Sensing

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Glossary

Acronym	Full name
CO2	Carbon Dioxide
HVAC	Heating Ventilation Air Conditioning
I2C	Inter Integrated Circuit
IAQ	Indoor Air Quality
IoT	Internet of Things
JTAG	Joint Test Action Group
MOEEBIUS	Modelling Optimization of Energy Efficiency in Buildings for Urban Sustainability
MCU	Micro Controller Unit
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
VOC	Volatile Organic Compounds
WSN	Wireless Sensor Network

1 Executive summary

The goal of this document is to provide the final list of the specifications for the MOEEBIUS NOD and define the types of commercial sensors, meters and actuators needed within the MOEEBIUS context to successfully fulfil the different use case scenarios of the project in order to offer the complete sensing and actuation functionality required by the MOEEBIUS framework. This document has been finalized taking into account the specification requirements for the end users from the project partners within the MOEEBIUS consortium.

More specifically, this task defines the distinct technological components that need to be included (i) in the MOEEBIUS NOD to enable design of the sensor NOD and (ii) in the MOEEBIUS System to enable design of the network to take place.

This technical specification is informed by the outputs of Deliverable D2.4 which define the system level specifications that need to be addressed so as to meet the MOEEBIUS vision from a use case requirements perspective.

2 Introduction

2.1 Scope of this Deliverable

This deliverable presents the results of the Tasks "T4.1 - Wireless Sensor/Actuator Network Specifications - Non-intrusive ambient conditions and occupancy monitoring" describing in details the technical specification associated with delivering the functional and technical requirements of the MOEEBIUS sensing NOD system and the integration of different -commercially available- hardware equipment (BMS tools, sensors, actuators and metering devices), that will be installed in premises, to further enable the implementation of the MOEEBIUS use cases.

The deliverable consists in detailed specifications for Non-Intrusive and Accurate sensing of indoor ambient conditions (types of sensors, sensor topologies on MOEEBIUS pilot sites, communication specs, etc.) in line with the overall project specifications defined in "D3.1 MOEEBIUS Framework Architecture including functional, technical and communication specifications"

Initially, the report describes the potential sensors (relevant types for energy related applications and comfort and health preservation within the built environment) that compose the MOEEBIUS NOD system, taking into account the end users and business requirements definition, MOEEBIUS Use Cases as well as the overall MOEEBIUS performance framework, formally specified under the activities performed in Task T2.1 "End-User Characteristics and Requirements" and Task T2.3 "Building and District performance assessment specifications and Key Performance Indicators" and presented in the corresponding Deliverables D2.1 [2] & D2.3 [4] and D2.4 [5] - definition of MOEEBIUS framework and individual components requirements.
Moreover, potential communications protocols have been investigated that may need to be supported to gather data from the sensors.
In this report, a special focus is given also to the potential wireless sensors, meters and actuators that need to be included in the MOEEBIUS network and interfaced with the middleware.

2.2 Deliverable Structure

The deliverable is structured and organized in the following chapters:

- Chapter 2 is the introduction of this report, outlining the main objectives and the purpose of the document.
- Chapter 3 presents the methodology for extracting the list of functional and technical specifications of the MOEEBIUS NOD along with the definition of main system components and features.

- Chapter 4 provides the details of the various components (wireless sensors, meters and actuators) that comprise the MOEEBIUS Framework and which are not satisfied by the NOD device.

3 MOEEBIUS NOD Specification

The goal of the project is the integration of different -commercially available- hardware equipment (BMS tools, sensors, actuators and metering devices) to further enable the implementation of the MOEEBIUS use cases. In addition, and as part of the activities in the MOEEBIUS project, a prototype IoT hardware device acting both as sensor and control unit has to be developed. Therefore, and apart from the available commercial solutions, a prototype combo IoT device has to be developed and integrate it within the context of the MOEEBIUS project.

The MOEEBIUS NOD will represent the system front-end towards appropriately understanding occupant behaviour in the built environment. Its purpose is dual: i) to **gather information about perceived ambient conditions** (with the integration of a variety of sensors such as luminance, temperature, humidity, etc.) at individual spaces and ii) to **collect user responses to these conditions** (through e.g. gesture-enabled control actions over lighting devices and HVAC loads). Therefore, the role of MOEEBIUS NOD component is to act as **combo device** tracking real time context conditions and further enabling the implementation of control actions (as a wireless switch button that send users' control commands to the different device types via MOEEBIUS platform). In such a way, MOEEBIUS provides to the end users /occupants' low-power, low-cost and usable/ intuitive means to express their preferences without the hindrance of going to a wall-mounted switch.

The MOEEBIUS NOD will wirelessly interface with Data Acquisition and Management Layer at Building Level, through an associated gateway, reporting sensing and users' settings data to the application layer, similar to other commercial sensors/actuators installed within the context of the project. The gateway is considered as a logical module of MOEEBIUS NOD, either physically placed in the MOEEBIUS NOD device or acting as an external entity for integrating different

3.1 Component Selection to meet NOD Functional / Non Functional requirements

The role of this section is to define the explicit specifications of the MOEEBIUS NOD, as the prototype hardware device developed in the MOEEBIUS framework for sensing and communications.

Defined by consortium requirements, MOEEBIUS NOD is a hardware combo device, to monitor building context conditions and further enable the interaction of occupants with devices through embedded actuators. The complexity of this device, considering also the development of MOEEBIUS NOD as a prototype unit, leads to the definition of an extended list of requirements related to the associated functionalities.

A high level taxonomy of the system requirements in main categories (e.g. sensing capabilities, control capabilities, networking issues, user experience etc.…) is considered for the better management of the MOEEBIUS NOD requirements.

3.2 NOD Concept

1. The NOD is a desktop device which will sense human presence, ambient temperature, humidity, air quality and light conditions in located rooms (or zones) and communicate these parameters wirelessly to a gateway.
2. The Nod device will also provide an intuitive and easy to use interface with feedback that allows a user to input and send commands to the Building management layer through a gateway to control the ambient environment in order to maximize user comfort. The latency (delay) should feel real time to the user. This will be more noticeable for changing the light levels.
3. The Nod will be battery operated. A rechargeable battery will be used with a battery life of a minimum 1 week. Energy harvesting will be incorporated into the device if appropriate.
4. This system will scale to 50 Nod devices and will send sensor data and control commands to the acquisition and building management layer through a gateway.

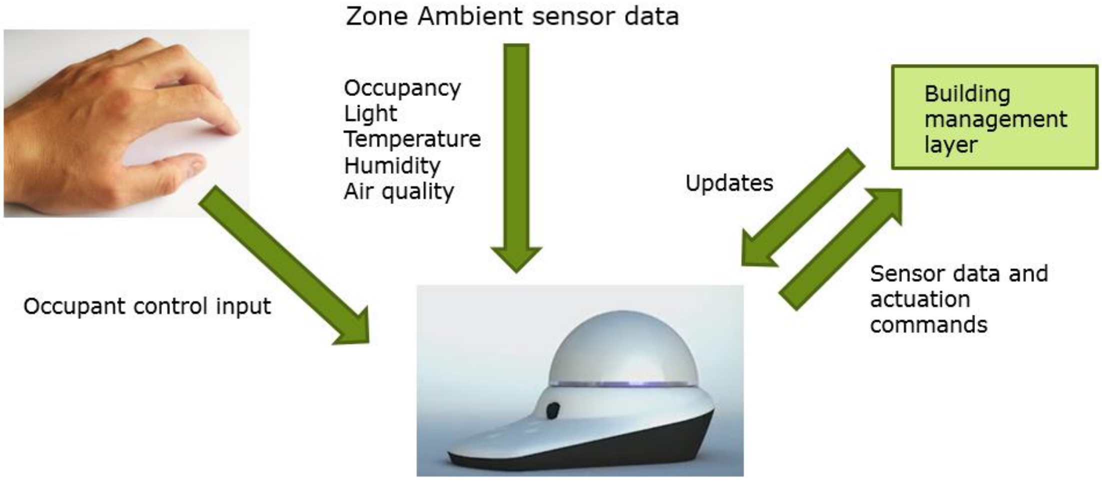

Figure 1 MOEEBIUS NOD Functionalities

3.3 Sensors specifications

The NOD should sense human presence, ambient temperature, humidity, air quality and light conditions in the user's vicinity (~5m) and communicate them wirelessly to the gateway/coordinator. Air quality aspects should cover VOC and CO2 emissions. The NOD should have efficient occupancy sensing capabilities that allow for the accurate sensing of workplace areas of individual occupants, reducing as much as possible noise and false alarms. All these sensors should preferably be on-board as the goal is to provide a single combo device.

Taking into account the inputs from the consortium partners a list with the sensors specifications has been compiled.

As the NOD is a table top device for indoor environment we are not expected to handle more than 1000 lux (anything above that level will be mainly contributed to external natural light). The 0-1000 scale will allow to have all the data we need to profile and control indoor lighting.

Proximity sensor is considered for activating the screen of NOD device, 0-20cm is the preferred range.

It is preferable to sense ambient temperature with an accuracy of +/-0.5°C at least and +/-5% for the humidity.

The sensor needs to have a range between 400ppm and 2500ppm with an accuracy of 50ppm at least. As also reported in deliverable D3.5 [7], studies suggested that indoor concentration of 700 ppm above outdoor CO2 concentration is used as the permissible CO2 limit according to ASHARE 62.1-2010.

In addition we can also have a VOC sensor to provide more accuracy to the monitoring and profiling data.

Occupancy sensor need to be on board of the NOD device to detect movement in 5 meter radius from NOD with a range of 360°C. When the movement is detected by the sensor (PIR) presence event is triggered, if no movement within a certain period then the NOD device triggers absence events.

In conclusion, taking into account the inputs from the consortium partners a list with the specification of each sensor that will be part of the NOD device has been compiled.

Sensor Type	Range	Accuracy
Light	0 – 1000lux	+/- 10 lux
Air Temperature	-20°C - +50°C	+/- 0.5°C
Air Humidity	0 – 100%	+/- 5%
Proximity	0 – 20cm	+/- 5cm
CO2 + VOC	400 – 2500ppm	+/- 50ppm
Occupancy	360°; 5m radius	+/- 50cm

Table 1 MOEEBIUS NOD Sensor Specifications

3.4 Communication protocols specifications

The network of NOD devices should adopt a standardized wireless mesh topology, architecture and information flow (to overcome deployment site obstacles, such as walls in indoor environments, and maximize communication reliability).

The selection of the network topology will take into account the building types and installations and the maximum distance from the gateway.

The network of NODs should be able to interface with the MOOEBIUS middleware or the internet (following the common information model) through a dedicated gateway component. Any type of information captured from the NOD will be reported to the middleware layer.

The NOD device should send sensor measurement data wirelessly to the network gateway (& coordinator). Each data need to be timestamped.

Upon booting, the NOD should configure itself to a specific state which will be provided by the gateway/coordinator upon request by the NOD.

The coordinator should enable communication of the gateway with all NODs (network size should be able to scale up to 50 NODs)

There are several options available that would allow achieving the desired communication platform that is required for the NOD. It is better to have more than one wireless module on the board in order to provide increased connectivity in deployment, and potentially reduce the interference impact on the network as the system can hop from ISM band to ISM band automatically.

Although the vision is that the NOD would communicate with other sensors and actuators via middleware, a multi radio standards based solution will allow flexibility and intercommunications with these sensors actuators and gateways in an opportunistic fashion.

As for the sensors section, taking into account the inputs from the consortium partners the following communication protocols have been selected.

Communication protocol	Frequency band
Wi-Fi	2.4GHz – 5GHz
Bluetooth LE	2.4GHz
Sub-1Ghz	433MHz – 868MHz

Table 2 MOEEBIUS NOD wireless communication protocols

3.5 Microcontroller

The NOD should have the minimum required processing power to pre-process and normalize sensor data locally before transmitting them to the gateway/coordinator. The decision of the microcontroller is mainly derived from the selection of the display, the SDK considered for the development of NOD, the availability of microcontroller and the interfaces offered to ensure connection with the rest of the NOD components. These needs to be balanced by the requirement to "future proof" the NOD firmware to mitigate for changing requirements within the consortium as regards system functionality based on deployment feedback.

3.6 Interaction with the user

User input should be received by the NOD via an intuitive and easy to use interface. The users will be able to set control settings on the different device types (HVAC and lighting) and further receive information about the current status of each device (control status).

The latency for receiving input commands and transmitting the information to the gateway/coordinator should be small enough (in the order of milliseconds) to feel like real-time to the user.

The NOD should be able to report its status (battery level, network configuration information, control & operational status etc.) and should have a common interface for controlling both HVAC and lighting within the building premises.

The NOD should provide real time status information to the user regarding selected mode of operation (e.g. automatic, manual, scenes) for luminance and temperature control and device state (e.g. battery low, connection lost).

Answers on the questionnaire submitted to the consortium partners regarding the User Interface of the NOD have brought 2 main options:

- Small low power display + touch buttons;
- App on the mobile device (smartphone, tablet), able to communicate with the NOD.

3.7 Power consumption – battery life

The NODs should be purely battery operated. A rechargeable battery should be used and the NOD should embed the charging circuitry for charging from a micro USB port.

The NODs should consume as little energy as possible for a given set of functions/operations NOD's battery life should preferably exceed 1 week in normal operating conditions.

In addition to battery charging process, harvesting functionality is not mandatory but it could be examined as an option for the optimized management of battery consumption.

For the desktop application of the NOD a source of energy harvesting is (ambient) light with typical illuminance (intensities) of 200 to 1000 lux. Since the operational environment is a typical office environment, the most common light energy source is overhead florescent lights.

3.8 External design – Enclosure characteristic and form factor

The NOD enclosure should not obstruct or influence the precision of measurements being performed by its internal sensors and be as less intrusive (visually and physically) as possible since it is intended for a table-top use and should ideally not exceed a typical size of 10x10x10cm.

The electronics of the NOD device should have a form factor to suit the enclosure to be designed (this implies an intertwined process of PCB and enclosure design iteration).

3.9 Expected data volume

When the NOD performs the sensors readings it will send data to the Middleware in one single packet. Considering to send data in text format, an approximate size of each packet (containing sensors values, timestamp and some info regarding the NOD identifier and site identifier) could be around 700 bytes. Assuming that the data will be sent every 5 minutes, the expected data volume of each NOD in one day is around 201.6kB.

3.10 Miscellaneous

The NOD should provide the capability to change its embedded software and/or its network-related configurations though USB or even over the air and comprise of an appropriate composition of already existing / mature technological sub-components where possible.

The NOD should (where possible) utilize commodity, off-the-shelf components as much as possible to drive down the bill of materials and integration costs and enable small/mid-scale procurement with small lead times.

It is preferable to have antenna on PCB for the wireless modules; alternatively, we should be able to hide the antenna within the proposed enclosure size (assuming of course that the enclosure material does not interfere with communications).

4 Component Commercial OTS sensors, meters and actuators which will need to be part of the MOEEBIUS system (but not included in the NOD)

Along with the explicit requirements for the MOEEBIUS NOD, we define the list of functional requirements for the rest of the commercial WSN/BMS devices (sensors, actuators, BMSs) integrated in the MOEEBIUS platform. This list actually defines the types of sensors needed within the MOEEBIUS context to successfully fulfil the different use case scenarios of the project.

Access on **building environmental conditions data (luminance, humidity, temperature)**, **occupancy presence/absence data, device operational data (status, operational model, settings), energy consumption data (total building, per device), health related data** through health sensors/BMS tools installed in premises reporting PM2.5, CO2 and VOC data.

Different **network topologies** will be considered for integrating the commercially available solutions, but the final selection should be defined by taking into account the communication protocol capabilities of MOEEBIUS Data Acquisition and Management Layer.

The **topology of sensors** installed (number of sensors/ placement of sensors) should take into account the BIM parameters and the pilot specific requirements defined by the different MOEEBIUS applications

The definition of the WSN/BMS requirements is tightly associated with the functionalities supported by Building Middleware Layer (see next section), as this is the layer responsible for the seamless integration of the different types of WSN/BMS in MOEEBIUS platform.

A list of possible wireless sensors, meters and actuators which will be part of the MOEEBIUS network is reported below indicating features, communication protocol (to be interfaced with the Building Management Layer) and relative price.

Company/Model	Applications	Operating range	Accuracy	Interface	Warm-up interval	Unit Price ($)
Gas Sensing Solutions/COZIR	CO2	0 to 2000ppm	+/- 70ppm	EnOcean	5 min	109
Leviton/WSWDR-I0W	Occupancy	Wide Angle = 2000 sq. feet Long Range = 1600 sq. feet		EnOcean	10s	100
Aeotec/Multisensor 6 (ZW100A)	Motion, temp., light, humidity, vibration, UV	Motion: 5m @ 120° field view Temp: -10 to 40C RH: 20 to 80 % Light: 0 to 1000lux Occupancy: 3 to 5m	+/- 0.5C +/- 5% RH	Z-wave		50
Elgato/Eve Room sensor	CO2, VOC, Temp., RH	Temp: 0 to 55C RH: 5 to 95%	+/- 0.3C +/- 3% RH	Bluetooth 4.0 Smart		80
Insteon/Motion Sensor	Occupancy	up to 110° arc, 40 feet		RF - 915MHz ISM Band		40
Pressac	CO2, Temp., RH	CO2: 0 to 2550ppm Temp: 0 to 51C RH: 0 to 100%	+/- 125ppm +/- 0.5C +/- 5% RH	EnOcean	2s	317
EnOcean/EOSC	Occupancy	10m diameter		EnOcean		120
DSC/WS4904	Occupancy	Covers 12m x 12m		RF - 433MHz		73
Echoflex/MOS-17C	Occupancy	12.2m x 5.5m (max)		EnOcean	60s	

Table 3 Supplementary COTS sensors

Occupancy wireless sensors:

- **Leviton WSWDR-10W:** Leviton LevNet RF Self-powered light sensor is wall mountable and has built-in solar cells that draw on available ambient light to power themselves. It senses objects up to 80 ft distance. Passive infrared sensor has both switched and dimmed capabilities. Self-powered technology enables the sensor to be operational after a minimum charge time of 1 minute. It communicates via 315 MHz EnOcean Radio Frequency technology; operating in the temperature range of 0 to 40 ^{o}C. It measures 26 mm x 45 mm x 20 mm. and features swappable wide angle (186 m^2) and long range (149 m^2) lens options. With 50 lux of illuminance, 30 transmissions per hour is achievable and it is fully charged in 6 hours from cold start with an illuminance of 200 lux.

- **Magnum Energy Mx-EOSC:** a wireless, solar-powered sensor that detects occupancy using passive infrared (PIR) heat and motion sensing and transmits EnOcean RF messages for efficient energy use. Measuring 160mm x 60mm x 37mm, its motion sensing range is 12m diameter with an RF transmission range of 25m. With 200 lux illuminance, it will start up from energy empty storage in 5 minutes and be fully charged in 25 hours.

Indoor Air Quality (IAQ) wireless sensors:

- **MONNIT MNS-8-W1-GS-C1 Carbon Monoxide sensor:** The MEMS-based sensor, measuring 45mm x 26mm, monitors the amount of CO gas in the surrounding air. It returns carbon monoxide level and temperature values to the iMonnit Online Sensor Monitoring and Notification System; where it stores both data points which can be reviewed and exported as a data sheet or graph. Notifications can be set up through the online system to alert the user when defined CO levels have been met or exceeded. With an Electrochemical Oxidation measuring principle, it boasts a CO gas measuring range between 0 and 1000 ppm with an accuracy of +/- 2%, sensitivity of 5 +/- 2 nA/ppm and resolution of +/- 0.5 ppm. Communication is via an 868 MHz Radio Frequency using an external 4" wire antenna with range of 200 to 300 ft. All powered with a single replaceable 3 V CR2032 coin cell battery lasting over a year on one reading every hour operation. Typical current consumption is 35 mA in Tx mode, 2 mA in measurement mode and 0.7 µA in sleep mode.
- **Elgato Eve Room (combo CO2/VOC/T/RH) sensor:** Eve Room senses indoor air quality, temperature, and humidity; it is powered by a sophisticated sensor that analyses volatile organic compounds (VOC). Taking advantage of Apple's revolutionary HomeKit technology, with Eve, you see your home at a glance, right on your iPhone and iPad. It has a 0 to 55^{o}C temperature and 5 %RH to 95 %RH operating range with a ± 0.3°C temperature and ± 3% RH accuracy. Measuring 79mm x 79mm x 32mm, it is powered by 3 x AA Replaceable Batteries with wireless connection via Bluetooth 4.0 Smart.
- **Pressac 60.CO2.SLR.TMP.HM.868 (combo CO2/T/RH) sensor:** designed to measure and report levels of Carbon Dioxide, ambient temperature and relative humidity in an internal environment, it is powered from ambient room light. Supporting the open EnOcean standard, it seamlessly connects with building management systems. CO2 measurement range is between 0 and 2550 ppm; temperature is between 0 to 51oC while humidity is between 0 and 100% RH. It measures 115mm x 80mm x 35mm.
- **Ionscience Corvus (combo VOC/T/RH/P) sensor:** a continuous, wireless VOC monitor for Indoor Air Quality comprising sensors for temperature, barometric pressure and humidity. It incorporates

Photoionisation detection (PID) sensor technology to detect volatile organic compounds (VOCs) down to low parts-per-billion (ppb) levels. PID detection range is from 0 to 50 ppm with an accuracy of ± 5 ppb and 5 ppb sensitivity. It can detect temperatures from -40 to 125 oC with an accuracy of ± 1 °C and 0.1 °C sensitivity. Relative humidity detection range from 0 to 99% RH with an accuracy of ± 4% and 0.04% sensitivity. Barometric pressure detection from 70 KPa to 106 KPa with an accuracy of ± 1.5% and 72 Pa sensitivity. Measuring 176mm x 122mm x 68mm, it communicates via 2.4 GHz wireless mesh network and is powered from 12 VDC or 100 – 240 VAC (15 W) mains power supply.

Temperature & Humidity combo wireless sensors:

- **Aeotec Multisensor 6:** It comprises six (6) sensors namely:
    - Motion sensor with a 5 m range and 120° field of view. Captured motion data can then be used for everything from security to heating management to energy saving.
    - Temperature sensor capable of accurately measuring between 10 and 50°C which can be reported to a smart home gateway.
    - Light sensor measuring light between 0 and 1000 lux.
    - Humidity sensor range is between 20 %RH and 80 %RH with an accuracy of ±5%RH.
    - Vibration sensor.
    - UV sensor.
    - All are powered using 5VDC USB or 2 nos. CR123A batteries (3V, 1500mAh each); offering up to 2 years' battery life. It communicates via Z-wave with a 150m range.
- **Echoflex RTS-1H-YW (combo T/RH) sensor:** wireless, self-powered sensors that detect temperature and humidity in interior spaces; featuring efficient solar power utilization; advanced diagnostics and excellent transmission range. Temperature operating range is from 0 to 40°C with an accuracy of 0.3°C and 20% to 95 %RH for relative humidity with a resolution of 0.4% RH. With exposure to 200 lux, startup is in 2 minutes; while being capable of operating for up to 200 hours in total darkness from maximum charge. It communicates via 868 MHz Radio Frequency. It measures 135mm x 72mm x 24mm.
- **Blue Maestro Tempo (combo T/RH) sensor:** measuring 85mm x 55mm x 35mm, its detection limits are: temperature - -40 to 75 °C with an accuracy of +/- 0.3 °C and Humidity – 5 to 95 %RH with an accuracy of 3 %RH. Communication is via Bluetooth Low Energy with 75 m line-of-sight wireless range. It is powered by two replaceable (2) AA batteries which typically last in excess of one year.

Smart Meters:

- ***ELSTER A100C / A102C***: The A100C family of domestic electronic single phase meters comply too DIN/BS specifications. The meter offers IrDA or IEC 62056-21 communications. This allows register values, security information etc to be read either optically or via a hard wired connection, making it ideal for AMR applications. The A102C records kvarh in addition to kWh.
- ***GLEN M14***: it is an Entire precision meter electronics. Features:
    - Power control and communication
    - One cubic inch size
    - Comprehensive metrology
    - IEC and ANSI 0.5% accuracy standards
    - Safety to UL and CE standards
    - Manufactured in high-volume
    - Cost-effective meter
    - Internet-enabled
    - Web server-equipped
    - Shunt or current transformer compatible
- ***GLEN GC6002R***: Ansi Meter DOE Compliant ANSI C12.20. Features:
    - Accuracy Class .5%
    - Form 2S
    - CT Sensor
    - Available with 200A latching relay
    - Relay, prepayment and multi-tariff
    - Full AMR / AMI functionality
    - Internet protocol modular communication
- ***Emlite***: the Smart Metering products are architected on our modular metering principle. The additional flexibility provided by modularity enables modules to be tailored for specific customer needs without the need for meter re-approval. Additionally, modularity enables the separation of Smart functionality from legally approved metrology and is especially important where firmware updates are concerned. In a modular Smart Meter, firmware can be updated without fear of disrupting metrology and register data. While actively working with third parties to introduce best in class communication technologies to Smart Metering, initial modules feature GPRS connection to the utilities back office system using open communication protocols and ZigBee Smart Energy communication to in-home devices. Initially focussed on the UK's SMIP smart metering functional set, the smart module expands the base meter functionality and provides a field exchangeable communications hub. The module can be used with any of the emlite meter variants including load control and twin element versions. Through the flexibility of modularity, modules can be quickly developed for individual client needs, providing tailored functionality and communications.

Actuators for dimming applications: a list of the manufacturers is the following

- Berker KNX
- Legrand
- Altenburger
- Gira
- Eltako Electronics
- Merten

***Actuators for HVAC applications*:** a list of the manufacturers is the following

- Siemens
- Samson
- Johnson Controls
- Honeywell
- Schneider Electric

They all have to communicate with the middleware. Format of messages can differ, but there is an open endpoint(s) in middleware consuming data message in agreed format. This section is more a question for pilot owners – what else they plan to install and why.

5 Conclusions

This deliverable documents the outcomes of Task 4.1, titled "Wireless Sensor/Actuator Network Specifications - Non-intrusive ambient conditions and occupancy monitoring." The basic input for this Task has been the MOEEBIUS deliverable D2.4, which enumerates the functional and non-functional requirements of the NOD device and MOEEBIUS wireless network and the questionnaire submitted to the consortium partners.

Initially, starting from the general idea of the NOD, specifications for the device has been defined regarding sensing capabilities, communication protocols and user interface. The NOD will sense attributes from the zone ambient environment around it and relays this information to the Building management layer. It will also send user input actuation commands to the Building management and provide feedback on execution.

In addition to this, the specifications of COTS devices (sensors, smart meters, actuators) that will be part of the MOEEBIUS network have been documented, following a table with proposed devices available on the market.

The outcomes of T4.1, as documented in the present Deliverable, form the basis for the development of the NOD, as well as the overall MOEEBIUS network.

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