# Final report

## 1.1 Project details.

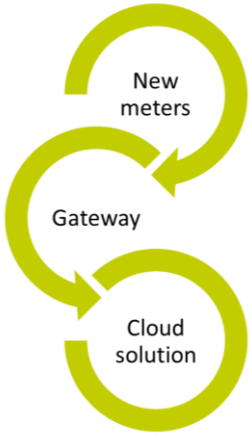
| | |
|---|---|
| **Project title** | Energibesparelse ved kontinuert overvågning på apparatniveau. |
| **Project identification (program abbrev. and file)** | Journal-nr.: 64013−0552. |
| **Name of the programme which has funded the project** | EUDP. |
| **Project managing company/institution (name and address)** | ReMoni ApS.<br>Sudkærvej 9<br>8752 Østbirk. |
| **Project partners** | ReMoni ApS.<br>Caverion A/S. |
| **CVR** (central business register) | ReMoni: 35212124.<br>Caverion: 10112354. |
| **Date for submission** | August 31, 2016. |

## 1.2 Short description of project objective and results.

The project objective is to demonstrate a system for monitoring technical installations - in an easy, cheap and flexible way.

The project has delivered the following results:

- A monitoring system, as a cloud based solution, with access and interface from PC or any mobile platform.
- Simple power meters, for fast an easy clamp-on installation on cables.
- Gateway, to secure granular data from sensor to cloud, for data analysis.
- Alarms on system and device level.
- System analysis and test results, for documented energy saving.
- Demo test system with test evaluation.
- Market and customer insights.




**Energy and Technical Monitoring**

**High Quality and Flexibility made Cost Efficient**

Danish version:
Projektets mål er at demonstrere et system for overvågning af tekniske installationer – på en nem, billig og fleksibel måde.

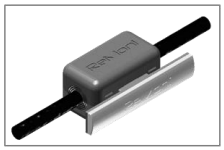
Projektet har leveret følgende resultater:

- Et overvågningssystem, som en cloud-baserede løsning, med adgang og interface fra PC eller enhver anden mobil platform.
- Enkle elmålere, der hurtig og nemt monteres udenpå på kabler.
- Gateway, der sikrer tilstrækkelige, kvalitets måledata fra målere til cloud, for dataanalyse.
- Alarmer, på system- og apparatniveau.
- Systemanalyse og testresultater, for dokumenterede energibesparelser.
- Demo test system med test evaluering.
- Markeds- og kunde indsigter.

## 1.3 Executive summary

The project has developed, tested and demonstrated an easy to install and flexible surveillance solution for technical installations. The solution includes the relevant hardware units and a cloud-based software solution. Results and learnings received during the development phase have been implemented in the solution.

Power sub-meter


Power main-meter


Gateway


Cloud

The project has resulted in two patent applications submitted in Denmark and international, respectively.

The electronic production has been set up at external production partner, and they have produced the electronic used in test and demos.

Dialogue with potential future distribution partners and customers has strengthen the market and business focus. Technical material for product introduction has been developed and used in the communication. The high focus on installation easiness has brought us to the decision to make small installations films for customers, to be used on mobile platforms (e.g. smartphone and tablet).

Dissemination activities have also established contact to new partners for future developments and business execution, national and international, e.g. the Danish company Vitani, who can integrate the ReMoni products with customer's existing Energy Management systems.

Future activities are directed commercialisation and market entry of the ReMoni solutions, estimated to primo 2017.

## 1.4 Project objectives

**Project objectives:**

It is possible to identify present and emerging problems and reduce overconsumption of energy by continuous monitoring each single device. The challenge today for installation such solution is the high installation and upstart expenses, and the difficulty to retrofit in existing installations.


The project objective is development and demonstration of a system for monitoring technical installation, where focus is on low cost, wireless and easy and flexible installation, in existing and new installations.

This requires the right meters, for real-time and continuously measurements of energy consumption on each single devise, for automatic generating warnings in case of over-consumption of energy or abnormal operation.

Project focus is on the ReMoni monitoring system with following main characteristics:

1. Use of small, wireless and cheap clamp-on meters, for continuously monitoring of energy consumption on single devices. Meters must deliver the needed granular data for the analytics.
2. An open-sourced cloud based system for data storage, analysis and system information with customer's eventual existing energy management system (BMS).
3. Use of complex mathematical models (analytics), rather than complex hardware.


**System overview**.

The monitoring system, receiving wireless measuring data from equipment and generating information and alarms on PC and mobile platforms.

The project covers following two project development phases:

Phase A: Prototype Demo - Development and demonstration of an operational prototype in practice.

Phase B: Production Maturation – wider tests and development of the prototype, product adaptions, set up of serial production, and establishing a commissioning, marketing and operation organisation.

**Project risk:**

Before project start, the project had identified following risks:

1. **Technical risk:**
   Unforeseen technical challenges.
2. **Core competences:**
   Core competences leaving the project.
3. **IPR and patents:**
   A patent application was submitted before the project started, and an additional patent application expected, and the outcome of the patent evaluation process was unknown.

The project experienced challenges according to item 1 (technical) and 2 (core competences) above. The project has been able to handle these challenges occurred.

The biggest challenges, and being the one with highest consequences, has been one of the original project partners leaving the consortium and project, one year into the project. The two remaining partners decided to reorganized the project and take over the leaving partners work and responsibility. This consortium change caused a project delay of a year, but also strengthen our focus on working with risk identification and handling.

The project has registered different technical problems. This have been problems with the delivery from sub suppliers and performance on electronic components. On the mechanical side there have been challenges with the clamp-on method used. This has resulted in several redesigns of the clamp-on principle with evaluation with partners and customers; and it has resulted in separate designs for the main resp. sub power meter; also in order to keep cost on the high-volume meter (sub power meter) down.

Furthermore, there have been a technical challenge in the cloud development and the used Microsoft Azure platform, in the open data API. This has been solved by changing from OData, which we experienced was not maintained, to REST API, giving us additional development work but it solved the challenges.

The IPR patent process was smooth, and the two patents have been achieved.

**Project implementation and milestones:**

The project implementation has been affected by the withdrawal of a project partner, which has costed a project delay on 1 year. The project had to take a step backwards, and ReMoni (who took over this partner's deliverables and responsibility) had to hire new employees and get them up-to-speed.

The project plan is built up on five work packages:

WP1 – Project Management.

WP2 – Develop the electronics.

WP3 – Online cloud data services.

WP4 – Demos.

WP5 – Dissemination.

The project had four ***technical milestones (M1-M4)*** and five ***commercial milestones (CM1-CM5)***:

M1: Product ready for full-scale demo: including full-scale prototypes of the electronics, data transfer, and cloud-service.

M2: Demonstrations successful: running over at least a 6 month's period.

M3: Product matured for serial production: including adaptions according to the experiences from the demos, scaling up both technologies and procedures for production flow, and quality control.

M4: Technical performance documented: using peer reviewed international journals and technical documentation.

CM1: ReMoni demos ready: to be presented for press and large customers.

CM2: The product is presented public: in the press, and at workshops and conferences.

CM3: Business concepts tested: on at least five potential customers, to get their input on how the concept can be improved.

CM4: Marketing and commissioning plans and tools developed.

CM5: Production agreements completed: with both local and global production companies.

All milestones, technical and commercial, have been delivered.

The partner withdrawal and the connected time delay has affected the work in WP4 and its commercial deliverable CM3, which have been delivered in a modified form. Due to the caused delay, the span of time for live demonstration test was substantial cut. To maximise the outcome and delivery, the project prioritised internal tests, lab tests and long-time testing at one external customer (instead of test installations at four external customers), to establish several test setups for securing system robustness and quality.

## 1.5 Project results and dissemination of results

The development has been through several development iterations. The project process and iterations are illustrated in pictures in the annex.


The power meter has been split out in two meters: Power main meter and power sub meter.

The power main-meter is easy to clamp into existing multi-wire cables, and further it receives its energy from the cable where it is mounted and has no need for battery supply.

The power sub-meter is constructed for easy installation on the outside of electrical cables. The sub-meter measures at any cable for alarm systems and two wire energy consumption on unit level. The sub-meter has an internal battery.

The main meter has an accuracy required for energy billing or reimbursement of tax.

In the cloud development process, partners and customers have been involved in design of the user interface and the design of the API (Application Programming Interface) against customers BMS (Building Management System).

**Main activities:**

Project development activities have been divided in following areas:

| | |
|---|---|
| (A) Hardware development. | (E) Calibration unit. |
| (B) Electronic production. | (F) Gateway |
| (C) Encapsulation. | (G) Cloud solution development; |
| (D) Embedded software, in sensor. | (H) Calibration algorithms. |
| | (I) User interface |
| Additional there is an area focusing on the overall system integration. | |

**Ad A: Hardware development:**

The HW development covers following hardware devices:

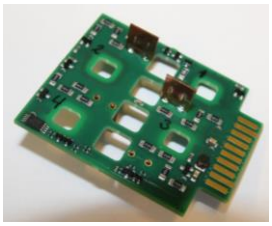
1) Transmitter PCB.
2) Power main meter, measuring PCB.
3) Power sub meter, measuring PCB.
4) Repeater PCB.

The repeater design is similar to the transmitter PCB.

The radio has been through several development iterations and tests, and radio design have changed to optimize transmission and the energy used for transmission.

See the annex for further pictures and information about development iterations and learnings.

*1) Transmitter PCB.*



*2) Measuring PCB, main meter.*

**Ad B: Electronic production:**

We have visited three electronic production manufacturers and have chosen ETK in Stilling as our preferred production partner.

Production of the different hardware units above have been set up, and all the test and demo prints (PCBs) have been produced at ETK.

Quality routines at ETK have been set up.

**Ad C: Encapsulation:**

Casing are developed and prototyped, in several iterations. Pictures in the annex shows some of the iterations.

Below the final power meters are shown, mounted on a cable.

**Main power meter.**


**Sub power meter.**

**Ad D: Embedded software, in sensor:**

The software in the power meters is developed and tested.

**Ad E: Calibration unit:**

Calibration of main meters can be made in production, and there is no need for calibration on site.

Sub meters have to be calibrated. A mobile calibration unit have been designed.

**Ad F: Gateway:**

**Gateway.**

The consist of the Raspberry Pi and a transmitter, connected using an USB cable.

The gateway receives the wireless monitoring data from meters and transmits measuring data to the cloud solution.

The gateway uses a Raspberry PI, for data handling and interface to cloud solution.

The ReMoni transmitter is connected, using an USB cable, for radio communication with the wireless meters.

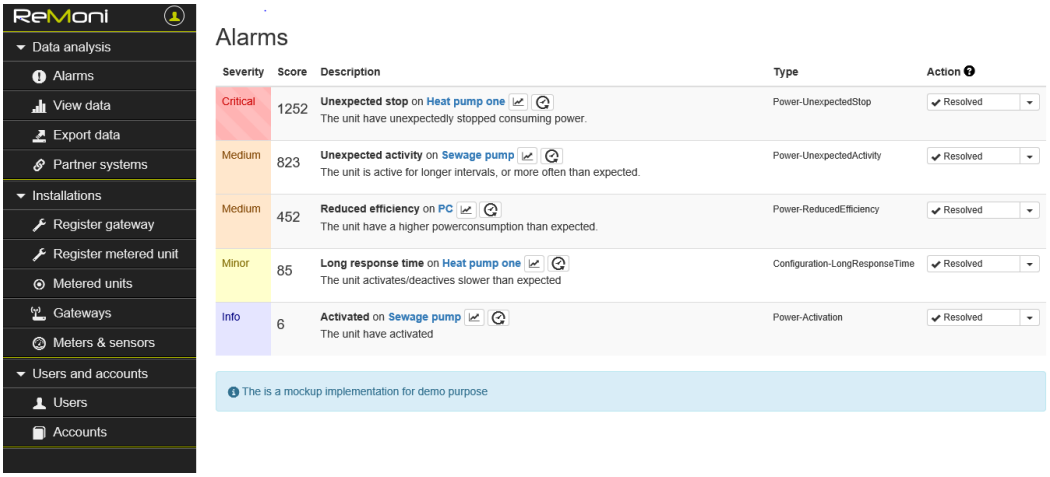
**Ad G: Cloud development:**

The cloud platform has been developed, receiving data from meters, analysing and evaluating data and present result and analyses on PC or any mobile platform (e.g. a smart phone).

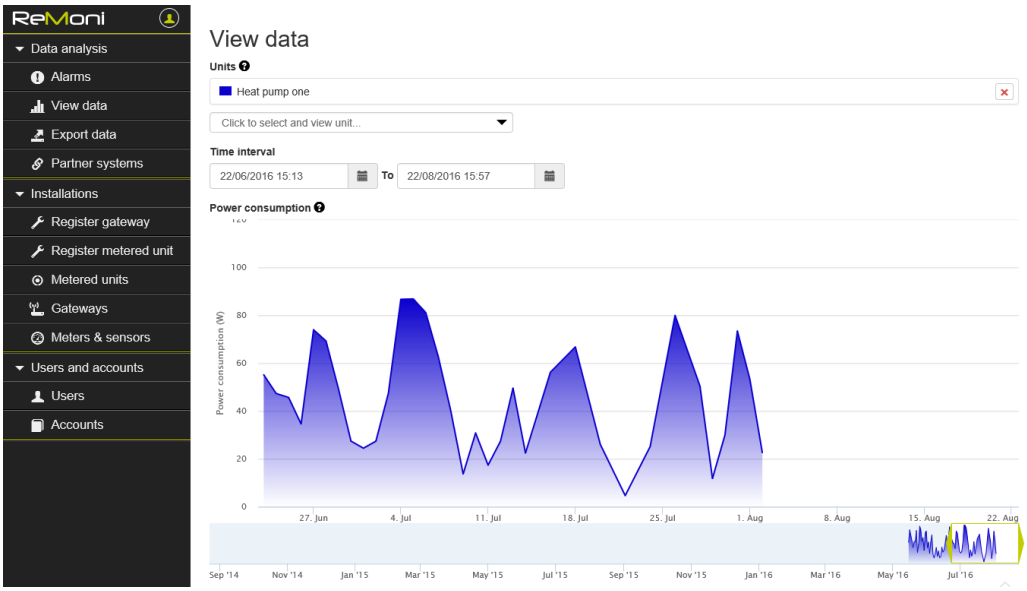
We have developed a strong solution, with an easy to access interface and API integration with customers BMS system. The platform has been tested and is ready for demonstration tests at customers and commercialisation.

See pictures below, and see portal.remoni.eu.

***Graphic view of alarm list:***



***Graphic view of measured data, for a heat pump:***




**Ad H: Calibration algorithms:**

Advanced algorithms are developed and integrated, making it possible to have a simpler power meter and with a lower cost. Algorithms have been tested.

**Demos:**

Demos have been running in lab, during development.

A mobile demo stand has been built, possible to transport and for presentation at potential partners and customers, but also for presentation at workshops, conferences and exhibitions.

A demo has been install March 2015 at Aarhus Kommune and have been running for more than 6 months. Test and result have been regularly evaluated, and product updates carried out according to feedback and results. See pictures in the annex.

**Dissemination:**

***Dissemination, in general:***

There have been several presentations at conferences and in professional forums. Some are mentioned below:

- Presentation at the EUDP Day in Vejle, January 2015.
- Presentation at the internal conference "Smart System Integration 2015" in Copenhagen, 11-12 March 2015.
- Samsung Workshop in Frankfurt 21/3-2014, with different technology partners as Miralix, Reeft, xFlex and sensorClip.
- Participation in the Building Green Exhibition, 29-30 October 2014.
- Presentation at the EUDP conference in The House of Industry (Industriens Hus), 6/6-2015.
- Conference, about smart industries, smart products and Internet-of-Things (17/11-2015).
- Conference day about development projects, at Teknologisk Institut in Denmark (14/12-2015).
- There have been presentations and dialogue with technical schools; that is VIA University College in Horsens and the School of Engineering (Ingeniør Højskolen) in Aarhus.

There have been several articles, and some are mentioned below:

- Article in Horsens Folkeblad, at the EUDP project startup, primo 2014.
- Info in P4 Østjylland, at the EUDP project startup, primo 2014.
- Article in Elektronik & Data 27/6-2014, http://elek-data.dk/artikel/branche-og-teknologi/banebrydende-teknologisk-fremskridt-inden-for-energistyrin
- Article in Electronic supply, 3/7-2014: http://www.electronic-suply.dk/article/view/133793/nyt_sensorkoncept_testes_i_stort_aarhusprojekt?ref=newsletter#.U7aL3vl_tSD
- Article in the magazine "Mandag Morgen News – Byggeeksport nr. 39", November 17th 2014.
- Articles in Aarhus Stifstidende and TV2 ØstJylland spring 2015 (due to nomination for the Entrepreneur Price).
- Article and case at the online startup Fora, http://www.vistartersgu.dk/en-opgave-som-skulle-loeses.
- Aarhus Stiftstidende, post from Dansk Erhverv, http://stiften.dk/laeserbrev/goer-som-i-oestbirk.
- Article in the Danish magazine "Samvirke".
- Information on partner's home pages and linkedIn profiles.

***Dissemination against customers:***
There have been dialogue with several customers; e.g Dong Energy (DK), COOP, Harald Nyborg, U-Montor (Norway and Ireland), ScanEnergi.

There have been dialogues with possible distribution partners, in Scandinavia, in East Asia, UK, India and Netherland.

There have been dialogue with different Danish cooperation partners and potential customers, in form of the municipality of Aarhus and Slots- og Ejendomsstyrelsen.


**Value chain, from electronic production to end-customer.**

Data sheets and user instructions have been developed, in a draft version. See ReMoni homepage at remoni.eu.

**Project outcome, business wise:**
The developed solution open for access to a huge market, with high expectations to sales and turnover. In sales year 5 we expect a turnover of 16 million €, coming from sales and subscriptions, of which 90% is expected to be export.

**Project outcome, in terms of employment:**
The employment at ReMoni during the project period has raised from 3 part-time to 15 employees (6 full-time and 9 part-time).

## 1.6 Utilization of project results

The project process and the project results has resulted in a strong system solution (consisting of hardware units, encapsulation and a cloud solution), two patents on main technology, setup of electronic production and technical communication material (datasheet and instructions).


Furthermore, we are achieved highly increased knowledge about relevant markets, customer and customer needs, during the project. A marketing plan has been performed, and the ReMoni has been updated, being more focused and strengthened.

Test and demos, together with dialogues with customers and partners, have indicated an increased focus on energy saving solutions, a need for alarms, but also an increased focus on lowering the investment costs. The project has confirmed, that our product is needed and customer are willing to invest in it.

***Market and market potentials:***
The market is split between:

- Industrial
- Predictive maintenance
- Energy management in buildings
- Certified billing meters

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| ***Industrial:*** | Around 1 in 10 of all enterprises (9.4 %) in the EU-28's non-financial business economy is manufacturing companies, counting over 2.1 million enterprises[1], of which over 2 million are SMEs.<br>In the manufacturing sector water and energy consumption accounts for 7,5% of the overall manufacturing costs.<br>The ReMoni solution can lead to a 10% saving on this consumption; meaning 40.000 € / year for a small 400 $m^2$ manufacturing plant. |

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|---|---|
| ***Predictive maintenance:*** | More than 60% of production managers regard the high implementation costs of predictive analytics solutions as a big obstacle[2].<br>Thus, the financial burden associated with the deployment of industrial analytics/predictive maintenance platforms is often referred as the most critical market barrier for commercialisation, stemming primarily from the large number of sensors required to cover all the plant equipment in order to gather sufficient data to perform the required analytical process and from the deployment of usually highly customised IT platforms. |

| | |
|---|---|
| ***Energy management in buildings:*** | The 2014 market for energy efficient building technologies was estimated to $12 billion, with an annual growth of 8.2 % [3].<br>The total ***Danish market size is 177 million €***. If 10 % of these are in actual market for ReMoni energy management and surveillance, the total Danish market size for the ReMoni technology is about 18 million €. |

[1] European Commission, "Annual Report on European SMEs 2013/2014: A Partial and Fragile Recovery", 2014.

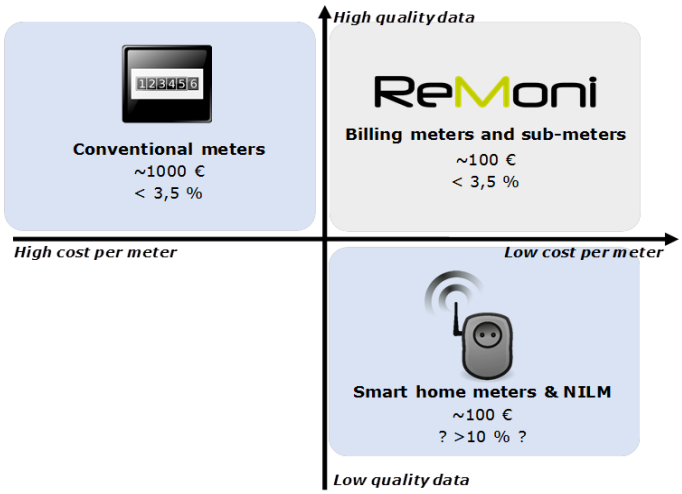
[2] Pierre Audoin Consultants, "Predictive Analytics in the Manufacturing Industry: Niche topic or mainstream?", 2014.

[3] Bloom and Goldstein, Navigant Research, Energy Efficient Buildings: Global Outlook, Q4 2014.

| | |
|---|---|
| ***Certified billing meters:*** | VAT registered companies can reimburse the tax for energy used for process purposes; in Denmark this is 0.12 €/kWh (2016). The European market potential is 83 mill. just for electrical meters.<br><br>Billing in rented apartments and offices, address existing installations without measuring sockets, is 40 mill. electrical billing meters.<br><br>The global billing market for energy consumption companies is 183 mill. meters/year.<br><br>The tax reimbursement is of high interest due to an identified demand at the companies but no acceptable solution available today. |

***Competition situation:***
The competitor situation has been followed and investigated during the project period. It clearly indicates that:

1) Existing energy management solutions are to complex and too expensive; furthermore; customers are tied to them at future expansions or changes – where customers want their freedom to operate and change partner.
2) Customer request smart and low cost clamp-on sensors. And customer's wants flexibility in the central control.




**Positioning of ReMoni meters, held against conventional solutions.**

***Realization of energy policy objectives:***
National and international, there is a big and increased focus on energy saving in buildings. Buildings account for 40% of the total energy consumption and 36% of the $CO_2$ emission in EU (according to the European Commission[4]).

The latest climate conferences, with COP21 as the latest on, showed an increased political focus. In Denmark this has resulted in the Danish Energy Agreement of March 22, 2012[5] and the 2013 climate plan[6], which adds up to a significant effort for energy savings in existing buildings and industries.

Under the title: "An energy-efficient society with less waste of energy" in the Energy Agreement of 22 March 2012, a significant effort for energy savings in existing buildings and processes is prioritised. This is followed up by a specific focus on the energy consumptions in existing buildings, by the EUDP, ForskEL, ForskVE, EL-FORSK, and Strategic Research Council Committee on Sustainable Energy and Environment.

The ReMoni solution addresses this focus. The scientific research has shown that the energy saving potential in existing buildings in EU is 10 % to 70 %, corresponding to saving of up to 1 billion € and 900 million ton $CO_2$ a year [7,8,9,10,11,12], and that there is a significant saving potential in both the public and private sectors [13].

[4] https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings.

[5] http://www.ens.dk/sites/ens.dk/files/politik/dansk-klima-energipolitik/politiske-aftaler-paa-energiomraadet/energiaftalen-22-marts-2012/Aftale_22-03-2012_FINAL_ren.doc.pdf

[6] http://www.kebmin.dk/sites/kebmin.dk/files/virkemiddelkatalog_web.pdf

[7] Sarah Darby, 2006, The Effectiveness of Feedback on Energy Consumption, University of Oxford.

[8] Marina Economidou et. Al, 2011, Europe's buildings under the microscope, Buildings Performance Institute Europe (BPIE).

***Strategy and activities, after the project:***
Our ongoing and future focus is establishment of a bigger demo setup and have the total system CE-approved, to be carried out during autumn 2016.

We will run commercialisation activities. This is closing of sales agreements, with Caverion and other distribution partners, generation of marketing materials and updating of the home page.

After the project completion the Danish Energy Management House "Vitani Energy Systesms A/S" has been involved in the ReMoni-Caverion cooperation. ReMoni deliver the product solution, Caverion the installation and service and Vitani the integration with customers BMS system. Both Caverion and Vitani will makes sales to customers.

The product solution is expected to be commercialized primo 2017.

## 1.7 Project conclusion and perspective

***Technical conclusions:***

1) High quality hardware units have been developed. This is two power meters and a gateway.
2) A strong and open-sourced cloud solution has been developed. The front end is simple and foreseeable, to be used at installation, for information and for alarm generation. See portal.remoni.eu.
3) Two patents on core technology are applied and obtained.
4) Test has proved compliance to requirement.

***Commercial conclusion:***
The market potential is huge and increasing, with an increased focus and political awareness on energy savings and buildings.

There is a high and increased demand cost-efficient solution for energy management and surveillance, including generating of alarms on abnormal operation and over-consumption.

Customer request flexible and cost efficient solutions; that's on sensor level and control level.

Setup of an international sale- and distribution network, according to the value chain and with focus on relevant partnerships with partners, installers and technical advisors.

***Future perspectives:***
The project has shown a big request after alarm generation on the daily operation. Therefore, future development will focus on the development of extended alarm modules, in a modular built design.

The project has strengthened our focus on the installation ease rather than lowering the unit costs further. The big savings for customer and distribution partners lay on the installation time (=installation cost). In the future development we will have an increased focus on the installation ease on the main power meter.

[9] THE EFFECTIVENESS OF FEEDBACK ON ENERGY CONSUMPTION, Sarah Darby, University of Oxford, 2006 (http://www.eci.ox.ac.uk/research/energy/downloads/smart-metering-report.pdf)

[10] Energistyrelsen (http://www.ens.dk/offentlig-og-erhverv/energiledelse)

[11] CarbonTrust (http://www.carbontrust.com/resources/faqs/technology-and-energy-saving/monitoring-energy-use)

[12] ENS: Energibesparelser i erhvervslivet (http://www.ens.dk/sites/ens.dk/files/politik/dansk-klima-energipolitik/politiske-aftaler-paa-energiomraadet/energiaftalen-22-marts-2012/Energibesparelser%20i%20erhvervslivet.pdf)

[13] Energiindeks Danmark (http://www.ds.dk/da/nyhedsarkiv/2013/3/energi/~/media/DS/Files/Downloads/Artikler/energiindeks.ashx)

# Annex 1. Publications.

***Publications:***

Horsens Folkeblad, "Millionstøtte til lille dims", 10. februar 2014:
http://hsfo.dk/article/20140210/ARTIKLER/140219997

Elektronik & Data 27/6-2014:
http://elek-data.dk/artikel/branche-og-teknologi/banebrydende-teknologisk-fremskridt-inden-for-energistyring

Electronic Supply, 3/7-2014;
http://www.electronic-supply.dk/article/view/133793/nyt_sensorkoncept_testes_i_stort_aarhusprojekt#.V7wwlY9OKUk

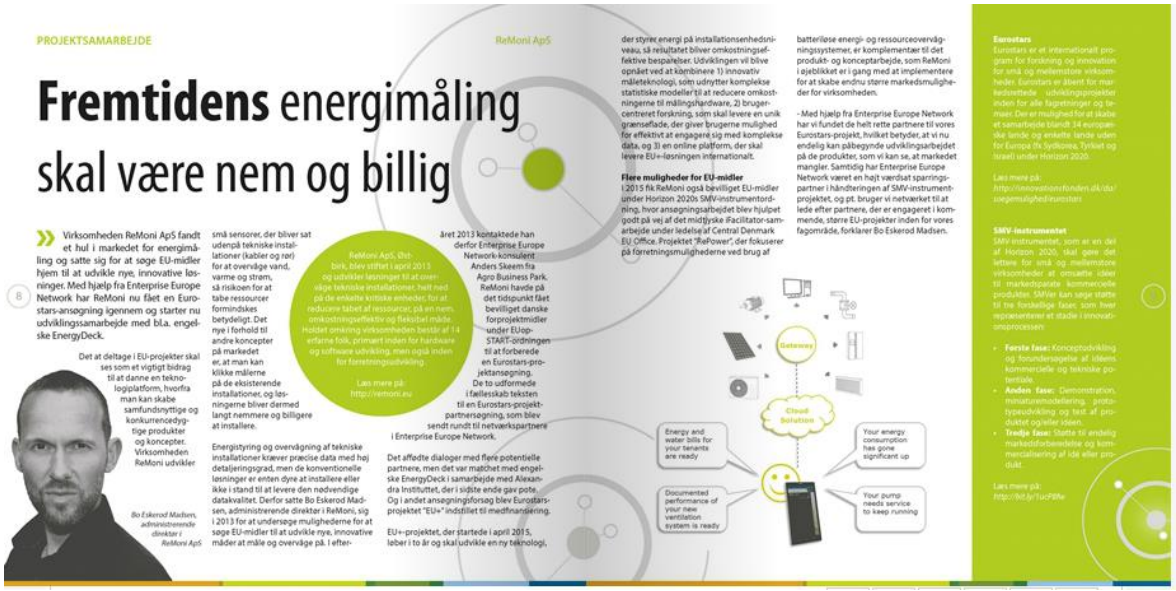
Aarhus Stiftstidende, 10. marts 2015:
http://stiften.dk/erhverv/her-er-de-9-nominerede-til-ivaerksaetterprisen-2015

ViStarterSgu.dk, 13. april 2015:
http://www.vistartersgu.dk/en-opgave-som-skulle-loeses/

Aarhus Stiftstidende, 8. december 2015, artikel fra Dansk Erhverv:
http://stiften.dk/laeserbrev/goer-som-i-oestbirk.

Samvirke, "Potteplanten går snart på Internettet", 22. september 2015:
http://oelklubforkvinder.dk/wp-content/uploads/Samvirke-oktober-2015.pdf (side 36).
http://samvirke.dk/forbrug/artikler/potteplanten-gaar-snart-paa-internettet.html

Enterprise Network Europe, forår 2016, "Fremtidens energimåling skal være nem og billig":
http://www.onlinepdf.dk/Books/onlinePDF.aspx?onlinepdf=3099d9e7-ce83 (side 8)



PROJEKTSAMARBEJDE

ReMoni ApS

# Fremtidens energimåling skal være nem og billig

Virksomheden ReMoni ApS fandt et hul i markedet for energimåling og satte sig for at søge EU-midler hjem til at udvikle nye, innovative løsninger. Med hjælp fra Enterprise Europe Network har ReMoni nu fået en Eurostars-ansøgning igennem og starter nu udviklingssamarbejde med bl.a. engelske EnergyDeck.

Det at deltage i EU-projekter skal ses som et vigtigt bidrag til at danne en teknologiplatform, hvorfra man kan skabe samfundsnyttige og konkurrencedygtige produkter og koncepter. Virksomheden ReMoni udvikler

Bo Eskerod Madsen, administrerende direktør i ReMoni ApS

små sensorer, der bliver sat udenpå tekniske installationer (kabler og rør) for at overvåge vand, varme og strøm, så risikoen for at tabe ressourcer formindskes betydeligt. Det nye i forhold til andre koncepter på markedet er, at man kan klikke målerne på de eksisterende installationer, og løsningerne bliver dermed langt nemmere og billigere at installere.

ReMoni ApS, Oestbirk, blev stiftet i april 2013 og udvikler løsninger til at overvåge tekniske installationer, helt ned på de enkelte kritiske enheder, for at reducere tabet af ressourcer, på en nem, omkostningseffektiv og fleksibel måde. Holdet omkring virksomheden består af 14 erfarne folk, primært inden for hardware og software udvikling, men også inden for forretningsudvikling.

Læs mere på: http://remoni.eu

Energistyring og overvågning af tekniske installationer kræver præcise data med høj detaljeringsgrad, men de konventionelle løsninger er enten dyre at installere eller ikke i stand til at levere den nødvendige datakvalitet. Derfor satte Bo Eskerod Madsen, administrerende direktør i ReMoni, sig i 2013 for at undersøge mulighederne for at søge EU-midler til at udvikle nye, innovative måder at måle og overvåge på. I efteråret 2013 kontaktede han derfor Enterprise Europe Network-konsulent Anders Skeem fra Agro Business Park. ReMoni havde på det tidspunkt fået bevilget danske forprojektmidler under EUREKA-START-ordningen til at forberede en Eurostars-projektansøgning. De to udformede i fælleskab teksten til en Eurostars-projektpartnersøgning, som blev sendt rundt til netværkspartnere i Enterprise Europe Network.

Det affødte dialoger med flere potentielle partnere, men det var matchet med engelske EnergyDeck i samarbejde med Alexandra Instituttet, der i sidste ende gav point. Og i andet ansøgningsforsøg blev Eurostars-projektet "EU+" indstillet til medfinansiering.

EU+-projektet, der startede i april 2015, løber i to år og skal udvikle en ny teknologi, der styrer energi på installationsenhedsniveau, så resultatet bliver omkostningseffektive besparelser. Udviklingen vil blive opnået ved at kombinere 1) innovativ måleteknologi, som udnytter komplekse statistiske modeller til at reducere omkostningerne til målingshardware, 2) brugercentreret forskning, som skal levere en unik grænseflade, der giver brugerne mulighed for effektivt at engagere sig med komplekse data, og 3) en online platform, der skal levere EU+-løsningen internationalt.

**Flere muligheder for EU-midler**

I 2015 fik ReMoni også bevilliget EU-midler under Horizon 2020s SMV-instrumentordning, hvor ansøgningsarbejdet blev hjulpet godt på vej af det midtjyske Facilitator-samarbejde under ledelse af Central Denmark EU Office. Projektet "RePower", der fokuserer på forretningsmulighederne ved brug af batteriløse energi- og ressourceovervågningssystemer, er komplementær til det produkt- og konceptarbejde, som ReMoni i øjeblikket er i gang med at implementere for at skabe endnu større markedsmuligheder for virksomheden.

- Med hjælp fra Enterprise Europe Network har vi fundet de helt rette partnere til vores Eurostars-projekt, hvilket betyder, at vi nu endelig kan påbegynde udviklingsarbejdet på de produkter, som vi kan se, at markedet mangler. Samtidig har Enterprise Europe Network været en højt værdsat sparringspartner i håndteringen af SMV-instrumentprojektet, og pt. bruger vi netværket til at lede efter partnere, der er engageret i kommende, større EU-projekter inden for vores fagområde, forklarer Bo Eskerod Madsen.



**Eurostars**

Eurostars er et internationalt program for forskning og innovation for små og mellemstore virksomheder. Eurostars er åbent for markedsvendte udviklingsprojekter inden for alle fagretninger og temaer. Der er mulighed for at skabe et samarbejde blandt 34 europæiske lande og enkelte lande udenfor Europa (fx Sydkorea, Tyrkiet og Israel) under Horizon 2020.

Læs mere på: http://innovationsfonden.dk/da/ansoegningsmuligheder/eurostars

**SMV-instrumentet**

SMV-instrumentet, som er en del af Horizon 2020, skal gøre det lettere for små og mellemstore virksomheder at omsætte idéer til markedsparate kommercielle produkter. SMVer kan søge støtte til tre forskellige faser, som hver repræsenterer et stadie i innovationsprocessen:

- **Første fase:** Konceptudvikling og forundersøgelse af ideens kommercielle og tekniske potentiale.
- **Anden fase:** Demonstration, miniaturisering, prototypeudvikling og test af produktet og/eller ideen.
- **Tredje fase:** Støtte til endelig markedsforberedelse og kommercialisering af ide eller produkt.

Læs mere på: http://bit.ly/1ucPBNv

**Publication (conference paper, "Smart Systems Integration", Frankfurt March 2015):**
"Easy Energy Monitoring by IoT Enabling Existing Devices", af Bo Eskerod Madsen.

***Home pages:***

For products and product documentation: www.remoni.eu.
For the ReMoni solution: www.portal.remoni.eu.
Youtube movie: https://www.youtube.com/watch?v=C5I5GlatScg&feature=youtu.be&noredirect=1

# Annex 2. COMPETITION – Comparison table:

| Measurement of POWER: | RePower | | Classic industrial systems |
|---|---|---|---|
| | *Sub-meter* | *Main meter* | |
| **Total system:** | | | |
| ***Total price:*** | Low | Low | High |
| **Buy + installation price (per meter):** | **€ 100** | **€ 100** | **€800-1.000** |
| **POWER meter:** | | | |
| ***Installation:*** | | | |
| **Cutting the cable at installation:** | **No [1]** | **No [2]** | **Yes** |
| **Installation without disconnection power:** | **Yes** | **Yes** | **No** |
| **Installation needs an electrical switchboard [3]:** | **No** | **No** | **Yes** |
| **Installation time per meter:** | **< 5 min. [4]** | **5-7 min. [5]** | **>30 min. [6]** |
| Ease of installation: | Easy | Easy/medium | Medium/difficult |
| Settings: | None | None | Yes (complex) |
| Installation expertise needed: | No | No | Yes |
| When installation space is limited: | Easy | Easy | Difficult |
| Ease for retrofit: | High | High | Middle |
| ***The metering:*** | | | |
| Accuracy: | ~5% | < 3.5% [7] | < 3.5% |
| MID certification, MID-MI003: | No | (Yes - pending) | Yes |
| Robust against external mobile signals: | Yes | Yes | No |
| ***Data transmission:*** | | | |
| Wireless data transmission: | Yes (868 MHz) | | Yes/No [9] |
| Transmission range (line-in-sight): | 450 m | | Typical 300 m |
| Batteries (for wireless meters): | Battery (lifetime) | Self-powered | Battery/external supply |
| ***Security and storage:*** | | | |
| Transmitted data encrypted: | Yes | | Yes |
| Acknowledge receiving [8]: | Yes | | Yes/no |
| Accumulated meter data storage: | Yes > 40 years | | Yes |
| **Gateway:** | | | |
| ***Receiving:*** | | | |
| Wireless data receiving: | Yes | | Yes/No [9] |
| Data receiving from external sensors and meters: | (wireless M-Bus [10]) | | Yes |
| Number of sensors to receive data from: | Up to 500 | | Variable |
| ***Data transportation to cloud / EMS:*** | | | |
| Ethernet: | Yes | | Yes |
| WiFi: | Optional | | Some |
| Mobile 3G / GSM: | Optional | | Some |
| ***Security and storage:*** | | | |
| Transmitted data encrypted: | Yes | | Yes/some |
| ***Price:*** | | | |
| Price level: | Low | | Middle-high |
| ***Additional devices:*** | | | |
| Need of other equipment in the installation: | No | | In some systems [11] |
| **Cloud Solution / Energy Management system (EMS):** | | | |
| ***System type:*** | | | |
| Web-based, cloud solution: | Yes | | No |
| Integration easiness in customer system: | Easy | | Middle |
| ***Functionality:*** | | | |
| Change of settings [12]: | Easy | | No / difficult |
| Predictive alarms [13]: | Yes | | Some |
| ***Security:*** | | | |
| Data security [14]: | Yes | | Some |
| Data accessibility [15]: | Easy | | Middle |
| ***Alarming:*** | | | |
| Alarms [16]: | Intelligent alarms | | Some |
| Warnings [16]: | Yes | | Some |
| ***Connection to mobile devices:*** | | | |
| PC's, tablets and mobile phones [17]: | Yes | | Some |
| ***Customer access to data:*** | | | |
| Easy access to and use of data [15]: | Yes | | No |
| Customer owner of data [15]: | Yes | | No |

DRAFT

[1] The meter is simply clamped directly on the outside of the double isolated multicore cable.
[2] Wire is not cut, but stripped.
[3] Electrical switchboard is the box where the conventional meter must be installed. The PowerMoni can be installed directly on the existing cable.
[4] ReMoni installation covers: Clamp the sensor on the outside of the power cable; after installation of gateway and a RePower main meter at the main.
[5] ReMoni installation covers: Stripping the power cable, mounting the power conductors and clicking on the cover; after installation of gateway.
[6] Classic industrial system installation covers: Switching off the power, cutting the electrical cables, rewire installation, meter installation in the electrical switchboard, mounting of data logger, eventual mounting of wireless module, gateway installation, cable work from sensor to gateway (if not wireless), gateway installation on Ethernet.
[7] Precision according to the MID directive MI-003, meter class A.
[8] Receive of acknowledge to verify that a measurement has been received.
[9] Requires add of a wireless communication module.
[10] Will be available later on.
[11] E.g. communication module, optical eye for remote reading, etc.
[12] Traditional heat meters have to be ordered with the right settings. The ReMoni flow meters have the settings possibilities in the cloud.
[13] ReMoni Cloud use data analyses for prediction on technical installation and actual aggregate operation, for generating warnings and alarms before aggregates break down.
[14] The ReMoni solution encrypted all customer data, and data in cloud is protected behind customer log-in. The ReMoni cloud stored data have automated backup functionality.
[15] All customer data can be fetched through the ReMoni API.
[16] Not all Energy Management Systems (EMS) offer alarms and warnings. ReMoni has self-learning alarms based on advanced statistical models, offering alarms and warnings on consumptions and operation.
[17] ReMoni use HTML 5 solution to ensure connectivity across platforms.

# Annex 3. MARKET ANALYSIS SUMMAY

The potential for a wireless electric meter (power meter) that requires no intervention in the power cable installation, is very large. The customer for the solution is going to be a very large part of the industrial companies, housing associations, public buildings and, to a certain extent, also private users.

If we look at the Caverions assessment of the value chain, it will, in order to achieve the desired success and at the same time be scalable, include the following indent:


**Sales partners (partners, installers and technical advisors):**
In order to achieve a market coverage that is high enough, it is required to access sales through a number of sales partners, in form of partners, installers and technical advisors:

- Electricity and plumbing contractors
- Engineering contractors
- Energy companies
- Property managers
- Energy consultants
- Consulting engineers

The list above is not exhaustive but cover the most relevant sales partners. Only by addressing all the actors in the market, there will be a sufficient market coverage with subsequent achievement of the desired market share.

Since the power meter does not require any authorization to install, there is also a market addressing property managers, technical service employees, energy consultants etc.

**Distributors:**
In order to cover the market for the relevant sales partners, it is the Caverion's assessment, that the product is to be marketed by a number of distributors, who secure storage and distribution, as well as marketing indirectly to sales partners.

Without a strong distribution nationally and internationally, it will not be possible to get the product sold into the market quickly enough to achieve "first mover" advantage.

Caverion recommend these distributors:

- Solar A/S
- LM GLASFIBER A/S
- Bdr. Dahl A/S
- Sanistål A/S

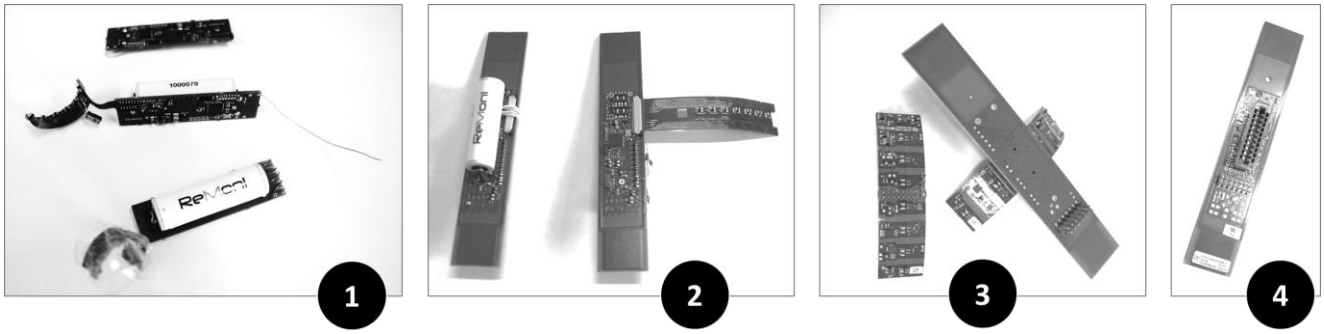
**Caverion A/S.**
*Bent Ole Jonsen,*
*Sales Director, Service Denmark.*

# Annex 4. OUR PROJECT JOURNEY.

## *Pictures and development phases.*

### A: Hardware development:

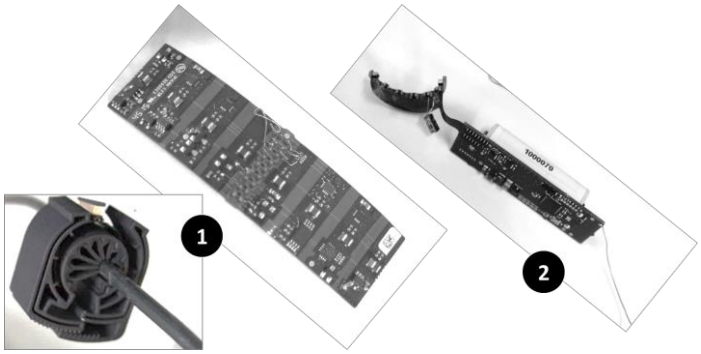
#### *A1: Hardware – the transmitter:*




The four pictures above show four transmitter development iterations. Here with some comments to the four iterations:

1) The thin wires show the antenna. In this design transmission range was insufficient.
2) PCB with measuring circuits, micro controller, PCB antenna and radio. The thin and flexible print horizontal at the transmitter PCB is an early cable collar PCB.
3) Further development of the transmitter PCP, without edge connector. This version has been tested according to radio performance and EMC requirements.
4) The final transmitter PCB. The plug is for connection to power main meter.

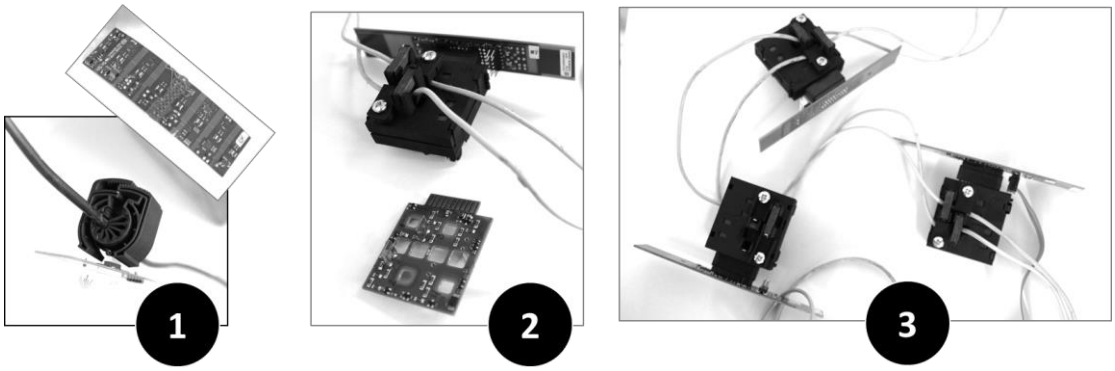
#### *A2: Hardware – the power sub meter:*




1) The first version of the power meter PCB, with the flex PCB (to the left) connected.

2) The flex print, flipped into the power sensor.

#### *A3: Hardware – the power main meter:*

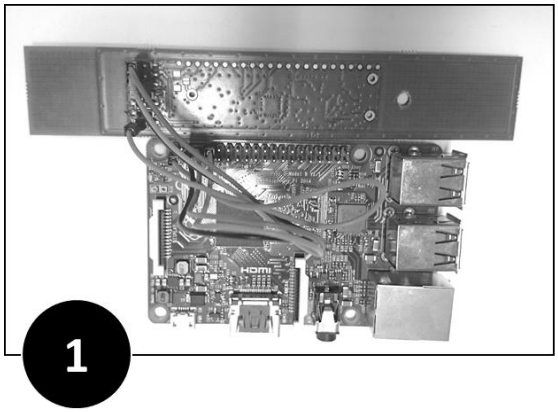


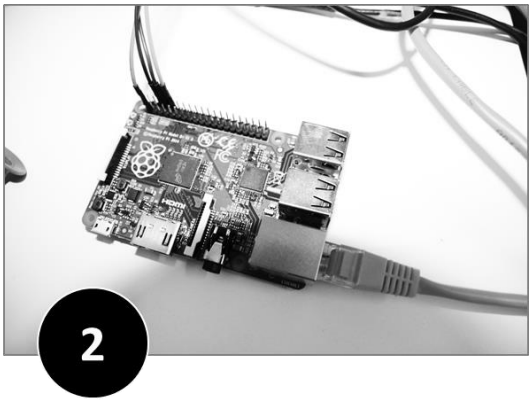

Above illustrates some of the final electronics for the main meter:

1) The first power meter, illustrated with the power sensor and transmitter PCB connected. The flex print shown in top of the figure is mounted inside the encapsulation surrounding the cable.
2) The final version of the main meter. The PCB shown is installed in the black casing shown in top of the picture, and with a bare transmitter PCB connected.

3) Test set up with three power main meters without the outer encapsulation.

***A4: Hardware – the gateway:***




1) An earlier version of the gateway PCB, with transmitter print (radio) connected (in top of the picture).
2) The final version of the gateway PCB. The cable installed in the plug is the internet connection. It is possible to connect other plug-modules, if alternative transmission with the central control is required, e.g. over mobile internet, Ethernet or WiFi.

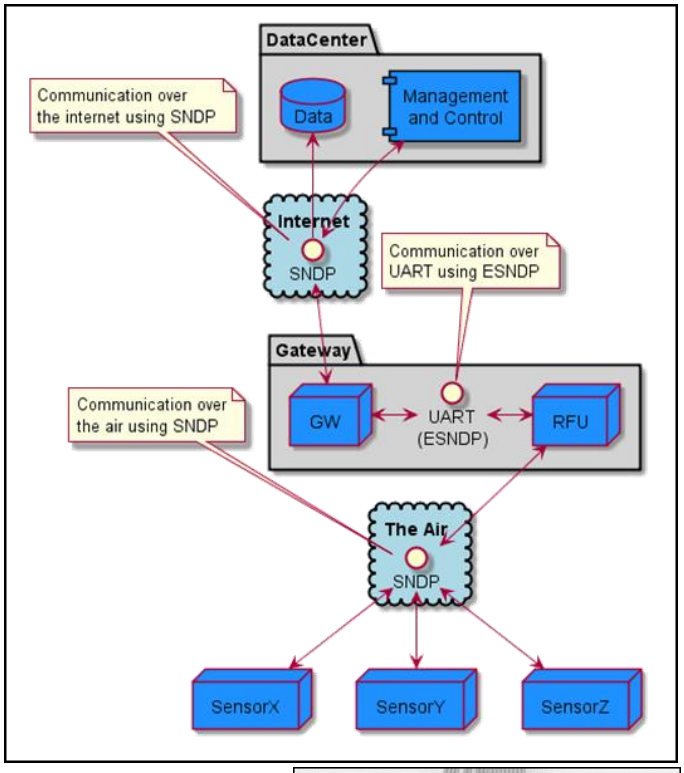
***A5: Hardware – Embedded software in the receiver:***

The micro controller in the transmitter unit handle data from meters and the transmission to and communication with the cloud.

This means that the embedded software must:

- Collect measuring data from meters.
- Handle data flow and data structures.
- Format data
- Control parameters
- Control software and hardware versions

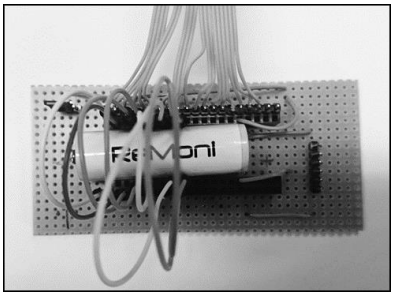
The figure besides shows the structure of the embedded software in the transmitter unit.




We have constructed a debug unit for the test and verification of the embedded software.

The debug unit makes it much faster to make sensor measurements. The embedded software is tested during several test steps.

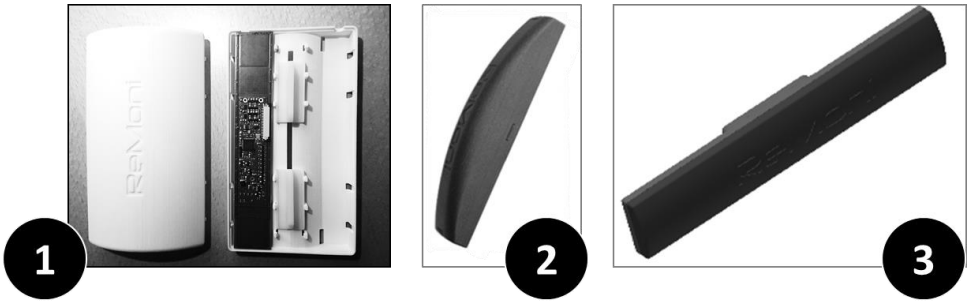
The figure besides shows the debug unit, which is developed internal at ReMoni.



### C: Encapsulation:

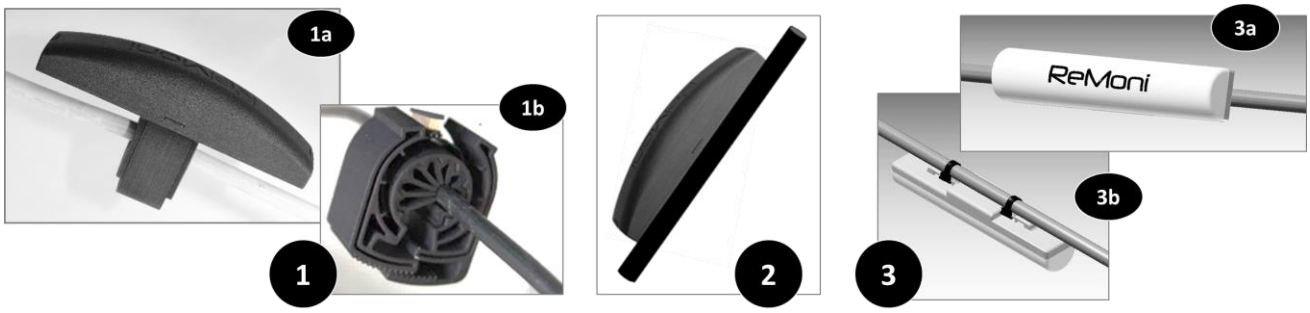
The encapsulation (casing) has been developed during several iterations. Some iterations are shown below.

***Transmitter; casing iterations:***




1) One of the first versions, of transmitter casing.
2) A later version of the transmitter casing.
3) The final version of the transmitter casing.

***Power meter; sub-meter casing iterations:***




The pictures above show three iterations loops for the sub meter:

1) Design with a cable collar, clicked around the actual cable. Picture 1b show the cable collar itself, and in picture 1a the transmitter is clicked on.
2) New click-on, for the mounting on the cable, but still the old transmitter.
3) Final design, where the sub meter is just attached around the cable using electric stripes, to ease the installation. 3a is seen from front of the sub meter, at 3b from the bottom side.

***Power meters: Main-meter casing:***


Above illustrate the final design of the main meter.

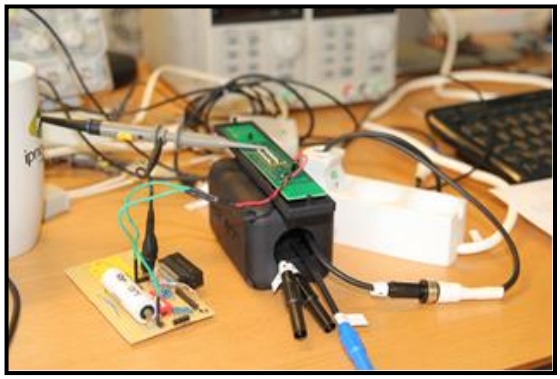
1) The bottom casing, with the PCB.
2) At the left the power sensor, at the right the transmitter (with the radio).
3) The power main meter, with power sensor and transmitter connected.

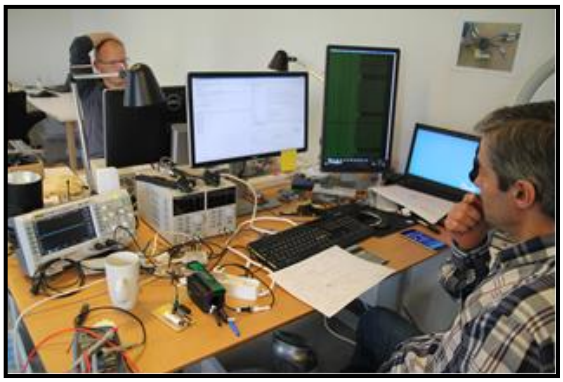
***Gateway casing; iterations:***



1) The first gateway casing used with a first prototype PCB inside.
2) We have decided to buy a raspberry Pi casing to gain better flexibility in the product.

***Pictures from the internal tests:***





***Pictures from demo test at Municipality of Aarhus (Aarhus Kommune):***