RUGGEDISED
Designing smart, resilient cities for all

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Written By	Roland van Rooyen (ROT)	2022-09-22
Checked by	Katelien van den Berge (ROT)	Oct 2022
Reviewed by	Katelien van den Berge Maarten Weide (UNR) Irene Lamme (UNR) Klaus Kubeczko (AIT) - Innovation manager	Oct 2022
Approved by	Albert Engels (ROT) – Coordinator Maarten Weide (UNR) – Project manager	2022-11-24
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Project partners:
01 - GEMEENTE ROTTERDAM (ROT)- NL
02 - UMEA KOMMUN (UME) - SE
03 - GLASGOW CITY COUNCIL (GCC) - UK
04 - RISE RESEARCH INSTITUTES OF SWEDEN AB (RRI)- SE
05 - ISTITUTO DI STUDI PER L'INTEGRAZIONE DEI SISTEMI SC (ISSINOVA) - IT
06 - AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH (AIT) - AT
07 - NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO) - NL
08 - ICLEI EUROPEAN SECRETARIAT GMBH (ICLEI) - DE
09 - ERASMUS UNIVERSITEIT ROTTERDAM (EUR) - NL
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13 - STATUTARNI MESTO BRNO (Brno) - CZ
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33 - GDANSKA INFRASTRUCTURA WODOCIAGOWO-KANALIZACYJNA SP ZOO (GIWK) - PL
34 - RISE ACREO AB (RA) - SE

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Executive summary

This report provides insight in one of the thirteen Smart solutions that are implemented in the Heart of South area in the City of Rotterdam. These innovative solutions are part of the RUGGEDISED program, which is subsidised by the European Commission and aims to test, implement and accelerate the Smart City model across Europe. Smart Cities include places were traditional networks and services are made more efficient with the use of digital technologies, for the benefit of its people. The Smart solution this document further elaborates on is R8: Energy management. This solution is related to others. The energy management system for example monitors several energy solutions (R1, R2, R4). Furthermore, the energy data can be an input for the 3D Digital City's operations model (R9).

Chapter 2 describes the functioning and goals of an Energy Management System (EMS) in Heart of South. An EMS monitors and manages energy streams between buildings to optimize demand and supply of energy. The system can for example detect malfunctioning installations and thus helps avoiding energy losses. For this purpose several relevant KPI's are used for which setpoints are set. In Heart of South the ambitions are set high. An EMS normally manages the energy system within a building, but this project aims to establish a system on area level. Not only data from buildings is supposed to be included, but also data from other energy related solutions, like from the geothermal heat and cold storage (R1), sewage water heat and cold extraction system (R2), pavement collectors (R4) and RES generation (R5). In the case of Rotterdam, all real-time data is gathered and analyzed in dashboard Simaxx.

In chapter 3 the implementation in Rotterdam is described. The plan was to connect all new and renovated buildings in the Ahoy area to the EMS. In reality, not all buildings were willing to be part of and to adopt/ implement the EMS, as it is an advanced and new system and thus costly to install while the functionalities are not all relevant to building owners. Currently, most of the sensors that are necessary for the EMS are installed in the Ahoy complex and the data is disclosed in Simaxx. The next step is to analyse the KPI's. Additionally, the functionality of coupling data from Simaxx to the 3D Digital City's operations model (R9) has been tested and implemented.

Chapter 4 elaborates on the business case. The estimated decrease in energy consumption is 164.132 kWh per year, which results in a CO_2 reduction of 66 ton per year, which represents 5 % of the building related energy demand for which BEST tables have been made.

Chapter 5 and 6 focus on conclusions, lessons learned and recommendations. The main conclusion is that the ambition to monitor and manage energy on area-scale is not completely fulfilled. Although the data of the Ahoy buildings is put into Simaxx, this is not the case for all the buildings and Smart solutions. A significant finding is that the solution must be client based and cost effective. Furthermore, it is very important to include the implementation of the EMS from the start of the overall project and pay attention to data privacy and security at all times. The replicability in other cities is high. However, there is no standardisation for Smart Thermal Grids, so every situation demands a tailormade approach. It is highly probable that in the near future there is an increased need for advanced EMS's.

Contents

1 Introduction

RUGGEDISED is a Smart City project funded under the European Union's Horizon 2020 research and innovation program. The European Commission defines a smart city as: "A place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses". The goal of the project is to test, implement and accelerate the Smart City model across Europe.
Within Rotterdam the main focus is on Smart Energy systems, with the goal to reduce import of energy from outside the area and produce as much as possible within the area itself.
In this report guidelines are given for choosing and implementing an Energy Management System (EMS). Main focus is implementing the EMS for managing thermal energy streams on different buildings and monitoring the implemented solar systems (photovoltaic). Besides this, the energy stream in the Smart Thermal Grid (STG) and energy generation of the pavement (asphalt) heat-cold collector and sewage energy system in the pumping station are being monitored. See figure 1.

Figure 1: An overview of the Heart of South implementations

1.1 Lighthouse cities

The current period in which we live is characterised by rapid technological development, strong globalisation of (social and economic) activities, a need to protect our living environment and to ensure social stability. In the European-funded Smart City project RUGGEDISED, the three lighthouse cities of Rotterdam, Umea, and Glasgow work together with a number of partners from academic, business and consultancy backgrounds to develop and test solutions to exploit and explore sustainable urban development opportunities offered by smart solutions.

The three overall aims of RUGGEDISED are:

1. Improving citizens' quality of life by offering a clean, safe, attractive, inclusive and affordable living environment.

2. Reducing the environmental impacts of activities, amongst others by achieving a significant reduction of CO2 emissions, a major increase in the investment and usage of renewable energy sources and an increase in the deployment of electric vehicles.
3. Creating a stimulating environment for sustainable economic development, by generating more sustainable jobs, stimulating community involvement in smart solutions (as consumers and as producers) and to boost start-up and existing companies to exploit the opportunities of the green digital economy and Internet of Things.

1.2 Smart thermal grid and smart electric grid in Rotterdam

The City of Rotterdam played an important role in the RUGGEDISED project. Rotterdam is the Netherlands second-largest city and is characterised by its diverse, multi-ethnic community and Europe's busiest port. The City of Rotterdam introduced the Heart of South, the city centre of the South side of Rotterdam, as their lighthouse district, see figure 2&3. Through RUGGEDISED the area is undergoing a transition, consisting of renovating event/ exhibition centre Ahoy and building new facilities like a congress centre, swimming pool and a cinema.

Figure 2: Map of the city of Rotterdam including the project area Heart of South

Figure 3: An overview of the Heart of South area and the Ahoy complex.

One of the main goals of the project in Heart of South is to connect several buildings in the area to a Smart Thermal Grid (STG), which is based on renewable energy sources and facilitates the exchange of heating and cooling between buildings. The establishment of the STG makes the Ahoy area natural gas free. The Smart Electric Grid (SEG) aimed to provide smart electric solution to the area, such as DC solutions, efficient and intelligent street lighting, solar energy generation, etcetera. The DC solutions turned out not to be feasible, due to a lack of commitment of the local grid operator, national legislation, safety rules and a negative business case. In that sense the remaining parts of the SEG consist of the efficient and intelligent street lighting and building related solar panels on Ahoy and Rotterdam Ahoy Convention Centre (RACC). The generated solar energy is fed back into the building connection, which makes it possible to deliver directly to the energy users/ appliances in the building, the surplus is delivered back into the national electricity grid.

In total 13 innovative solutions are implemented in the area, from which several solutions contribute to the establishment of the STG and the SEG. The solutions are highly related; for example, some solutions focus on generating energy, while other solutions focus on the storage or usage of that energy. See figure 4 for an overview of buildings and solutions connected via either the STG and/or the SEG. The bus station charging station for e-buses (here indicated with cars) can be seen, as well as the Smart lighting in the public area. The grey dotted line indicates the conventional electricity grid (indicated with Regular AC). On the thermal side (STG) the connection to the district heating (indicated with SW) can be seen, as well as the Aquifer Thermal Energy Storage (ATES) next to Ahoy and the International Conference Centre (ICC/RACC).

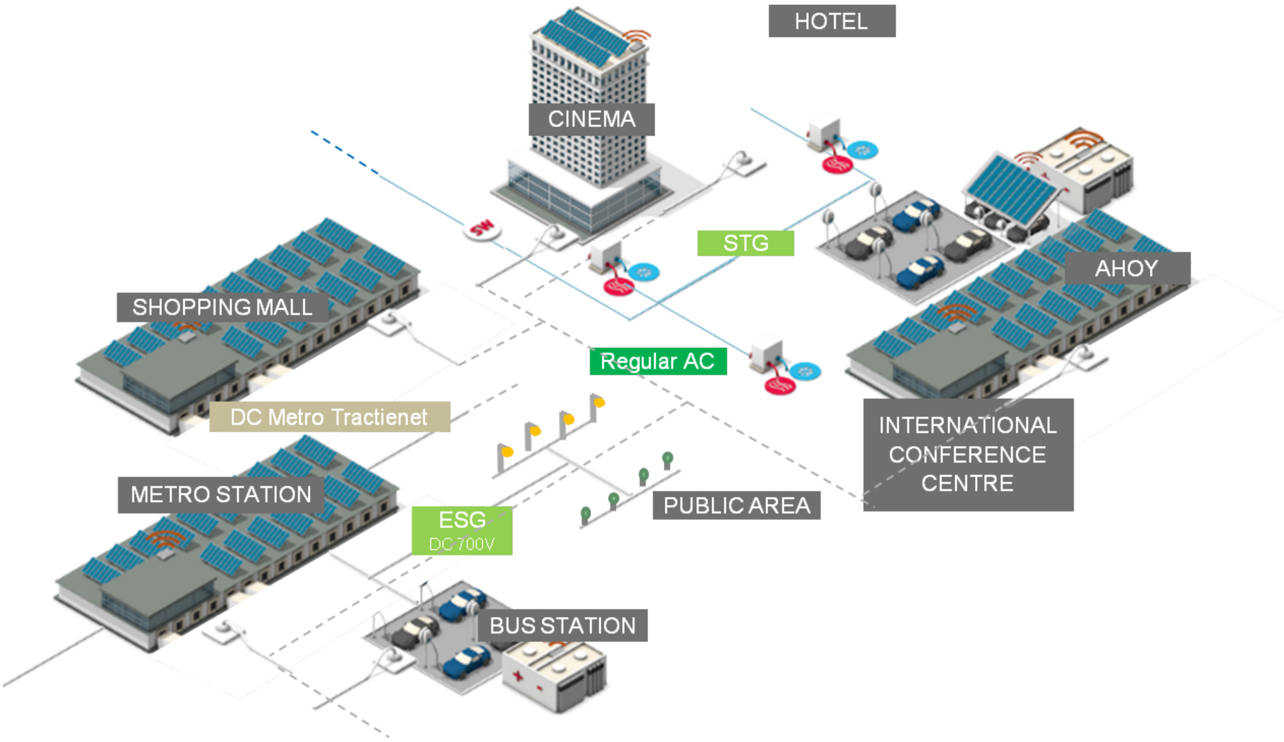


Figure 4: An overview of the buildings and solutions that are possibly connected to the STG and SEG/ ESG in Heart of South

2 Energy management system

The primary role of an Energy Management System (EMS)[1] is to achieve a reliable functionality of an energy grid, maximizing the penetration of renewable energy and optimizing the cost and economic efficiency. For meeting these goals, the EMS has to solve the optimization problem of balancing the demand and generation of energy, including the use of storage. The overall system thus tries to optimise energy flows in the most efficient way; a dynamic, constantly matching equilibrium between assets that need energy and that demand energy becomes active.

To realise this, real time energy data is needed. Part of the EMS is therefore measuring and monitoring energy demand and supply. The real time data can be gathered and analysed in a data-exchange platform/dashboard. In the case of Rotterdam this platform is called Simaxx. Simaxx provides insights in the functioning of building installations, usage of energy per event or location and reports about energy consumption and malfunctioning in monitoring. Furthermore, the system can give insight in costs for maintenance of installations and facades. Building owners can set Key Performance Indicators (KPI's) to detect and visualise for example unusual energy consumption.

Nowadays, energy-monitoring and -management systems exist on building level, but a system on area level, including multiple buildings, is rare. Establishing a system on area level is complicated. This is due to the fact that in an EMS building information is automatically interpreted and analysed by thousands of existing algorithms and when new buildings are added, all these algorithms need to be updated since the overall area performance changes.

Local Electricity Markets, 2021, Quoc TuanTran et al, pages 159-175

3 Implementation in Rotterdam

3.1 Ambitions

As mentioned in chapter 2, an EMS normally is built at building level to gain information on and optimize the energy streams (demand and supply). The ambition for RUGGEDISED was a lot higher: implementing not only an EMS per building, but also build an overarching EMS on area level, which then connects to a city-wide data platform, the 3D Digital City's operations model (Smart solution R9).

The plan was that all new and renovated buildings in the Ahoy area for which also a BEST table was submitted, would be part of the EMS. These buildings are: the Swimming pool, Arts building, Congress building Ahoy, International Congress Center/ Rotterdam Ahoy Convention Center (ICC/ RACC) and 84 new houses. Furthermore, it was planned that several other Smart solutions would be monitored, like charging points. Figure 5 shows what building related energy streams and other smart solutions were planned to be monitored.

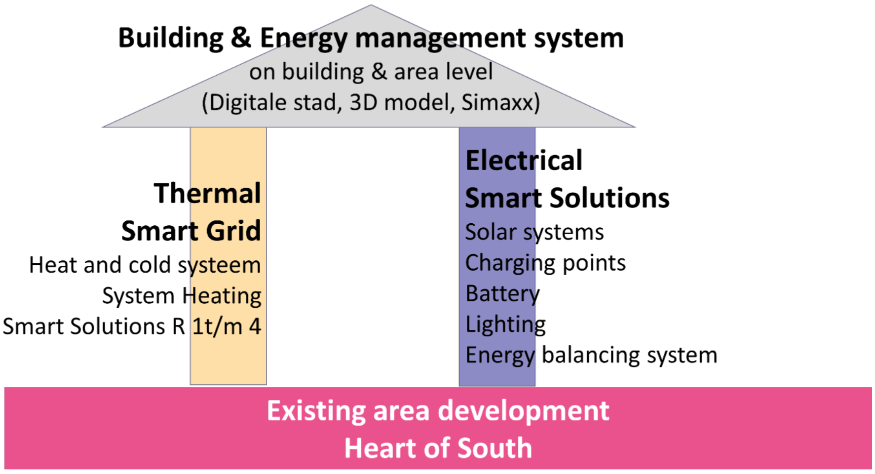


Figure 5: Scheme of the input for the Energy management system

3.2 Partners and roles

There are several parties involved in the implementation of the EMS within the RUGGEDISED project. Energy company Eneco is responsible for implementing the EMS and works close together with installation company ETP, which is implementing the energy solutions and sensor systems. Furthermore, building contractor Heijmans is involved, as they are a trusted Solution Integrator of Simaxx. Simaxx is a software platform with a dashboard, created in the Netherlands and now owned by company Tyrell Building Technologies. Simaxx uses data from Building Management Systems, but also data from other sensor-systems. Simaxx is also the name of the management software itself. With Simaxx data can be gathered and analyzed. Simaxx realizes the actual installation of the equipment and the accompanied subscription to the service. As the City of Rotterdam not only is the owner of some of the buildings, but also a building user and responsible for monitoring and doing project management of RUGGEDISED, they are committed to solve issues that occur. Together, Eneco, Simaxx and the City of Rotterdam form the working group that implement the Simaxx monitoring system (EMS). Another partner is AIT. This organization supports the Municipality of Rotterdam in the monitoring process and will check and analyze if the gathered data is consistent and reliable.

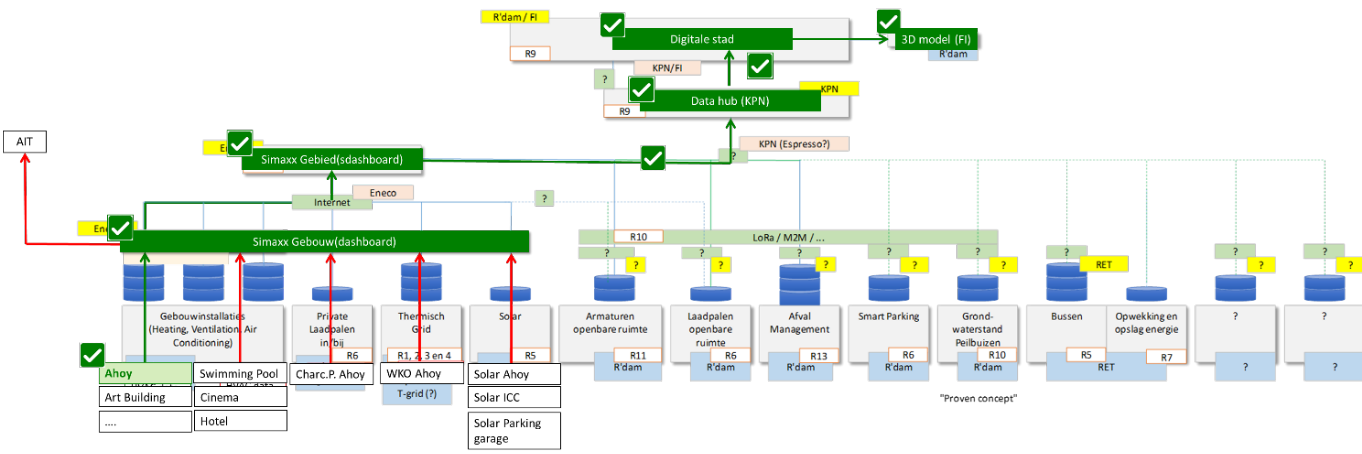
There are also parties involved in the usage of the system. The building owners must give their consent for implementing the EMS within each building, while the building users or tenants should at the end pay for the costs involved in installing the equipment and the accompanied subscription to the service. From privacy and data security point of view, the data owner should give his consent on using the data in the Simaxx dashboard and share the data with AIT for monitoring purposes.

3.3 Status monitoring

Due to several delays in realisation of Smart solutions and building developments and also due to COVID-19, not all of the sensors needed for the monitoring via the EMS are realised yet (August 2022). The latest status is that the sensor system of the following items is monitored directly through the EMS:

- STG with Smart solutions geothermal heat-cold storage and heat pumps (R1), thermal energy from waste streams/ sewage water heat extraction system (R2) and pavement heat-cold collector (R4).
- SEG/ electrical solutions with R5: monitoring the Solar systems of Ahoy and International Congress Center (ICC/ RACC)
- Buildings: Congress building Ahoy and ICC/ RACC

Figure 6 shows the hierarchical structure of the monitoring system. The yellow question marks indicate that there is no data platform. The green question marks mean that the type of data is not known yet.



Data
Data owners
Connection
Potential alternative connection
Connection-type
Responsible for connection
Platform
Platform owners
R Solution with subsidy

Figure 6: Scheme of the data flow for the Energy management system

Not all energy-related Smart solutions were supposed to be in Simaxx; some solutions are based on yearly data (not real-time) (R7, R11 and R13). Furthermore, in one building Simaxx is implemented (swimming pool), but with a relatively small amount of sensors. This building does not form a part of the EMS, since no energy-consumption related sensors were installed, but climate regulation sensors, e.g. thermostatic information. The following Smart solutions and buildings are currently monitored through regular monitoring, see figure 7&8 for a graphical overview:

- Swimming pool (smart meter)
- Arts building (smart meter)
- 84 near zero energy houses (only solar (photovoltaic), calculations based on specifications as built)
- R7 Optimizing the E-bus fleet (data sheet/ yearly data)
- R11 Efficient and intelligent street lighting (data sheet/ yearly data)
- R13 Smart Waste Management (data sheet/ yearly data)

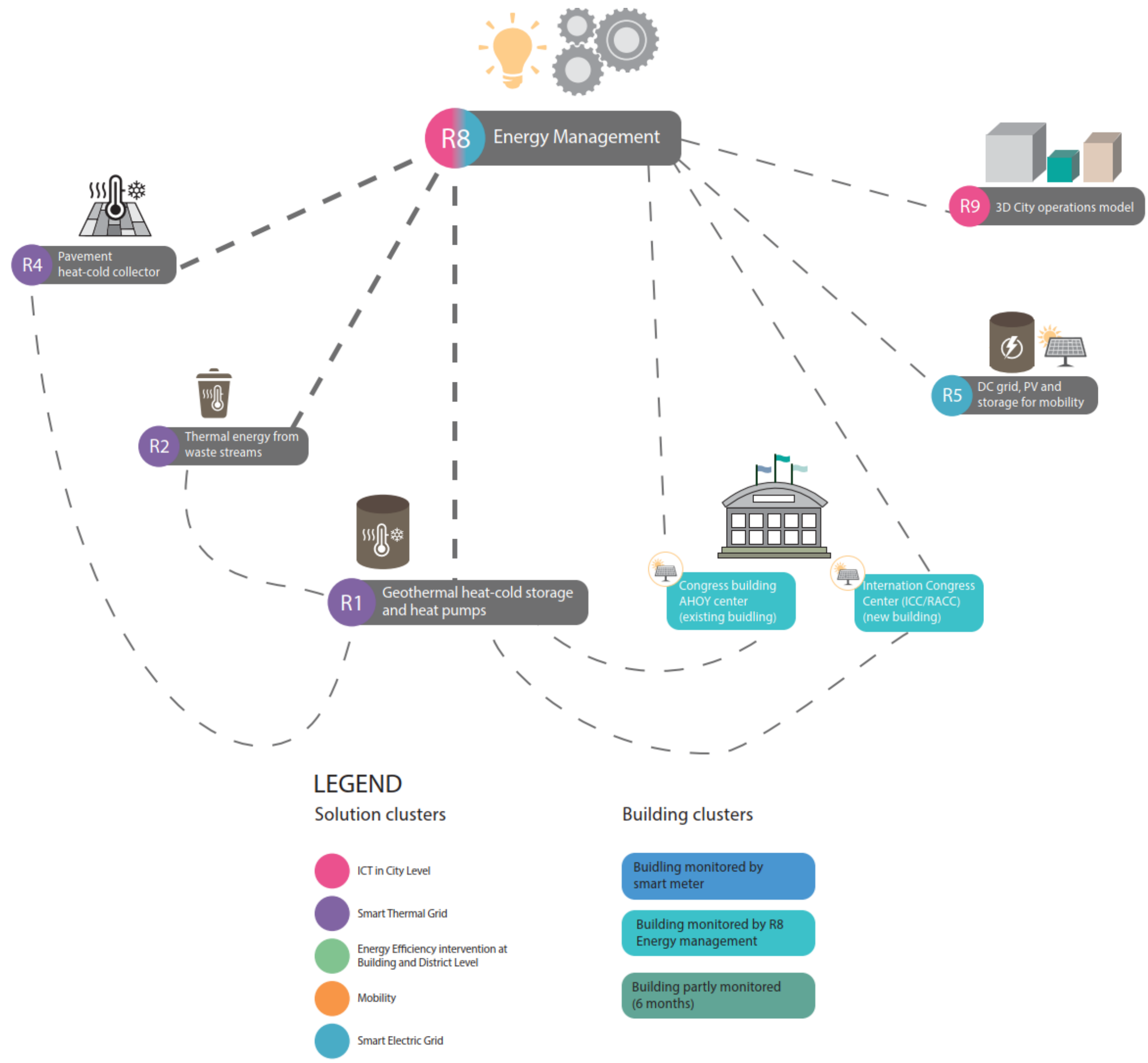


Figure 7: Scheme of the items directly monitored through Energy management system (Source: AIT)

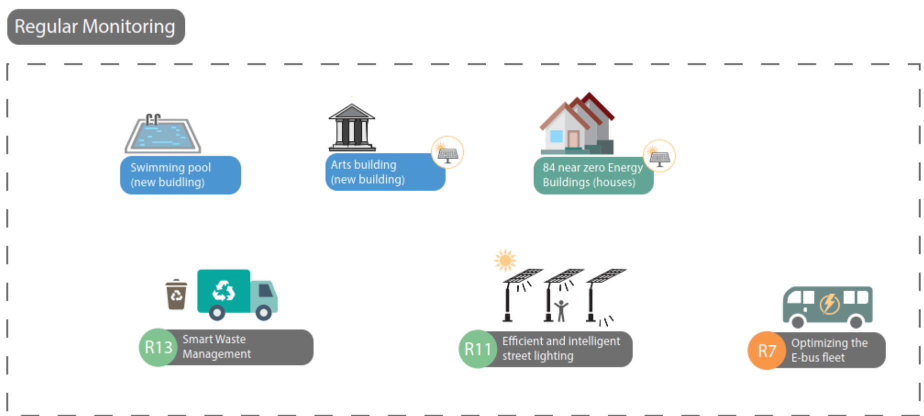


Figure 8: Scheme of the items regularly monitored (Source: AIT)

At the moment, it has been tested how the data can be coupled to the Digital City 3D model (Smart solution R9), but due to privacy and data protection issues the data-coupling, which is realized, won't contain detailed data but only total energy consumption (heating, cooling and electricity) on building level and indicated with a few colours. This means that the functionality has been successfully tested, but implementation of more detailed data will not be done.

The company Future Insight created a data connection that gives a live feed of the coupled parameters in the 3D model Here you can see a visualisation of the live mobility: the buses of RET with actual location and whether they are on schedule (green) or delayed (red).

3.4 Benefits

Several internal stakeholders benefit from the data that comes from the established EMS. The technical operator/asset manager of Ahoy for example gets information on the functioning of building installations (like ventilation, heating and cooling). He can detect unusual energy consumption by setting KPI's per installation. This information contributes to contract management, as with this data can be checked whether the promised installation functionalities are met. As well as that system failures can be detected immediately, and accurate mitigation can be taken. Furthermore, the contract manager receives information the same time it takes to solve a problem after an automatically generated notification. Even more interesting is that preventive maintenance can be done, before systems fail. The reliability of the systems thus improves. Optimising energy use by the technical staff is discussed per energy consumption sector and how energy use can be optimised. Before Ruggedised the technical staff of Ahoy had almost no insight in where what amount of energy is used. Now they have adequate insight and are able to optimise (reduce) energy consumption. Another functionality is that the event manager can see if the required comfort levels are met and how much energy is used per event or location. This way, different users of the halls can be billed per square meter. All data is visible for Ahoy in the Simaxx dashboard (figure 10). The dashboard shows for example the total energy consumption of Ahoy as well as the energy consumption of the different exhibition halls. For the whole area HoS the power production and usage is not connected to each other, but for each building (or the Ahoy complex) energy consumption is optimised by using the monitoring system.

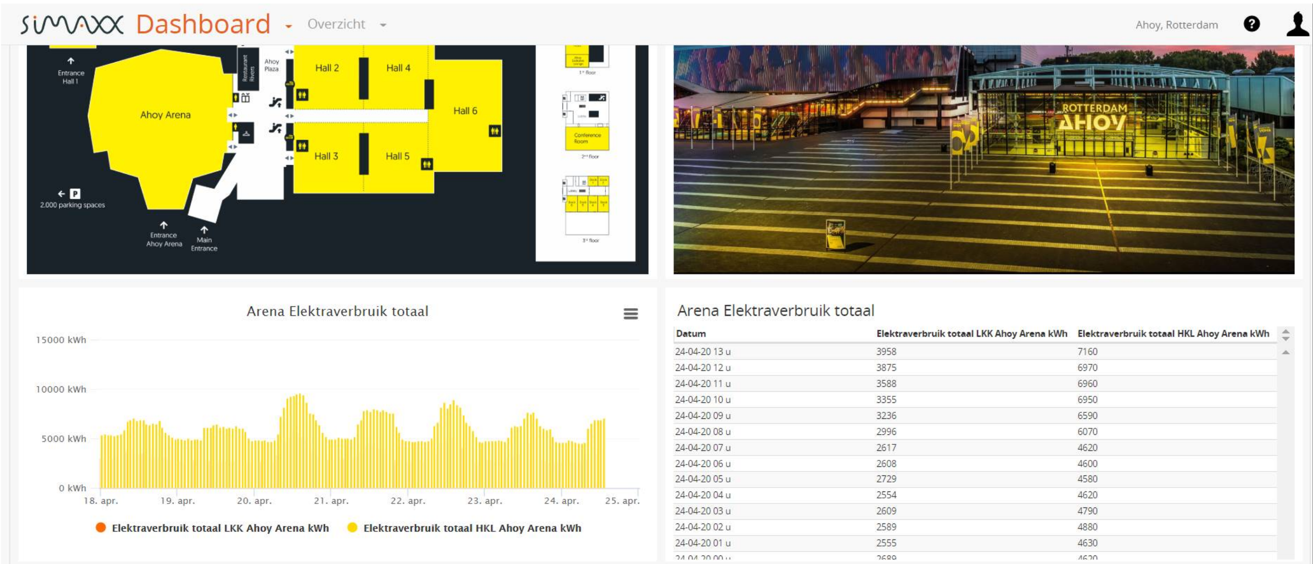


Figure 9: Simaxx dashboard used for Ahoy (dummy data)

On a higher hierarchical level, building related data can be put and analysed in the Simaxx area dashboard. The building owner can potentially see his building/asset in the model, but also other buildings and Smart solutions in the RUGGEDISED area. At this moment Ahoy and RACC use two Simaxx dashboards: one for building related information such as comfort levels and one for the RUGGEDISED parameters which are all energy related, such as temperatures of components in the STG, flows and generation of solar.

4 Business Plan

4.1 Financial concept

Originally the idea was that the EMS would be implemented in the buildings which would connect to the Smart Thermal Grid (STG). For the electrical part, only the solar panels (photovoltaic) of Ahoy and RACC feed data into the EMS. Since the Arts building and Swimming pool were not connected to the STG, the benefits implementing Simaxx EMS was minimal. The Swimming pool did implement Simaxx, but uses it only for supervision of the installations, which are not energy related. This was done despite efforts of Eneco and City of Rotterdam to try to implement Simaxx EMS in those two buildings. These buildings already had their own Building Management System and Simaxx implementation would be added on top of this with less added value of the area dashboard by lacking the connection to the STG.

Since some of the functionality of Simaxx is related to the area level and operation of the STG, the financial gain for the individual building user is somewhat limited. Therefore 50% of the implementation costs of Simaxx was paid/ subsidized by Eneco.

Since the building related users are Congress Center Ahoy and International Congress Center (ICC/ RACC), they benefit from a tailor-made solution of Simaxx, which gives them the opportunity to bill energy per event or per sub-location. This is very important: to think from the customer needs and start there before implementing a too complex solution.

The sensors are almost all owned by Ahoy, except for the assets owned by Eneco: the ATES, heat pump system and district heating. This means that Ahoy can have their own building related EMS. Since Eneco is optimizing between using either district heating or heat from the ATES/ heat pump system, they are the ones who profit from a more efficient system. They are billing Ahoy and RACC for using heat on total level, not for ATES/ heat pump heat or district heat separately. The electricity consumed by the ATES/ heat pump system is also paid by Eneco. So Eneco has intrinsic motivation to optimize the use of the ATE/ heat pump system, in relation to the use of district heating.

4.2 Estimated impact

Since the EMS is just recently fully operational, at this moment (August 2022) only an estimation can be made on the impact. Furthermore, the direct impact of an EMS cannot be measured, the effect could only be measured if there would be a representative “before” and “after” situation with all other factors staying the same (type of energy consumption, installations, use of the buildings). The most important factors why this wasn’t the case for Ahoy and RACC were:

- COVID-19: the building was closed for a long time (more than a year) and started gradually after this lockdown and was used also in a different way as a COVID-19 hospital;
- Type of heating and cooling installations have changed, including the steering on performance;
- Switching to low temperature heating and high temperature cooling, which ask for other pre-heat or cooling times. It takes longer to reach the target temperatures;
- Less passive heat generation by more energy efficient equipment of event organizers, e.g. LED lighting: in summer less cooling demand but in winter a higher heating demand.

An interview was held with the energy coordinator of Ahoy and RACC to get a grip on what would be a good estimation of the functioning of the EMS at Ahoy and RACC. The estimated decrease in energy consumption, based on the solutions and buildings connected, is now judged on 164.132 kWh per year. This will result in a CO_2 reduction of 66 ton per year. The original estimation at the start of the project was that the savings would represent 10% of the total energy consumption of the buildings with a BEST table. Due to the above recent developments, this impact is scaled down and now calculated as being 5% of the total energy consumption of the buildings with a BEST table. The above mentioned figures are calculated with this new assumption.

4.3 Expected costs

The costs for implementing an EMS, in this case Simaxx, are depending on the exact solution and therefore the implementation for RUGGEDISED for the STG and the buildings Ahoy and RACC are not representative for other projects and buildings/areas. The function of Ahoy and RACC are unique and have asked a specific approach: there’s one dashboard for the general energy coordinator within Ahoy/ RACC and there’s one dashboard for RUGGEDISED in which more specific the energy performance of the STG and connected sources can be monitored.

It’s important to acknowledge that without 50% subsidy given to clients Ahoy and RACC, this client based solution wouldn’t have been implemented. This doesn’t mean that there isn’t a positive business case possible looking at a longer period and all the direct and indirect gains, but addresses the fact that a lot of building users in general are not having the capacity, knowledge and focus on energy optimization. This is simply not their core business.

Next to the investment, each customer of Simaxx has to pay a fixed monthly fee for using and for maintenance of the platform.

5 Lessons learned & Guideline

The implementation of the EMS in the Heart of South area results in several lessons learned, which are described below. Corresponding to the lessons, recommendations are given to organisations that are interested in establishing an EMS in the future.

1. **Complexity and TRL of EMS**
   The Technology Readiness Level (TRL) of Simaxx as an area EMS was not as high as expected. At the start of the project this was regarded as an almost ready tool for area monitoring, but one year later it turned out that for the functions on top of the building level, still extra functionality had to be added to the tool. Partly this has been done during the project, but only on some minor issues. This resulted in an EMS, with according sensors, on building level instead of area level (which was the ambition). The implementation process showed that an EMS on area level is much more complex than expected in the proposal stage. This can be confirmed by the fact that there are no other projects in the Netherlands on area level. Bottomline of the functionality of the realized EMS is that it's practically a monitoring tool, not a management tool. This would indicate that the realized EMS supplies data but it's not possible to steer the installations and optimize energy consumption automatically from the centralized area EMS.

   Guideline: at the beginning of the project a market consultation must be done to predict more precisely which functionalities are possible and which functions are useful and anticipating on future developments.

2. **Meet client expectation/wishes**
   It is important to match the functionalities of the system with the expectations of the client. In this case, Ahoy had the intention to gain insight into direct savings. Simaxx however offers much more possibilities. Therefore, it is questionable if the complex implementation process of Simaxx is worthwhile. A simpler monitoring system might have been more suitable.

   Guideline: commercial customers require a less fancy tool with less possibilities so it can provide a more plug and play system and give financial information/ costs savings. For customers who want to really dive into their system, the Simaxx platform can still be interesting since it offers easier Key performance indicator (KPI) analyzation and the process of automatic warnings if KPI's are beyond set limits. But this needs a lot of effort of the client and special knowledge of the operator of the EMS, which also can be hired at a consulting firm. On the long run this could be profitable.

3. **Cost effectiveness**
   The EMS should match a price for implementation and operation which is according to the usage and energy savings.

   Guideline: manage on beforehand the expectations on savings and the price of installation and operation of the EMS. It should have a reasonable payback time. In the case that asset managers do want to establish an extended EMS but do not have the budget, they might explore possibilities to obtain money from a non-profit investment bank. A good example is the National Investment Bank in Denmark, who apply a sustainable financial model.

4. **Monitoring per real estate sector on different subjects**
   Every type of real estate building should be monitored, and different elements have to be included, as is shown within RUGGEDISED. Examples of subjects are: square meters, energy consumption, costs for maintenance of the installation, costs for maintenance of the facade. Monitoring different subjects offers opportunities for data driven asset management.

   Guideline: try to combine the energy KPI's with other monitoring KPI's, so the overall system costs become lower. Use the scope of asset management.

5. **Profitability electricity exchange depends on local circumstances**
   In the Netherlands, there are currently regulations in play that complicate the exchange of energy between buildings. For example, there exist grid fees on energy exchange and therefore it is not

financially interesting to deliver electricity to another building. The permission of the local grid operator is needed. But besides the needed permission, an Electric Smart Grid is not financially feasible in the Netherlands at the implementation date of RUGGEDISED. National regulations changed in 2022 which would make it more profitable now for non-private (utility) buildings.

Guideline: investigate national and local energy laws and regulations carefully.

6. **Profitability heat and cold exchange depends on local circumstances and an EMS**

   This project shows that heat and cold exchange between buildings is legally possible. In the Netherlands, taxes on heat and cold exchange do not exist. However, heat and cold has to compete with prices of alternatives. In the case of Rotterdam; with prices of district heating. Another condition for heat and cold exchange is a well-functioning EMS, that regulates the streams of heat and cold and can put merit orders depending on real-time prices of different heating and cooling sources. Also, an important aspect is that the exchanged amount of heat should be significant. For very energy efficient buildings, it's less profitable due to the high capital costs of the needed infrastructure. Such was the case in RUGGEDISED for coupling the Ahoy and RACC to the Swimming pool and Arts building.

   Guideline: in the Netherlands heat and cold exchange on area level between several buildings can be profitable as there are no national regulations that discourage the exchange. The profitability however largely depends on local regulations. Furthermore, an overarching EMS is necessary to manage and monitor the energy streams.

7. **Split incentive EMS**

   In the EMS used in this project there was a split incentive of the building owner and the building user. The building owner normallyt has to invest in the hardware of the installations, while the building user/ tenant is having profits from an efficient energy system. To tackle this, it could be arranged that a certain percentage of the energy saving profits is given to the building owner.

   Guideline: at the beginning of the project a precise analysis must be done on where the returns of investments in the energy system and the savings gained with an EMS land. Then building owners and users must be involved from the beginning, so that there is maximum commitment for the developed EMS solution.

8. **Manage data privacy and security matters from the start**

   In this project, there was an uncertainty on the data requirements of AIT at the start of the project. It was not clear at the beginning of the project on what abstraction level AIT expected the data to be and with whom AIT was planning to share the information with. This resulted in delays because building owners wanted to have clear who would have access to the data and where it would end up before they gave permission.

   Guideline: to overcome that data privacy and security issues delay the project, it is wise to 1) make clear what exactly is needed on data,2) who owns this data,3) to involve data owners from the start and 4) to be able to manage their expectations on what is done with energy data in the EMS.

6 Conclusion

From the technical point of view, the ambitions are not completely fulfilled, as the system currently only works on building level and for a small part on area level. The managing part of the EMS has not been implemented not only due to limitations of the used platform, but also because of lack of interest by different building users and unwillingness to share data between different partners. This is because of focus on the core business of companies and improving their own business/ product has simply a higher return on investment than saving energy. The current high energy prizes however can change this. However, there are several KPI's established, which provide building owners with relevant information on among others energy savings.

Some conclusions on financial and organisational aspects can be made. The implementation of the EMS in the RUGGEDISED project shows that to arrange smart energy management in the area, it is very important that building owners are aware of how is dealt with the data and give permission to use it. Most stakeholders only want to share data when it leads to significant money savings, and they want this to be proven on beforehand. Organisations that want to establish an EMS must keep in mind that energy management is not the core business of building users and that each euro invested in energy savings can be spend with a higher return on investment elsewhere in the company. It is therefore recommended that they are provided with a turn key solution for an EMS with easy to understand KPI's on at least financial savings or that they hire the expertise. In other words, make energy management as simple as possible and include as relevant features for customers as possible, so that they have an incentive to adopt the system.

Regarding the replicability of this solution: technically replication is possible in all cities, but organisationally it depends strongly on national and local laws, regulations and agreements. Energy company Eneco foresees that demand of sustainable (locally generated) energy will grow exponentially. This implies that collaboration between building owners concerning balancing energy becomes inevitable in the near future. In fact, several Dutch cities are implementing an EMS as well, like Utrecht at their Central Station and The Hague in the City Centre. The lessons learned from this project are therefore very valuable.

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