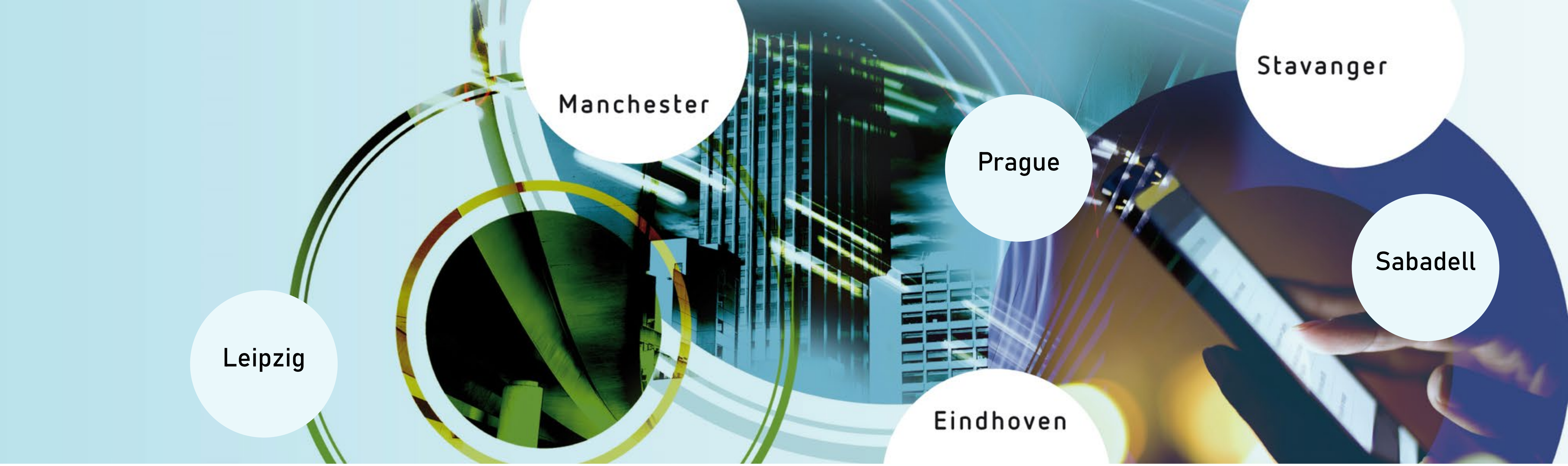

FACT SHEETS

Triangulum smart city innovations and solutions implemented in the Lighthouse Cities

Stavanger • Manchester • Eindhoven

This Project has received funding from the European Uninon's Horizon 2020 Research and Innovation Program under Grant Agreement No 646578

triangulum

DEMONSTRATE·DISSEMINATE·REPLICATE

The three-point project Triangulum is one of 14 European Smart Cities and Communities Lighthouse Projects, set to demonstrate, disseminate and replicate solutions and frameworks for Europe's future smart cites. The Lighthouse Cities Manchester (UK), Eindhoven (NL) and Stavanger (NO) serve as testbeds for innovative projects focusing on sustainable mobility, energy, ICT and business opportunities. The project consortium combines interdisciplinary experience and expertise of 22 partners from industry, research and municipalities who share the same objective and commitment to develop and implement smart solutions to replicate them in the three follower cities Leipzig (D), Prague (CZ) and Sabadell (ES). The project has Tianjin (CHN) as an observer city.

The overall budget of Triangulum is 30 million Euros (2015-2020). The European Commission funding (Horizon 2020) totals 25 million Euros.

The project is coordinated by Fraunhofer Institute for Industrial Engineering IAO in Stuttgart and supported by Steinbeis-Europa-Zentrum.

An exceptional feature of the project is the ICT architecture and the Smart City Framework that will be developed in the Lighthouse Cities and rolled out in the Follower Cities. A modular approach will enable flexible (business) solutions that address individual challenges and requirements of our cities and their stakeholders. To this point, Triangulum exhibits 29 solution modules and 69 use cases addressing the individual challenges and requirements of its Lighthouse Cities and involved stakeholders.

Design and edition (in alphabetical order)
Catalina Díaz, Trinidad Fernández, Andréia Lopes Azevedo (Fraunhofer IAO)
Bettina Remmele (Steinbeis-Europa Zentrum)
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Contributors
All Triangulum Partners, with especial contribution from the lighthouse cities local coordination teams:
Manchester: Martine Tommis (Manchester City Council)
Eindhoven: Delia Mitcan, Yoka Louwman (Gemeente Eindhoven)
Stavanger: Gerd Seehuus, Eline Vigre (Stavanger Kommune)

February 2020
https://www.triangulum-project.eu/

Public transport with electric buses

Mobility | Stavanger, NO

Photo source: Eilin Tvedt-Gundersen

The County Council of Rogaland and Kolumbus AS run a demonstration project with 3 electric buses. The buses are used in ordinary routes. The main interests of the project are: (1) focus on state of the art technology, (2) learn how these buses can be used within the existing public transportation system the best way, (3) learn how today's system must be adjusted to the use of electric buses, including the installation of charging stations and maintenance of the buses. A design competition was organized in the county upper secondary schools to create awareness about the e-bus.

Measured Impacts

135 tCO2 reduction
250 kg CO reduction
66 kg NOx reduction

project scale **Regional level**

development type **Upgrading**

Benefits

- ☑ Reducing use of fossil fuels
- ☑ Improving air quality
- ☑ Reducing GHG emissions
- ☑ Supporting environmental transport
- ☑ Promoting emission free vehicles

Lessons learned

- E-buses mainly represent a robust technology.
- E-buses reduce diesel consumption and thus saves the environment and reduces fuel costs
- Customer focuses on comfort and services (punctuality) and not on technology (EV or not doesn't matter)
- Mixed fleets are more complicated to operate (e.g. different ranges and maintenance patterns). A continuous learning process is needed.
- Bus drivers are positive when buses are reliable. Range fear was just a problem in the beginnin.
- Experience and knowledge in handling e-buses was gained through the demonstration project and a training programme.

Challenges

- The inexperience of the bus manufacturer lead to major delay in delivery.
- The introduction of electric buses requires adjustments and investments in the existing infrastructure (e.g. charging points, power network).
- E-buses still are more expensive than standard diesel buses. For public bodies with limited budgets it is therefore a challenge to invest in electric buses and the necessary infrastructure.
- The lack of an existing service network in Norway and the lack of knowledge and experience in handling e-buses have been a challenge. The problem of not having a service/garage network will most likely be solved as more and more manufacturers of e-buses enter the market.

Supporting factors

legal

Norwegian National Transportation Plan states all City buses must be emission free by 2025.
Decision by the county council in 2019 to implement e-buses on all urban routes in the Northern part of the county which represents approximately 28 % of all route production in the Northern part of the county.
In 2015 the county council decided that buses for the future BRT-system preferably to be electric.

infrastructural

Uses existing inner-city roads dedicated to public transport (and electric vehicles).

financial

Existing agreement between local, regional and state authorities on how to finance transportation infrastructure, including public transportation
VAT waiver on e-buses (VAT : 25%).
Electricity in Norway comparatively cheap.

Contacts

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Blink innovative video solutions

ICT | Stavanger, NO

Photo source: https://www.flickr.com/photos/lysekonsern/32787374997/in/album-72157685181027796/

Lyse AS has developed a video communication platform called "Blink" together with sub-contractor "Norsk Telemedisin". It has the potential to save energy in terms of mobility, in addition to being an innovative ICT solution. Following tests in Stavanger pilot homes, the solution was tested for replication in Prague and Sabadell, 2 of the Triangulum follower cities. Blink can be fitted with two-step authentication for users such as doctors and patients and in other settings with sensitive information. In Triangulum, the replication phase concentrated round usability in care environments with key elements being simplicity and privacy/safety for users.

Measured Impacts

GDPR constraints does not allow for any measurement. However, reports conducted by user groups in the follower cities point to valuable experiences in communicating with ease in a secure manner between care providers and care receivers.

project scale **Individual sites**

development type **New installation and new technology**

Benefits

- ☑ Less energy needs
- ☑ Increased quality of life for care receivers
- ☑ Time saved
- ☑ New communication tool for remote next of kin

Lessons learned

- It is essential for the responsible partner such as Lyse in this case, to maintain close relations with follower cities well ahead of and during replication activities.

Challenges

Initial version proved too complicated – causing 2 major delays and the development of a completely new solution.

Supporting factors

infrastructural: Broadband capacity at piloting sites at a minimum of 2mb/s.

financial: Time saved in avoiding driving for care personnel.

geographical: Situated in Stavanger.

social: Socially inclusive effects for patients and next of kin.

Films

Triangulum film:
https://www.youtube.com/watch?time_continue=1&v=U7LjCSNoW20&feature=emb_logo
Triangulum cartoon:
https://www.youtube.com/watch?time_continue=53&v=Zwv86eFRHfg&feature=emb_logo

Contacts

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case studies

Central Controller – Demand Response System

Energy | Stavanger, NO

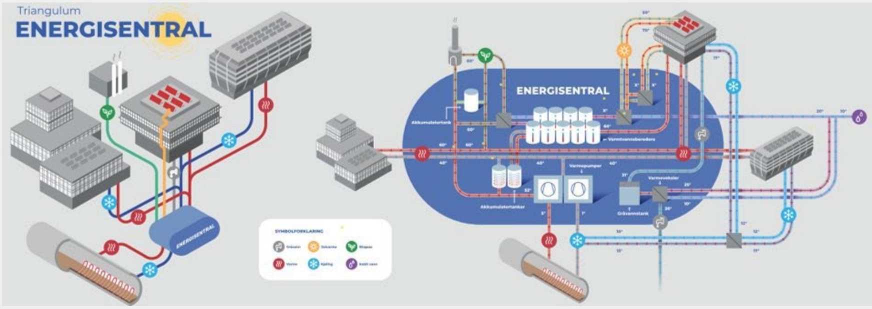

Photo source: ProContra

The overall aim of the task is to demonstrate innovative use of local renewable energy sources other than fossil energy and hydropower, to make the solution relevant for replication in Norway and other European cities.
Stavanger municipality needed to renovate its old power plant, installed in 1970. To be able to meet the Triangulum targets, the municipality have developed and built a new Central Energy Plant (CEP) for heating and cooling, with at least 75% energy from renewable sources. The biggest innovation in the system is that the heat pumps get heat from the city's main drain line tunnel. A heat exchanger system has been established and installed for extracting energy from the wastewater and sewer system.
CEP has used various systems such as heat pump technology with waste heat exchangers in drainage tunnels, together with grey water recovery of shower water and solar collectors in an interaction. Biogas is used as peak load.
The CEP is owned by the municipality of Stavanger and is automated, monitored and remotely controlled from the operation centre by employees in the municipality.
This technical solution for use of waste heat has not previously been used in Norway.

Measured Impacts

tCO_2e 473 (84%)
1 250 000 NOK Total annual savings
26 real time data feeds

project scale **Individual site**

development type **Retrofit/ Technology**

Benefits

- Reduce GHG emissions
- Reduce peak demand
- Improve data availability
- To reduce the use of fossil fuels
- Reduce operating costs
- Decreasing energy consumption
- Decreasing energy costs
- Improve energy efficiency
- Improved Technology knowledge

Lessons learned

- Academically highly involved project manager who manages the project from start to finish
- The importance of concept study and use of possible sources of energy and combination of different sources to assess energy use and greenhouse gas emissions
- Tendering, advertising and evaluation are time-consuming
- Open data – be clear about the source and availability of relevant datasets
- Test operation and function testing is important for error correction and to ensure the delivery of an automated, monitored and remote-controlled system

Challenges

- This technical solution for use of waste heat has not previously been used in Norway.
- Time requirements in the procurement regulations can increase the time spent on a project.
- The availability of data streams and different data in different formats.
- Maintain heat production during renovation
- Can heat exchangers installed in pipes directly finished from the factory be standardized? Questions must be answered by pipe manufacturers.

Supporting factors

infrastructural
Suitable site for location.
Stavanger municipality owns the drainage tunnel and can utilize this without other stakeholders having to be involved.
All cities have drainage solutions that can be utilized as energy sources together with heat pump technology in a power plant.

financial
The CEP is fully part of the Triangulum funding. The municipality of Stavanger provided additional funding to retrofit OK19.

geographical
Stavanger. Located in Olav Kyrres Gate 19

social
Contribution to carbon reduction targets for 2030

partners
Stavanger Municipality / Norconsult / Dansk Kloak Renoveringsteknik / Norwegian Pipeline Drilling / Klimaservice / DNF

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case studies

Smart home automation

Energy | Stavanger, NO

Photo source: Lyse AS

Lyse has installed smart gateways with home automation equipment in 100 homes, a school gym and a nursing home in Stavanger.

This allows residents to control lights and heating, and to see an overview of their energy use and enjoy decision support via a dedicated in-home display. For the nursing home, similar solutions were installed in 8 rehabilitation rooms at the nursing homes with elderly patients.

Measured Impacts

Mean of annual energy consumption per residence reduced by **26,06%**

project scale **Individual sites**

development type **New installations**

Benefits

- ☑ Carbon savings
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs
- ☑ Improving energy efficiency
- ☑ Awareness of electrical use
- ☑ Higher comfort

Lessons learned

- Do not underestimate the value of recruiting pilots thoroughly and following them up on a day to day basis.

Challenges

GDPR compliance caused constraints on data contribution from pilot homes

Supporting factors

infrastructural	Grid and fibre capacity
financial	Power and fibre capacity supplied by Lyse
geographical	Hillevåg Area of Stavanger
social	Contributing to a more energy conscious society
partners	Stavanger municipality

Films

Nursing home testing smart technology:
https://vimeo.com/298157791

Contacts

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case studies

Cloud data platform for Stavanger

ICT | Stavanger, NO

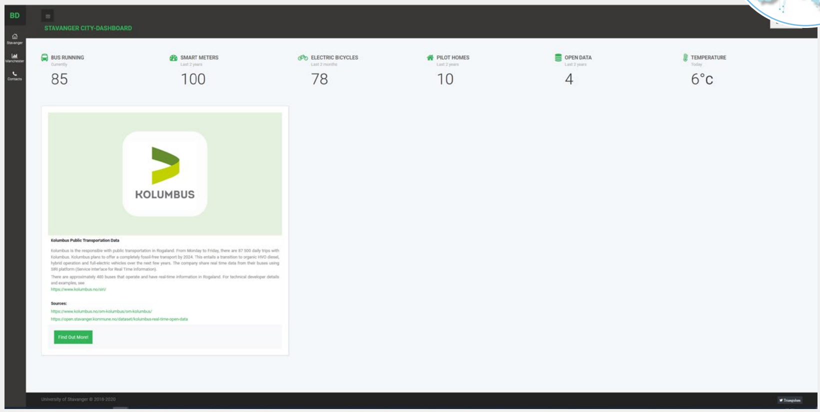

Photo source: UiS

It is an ICT Platform which facilitates collection, storage and processing of Smart City Data. It provides data access. Built from scratch by researchers based on cutting edge knowledge on a shared pool of computing, storage and networking resources. Open Source prevents vendor lock-in. Design of the Platform prevents data Lock-in.

Measured Impacts

60.04 Terabytes of HDD

1.6 Terabytes of SSD

20 physical cores

Can host up to **160** virtual machines

40.0 Gb/s Full bisection bandwidth

project scale — **Beyond city level**

development type — **Technology**

Benefits

- ☑ Ability to use resources from different geographical locations
- ☑ Modular micro-service-based design

Lessons learned

- Start with a background study/reference architecture/ best practices and guidelines
- Generate cross-disciplinary working groups, to understand the different requirements
- Finding the balance between emerging technologies and the mature ones

Challenges

- Availability of data streams
- Different data in different formats

Supporting factors

infrastructural — University of Stavanger data centre

financial — As a public institution, access to public funding is available, vendors often provide equipment at a reduced fee as it is for University. No profit needs to be generated.

geographical — Beyond city level

social — Creating access to data

partners — University of Stavanger

Contacts

UiS

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case studies

Data analytics toolkit - http://triangulum.cs.ux.uis.no/
ICT | Stavanger, NO

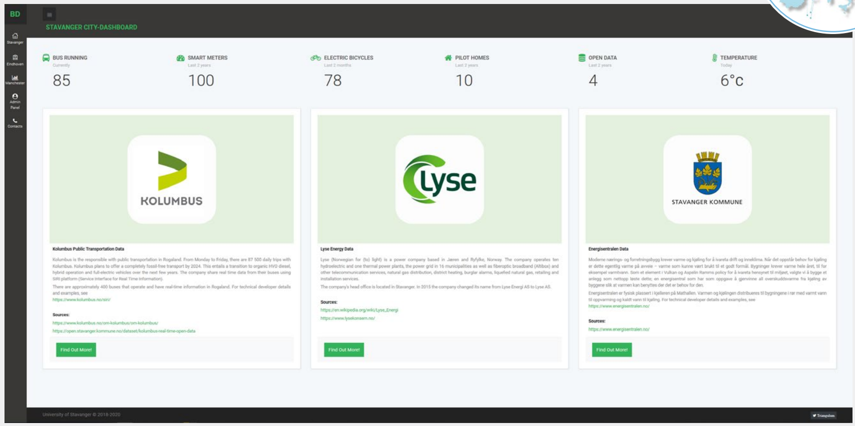

Photo source: UiS

It is a framework and generic tools for big data analytics, which will be useful for the citizens and replicable for cities and companies. The aim is exploiting the open data sources, combining variability of different data sources, analysis of high volumes of data at a high velocity from a city and other public sources. The framework allows the analysis of data monitored and stored in the data hub developed in the project. The aim of this framework, along with the frontend dashboard is to provide a holistic and integrated view of the data.

Measured Impacts

4 datasets hosted

35 completed impact indicators

project scale **Beyond city level**

development type **Technology**

Benefits

- ☑ Increasing transparency
- ☑ Improving data availability
- ☑ Facilitating citizen engagement

Lessons learned

- Start with a background study/reference architecture/ best practices and guidelines
- Generate cross-disciplinary working groups, to understand the different requirements
- Finding the balance between emerging technologies and the mature ones

Challenges

Challenges centred primarily around data security and GDPR. The original idea was to use open data with anonymous data, but with GDPR, adjustments needed to be made. Although UiS maintained throughout the project that they would only accept open data, we also understood that for a proper demonstration project, we had to demonstrate the inclusion of closed data. This caused additional challenges, time, and resources in order create a structure that would properly balance data utility with data security.

Supporting factors

infrastructural — University of Stavanger data centre

financial — As a public institution access to public funding is available, vendors often provide equipment at a reduced price as it is for University. No profit needs to be generated.

geographical — Beyond city level

social — Creating access to data

partners — University of Stavanger

Contacts

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case studies

Microgrid Central Controller

Energy | Manchester, UK

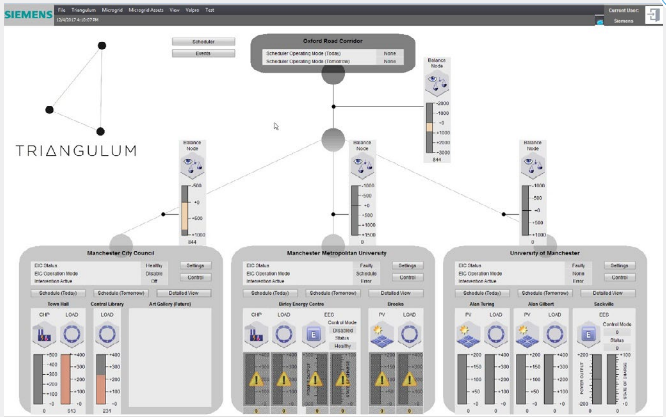

Photo source: Siemens

Micrograds are Low Voltage distribution networks made up of distributed generators (DG), storage devices and controllable loads operating either interconnected or isolated from the main distribution grid. The controller aims to optimise the operation of the Microgrid. Siemens created a city level cloud based energy management platform - a Virtual Power Plant. The platform provides visibility of energy consumption in buildings on the Oxford Road Corridor. The platform integrates to individual Building Energy Management Systems (BEMS). At times of peak demand and high energy prices, the Central Controller (CC) can instruct the BMS to reduce consumption. It integrates with flexible electrical energy storage assets with green generation such as solar PV, with a more intermittent generation, to ensure a constant electrical supply. Reducing peak load decreases the likelihood that the UK's energy system operator will instruct back-up, typically polluting. Bringing together flexible load, storage and generation assets throughout the city into a smart cloud-based management system, demonstrates how sustainable solutions can drive operating cost reductions, reduce city emissions, engage citizens and how city stakeholders can create additional revenues from their existing assets and estates.

Measured Impacts

€2,139,364
tCO_2e 5,250

Per annum

project scale **Across sites**

development type **Retrofit**

Benefits

- ☑ Carbon savings
- ☑ Enhance grid stability
- ☑ Improving data availability
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions and peak demand
- ☑ Decreasing energy costs
- ☑ Improving energy efficiency

Lessons learned

- Flexibility in design – different stakeholders require different solutions
- Open protocols and modifications support implementation
- Need building managers involved at onset

Challenges

- Robust baseline data
- Early identification and engagement of stakeholders is critical to success.
- Investment rationale for existing and emerging energy technologies changes rapidly.

Supporting factors

infrastructural — Needs BEMS and communications infrastructures

financial — Monetary savings

geographical — City Centre

social — Contribution to carbon reduction targets for the city

partners — Manchester Metropolitan University, Manchester City Council, University of Manchester, Siemens

Films

https://youtu.be/nff65-0I3kI

Contacts

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case studies

Building Optimisation – Manchester Art Gallery

Energy | Manchester, UK

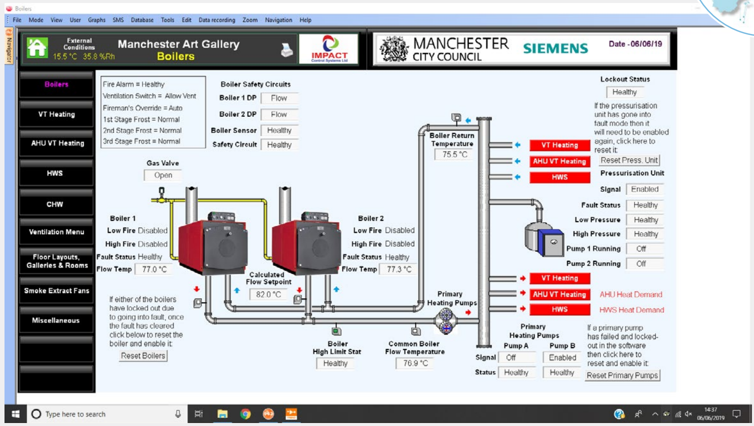

Photo source: Siemens

Looking at how much energy a building consumes and reducing this to its optimum is the first step in any energy improvement programme. Manchester City Council worked with Siemens to undertake a series of 'Investment Grade Audits' (IGA's) assesing how Manchester Art Gallery was operating against the original design parameters, and how the introduction of new technologies could reduce energy consumption plus benefit the buildings and its users. The audit on the Grade-2 listed building advised a replacement BEMS could return significant savings. A new Siemens Desigo CC BEMS platform was installed. The graphical interface allows easy operation with visualisation of real time and historical data. The system is expected to deliver circa £40,000 savings, with a 24% reduction in gas consumption and 12% saving in electricity use. In terms of greenhouse gas emissions, this improvement equates to an expected 190,404 kg/ year of CO2 emissions savings. This "Behind the Meter" innovation help ensure a sustainable future for historic buildings, but also preserve the artefacts at the correct temperature.

Measured Impacts

Energy and carbon reductions:

Gas consumption **24%** ,
Electricity **12%** ,CO2 **15%**

Improved energy rating from a D to C category, with associated financial savings.

project scale **Individual site**

development type **Retrofit**

Benefits

- Reducing use of fossil fuel
- Reducing operational costs
- Reducing GHG emissions
- Decreasing energy consumption
- Decreasing energy costs
- Improving energy efficiency

Lessons learned

- In multi-use buildings it is important to consider energy usage and sustainability, alongside environmental conditions for artefacts as well as staff and visitor comfort.
- Post installation training and handover is crucial
- The in-depth audit revealed some existing equipment was faulty or in need of replacement.

Challenges

The demands of historic buildings and older infrastructures.

Supporting factors

infrastructural — Existing building

financial — Demonstrates how an existing historic building can be made more efficient

geographical — City Centre

social — Contribution to carbon reduction targets for the city

partners — Manchester City Council, Siemens

Films

https://youtu.be/nff65-0I3kI

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case studies

Energy Storage System

Energy | Manchester, UK

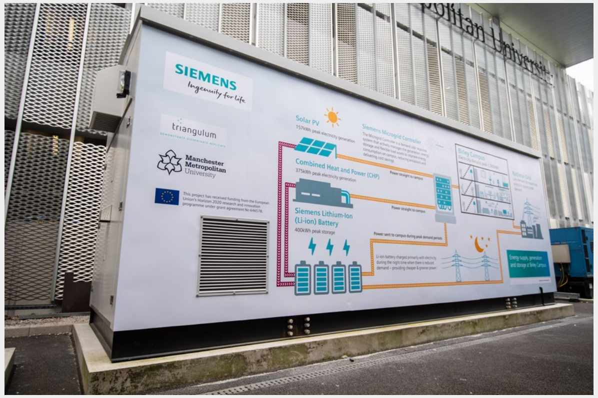

Photo source: Siemens

Siemens has worked with Manchester Metropolitan University (MMU) on its onsite energy system and have installed a Lithium-ion battery to integrate with current onsite generation. The Birley Campus, opened in 2014, consists of an academic building and halls of residence for 900 students. Primarily charged at night-time from the grid supply (when prices are low), the 400kWh Lithium-ion battery storage works with the 375kWh Combined Heat and Power generation, the 157kWh solar panels to supply to provide the Birley Campus with cheaper, and greener power. The battery is discharged at peak periods when the price of energy from the grid is high. The power is greener as more fossil fuels are used to generate power at times of high demand. This is all controlled by a microgrid controller with a demand side response system that actively manages generation, energy storage and flexible load assets to improve energy consumption on campus, reduces emissions and delivers cost savings. As the UK's number one green university in 2017's People and Planet University League, sustainability is a key topic in the curriculum, with students learning about the energy centre and battery storage.

Measured Impacts

Savings per annum
€34,000

project scale **Individual site**

development type **New installation**

Benefits

- ☑ Additional energy generation
- ☑ Carbon savings
- ☑ Enhance grid stability
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs
- ☑ Improving energy efficiency

Lessons learned

- Including the District Network Operator as a project partner could have addressed the regulatory issues

Challenges

- Obtaining regulatory approval
- Project funding structure required an asset transfer

Supporting factors

infrastructural
Grid capacity
Suitable location

financial
Demonstrates potential of battery storage to manage peak demands

geographical
Oxford Road Corridor

social
Contributing to MMU being one of the top sustainable campus' in the UK
Contribution to carbon reduction targets for the city

partners
Siemens, Manchester Metropolitan University, Manchester City Council

Films

https://youtu.be/nff65-0I3kI

Contacts

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Grid Independence Study

Energy | Manchester, UK

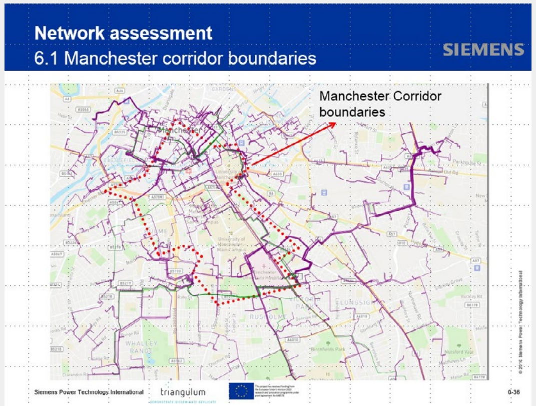

Photo source: Siemens

With the ambition to develop the Oxford Road Corridor into a 'Smart Corridor', Siemens carried out a study to emulate conditions for partial or full 'Corridor' energy independence from the grid using unconstrained and constrained network analysis. With ambitions for the future of 20-25% of energy being delivered by local, low carbon resources, the study investigated how renewable technologies could be integrated into the existing electrical network.

The current electrical system in the UK has been designed for energy to flow one way from the point of centralised generation like power stations to the point of use. With the increase of local and onsite energy generation and traditional energy consumers being producers and trading their energy, the energy system now needs to be bidirectional so energy can flow both ways. The system has not been designed to have many points of local generation so it needs careful analysis about where new generation can be put in with the right infrastructure sitting around it to enable it to balance with the existing grid.

Measured Impacts

N/A

project scale **Individual site**

development type **Retrofit**

Benefits

- ☑ Additional energy generation
- ☑ Carbon savings
- ☑ Enhance grid stability
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs
- ☑ Improving energy efficiency

Lessons learned

- Including the District Network Operator as a project partner could have enhanced the work

Challenges

Engagement with the District Network Operator

Supporting factors

infrastructural: Existing grid

financial: Demonstrates the potential for financial savings

geographical: Oxford Road Corridor

social: Contributing to MMU being one of the top sustainable campus' in the UK
Contribution to carbon reduction targets for the city

partners: Siemens, Manchester Metropolitan University, Manchester City Council

Contacts

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www.siemens.co.uk/triangulum

case studies

Photovoltaic Installation on BREAM Excellent Building

Energy | Manchester, UK

Photo source: Manchester Metropolitan University

A 584 solar panel array was installed on the BREEAM Excellent certified academic Brooks building at the Manchester Metropolitan University Birley Campus. The roof was pre-constructed to allow for PV installation.

The peak electrical output of the PV array is 157 kWp. At its peak output it can supply approximately 30% of the Brooks Building electricity demand.

Measured Impacts

140,000 KwH per annum

Saving **€18,500**

Carbon saving **30,589 kg**

project scale **Individual site**

development type **Retrofit**

Benefits

- ☑ Additional energy generation
- ☑ Carbon savings
- ☑ Enhance grid stability
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs
- ☑ Improving energy efficiency

Lessons learned

- Ensuring building and roof integrity is suitable for PV – a number of buildings surveyed were not suitable

Challenges

Project funding meant that an asset transfer was required

Supporting factors

infrastructural
Grid capacity
Suitable building with structurally sound roof pre-constructed to be PV ready

financial
MMU provided additional funding to maximise the PV array

geographical
Corridor Manchester

social
Contributing to MMU as one of the top sustainable campus' in the UK
Contribution to city's carbon reduction targets

partners
Manchester Metropolitan University, Manchester City Council

Films

https://www.youtube.com/watch?v=0zD9_HTairg

Contacts

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case studies

Shared Corporate Electric Vehicles

Mobility | Manchester, UK

Photo source: Manchester Metropolitan University

Two electric cars were purchased as corporate shared vehicles for staff use at Manchester Metropolitan University. They are used for visiting other university sites and external visits such as recruitment days at schools and colleges. Cars are booked via an online system managed by Enterprise Car Club. Staff access the car using an electronic card.

Measured Impacts

55,000 km travelled

Emissions not emitted:

PM **274g**

CO **34.28kg**

CO_2e **6.5T**

NOx **16.45g**

project scale **City Wide**

development type **Replacement**

Benefits

- ☑ Carbon savings
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs

Lessons learned

- Need for dedicated charging infrastructure
- Training for new users

Challenges

- Ensuring charging infrastructure – additional charging points were installed
- Data gathering without tracking user movements

Supporting factors

infrastructural: Existing shared car scheme

financial: Reducing costs of staff travel

geographical: Corridor Manchester

social: Contributing to MMU as one of the top sustainable campus' in the UK
Contributing to city targets for carbon reduction 2038

partners: Manchester Metropolitan University, Enterprise Car Club, Nissan

Films

https://youtu.be/ACFeyVznmwA

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case studies

Leased Electric Vehicles for Estate Management

Mobility | Manchester, UK

Photo source: University of Manchester

Manchester City Council and the University of Manchester replaced a number of their diesel vehicles with leased electric vehicles. This provided an opportunity to support the transition to EVs by practical experience. The vehicles are primarily used for deliveries and operational services.

Measured Impacts

118,000 km

PM **589g**

CO **74.17kg**

CO_2e **13.93T**

NOx **35.32g**

project scale **City Wide**

development type **Replacement**

Benefits

- ☑ Carbon savings
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs

Lessons learned

- Need for dedicated charging infrastructure
- Understanding leasing terms

Challenges

Lack of dedicated parking for some vehicles.

Supporting factors

infrastructural: A small number of existing charging points

financial: Reducing costs

geographical: City wide

social: Contributing to city targets for carbon reduction 2038

partners: University of Manchester, Nissan, Manchester City Council

Films

https://youtu.be/ACFeyVznmwA

Contacts

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case studies

eCargo Bikes – Try Before You Buy

Mobility | Manchester, UK

Photo source: Manchester City Council

Manchester City Council leased four electric-assist cargo bikes and trailers for "Try Before You Buy", were made available on short term loan to local businesses, universities and city departments free of charge. They make the delivery of goods both low carbon and convenient. Some users went on to buy and become long term users. For example Lunchbrakes, a local caterer delivering to venues, the locksmith at Manchester Metropolitan University and the residence manager at the University of Manchester. The Linkalock system was trialled for tracking and shared use.

Measured Impacts

2891 days of use

Average **3** trips a day

Over **4** years

project scale **City wide**

development type **New initiative**

Benefits

- ☑ Carbon savings
- ☑ Reducing use of fossil fuel
- ☑ Reducing operational costs
- ☑ Reducing GHG emissions
- ☑ Decreasing energy consumption
- ☑ Decreasing energy costs

Lessons learned

- Cargo bike expertise is essential
- A 'cycling champion' in partner organizations.
- Training and protective equipment e.g. helmets
- Leasing model provide users to try a range of different options

Challenges

- Storage of a larger than average bicycle
- Modal shift – driving to cycling is behavior change
- Driving culture and perception of cycling vs. vehicles
- Market is still maturing e.g. tracking systems, different models of bikes

Supporting factors

infrastructural: A company to provide support, maintenance and management

financial: Reducing transport costs
Emissions savings

geographical: City wide

social: Contributing to city targets for carbon reduction 2038
Reducing congestion

partners: Manchester City Council / Manchester Bike Hire / University of Manchester / Manchester Metropolitan University

Films

https://youtu.be/ACFeyVznmwA

Contacts

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case studies

Data Visualisation Platform – www.manchester-i.com

ICT | Manchester, UK

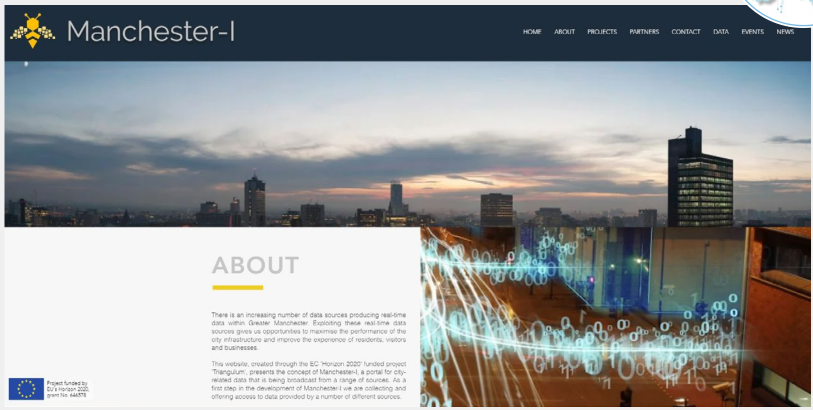

Photo source: University of Manchester

Manchester-i is the Triangulum portal for city related data, collecting and providing access to data from a number of sources. Developed by the University of Manchester, it uses open standards, and is hosted on www.manchester-i.com. The availability of open data can stimulate the creation of digital products and services that enhance people's lives. Data can also inform the long-term development of a city with planners able to better understand the constraints that result from the existing infrastructure. Visualisation tools created as part of the project allow users to bring the data to life using dashboards, virtual reality and augmented reality.

Manchester-i will be incorporated in to the Manchester Urban Observatory. This is a UK-wide collaboration to measure and analyse urban environments. UoM received £1M funding from the UK Collaboratorium for Research in Infrastructure and Cities (UKCRIC), a network of interlinked urban infrastructure observatories across the UK. The data will be open access and equipment used available to other organisations. https://www.urbanobservatory.manchester.ac.uk/.

Measured Impacts

13 real time data feeds

4 organisational users

172 users

189 times data download

project scale **City level**

development type **Technology**

Benefits

- ☑ Central location for city data
- ☑ Data availability
- ☑ Increased transparency

Lessons learned

- Open data – be clear about the source and to specify the reuse rights for datasets.
- End user involvement is an important
- Data demonstration needs positive user experiences to support stakeholder adoption.

Challenges

- Availability of data streams
- Data formats

Supporting factors

infrastructural	University of Manchester data expertise
financial	Additional funding via Urban Observatory project
geographical	City wide
social	Enables access to create economic, social and environmental value
partners	University of Manchester

Films

https://youtu.be/AQBXCO-dbFY

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Data Innovation Challenges

ICT | Manchester, UK

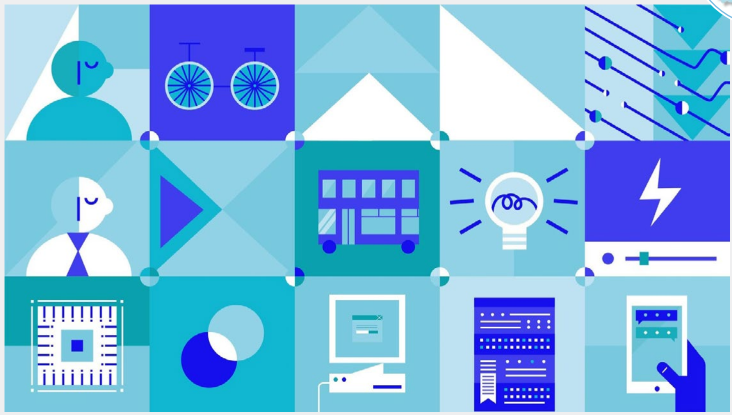

Photo source: Manchester City Council

A series of innovation challenges was held to encourage users to engage with the data and project platforms, focused on the following areas:

- Immersive technologies and the Virtual Reality Cycle
- A CityGML Challenge, as a collaboration with Ordnance and the Open Geospatial Commission (OCG), launching a CItyGML Challenge to develop software to demonstrate a CityGML version 3.0 (www.opengeospatial.org/CityGMLChallenge). This resulted in https://manchester.virtualcitymap.de/#/legend
- Innovate4Manchester was an innovation event held in three phases– a) A workshop for city stakeholders to identify city issues and problems to be addressed using project data. b) An open invite to citizens and businesses to generate and develop potential solutions / innovative ideas based on the city stakeholder workshop. c) A workshop for the best submission.

Measured Impacts

60 participants

project scale **City level**

development type **Technology**

Benefits

- ☑ Increased transparency
- ☑ Citizen engagement

Lessons learned

- Early engagement to encourage tech companies
- Availability of relevant datasets

Challenges

- Availability of data streams
- Attracting technology companies
- Curation of datasets

Supporting factors

infrastructural: University of Manchester, Open Geospatial Commission, Ordnance Survey Geovation Team

financial: Additional support from Ordnance Survey

geographical: City wide

social: Citizen engagement

partners: University of Manchester, Ordnance Survey, Open Geospatial Commission

Contacts

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case studies

Sustainable energy supply by soil sanitation

Energy | Eindhoven, NL

Photo source: VolkerWessels

The system can extract energy while purifying the soil. It is much cheaper than removing it (5-10 times less expensive).
It is a low cost system which aims at purifying soil in combination with extracting energy from ground water using heat pumps. It is an open system which directly pumps water into the soil, 2.7Mm3/yr. The system works for VOCs (fluorides & chlorides) water soluble.

Measured Impacts

CO_2 kg/month reduction
23952,413

project scale **Neighbourhood**

development type **Brownfield development**

Benefits

- Reducing use of fossils
- Reducing water pollution
- Supporting the sustainable use of land
- Improving the air quality
- Reducing GHG emissions
- Purifying soil, less time to reuse a polluted area

Lessons learned

- Extraction of pollutants more efficient than expected
- The groundwater system in the whole area should be studied before designing the system. Public companies should manage influence the groundwater systems in the whole region to reduce the conflicts in the neighbouring systems.

Challenges

- Robust baseline data
- Early identification and engagement of stakeholders is critical to success.
- Investment rationale for existing and emerging energy technologies changes rapidly.

Supporting factors

infrastructural: Industrial areas from the city are being converted to residential areas. Polluted soil is present in such cases. Demand for heating and cooling both nearby (business or houses who have demand).

financial: Energy costs of the area

legal: Dutch law to clean soil and groundwater before constructing on site and also using heat pumps. Polluter of the soil is the one responsible for puryfing the area. Dutch regulation: (energy labels) EPC standard 0.3. Regulation: to extract balanced heating and cooling from the ground.

geographical: Eindhoven – Strijp-S

social: Availability of customers to use the produced energy

partners: VolkerWessels /City of Eindhoven

Contacts

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case studies

Switching from steam based to water based heating systems powered by biomass

Energy | Eindhoven, NL

Photo source: VolkerWessels

Changing steam pipes to district heating based on water as energy transmitter. The power is supplied via a biomass power plant owned by the municipality. Pipes can be used with any other water based heat production system. The biomass power plant is fueled by the waste of public green spaces.

Measured Impacts

100%

CO_2kg/month reduction
154832,53

project scale **District level**

development type **Upgrading**

Benefits

- ☑ Reducing use of fossils
- ☑ Reducing GHG emissions
- ☑ Increasing share of renewables
- ☑ Increased autonomy with regards to energy supply/self-sufficiency

Lessons learned

- An agreement between the private sector and municipality regarding sustainability goals and compensation is necessary
- The process of collecting and providing the garbage to the biomass power plant needs significant improvement
- The process of transforming the plant is highly complicated as there are only a few suppliers of the biomass plant existing in the market

Challenges

There are no challenges.

Supporting factors

infrastructural	Built on a site of a former CHP-plant that was replaced with this system, highly functioning waste collection system for pruned green
financial	Energy costs in the area, public subsidies for the biomass power plant
legal	Dutch Regulation: Energy labels EPC standard 0.3
geographical	City of Eindhoven – Strijp-S – Lot of biomass produced in the city
social	Good relationship with the energy company that built the plant
partners	VolkerWessels, City of Eindhoven

Contacts

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Smart control of individual rooms and floors in existing buildings

Energy | Eindhoven, NL

Photo source: Municipality of Eindhoven

The system allows interactive monitoring and control of heating, ventilation and lighting through a mobile application of individuals rooms/floors independently. The system works on predictive control algorithm to automatically adjust the room to its user when needed. The system monitors window openings, temperature and occupancy. The system at the floor level monitors the CO2 level, occupancy and temperature. It gives users insights into energy use and promotes sustainable behaviour. (e.g. receive message when you open window in winter but want higher indoor temp).

Measured Impacts

29 sensors in **24** rooms

Relative heating energy reduction percentage on average: **12,48%**

project scale **Individual site**

development type **Upgrading**

Benefits

- ☑ Reducing operation costs
- ☑ Improving personnel efficiency
- ☑ Improving air quality
- ☑ Decreasing energy consumption in buildings
- ☑ Improving energy usage efficiency
- ☑ Shaving peak energy demand
- ☑ Reducing energy bill
- ☑ Increase comfort, can improve safety in emergency situations as occupancy is monitored, cleaning and maintenance facilities can be more efficient

Lessons learned

- Important to have well-functioning hardware(technology) as failure during piloting can lead to reduced trust on the technology
- Promotion is needed to encourage use of the App as a change in behaviour is expected

Challenges

- The Use case did not provide the expected end results due to:
- The existing HVAC infrastructure did not allow individual room control and installing new room controls was too expensive. High ROI period
- The heat losses form the connecting pipes to radiator are too high. Hence, enough energy not saved.
- Air conditioning system able to only control per wing and not per room.

Supporting factors

infrastructural: EPC Ratings (Energy labels) to be maintained for each building

financial: Strong financial benefit foreseen as heating service provider charges occupants fixed fee

geographical: Eindhoven – Strijp-S district

partners: VolkerWessels

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case studies

Fibre optic infrastructure in Strijp-S

ICT | Eindhoven, NL

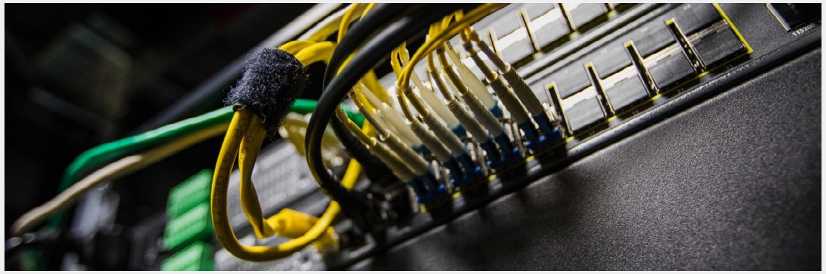

Photo source: VolkerWessels

500km of Fibre Optic(Backbone) cables have been installed in ducts in the Strijp S district (68 acres) for improving connectivity in the area. The Fibre Optic network acts as a Backbone for additional data related services in Strijp-S. 227 smart light poles are directly connected to the fibre - 400 poles in total through gateways in the other poles.

Measured Impacts

350 home connections
7.050 office connections

project scale **District level**

development type **Brownfield development**

Benefits

- ☑ Encouraging digital entrepreneurships
- ☑ Enabling new business opportunities
- ☑ Improving data availability
- ☑ Enabling many kinds of new services, less latency in transmission (high transmission speed)

Lessons learned

- Combine the installation of the fibre optic infrastructure with other ground works required
- As much communication as possible with potential partner (e.g. providers to have several access points to prevent vendor lock-ins, city council to provide permits and investment money, responsible persons in the city administration)
- Capacity will grow due Technological developments in fibre - meaning ducts with the same size will carry more capacity

Challenges

Defining the future usage patterns and requirements together with a wide variety of potential users. Receiving the permits in time (connection to local poles, digging permit).

Supporting factors

geographical — Eindhoven – Strijp-S – Densely populated area with many different small companies

partners — VolkerWessels , City of Eindhoven - Implemented through a PPP with the local municipality that allowed shorter processes

other — Area built as a smart data driven area and therefore in need for a strong data backbone. Huge variety of different data related services expected in the area.

Contacts

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case studies

Public Wi-Fi

ICT | Eindhoven, NL

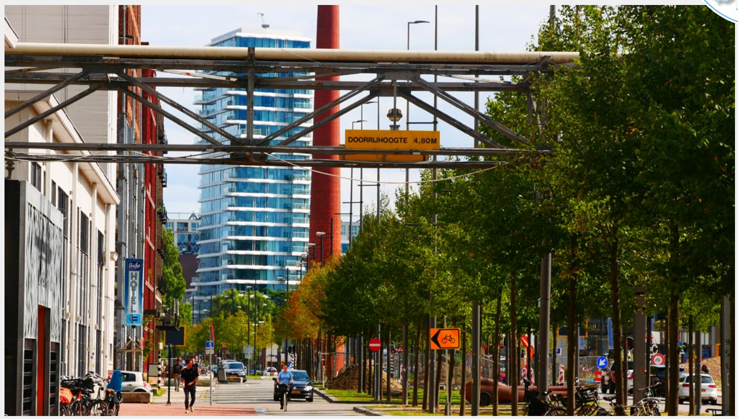

Photo source: Municipality of Eindhoven

Providing open and free Wi-Fi to inhabitants and visitors of Strijp-S. 18 hot-spots are planned. Direct access to the site-related internet services is enabled. Inhabitants use the same access in public space as they use at home.

Measured Impacts

18 smart lampposts

20 directly involved citizens

project scale **District level**

development type **Upgrading**

Benefits

- ☑ Encouraging digital entrepreneurships
- ☑ Improving quality of life
- ☑ Improving data availability
- ☑ Simplifying connectivity to the internet, extension of backbone

Lessons learned

- Privacy regulations have to be taken into account

Challenges

To link all the different hot-spots (indoor and outdoor) to a seamless network

Supporting factors

infrastructural: Fibre optic infrastructure

partners: VolkerWessels

other: Owner of the fibre backbone owns and operates the Wi-Fi

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case studies

Public sound sensor safety project

ICT | Eindhoven, NL

Photo source: Municipality of Eindhoven

Sound sensors in the public space that are attached to the smart light poles enabled to detect specific sounds such as gunshots, car alarms and screams. The sensor is able to find out the exact position of a sound source. Safety features are enabled without continuously perceived intrusive monitoring via cameras. The neighbourhood watch receives access to relevant safety information via an app.

Measured Impacts

7 smart lampposts
20 directly involved citizens

project scale — **District level**

development type — **Technological development**

Benefits

- ☑ Improving personnel efficiency
- ☑ Improving life quality
- ☑ Increasing safety
- ☑ Customized sound analytics

Lessons learned

- Safety issues are less pressing in the area and therefore the push towards implementation lower
- Interaction with other systems should be taken into account early. Getting the app accepted takes more time than expected
- Sensors work very well in combination with video surveillance systems to add additional information to the case

Challenges

Tuning of the sensor needs to be specific to the surrounding and is therefore time-consuming. Combination of sensing and acting via the smart lights is not trivial.

Supporting factors

infrastructural — Fibre optic infrastructure

social — In the early stages of the district development safety has been a concern

partners — VolkerWessels

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case studies

Renovation of semi-attached homes of privately owned apartments and houses using Woonconnect tool

ICT | Eindhoven, NL

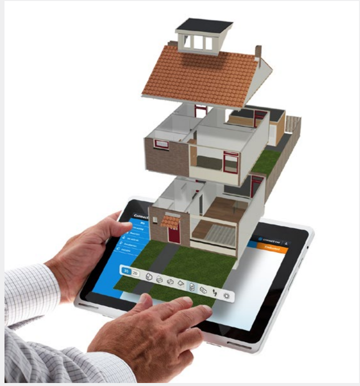

Photo source: Municipality of Eindhoven

The digital 3D-tool WoonConnect allows the housing association and apartment owners to improve their apartments and see the influence of their behaviour (i.e. showering, heating) and the expected results of the renovation. It shows the different renovation options available through different suppliers via a two-sided platform approach that even allows direct contracting. Decision making is collective. The tool provides direct feedback on the web-application what the influence of renovation is. A homeowner can directly receive an offer for a renovation option.

Measured Impacts

Number of activated digital keys by households: **284**

Number of households that made a renovation scenario: **174**

project scale **Individual site**

development type **Upgrading**

Benefits

- ☑ Decreasing energy consumption in buildings
- ☑ Improving energy usage efficiency
- ☑ Reducing energy bill
- ☑ Improving social integration
- Improving life quality

Lessons learned

- Main factor for implementation is the reduction in energy bill. Know your customer: is the digital tool right for the user
- Finding right scenarios important to encourage users. Complete self-service tool is difficult. Need some help for getting started
- Don't start with Energy use. Luring them in is a challenge. Important to start with someone who knows the neighbourhood well. Spreading message through social groups.
- Privacy of Data: Who will use the information? Who sends the message

Challenges

Decision making is a challenge as collective process. MARKETING and helping the customers through the process. Trust Issue with who the contractors are in the list. Finding the right offer for the apart¬ment building.

Supporting factors

infrastructural: Existing apartment buildings

financial: Private investments or/and state subsidies

geographical: Eindhoven – EckartVaartbroek district

social: Availability of customers to try and use the new technology

partners: KPN

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case studies

Public charging infrastructure

Mobility | Eindhoven, NL

Photo source: Municipality of Eindhoven

14 type-2 AC chargers in Strijp-S with two charging points. One located in a parking garage and two in open parking lots. Planned app shall trigger the user to unplug the car once it is readily charged. Also one DC/fast charger have been implemented.

Measured Impacts

kgCO_2eq/a (saving %) **31.23%**

kWh/a (saving %) **31.09%**

project scale **District level**

development type **Upgrading**

Benefits

- ☑ Reducing use of fossils
- ☑ Improving the air quality
- ☑ Reducing GHG emissions
- ☑ Supporting environmental efficient transport
- ☑ Promoting sustainable behaviour
- ☑ Promoting electrical vehicles
- ☑ More efficient use of charging infra-structure

Lessons learned

- Takes much effort if there is a shared electricity access point
- Additional meter at access point to the real estate grid had to be installed
- Maximum available capacity is a bottleneck in already in use buildings

Challenges

Charging points are connected to the real estate and not directly to the public grid. Billing between the building and the charging station owner is necessary.

Supporting factors

infrastructural	Plugging on the existing infrastructure
financial	Several subsidies for electric vehicles and charging stations from the Dutch national ($)) government
geographical	Eindhoven – Strijp-S
partners	VolkerWessels /City of Eindhoven
legal	European standards for plugs and communication (charging pole-car) now available.
other	Political push towards electrical vehicles

Contacts

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case studies

Parking management system

Mobility | Eindhoven, NL

Photo source: Municipality of Eindhoven

A mobility management system which guides motorized transport using 3 large LED display sites, online and via an app. The system will recognize cars using visual license plate recognition and other modes of transport via a smartphone app. Occupancy of parking lots is increased. The most suitable parking lot is recommended and displayed to the user via the screens. If no personalized information are available, general occupancy information are displayed. The system will be able to recognize patterns and adopt the mode of operation. For cyclists and bikes three wayfinders (multidirectional LED screen with route information) were installed.

Measured Impacts

Average parking occupancy percentage per week increased by **11.49%**

251 end users are involved

project scale **District level**

development type **Technological development**

Benefits

- ☑ Reducing traffic congestion
- ☑ Improving the air quality
- ☑ Supporting the sustainable use of land
- ☑ Promoting sustainable behaviour
- ☑ Reduced park searching time, extended lifetime of existing hardware, more efficient use of parking space

Lessons learned

- Important to get detailed existing information(hardware, software, infrastructure) with all the vendors and parking systems in the area.
- Understand who the end-user is(residential users/office goers) and what they expect from the management system. What changes are expected in the near future w.r.t service needed in future.
- Useful to have a system which can work with different vendors as it makes it easier to replicate in different regions.

Challenges

Several vendors operate the different parking spots (system integration is necessary, proprietary APIs). Existing parking management system with existing infrastructure and hardware. Digital infrastructure to connect the parking hardware to fibre optic infrastructure. (e.g.. payment system, cameras etc. Maintaining privacy has been a challenge.

Supporting factors

infrastructural: Parking garages with management systems that needed replacement

legal: A deal with the municipality allowed the developer to decrease the number of parking spaces that would have been required in a mixed use area by law - by developing a smart management system. It makes existing analogue hardware digitally controllable.

geographical: Eindhoven – Strijp-S

partners: Mobility S as a parking reservation service provider through permits. Data collected like license plates provided to Mobility S. Real estate company has a major share in the management company.

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case studies

Single base bike sharing & Point-to-point station bound bike sharing

Mobility | Eindhoven, NL

Photo source: Municipality of Eindhoven

12 bikes operated locally by Mobility S as a service for visitors, workers and inhabitants. A mixture of ebikes and normal bikes is offered in a station bound bike sharing system located at one of the entrances of Strijp S. Bookings are done via a smartphone app, via the website and in an office located at the station. Different types of bikes are available (e.g. electric). Special offer from the district for the district.

Measured Impacts

725 citizens be involved

Number of trips: **3548**

project scale **District level**

development type **Upgrading**

Benefits

- ☑ Reducing use of fossils
- ☑ Reducing GHG emissions
- ☑ Improving air quality
- ☑ Supporting environmental efficient transport
- ☑ Reducing traffic congestion
- ☑ Promoting sustainable behaviour
- ☑ Improving public transport
- ☑ Promoting use of active modes
- ☑ New job opportunities for people distant to the labor market (mainte-nance of bikes), marketing exposure (through branding of the bikes)

Lessons learned

- People own their own bikes and therefore there is no real need for sharing. Sharing mainly for tourists.
- New mobility options need to be incentivized to create a user base.
- The bike sharing has to fit to mobility needs in a suitable way - a significant use case is needed.

Challenges

Find suitable locations that are easily accessible via other transport modes - those are in areas where floor space is scarce and expensive.

Supporting factors

infrastructural — Good bike lanes available in the district and beyond.

geographical — Eindhoven – Strijp-S district, direct interaction as the office of the operator in located on-site

partners — VolkerWessels

social — Strong biking community

Contacts

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case studies

Smart City Platform

ICT | Eindhoven, NL

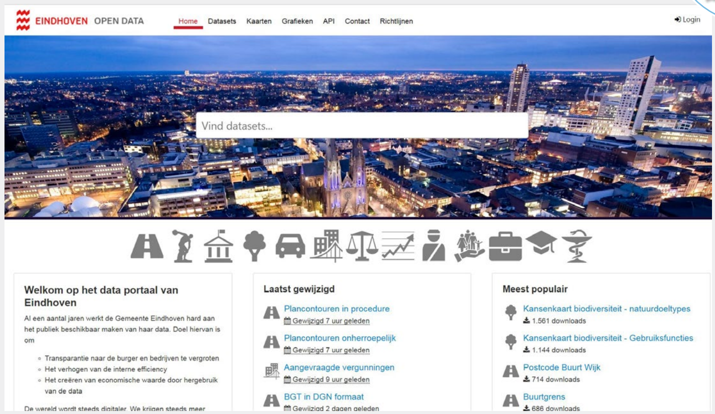

Photo source: Municipality of Eindhoven

A data portal of the City of Eindhoven to upload, share, use, analyze and visualize public data sets. After a market consultation and testing to build and operate an own data portal, the city of Eindhoven decided to choose for a commercially available platform from Open Data Soft.

Measured Impacts

Number of viewed times per month: **96000**

Number of times actively downloaded per month: **3912**

project scale **City level**

development type **Technological development**

Benefits

- ☑ Encouraging digital entrepreneurships
- ☑ Facilitating citizen engagement
- ☑ Improving data availability
- ☑ Increasing transparency

Lessons learned

- There is a shift from just having an open data portal, to a portal incorporated in a wider vision to create a smarter society.
- The focus should be on the usage of the data usage via the platform and Not on the portal and the storage on it.
- Important to understand data ownership. Metadata of all municipal datasets are available publicly. A decision tree is available to decide on which data to make available.

Challenges

Decision and process towards making data available from the municipality. Migrating existing data from an old platform to the open data portal was challenging

Supporting factors

infrastructural: Increasing number of (real time) data sets available in the city.

geographical: Eindhoven

social: Availability of customers to use the produced energy

legal: Strict but clear EU legislation/regulations

partners: City of Eindhoven

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case studies

Smart interactive light route for walking and running in Eckart

ICT | Eindhoven, NL

Photo source: Municipality of Eindhoven

To encourage walkers, joggers and runners lights are embedded in a foot walk around two ponds in Eckart. People can trigger the system via panels at several different locations around the ponds and choose a walking/running speed. The floor embedded 4-coloured lights follow users in the speed they have decided on. The solar powered tiles are embedded every 20m. The lights stimulate social interactions and enhance usability of the public space

Measured Impacts

Smart lampposts: **31**

How many times the running system has been used per day:
64.95

project scale **District level**

development type **Technological development**

Benefits

- Increasing social interaction
- Improving life quality
- Increasing safety
- Promoting use of active modes
- Increased district pride

Lessons learned

- A close tie to the local community and a joint design process building on it is highly recommended. However do Not expect everyone to show up (an outcome of 4% from invitations is Normal)
- Use an area with high and constant solar power provision (less shadow) to make sure enough energy for the light is produced
- Not all citizen groups are joining the design sessions, there will most likely be „usual suspects" joining. For involving specific groups (like students) additional efforts are needed. Bring different kinds of project related personnel to get in touch with the citizens in the sessions.

Challenges

The walking path needed to be completed to form a full round around the pond. The electrical part of the system needs updates so that the system becomes solid to all kind of weather un-normal conditions

Supporting factors

infrastructural: Walking path was partly already existing however underutilized before.

geographical: Eindhoven – EckartVaartbroek district

social: Strong social interaction between different stakeholders & willingness to the municipality to improve the area

legal: Strict but clear EU legislation/regulations

partners: City of Eindhoven

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case studies

Renovation of semi-attached homes of housing association using Woonconnect tool

Energy | Eindhoven, NL

Photo source: Municipality of Eindhoven

The project aims to involve tenants into the process of renovating and maintaining homes owned by the social housing association Woonbedrijf. It enables tenants to make informed decisions on what pre-defined renovation options they want to realize. The digital 3D-tool WoonConnect allows tenants to see the influence of their behaviour (i.e. showering, heating) and the expected results of the renovation.

Measured Impacts

kgCO_2eq/a (saving)
86043,24

kWh/m2a (primary energy demand saving) **86,52**

project scale **Neighbourhood**

development type **Retrofitting**

Benefits

- Decreasing energy consumption in buildings
- Improving energy usage efficiency
- Reducing energy bill
- Improving social integration
- Improving life quality
- The renovation allows the housing association to directly interact with the tenants, renovation is now possible on an individual household level, improved living conditions for tenants

Lessons learned

- Not all tenants prefer digital interaction (via the tool) or interaction in general. Main influencing factors are age, trust in private and public authorities.
- Data privacy in the homes is perceived much more pressing than in other digital areas (such as social media).
- The direct and personal interaction at kitchen-tables was highly important for the success of the project - therefore the process was redesigned to use WoonConnect as a self-service and as a guided experience. Know your customer: is the digital tool right for the user. Design a customer journey before you begin.

Challenges

Privacy - Creating enough trust for the data to be collected through the WoonConnect tool. Many partners involved interested in many different kinds of data and therefore tenants became afraid of the type of questions asked and the possible uses of the data.

Supporting factors

infrastructural: Existing residential houses

legal: Housing association bound by law to maintain and improve the houses. Agreement to improve the average social house to energy label B. Official regulation to have an energy label on each home.

geographical: Eindhoven – EckartVaartbroek district

social: Availability of customers to try and use the new technology

partners: Woonbedrijf

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