
Sustainability for Underground Stations

to exemplify the work of the business unit *Power Efficiency*

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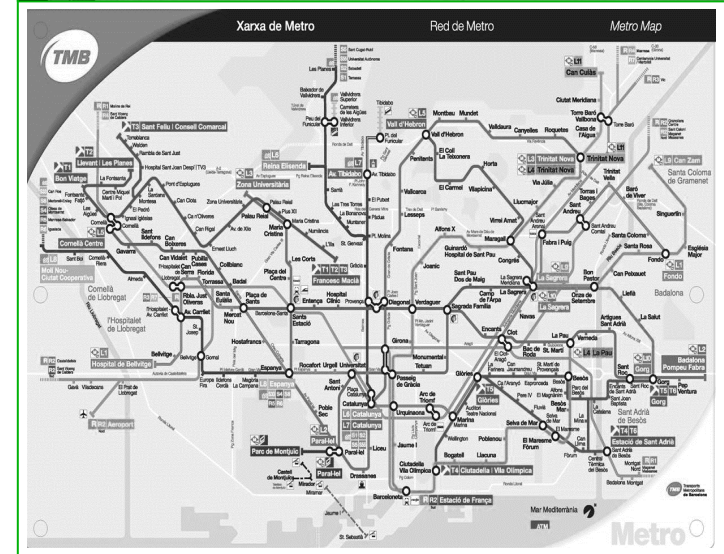
SUSTAINABLE ENERGY MANAGEMENT FOR UNDERGROUND STATION

- Goal: Reduction of energy consumption of a metro station in Barcelona >5% under real functional conditions.

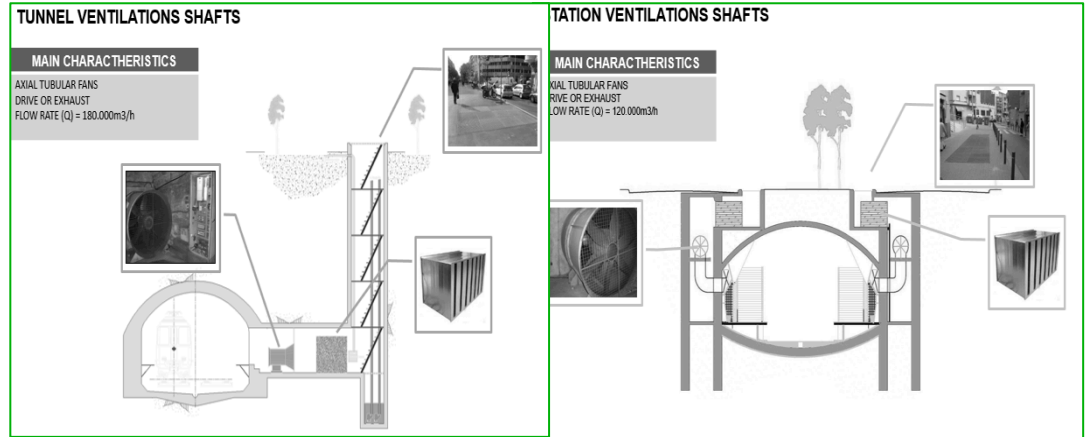




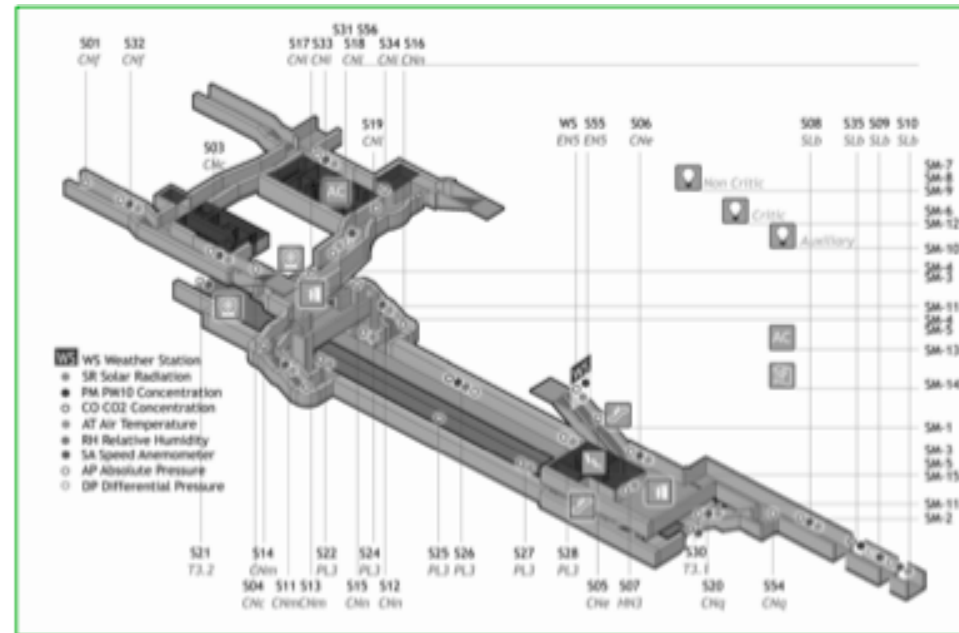
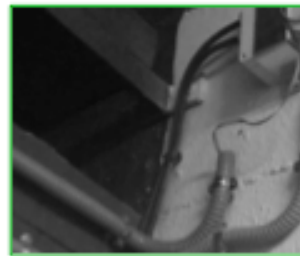
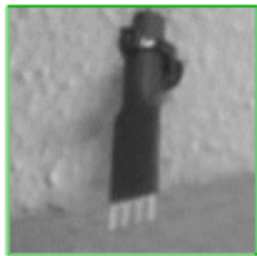
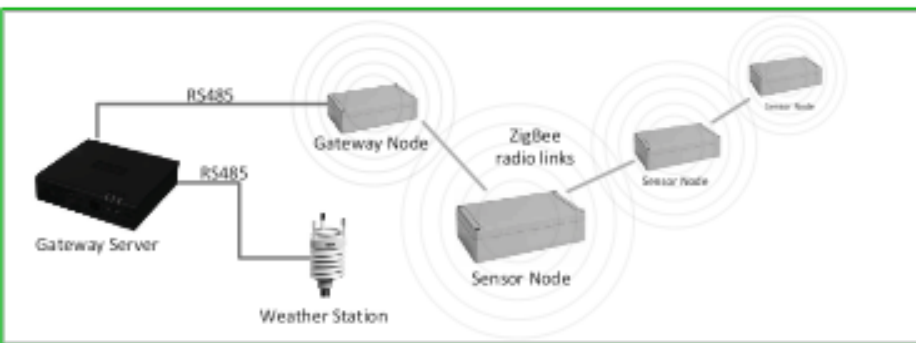
- **Metro stations** are big energy consumers
 - Barcelona Metro Network uses 63,1 Million kWh/year
- A third is used by the metro stations
- **Savings of 5%** a Year, correspond to the average consumption of **700 households**



- Tunnel- & Station-ventilation
- Old Lightning technology (T8 Technologie)
- Escalators and elevators

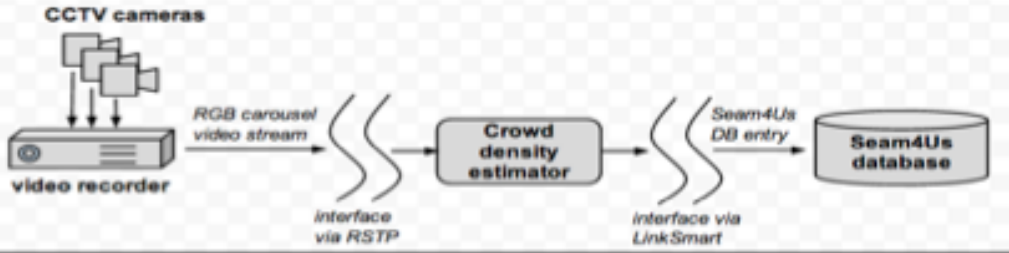


THE SENSOR NETWORK

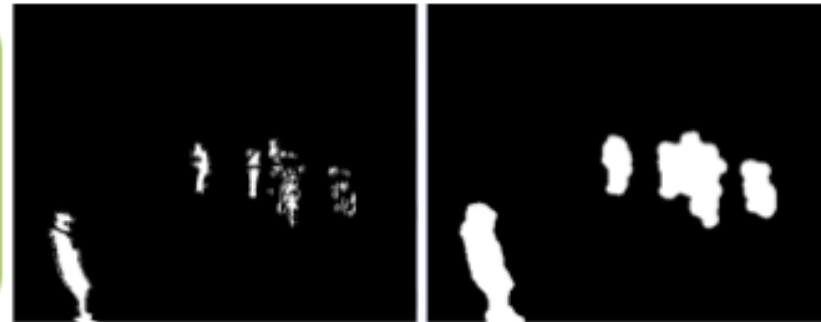


A **very low-power sensor network**, with battery powered sensors, and a reliable communication framework with a **fault tolerant architecture** have been deployed in the station to monitor energy consumption and the environmental parameters.

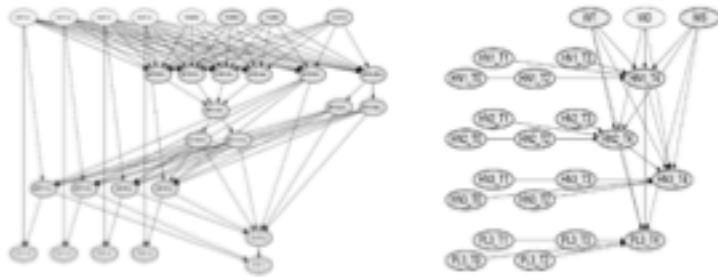
THE SENSOR NETWORK



A CCTV based occupancy detection system runs on top of the surveillance system and provides in real time the occupancy levels for each ambient.



THE CONTROL SYSTEM



Predicting

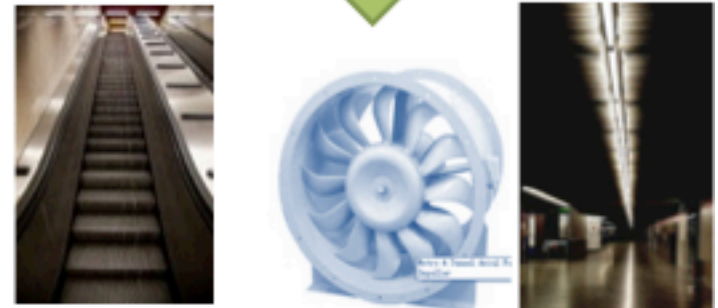


Controlling

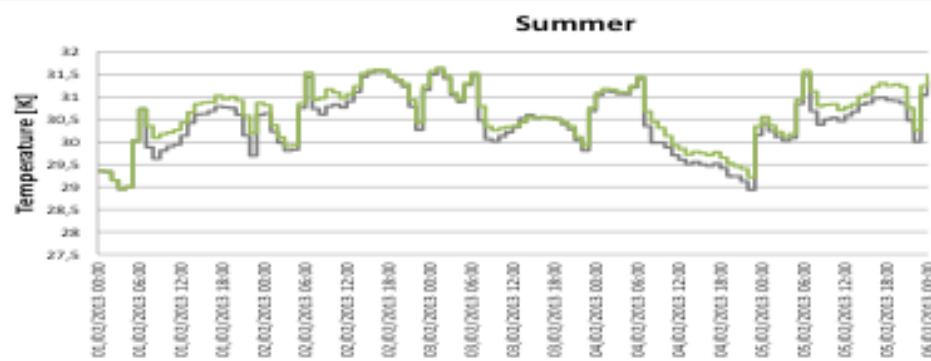
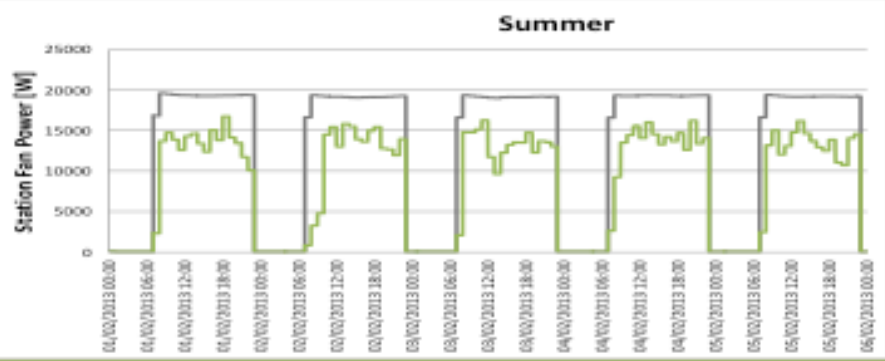
Sensing



Actuating



THE CONTROL SYSTEM



The control system estimates the future thermal and airflow conditions of the station on the basis of the past history, of the weather forecasts, and of the occupancy predictions. On this basis it selects the best speed for fans, escalators and the most suitable lighting levels, thus providing the best possible comfort and the highest possible energy saving.

THE SYSTEM INTEGRATION



Seamless system integration has been achieved by means of the **Linksmart middleware**.

The event based Linksmart middleware provides **sensor and component abstraction**.

Devices and software components subscribe to the event manager either to store or receive data.

The Linksmart Event Manager stores every sent event into a database.



THE DECISION SUPPORT SYSTEM

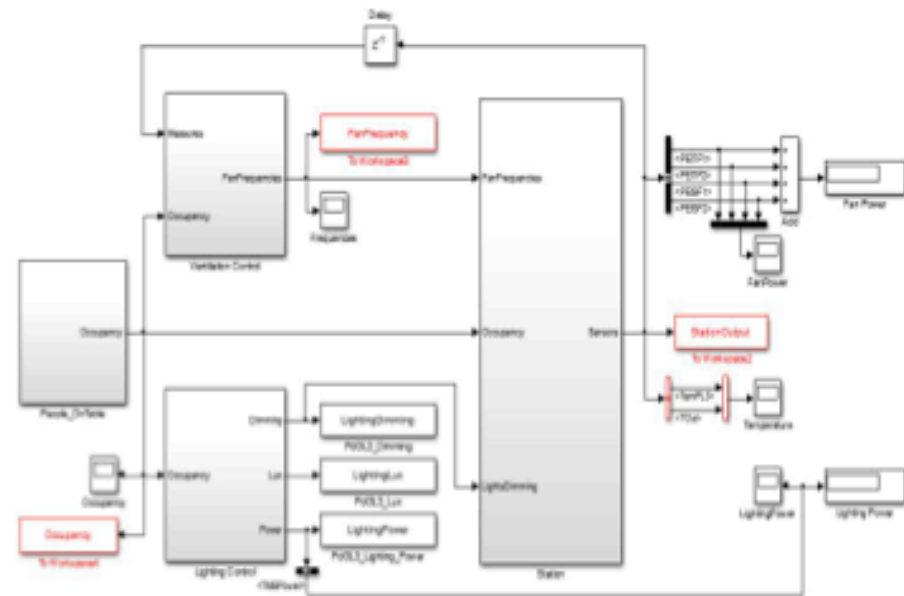


A critical aspect for the **investment planning** in the SEAM4US technology is the **assessment of the approach in terms both of the amount of the energy saving and of the installation and operational costs.**

The seam4us pilot in Passeig De Gracia requires low investments in absolute terms, with pay back periods that are in the range of 3-5 years. But **different implementations may require different financial efforts.**

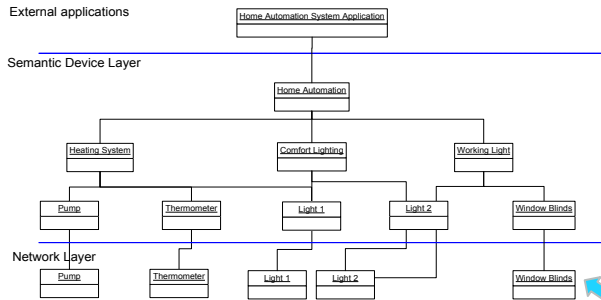
Financial planning = performance model + cost model

The Performance Model - The SEAM4US project has developed a **metro station modelling library** and a **co-simulation architecture** that is able to estimate the performance of SEAM4US installations in different stations.



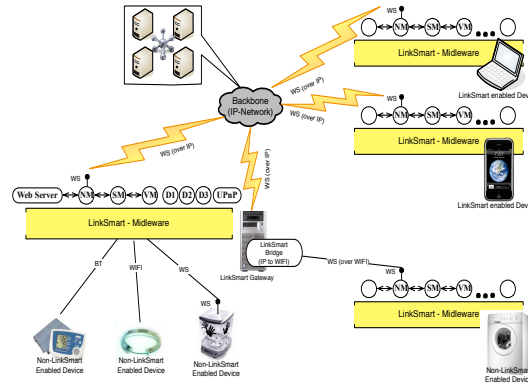
LinkSmart - Middleware

Developers semantic devices



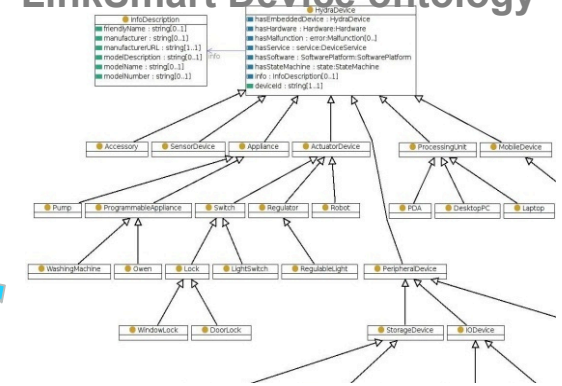
Manages many device access protocols

- Bluetooth
- RF
- ZigBee
- RFID
- WiFi
- Serial ports



LinkSmart Network

LinkSmart Device ontology



Semantic discovery

Network discovery

Physical discovery

UPnP Wrappers



The cost model provides **cost information for every scenario defined in the performance model.**

The cost estimation is based on the knowledge gathered during the pilot of the SEAM4US project, allocating accurately the costs for each deployed technology.

	Baseline (Energy Audit)		CP0: Normal		CP1: Max Saving		CP2: Max Comfort	
Load categories	Yearly consumption (MWh)	Role Percentage	Yearly consumption (MWh)	Saving Percentage	Yearly consumption (MWh)	Saving Percentage	Yearly consumption (MWh)	Saving Percentage
Lighting	239.91	40%	187.61	22%	145.39	39%	203.93	15%
Ventilation	75.81	13%	50.72	33%	46.93	38%	48.67	36%
Escalators	37.34	6%	25.17	33%	25.17	33%	25.17	33%
Controlled Energy	353.07	59%	263.50	25%	217.48	38%	277.77	21%
Demand Driven controllable equipment	128.72	21%	128.72		128.72		128.72	
Out of Scope Equipment	118.25	20%	118.25		118.25		118.25	
Total consumption	600.04		510.47	15%	464.45	23%	524.73	13%

The SEAM4US pilot, demonstrates an average **25% of energy saving** of the controlled systems, which corresponds to about the **15% of the total energy consumed by the whole station**. This figure, scaled up to the whole metro network of Barcelona, corresponds to **11.5 GWh/year**, which is the energy consumed approximately by **3750 households!**

Business Unit Power-Efficiency



Current projects

- **Optimization of energy consumption by intelligent realtime monitoring and control:**
 - [ME3Gas](#) – Middleware for Energy Efficient Embedded Services and Smart Gas Meters
 - SEEMPubS - Smart Energy Efficient Middleware for Public Spaces
- **Simulation und Decision support for Energy savings**
 - Adapt4EE - Enterprise Data modelling to manage enterprise environment
 - SEAM4US - Sustainable Energy mAnageMent for Underground Stations
- **Optimization of load distribution in Energy networks**
 - [GreenCom](#) - Energy Efficient and Interoperable Smart Energy Systems for Local Communities
 - [Flex4Grid](#) – Prosumer Flexibility Services for Smart Grid Management
- **Sustainable ICT-support for Smart Cities**
 - [ALMANAC](#) - Reliable Smart Secure Internet of Things for Smart Cities
 - DIMMER – District Information Modeling and Management for Energy Reduction
- **Optimization of Energy consumption by process transparency in the production**
 - E3-Produktion – CPS Production in Industrie 4.0
 - [ebbitts](#) - Enabling Business-based Internet of Things and Services
 - [BEMO-COFRA](#) - Brazil-Europe - MOnitoring and COntrol FRAmework
 - [Satisfactory](#) – A collaborative and augmented enabled ecosystem for increasing SATISfaction and working experience in smart FACTORY environments
- **Internet of Things – Middleware and Tools**
 - HYDRA - Middleware for networked embedded systems
 - [IMPRESS](#) – Intelligent System Development Platform for Intelligent and Sustainable Society



Services

- Substantial experience and Know-how in the development and use und of IoT and CPS for ressource efficiency in production and Smart Cities.
- Consulting for system adjustment, installation, use and evaluation in industrial sector.
- Producing and industrial companies with high energy demand
- Industrial business and commercial/office buildings with energy-demanding layout
- Public buildings and municipal companies , like e.g. public transportation services and public services.
- International cooperation: 2 EU-Brasilien projects



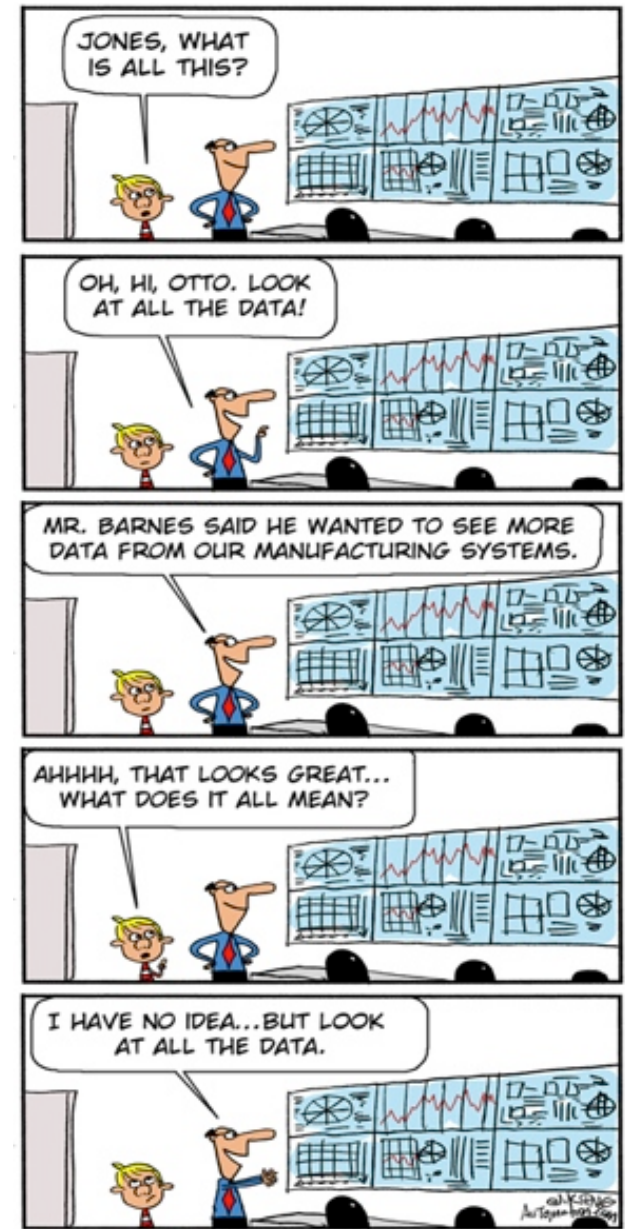
Thank you for attention!

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http://www.fit.fraunhofer.de/fb/ucc_en.html



<http://www.automation.com/library/comics/otto-has-the-cap-comic-series/otto-mation-comic-april-23-2014>