# CASCADE methodology and tool: appliedICT for energy efficient airports

# CASCADE Methodology and tool: applied ICT for energy efficient airports

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***Abstract:*** *This paper gives an overview on the CASCADE project, methodology and on a stakeholder-centered solution called the CASCADE Tool that integrates Fault Detection and Diagnosis (FDD)into a comprehensive energy management system. Two major European airports are used as the test bench of the CASCADE solution. The solution delivers a common integrated platform including several innovative commercial and under development technologies including an ISO-50001 energy management software, advanced data visualization and FDD which has become a robust scientific field offering proven methods for the optimization and more effective operation of HVAC systems.*

***Keywords: Energy Management Systems ,FDD, ICT, Airports***

## 1. Introduction and CASCADE project overview

Airports are essential infrastructures. They handle millions of passengers annually and the number is increasing due to the overall impact of a globalized economy [1]. Airports have become larger and more numerous being one of the largest energy users among large building clusters. Airports also utilize numerous Information and Communication Technology (ICT) systems and tools to support flight technology, safety requirements and demanding operative levels. Airport managers constantly operate under pressure to maintain high levels of service that often conflicts with ever increasing environmental obligations [2]. Some recent responses to this challenge are reflected in the airport-focused sustainability programs like the Sustainable Airports Manual in the US [3], or the Airport Carbon Accreditation in Europe [4]. These schemes are aimed to support a significant reduction of $CO_2$ emissions and a challenging vision towards carbon neutrality. Energy use is often the second operating expense at airports, only exceeded by personnel [5], hence a reduction on energy demand would impact significantly on airport operative results whilst improving sustainability performance [6].

CASCADE is a European FP7 research project which is developing facility-specific measurement-based energy action plans for the airport energy managers that are underpinned by Fault Detection Diagnosis (FDD) methods [7]. A framework and methodology for building customized ICT solutions is under development in order to integrate with and on the basis of the existing ICT infrastructure and operational procedures [8]. A measurement framework and minimal data set will be established to control and benchmark the equipment performance, to optimize user behaviour, and to match client specifications. FDD enables state-of-the-art energy management because it can be used to suggest problems in system/equipment efficiency, and operational settings. CASCADE is aiming also at turning FDD into the actionable information by developing an energy action plan that links Actions-Actors-ISO Standards [9] through a web-based management tool (discussed in section 3 of the paper).

The developed ICT solution will be able to integrate with existing systems and will target a 3-year return on investment and 20% reduction of energy consumption and 20% reduction of CO2 emissions. CASCADE will achieve these objectives in time by:

1. Engaging the client, determining their needs, and encouraging organisational change;
2. Integrating new ICT technologies with the systems present at client facilities;
3. Collecting data on user operation and equipment performance;
4. Applying fault detection methods across operational scenarios and equipment performance benchmarks;
5. Making an Energy Action Plan that links actors, actions, and ISO standards based on facility specific data and providing cost/benefit (kWh, $CO_2$, Euros).

CASCADE approach focuses on the actions which airports can take in order to address GHG sources within their control and influence, fully in the line with ACI guidelines and recommendations for the future strategic airport planning and management [10]. Energy management actions in large organizations, such as airports, span across different levels from the top level with the overall energy policy and planning to the bottom with scheduled and emergency based operation and maintenance. The challenge of the CASCADE project is to develop a methodology and tool that brings these two separate worlds together, this is what will be presented in the next two sections.

## 2. CASCADE methodology

One of the main objectives of the CASCADE project is to assemble a solution envisioning a new age of Building Management Systems driven by:

- The integration of a number of dissimilar technologies and knowledge fields;
- The ability to be easily integrated besides existing BMS system, leveraging existing assets;
- An interest for fetching innovative FDD based automation into a wider energy management standard;
- The use of protocols for results verification and measurement;
- The search of a pervasive solution that meets standards and stakeholders needs along an entire organization. Software acting as guidance and facilitator rather than a burden.

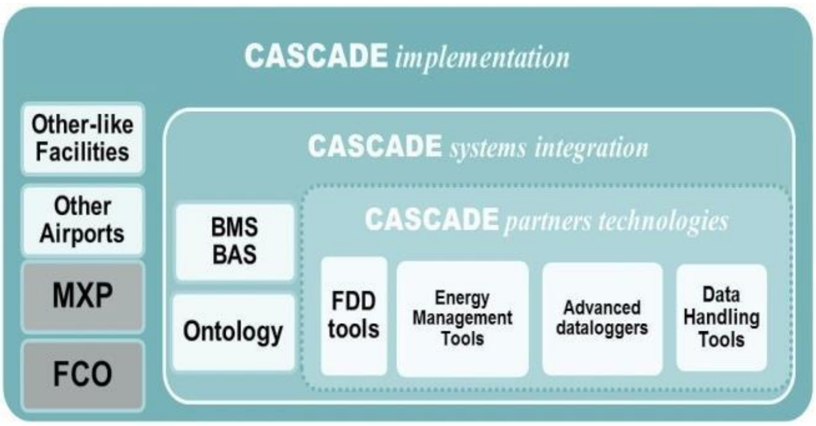


*Figure 1 CASCADE Conceptual Boundaries*

As shown in Figure 1, the project conceptual inner group is based in three components: FDD software, energy management software and advanced data logging systems. An external layer represents the systems integration group, this is the combination of the different IT solutions with the existing BMS/BAS systems. The airport ontology structures data through the different layers, allowing for the whole implementation. Finally closing the whole, a methodology for software implementation is under development and aims at the adaptation and replication of the tested solution to other airports and similar facilities. At this regard requirements gathered during the initial stage of this research established a need for a technology solution with high scalability and replicability potential. A modular, flexible and structured approach was required to support short deployment times through a diversity of facilities differing in size, location, energy systems, or governed by different organizational structures. Three main factors have been identified as confronting this requirement, which adds to the commonly known barriers to ICT renovation of inherent complexity, unforeseeable requirements and perpetual change [11]. These are:

***i.* Growing complexity of data interfaces**. Organizations hold, operate and maintain a diversity of ICT assets generating disparate and unconnected data sets. Within the building sector, a variety of protocols such as BACnet, CAN, KNX/EIB or MODBUS impose a lock-in barrier to develop a comprehensive data integration solution [12]. This problem was confronted by adopting a multi-paradigm Serviced Oriented Architecture (SOA) framework where loosely coupled systems interact committing to a set of business and data transformation rules (BR/DTR) using flexible file format such as XML or JSON. In addition, an ontology metadata layer was chosen to support the integration and interoperability of the mentioned fragmented data structure.

***ii.* Energy management readiness of legacy systems.** Data generated by existing building management systems (BMS) is often insufficient or incomplete to serve energy efficiency analysis. These technologies are designed to monitor real time variables at several system points and facilitate remote operational control of settings such as schedules or setpoints. Implementing energy management software that uses advanced visualisation techniques [13] and FDD methods requires careful consideration regarding existing data storage capacity, quality of data, BMS protocol compatibility and sensor reliability among others [14].

***iii.* Considering interaction of human and physical systems.** Complex infrastructures are operated according demanding standards driven by legislative obligations or strategic sustainability programmes. Systems operation is influenced by organizational style and subject to existing contractual arrangements affecting operations and maintenance (O&M) day to day practices. Moreover, know-how of energy efficiency in practice is often buried by arcane knowledge and sometimes locked by facility management companies. Introducing new standards like the ISO 50001 represents an opportunity to build a common pool of engineering expertise within an organization, and to minimize interpretation of ISO 50001 principles [15].

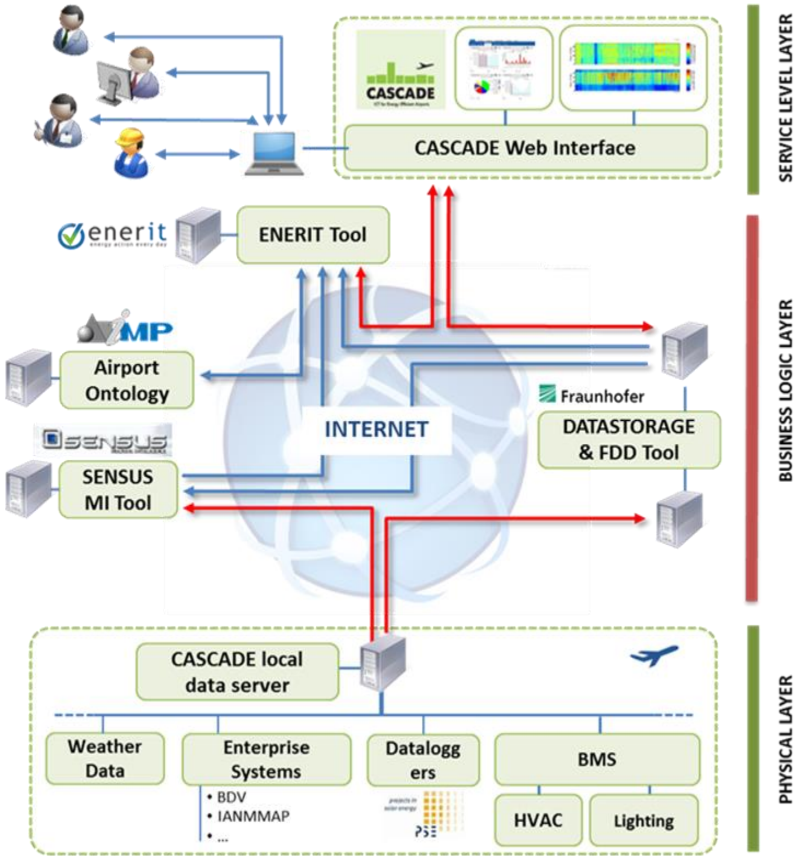


*Figure 2 The CASCADE Architecture*

As a result of this discussion, Figure 2 shows the "three tiers architecture" proposed as the backbone of the CASCADE methodology and tool. In the physical layer, existing infrastructure plus additional sensors and advance data loggers feed the automation systems currently in place at the facility. The automation systems comprehend both field level controllers and automation control triggered by SCADAs and proprietary BMS. A database with historical trends is implemented. FDD is performed remotely operating conceptually as Software as a Service applications (SaaS). Airport Ontology is a meta-data layer structuring and describing the airport infrastructure related data, the ontology is delivered with accompanying application programming interfaces (APIs) for extracting the needed information by querying the ontology. Querying the ontology can be achieved in two ways each way requiring a specific API: First way is to communicate with the ontology "locally" so that the ontology is stored in a local CASCADE server simply by calling the corresponding functions for retrieving the needed information provided by predefined API. The second method is to access the ontology via a web-service by sending the requests and receiving the response carrying the needed information wrapped up into the XML message. With regards to the front end layer, the approach is to support enhanced Energy Management both at the ISO 50001 management level and also at the operational level of HVAC system. This is better described in the next section.

## 3. CASCADE tool and implementation approach

At this point of the project (Month 30) the main functionalities of the CASCADE tool are available to be tested at the pilots. The main objective of this section is to show what are these functionalities and the methodology to select them with the end users in the 2 project pilots.

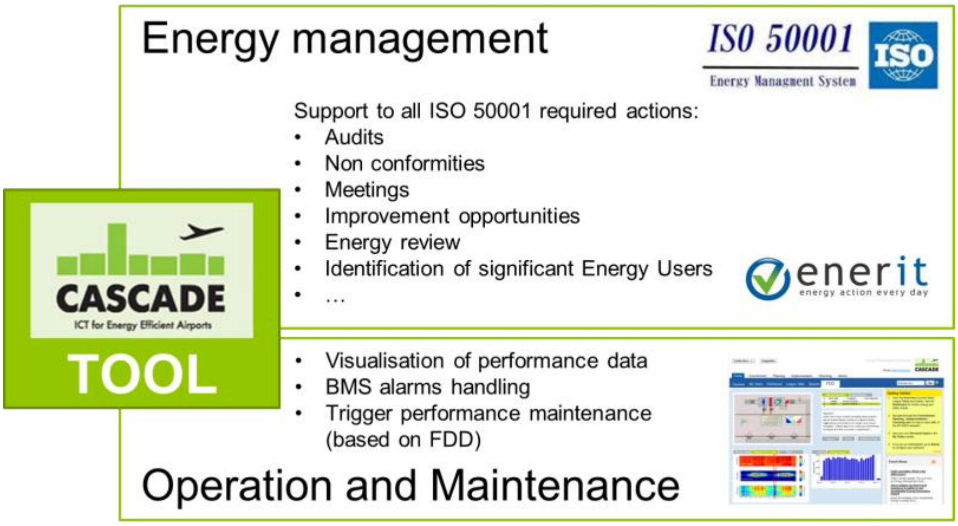


*Figure 3 The CASCADE Tool overview*

As shown in Figure 3 the CASCADE tool can be seen as a tool that keeps together two main groups of functionalities that refer to two different types of users. The first part is Energy management part of the tool and it has been developed and targeted for the use of the people involved with Energy Management Systems (EnMS) in accordance with ISO 500001 standard. This part supports all the activities to be carried out and as part of the standard certification process (including certification maintenance/renewal) such as: Internal Audits, Non conformities, Meetings, Improvement opportunities, Energy review, Identification of Significant Energy Users (SEU) and Energy Performance Indicators (EnPI).

The second part is the Operation and Maintenance part of the tool and it has been developed and targeted for the use of the people involved with daily monitoring of energy systems operation and performance though the Building Management Systems graphical user interface available in the control room. The CASCADE Operation and maintenance tool offers data analysis intelligence that sits on top of data available from the BMS that are currently analysed by hand form the operators. These intelligence spans on three main functionalities that are the trigger for a performance maintenance and include: advanced and aggregated visualisation of performance data, BMS alarms handling and Fault Detection and Diagnosis.

These 2 worlds (management and operational) are normally not really linked since the overall energy management activities focus at the macro level with a yearly time frame (same as ISO50001 standard cycle) and the operation and maintenance ones relate more to the daily/hourly operation focusing more at the micro level of operational problems. One of the objective of CASCADE is to bring these 2 worlds together and strengthen the link between energy management actions with daily and real time operation. Although this is a very big challenge  we firmly believe and are starting to appreciate that a common platform (such as the CASCADE tool) is a good strategy to start this mutual engagement process which in turn will lead to a better energy management and higher energy savings.

The functionalities selection and testing is a very key process or the overall project development and needs to be treated in a careful way since if not handled properly it may jeopardise both the development effort of the technology providers and the opportunity for pilot leaders to test and adopt cutting edge solutions. The main steps to follow got optimal pilot implementation of the CASCADE solution are the following:

1. Identify key users in the organisation that are currently working on the activities covered by the tool (both energy management and energy system operation and maintenance)
2. Organise one (or more) meetings with the key players with the aim to: Understand the current processes and workflows in the organisation; Show the tool functionalities in detail with concrete examples with a live and interactive user experience; Identify interesting functionalities and rank them based on their strengths and weaknesses; Identify required customisation of tool functionalities or workflows to match the current ones in the organisation; Identify the different departments to be involved in the use of the tool within the organisation and list the names of the end users for each of the selected functionalities; Quantify with an order of magnitude the expected use of the selected functionalities (e.g. number of the audits, meetings, significant energy users, improvement opportunities…)
3. Draft real life scenario on how the tool will be used based on the iterative meetings described at point (2)
4. Agree on a concrete implementation plan based on point (3)
5. Train the selected people specifically on the functionalities they will use

## 4. Conclusions

This paper gives an overview of airports role on energy consumption in EU and US levels and the importance of research in this field. An overview of the FP7 CASCADE project is also given in the introduction to show what is the direction followed by the research community and what are the cutting edge ICT solutions currently under development. The paper also describes in detail the CASCADE approach and methodology and gives some details on the proposed tool for the targeted stakeholders and an idea on how this tool could be brought in to support Airport Managers and HVAC systems operators to achieve higher level of energy performance and a more systematic Energy Management System (ISO 50001) implementation.

## References

[1] Eurocontrol. Medium-Term Forecast: IFR Flights Movements 2012-2018. 2012.

[2] Costa, A. Blanes, L.M., Donnelly, C., & Keane, M.M. Review of EU airport energy interests and priorities with respect to ICT, energy efficiency and enhanced building operation. Proceedings of the 12th International Conference of Enhanced Building Operation. ICEBO 2012. Manchester, UK. 2012.

[3] CDA. Chicago Department of Aviation. Sustainable Airport Manual. 2011

[4] ACI Europe. Airport Carbon Accreditation. [Online] available from http://www.airportcarbonaccreditation.org/ [Accessed on 01 Feb 2012]

[5] TRB. Transportation Research Board. Research Result Digest 2. Model for improving energy use in U.S. airport facilities. December 2007.

[6] Blanes, L.M., Costa, A. and Keane, M.M. Simulation to Support ISO 50001 Energy Management systems and Fault Detection and Diagnosis: Case Study of Malpensa Airport. Proceedings of the 13th IBPSA Conference. BS 2013. Chambery, France. 2013.

[7] http://www.cascade-eu.org - CASCADE ICT for Energy Efficient Airports.

[8] Blanes, L.M., Costa, A., Rehault, N. and Keane, M.M. Integration of Fault Detection and Diagnosis with Energy Management Standard ISO 50001 and Operations and Maintenance of HVAC systems . Proceedings of the 11th. REHVA World Congress & 8th. International Conference on IAQVEC. CLIMA 2013. Prague, Czech Republic. 2013.

[9] ISO 50001 – Energy management systems. Requirements with guidance for use. Geneve: International Standards Association. 2011

[10] ACI. Policies and Recommended Practices Handbook, Geneve: Airports Council International. 2009.

[11] McGoveran, D.. Embracing SOA.. the benefits of integration independence. Tech. rep., Alternative Technologies. 2006.

[12] Costa, A., Sterling, R., Blanes, L.M., Howley, M. and Keane M.M. A SWOT framework to investigate the integration between Building Management Systems and Fault Detection and Diagnosis tools. Proceedings of the 5th. International Conference of Applied Energy. ICAE 2013. Pretoria, South Africa. 2013.

[13] Blanes, L.M., Foncubierta J.L., Costa, A., and Keane, M.M. EDVE: An Energy Diagnosis Visualization Environment. Proceedings of the CIBSE ASHRAE Technical Symposium. 2014. Dublin. 2014

[14] California Commissioning Collaborative. The Building Performance Tracking Handbook. 2011.

[15] Dorr, M., Wahren, S., Bauernhansl, T., Methodology for energy efficiency on process level. Procedia fCIRPg 7 (0), 652 – 657, forty Sixth Conference on Manufacturing Systems. 2013.