



(<http://alarcos.esi.uclm.es/ginseng2016/home>)

GInSEng 2016

2nd Green in Software Engineering Workshop

29th August 2016, Amsterdam

ICT4S
ICT for Sustainability

(<http://ict4s.org/>)

Agenda

Ginseng Tentative Program	
Time	Activity
8:15 - 9:00	Registration Workshop
8:30 - 9:00	Welcome with refreshment
9:00 - 10:30	Invited Speech: Robert Decker
10:30 - 11:00	Coffee break
11:00 - 11:25	Title: GreenITAudit: A Tool to Audit the Green IT. Authors: J. David Patón-Romero and Mario Piattini.
11:25 - 11:50	Title: How to cast the approaches on green software engineering upon t Authors: Eva Kern.
11:50 - 12:15	Title: Static Energy Consumption Analysis in Variability Systems. Authors: Marco Couto, Jácome Cunha, Joao Fernandes, Rui Pereira and
12:30 - 13:30	Lunch break
13:30 - 13:55	Title: In search of energy efficient architectural patterns. Authors: Gianantonio Me and Coral Calero.
13:55 - 14:20	Title: Five years of green in software engineering: the Number of the Be Author: Coral Calero.
14:20 - 14:35	Warm up: Converging Research and Practical Green IN Software Engine
14:35 - 16:00	Working groups – 15:00 Tea break
16:00 - 17:00	Wrap up
17:00	Closing

Last updated: July 26, 2016

GreenITAudit: A Tool to Audit the Green IT

J. David Patón-Romero, Mario Piattini

Alarcos Research Group, Institute of Technologies and Information Systems

University of Castilla-La Mancha (UCLM)

Ciudad Real, Spain

{JDavid.Paton, Mario.Piattini}@uclm.es

Abstract—It is very important to audit Green IT, as it is a very young field, and although there are good practices, organizations have not a method for auditing them. In this paper we present *GreenITAudit*, a software tool for carry out the entire phase of evaluation or audit of Green IT. This tool covers various processes of the COBIT 5 framework, which is a framework for the control and audit of IT-related areas. Thus, based on these COBIT 5 processes, the *GreenITAudit* tool allows to audit the governance and management of Green IT in an organization.

Index Terms—Audit, Green IT, Tool

I. INTRODUCTION

Green IT is fast becoming in an increasingly important and indispensable area in an increasingly sustainable and efficient world, providing multiple benefits to the organizations that implement it. Therefore, organizations are getting closer to this “green” idea, and the number of organizations that are embracing the idea of Green IT is growing.

However, Green IT is a very young field and, although there are good practices, each organization implements it according to its own criteria. That is why it is extremely important that there is some mechanism to control that these Green IT implementations are sufficient, correct and operate as expected. And here is where audits come into play.

Unfortunately, only few studies currently exist on the area of Green IT audits [6], and the studies that exist highlight the importance of carrying out this type of audits. Therefore, it is extremely important to develop the necessary tools to carry out this type of audits, due to the fast boom that Green IT is experiencing and to the great importance it will acquire in the coming years.

For these reasons, we have developed a tool (named *GreenITAudit*), based on COBIT 5, to perform Green IT audits.

The rest of this study is organized as follows: Section II contains the related work about Green IT audits. In Section III the background of the areas of Green IT and audits is explained. In Section IV the *GreenITAudit* tool is described and main functionalities of it are shown. And finally, in Section V, the conclusions and the future work to be done in the *GreenITAudit* tool are presented.

II. RELATED WORK

Currently, there are hardly studies related to the area of Green IT audits. In [6] a systematic mapping study on this area of Green IT audits is carried out.

Through this systematic mapping study, in which only two of the thirteen analyzed studies are closely related to Green IT audits, the practically no existence of research or studies related to the topic of Green IT audits and the no existence of Green IT auditing frameworks are demonstrated.

These two studies closely related to Green IT audits are about: on the one hand, an analysis of the state of the art of Green IT, which shows the importance of carrying out audits in this field [4]; and, on the other hand, a survey on the experiences and opinions of internal auditors from different organizations in relation to Green IT [5].

The rest of the analyzed studies of this systematic mapping study are not directly related to the area of Green IT audits. These studies only contain some characteristics and/or techniques about Green IT that can be used to develop an auditing framework for this field.

Therefore, the great novelty of the field of Green IT audits and the need to develop it can be observed, which converts the tool presented in this study in innovative in both areas of Green IT and audit.

III. BACKGROUND

A. Green IT

The Green IT, as defined in [2], refers to “*the study and practice of design, manufacture and use of hardware, software and communication systems with a positive impact on the environment*”. Therefore, as we can see from this definition, the Green IT has emerged with the goal of bringing the idea of sustainability [1] to the IT.

It is also important to note the two main perspectives that are identified in the Green IT. Erdélyi [3] argues that IT can contribute to sustainability from two perspectives: on the one hand, the “Green by IT”, in which the IT provide the necessary tools to carry out activities in a sustainable way with the environment (i.e., IT as enabler in the sense of Unhelkar [7]), and on the other hand, the “Green in IT”, which aims to reduce the impact of the IT themselves on the environment.

B. COBIT 5

COBIT 5 (Control Objectives for Information and related Technology) [8] is a framework developed by ISACA (Information Systems Audit and Control Association), which has its origin in the control and auditing of IT.

COBIT 5 has a series of guides and professional frameworks for the governance and management of different areas of IT (such as security), see Fig. 1, through which can carry out audits in these areas. However, COBIT 5 does not have any specific guide for Green IT or sustainability.

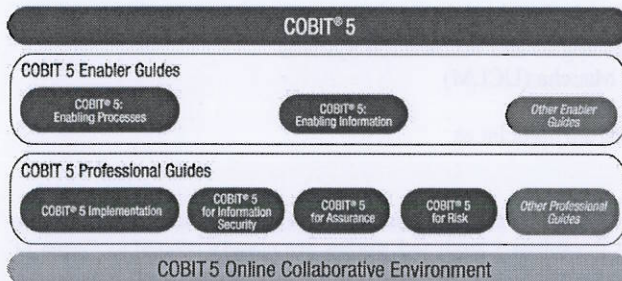


Fig. 1. COBIT 5 product family.

In these guides, COBIT establishes 7 enablers, as can be seen in Fig. 2, which come to define organizational resources for the governance and management of a particular IT area.

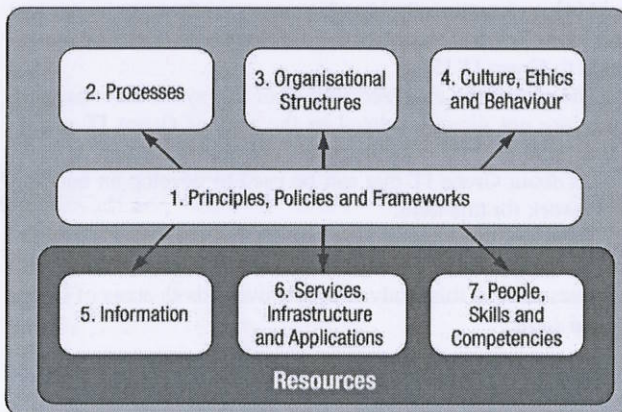


Fig. 2. COBIT 5 enablers.

Below is show a brief definition of each of these 7 enablers:

- Principles, policies and frameworks: are the mechanisms used by the governance and management boards to transmit/communicate directions and/or instructions for the correct development of activities.
- Processes: define a set of best practices and activities to achieve certain objectives and to produce a series of outputs to achieve the goals of the organization.
- Organizational structures (or roles): are the key elements in decision-making in an organization.
- Culture, ethics and behavior: are a pattern of behaviors, beliefs, assumptions, attitudes and ways of doing things in the right way, in order to achieve the success of the organization.
- Information: is the information coming from the different systems and organizational processes used to govern and manage the different areas of the organization.

- Services, infrastructure and applications: serve to provide to the organizations an information system and services to carry out business processes.
- People, skills and competencies: are the characteristics that must have the people who will be responsible for certain aspects of the organization, to ensure that the activities of their area are successful and give value to the organization.

Of these enablers, it is important to note the processes enabler, which is divided into two areas: governance and management.

This enabler has 37 processes organized into five domains: one domain relative to IT governance (Evaluate, Direct and Monitor (EDM)), and four domains related to IT management (Align, Plan and Organize (APO); Build, Acquire and Implement (BAI); Deliver, Service and Support (DSS); Monitor, Evaluate, and Assess (MEA)).

This enabler has been highlighted as it is these processes that are evaluated in an audit and through which the audit questions are established.

For this evaluation or audit process, COBIT 5 provides three main phases:

1. Determine scope of the audit initiative: this phase is for establish what is to be audited (i.e., the specific domains and processes that must be taken into account) and for identify what are the relevant characteristics of the specific implementation to be audited (stakeholders and their interests, specific enablers and its level of implementation, etc.).
2. Understand the specific enablers of the area in question, set suitable audit criteria and perform the audit itself: during this phase, the audit itself is carried out. To do this, the audit criteria must be established, the different specific enablers of the area in question must be understood and the necessary assessments on these enablers must be made.
3. Document and communicate the results of the audit: in this final phase, all the results obtained in the audit are collected, documented and communicated to the relevant stakeholders.

IV. GREENITAUDIT

GreenITAudit is a web application developed with the aim of allowing the conduct of Green IT audits.

This tool is based on the "Governance and Management Framework for Green IT" that we developed in order to establish the necessary aspects to implement a governance and management of Green IT in an organization, and to carry out Green IT audits.

In the "Governance and Management Framework for Green IT", for each of the enablers that establishes COBIT 5, we have defined and developed the specific characteristics and aspects of governance and management of Green IT that we considered appropriate.

Is important to note the processes enabler. From the 37 processes of this enabler in COBIT 5, we have chosen 15 processes that have been considered more directly related with the field of Green IT. These processes are as follows:

- Governance processes:
 1. EDM01. Ensure governance framework setting and maintenance.
 2. EDM02. Ensure benefits delivery.
 3. EDM03. Ensure risk optimization.
 4. EDM04. Ensure resource optimization.
 5. EDM05. Ensure *stakeholder* transparency.
- Management processes:
 6. APO01. Manage the IT management framework.
 7. APO02. Manage strategy.
 8. APO06. Manage budget and costs.
 9. APO08. Manage relationships.
 10. BAI02. Manage requirements definition.
 11. BAI03. Manage solutions identification and build.
 12. BAI09. Manage assets.
 13. DSS01. Manage operations.
 14. MEA01. Monitor, evaluate and assess performance and conformance.
 15. MEA03. Monitor, evaluate and assess compliance with external requirements.

For each one of these 15 processes, we have defined: on the one hand, goals and metrics specific of Green IT; on the other hand, the RACI (Responsible, Accountable, Consulted, Informed) matrix of Green IT roles and specific practices of the process; and, finally, the specific practices of the process, identifying the inputs and outputs as well as the specific activities of Green IT.

From these specific activities of Green IT established in each of the 15 processes, we have been defined 121 Green IT audit questions, which are included in the *GreenITAudit* tool and will guide the auditors to audit the governance and management of Green IT in an organization.

Following shows, firstly, how to create and perform Green IT audits with *GreenITAudit*, and, secondly, the audit results report that the tool creates.

A. Green IT Audits

The main functionality of the *GreenITAudit* is based on the creation and realization of Green IT audits. To do this, through the “New Audit” option an auditor can create such types of audits, and expanding the “Audits” option from the menu of the sidebar he can access the different audits created.

Once the auditor access to these options, he can introduce all necessary information about the Green IT audit that it will be performed.

Below, different views that support these functionalities for creating and performing audits are shown, from which the views to enter audit data and client (Fig. 3 and Fig. 4, respectively), the view of information about the progress of the audit (Fig. 5), and the view from where the questions of Green IT audit can be filled (Fig. 6), can be seen.

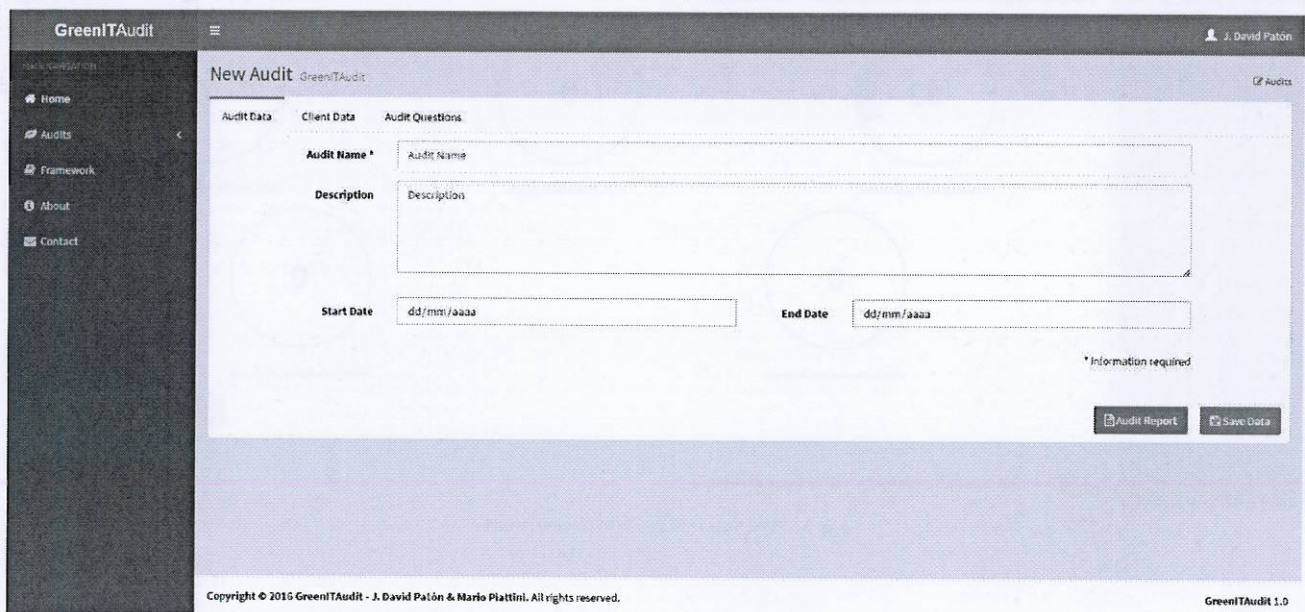


Fig. 3. “Audit Data” view in *GreenITAudit*.

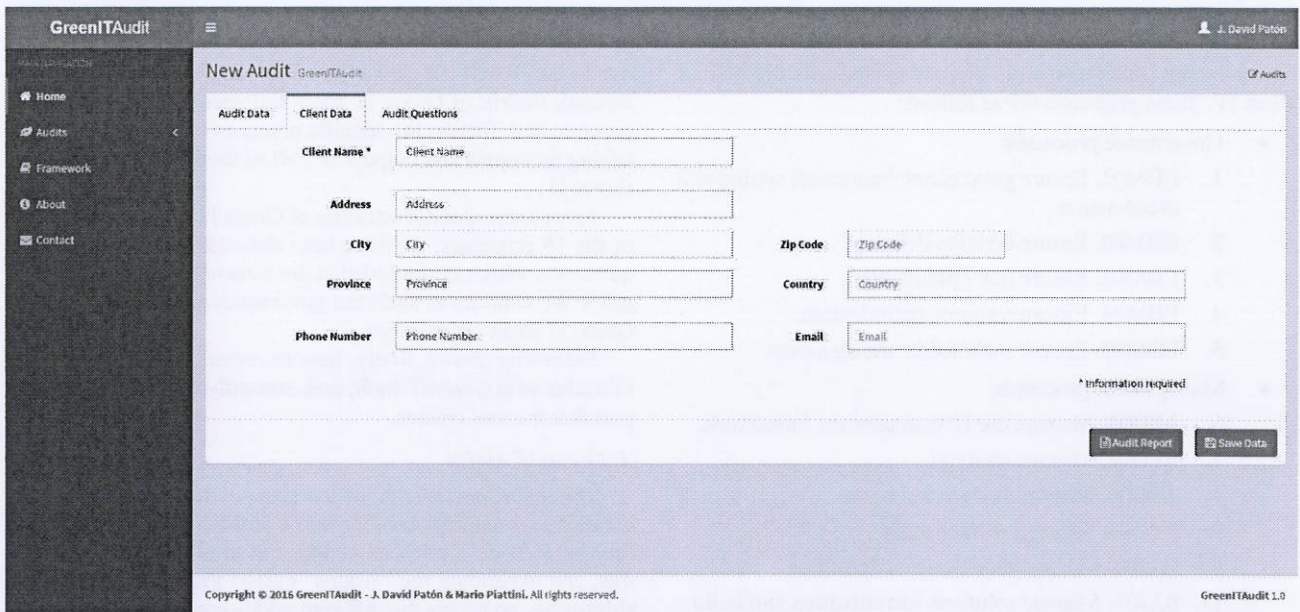


Fig. 4. "Client Data" view in *GreenITAudit*.

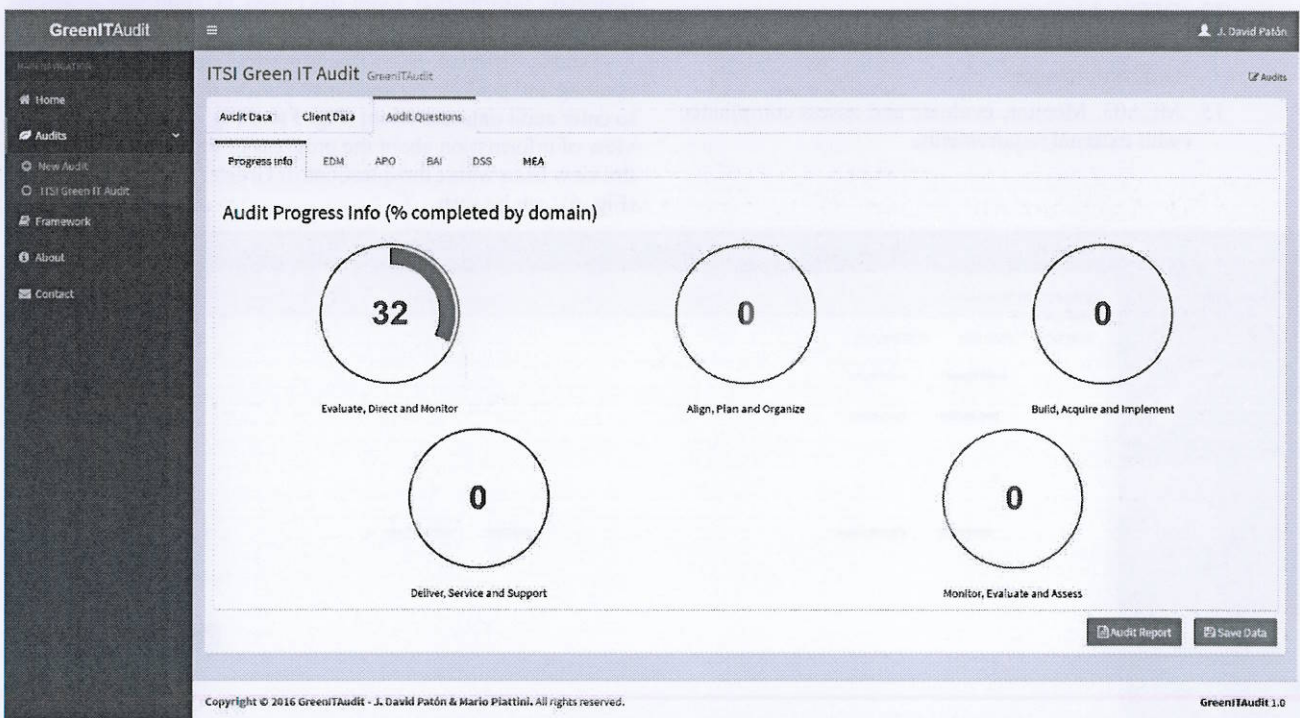


Fig. 5. "Progress Info" view in *GreenITAudit*.

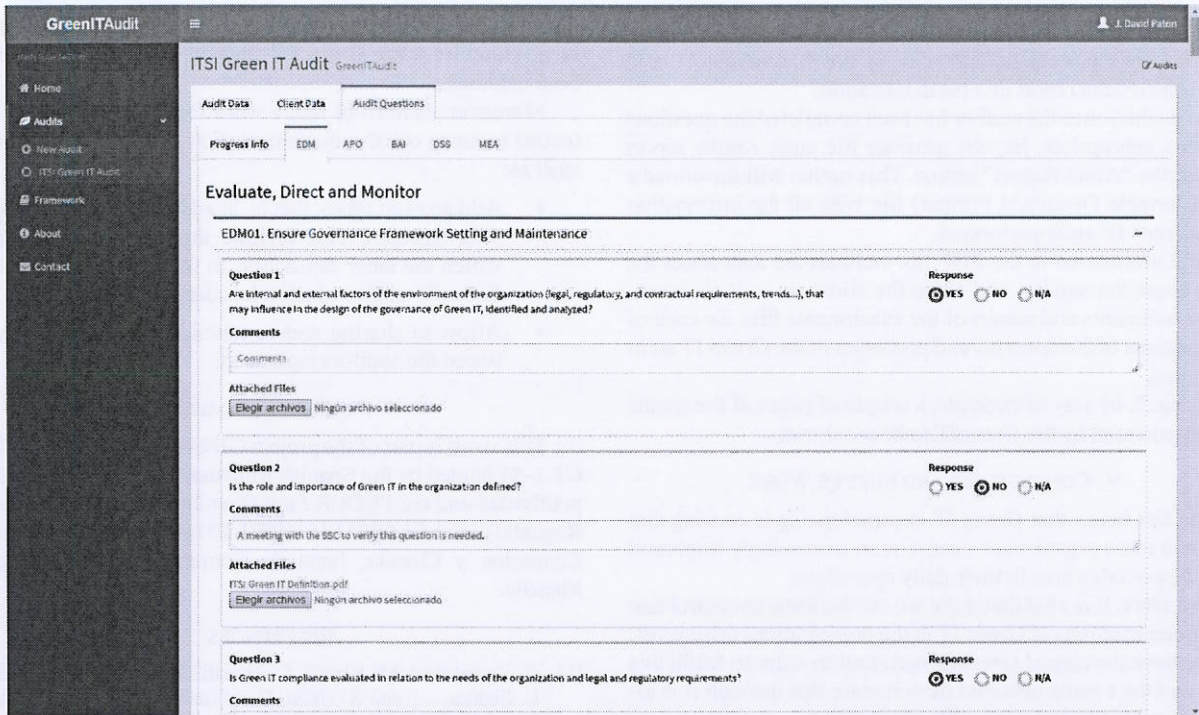


Fig. 6. "Audit Questions" view in *GreenITAudit*.

AUDITOR INFORMATION		GREEN IT AUDIT REPORT		
AUDITOR INFORMATION		EDM01. Ensure Governance Framework Setting and Maintenance - Green IT Questions		
Name:	J. David	Question 1	Response	Attached Files
Surname:	Patón	Are internal and external factors of the environment of the organization (legal, regulatory, and contractual requirements, trends...) that may influence in the design of the governance of Green IT, identified and analyzed?	Yes	
Company:	University of Castilla-La Mancha	Comments		
Address:	Paseo de la Universidad, 4	Question 2	Response	Attached Files
City:	Ciudad Real	Is the role and importance of Green IT in the organization defined?	No	ITSI Green IT Definition.pdf
Province:	Ciudad Real	Comments		
Zip code:	13071	A meeting with the SSC to verify this question is needed.		
Country:	Spain	Question 3	Response	Attached Files
Phone:	(+34) 928 296 300 Ext. 3715	Is Green IT compliance evaluated in relation to the needs of the organization and legal and regulatory requirements?	Yes	
Email:	J.David.Paton@uclm.es	Comments		
		Question 4	Response	Attached Files
		Are the principles that will guide the design of Green IT enablers defined?	No	
		Comments		
		Green IT principles are missing.		
		Question 5	Response	Attached Files
		Is there a model for Green IT decision-making defined?	No	
		Comments		
		It remains to check with the SSC.		
		Question 6	Response	Attached Files
		Is senior management committed to Green IT?	Yes	
		Comments		
		Question 7	Response	Attached Files
		Are different responsibilities and authorizations of Green IT assigned, based on the design of the governance principles and the decision-making models of Green IT defined by the organization?	No	
		Comments		
		It remains to check with the SSC.		
		Question 8	Response	Attached Files
		Are there reporting and communication systems about the performance and compliance of the Green IT for decision-making in this area?	N/A	

Fig. 7. Results report generated by *GreenITAudit*.

B. Results Report

Another important functionality of the *GreenITAudit* is to export the results report of a particular audit.

To do this, once the auditor has been completed the questions it deems appropriate, he can generate the audit results report through the “Audit Report” option. This option will download a PDF (Portable Document Format) file with all the information about Green IT audit performed.

The information in the PDF file includes the data about the audit, about the auditor, and about the client, as well as the answers, comments and names of the attachments files for each of the questions of the domains and processes of the Green IT audit conducted.

In Fig. 7, by way of example, a couple of pages of the results report generated by the *GreenITAudit* are shown.

V. CONCLUSIONS AND FUTURE WORK

The fast boom that Green IT is experiencing is causing that more and more organizations see it as an increasingly important and indispensable area in their daily operations.

Therefore, it is vital that there are mechanisms to control that the implementations of Green IT in the organizations are correct.

We have developed *GreenITAudit* tool in order to fulfill this need, and the results obtained demonstrate that through it is already possible to carry out audits of Green IT.

Therefore, the *GreenITAudit* tool and the “Governance and Management Framework for Green IT” on which the tool is based, would be located in the COBIT 5 product family as shown in Fig. 8.

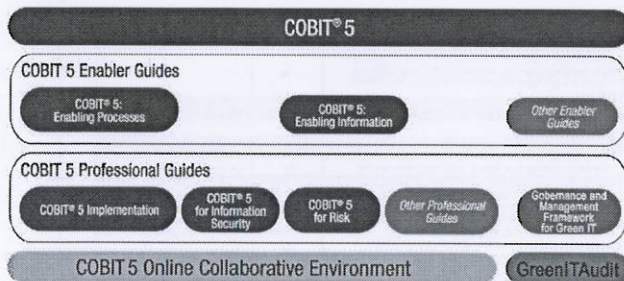


Fig. 8. *GreenITAudit* in COBIT 5 product family.

Furthermore, the *GreenITAudit* tool has been used in a practical case in which we have audited the Institute of Technologies and Information Systems of the University of Castilla-La Mancha. Through this practical case, promising results have been ob-

tained and a first validation both the “Governance and Management Framework for Green IT” and the *GreenITAudit* tool has been achieved.

Moreover, as lines of future work for later versions, it is intended to carry out the implementation of new functionalities, such as:

- Add account types, that is, in addition to the existing auditor account, also include the client account, from which the latter can access to the results reports of the Green IT audits which it has done to him.
- Allow to sharing and conducting Green IT audits between the auditors registered.

ACKNOWLEDGMENT

This work is part of the project GINSENG (TIN2015-70259-C2-1-R) funded by the Spanish Ministerio de Economía y Competitividad and the FEDER fund (Fondo Europeo de Desarrollo Regional); and GLOBALIA (PEII-2014-038-P), Consejería de Educación y Ciencia, Junta de Comunidades de Castilla-La Mancha.

REFERENCES

- [1] G. Brundtland, M. Khalid, S. Agnelli, S. Al-Athel, B. Chidzero, L. Fadika, ..., and S. Okita, *Our Common Future* (‘Brundtland Report’). Oxford University Press, Oxford, OX, United Kingdom, 1987.
- [2] C. Calero and M. Piattini, *Green in Software Engineering*. Springer International Publishing AG, Cham, ZG, Switzerland, 2015.
- [3] K. Erdélyi, “Special factors of development of green software supporting eco sustainability,” in *IEEE 11th International Symposium on Intelligent Systems and Informatics (SISY)*, pp. 337-340, 2013.
- [4] C. Gabriel, “Why it’s not naive to be green,” in *Business Information Review*, vol. 25, pp. 230-237, 2008.
- [5] G. L. Gray, W. G. No, and D. W. Miller, “Internal Auditors’ Experiences and Opinions Regarding Green IT: Assessing the Gap in Normative and Positive Perspectives,” in *Journal of Information Systems*, vol. 28, pp. 75-109, 2013.
- [6] J. D. Patón-Romero and M. Piattini, “Indicators for Green in IT Audits: A Systematic Mapping Study,” in *3rd International Workshop on Measurement and Metrics for Green and Sustainable Software Systems (MeGSuS)*, 2016.
- [7] B. Unhelkar, *Green IT Strategies and Applications: Using Environmental Intelligence*. CRC Press, Boca Raton, FL, USA, 2011.
- [8] COBIT 5 - An ISACA Framework, <http://www.isaca.org/cobit>