Green Sustainable Data Centres

Study Guide
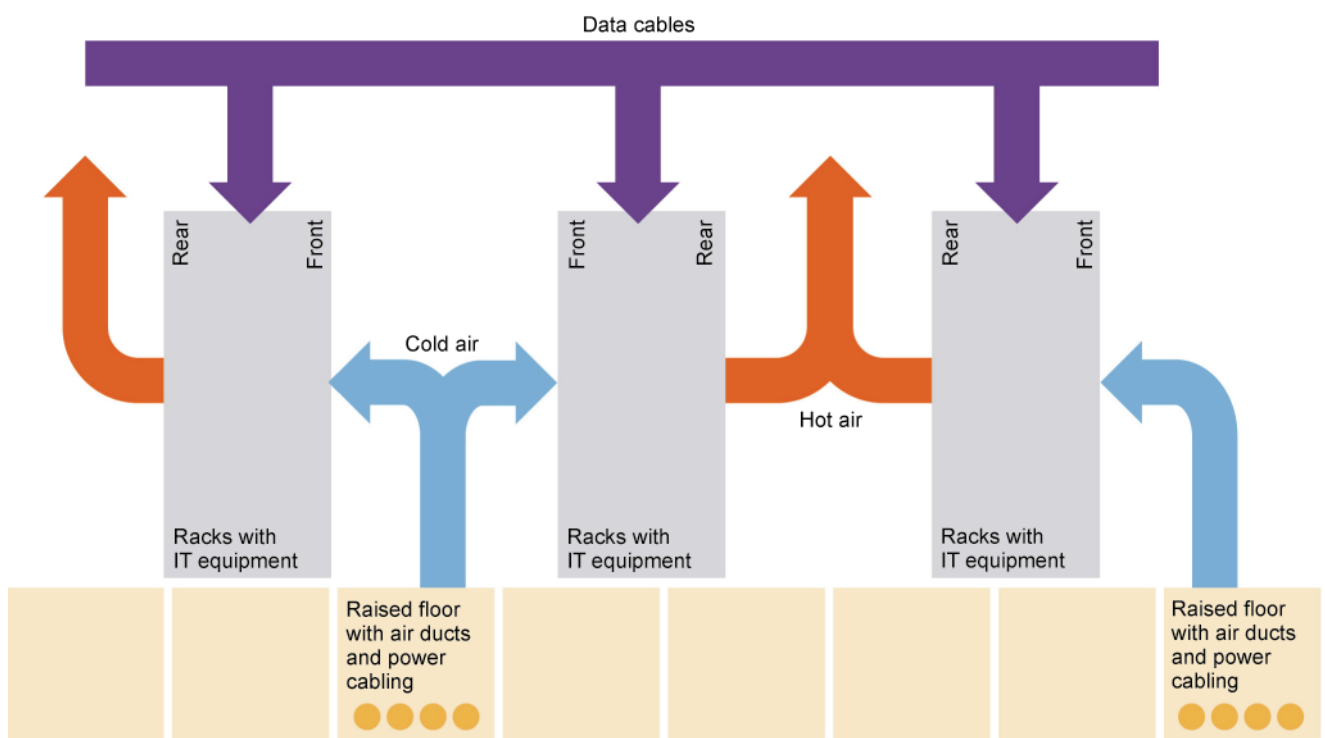
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Content

Study Guide

Study Guide

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The e-InfraNet project http://e-infranet.eu/ Action Plan, which is based on the policy document 'Green Sustainability Policies for e-Infrastructures' states that "…Green ICT awareness and skills development could be better addressed in education curricula and benefit from coordination at European level".

This course is aimed at IT-managers in general, because greening of IT requires greening the data centre where most of the energy is consumed. This course is specifically aimed at meeting the education *Data centre and IT* and development needs of the community of *data centre and IT* *professionals* *professionals* who will develop, support and maintain the physical resources which comprise the e-InfraNet.
This community is most able to adopt the working practices which will be discussed, thereby securing the environmental sustainability of the e-InfraNet infrastructure. Targeting those with responsibility for e-InfraNet implementation, maintenance and operation will allow us to emphasise the practical means to assess and deliver a sustainable infrastructure whilst also exploring the justification and theory which supports this.
The course is based on current and emerging measurement, environmental audit and assessment techniques, standards and recommended *EU Code of* best practice. It is based, more specifically, on the *EU Code of Conduct on* *Conduct on Data* *Data Centres* and other best practice directives from internationally *Centres* recognised bodies such as the Green Grid and the Uptime Institute as the underpinning theme for the course. Placing such material at the centre of the learning material means that standards and recommendations will be promoted automatically. The inclusion of a number of operational data centres in our consortium (Ireland, Finland, Spain) offers access to 'live' resources and practices, and provides locations for workshop activities.

1 Course Description

The goal of the course is to give you an understanding of what Green Sustainable data centres are and that you can make an assessment of the data centre. We do not expect that you know every detail. Therefore there are assignments with feedback and a course project that is gradually built up.
Project EISTER The course was developed in the *project EISTER* financed by the ERA-NET joint programme in which Belgium, Finland, Ireland, Latvia and the United Kingdom agreed to join as the e-InfraNet project partner countries. The Netherlands, Portugal and Spain, as e-InfraNet partner

countries joined on special financing conditions. As a result, this ERA-NET open call "Transnational Educational Programme on Green Sustainable ICT" joined 8 partners in EISTER project:
– Leeds Metropolitan University from UK (project coordinator, Professor Colin Pattinson)
– Riga Technical University from Latvia (professor Ilmars Slaidins),
– University College Dublin from Ireland (Senior Lecturer Damian Dalton)
– Open Universiteit in the Netherlands (Assistant Professor Anda Counotte-Potman)
– Kajaani University of Applied Sciences from Finland (Lecturer Joona Tolonen)
– University College of West Flanders (Howest) from Belgium (Senior Lecturer Johan De Gelas)
– IST - Technical University of Lisbon from Portugal (Assistant Professor Paulo Carreira)
– CénitS - Supercomputing Centre of Extremadura - from Spain (César Gómez-Martín Supercomputer Team Leader at CénitS and Assistant Professor at the University of Extremadura).

It was a well-balanced consortium with partners with expertise in course content (United Kingdom, Ireland, Belgium, Portugal and Netherlands); expertise in the development of distance learning and on-line material (Latvia, Netherlands); experts from the data centres ready to create Case studies and organize Workshops (Finland, Spain). Inclusion of the operational data centres in the consortium offers access to 'live' resources and practices, and provides locations for workshop activities.

1.1 TO WHOM THE GREEN SUSTAINABLE DATA CENTRES COURSE IS DESIGNED FOR?

Data centre and IT professionals

This course is specifically aimed at the community of *data centre and IT professionals* responsible for developing, supporting and maintaining facilities of the data centres. This community is most able to adopt the working practices which are discussed in the course, thereby securing the environmental sustainability of the e-InfraNet infrastructure.
This course can be studied on its own or in the context of one of the participating universities. In that case the course is evaluated by developers with *5 ECTS* (European Credit Transfer System).

5 ECTS

The course *Green Sustainable Data Centres* is designed and can be used as an introductory course for a MSc Programme. It is covering main topics of such eventual programme in short. The IT professional in this course can obtain *insight* in what sustainable data centres are. The learner should have a *bachelor degree in Computer Science* or comparable knowledge.

Insight
Bachelor degree in Computer Science

Open Educational Resource (OER)

The course resources are available as an *Open Educational Resource (OER)* for eventual users at universities, colleges and training centres to build up their courses and study programmes. Therefore in this Study Guide you may find just one possible option of the course implementation, but can also modify course structure and content according to your needs. The course resources can also be used for self-learning and as the data centre audit instruction resource without any tutoring.

1.2   TUTOR

For e-learning courses tutoring is equally as important as in traditional education, but the tutor's role is different. It is not expected for the tutor to 'lecture' or 'teach' learners in face-to-face tutorials. The main role of *Facilitate learning* the tutor in the course is to *facilitate learning*, provide advice and feedback, encourage and support learners.

If some institution (university or training centre) is going to implement this course, it is advised to select carefully an appropriate tutor and/or provide training for tutors.

Besides an expertise in the subject matter, it would be very welcome if the tutor has previous experience of delivering training of e-learning courses. The best option could be if this tutor has undertaken training of the *Green Sustainable Data Centres* course first as a learner, under the guidance of the course authors. It would provide the tutor with an in-depth understanding of the Chapter content and the motivation of the authors of each of the Chapters. It is the only way in which to obtain the tacit knowledge of the Chapter author learning the subject in close contact and under his supervision.

It is very useful for a new tutor to acquire experience in tutoring as an assistant (or just learner) in the Green Sustainable data centres course or any other course being tutored by an experienced tutor.

1.3   COURSE AIM AND LEARNING OBJECTIVES

Aim of the Green Sustainable Data Centres course is to provide e-Infrastructure professionals with the knowledge and skills needed to perform a sustainability audit and prepare a strategy to update the data centre.

On completion of this course, learners will be able to:

Carbon footprint – Understand the place of the data centre in the overall *carbon footprint* of IT provision.

Measurement methods – Select suitable *measurement methods*, plan and conduct measurement to assess the environmental performance of the data centre.

Reduce its environmental impact – Make decisions informed by those measurements to modify behaviour of the data centre to *reduce its environmental impact*.

Recommendations – Apply relevant national and international standards, policies and *recommendations* to their place of work.

These learning objectives are for the Course and in each chapter you will find the learning objectives specific for that Chapter.

1.4   PREREQUISITES FOR LEARNERS

As this course is targeted to IT professionals working in e-Infrastructure objects it is expected that learners have at least a bachelor degree in Computer Science or comparable knowledge.

The learner must have a computer with internet access. Basic information on how to use course materials, other resources and virtual learning environment will be provided during the first introductory workshop.

It is important that the learner has access to information and data related to the data centre facilities, specifications of equipment, energy consumption etc. The best option is that he or she works within the data centre in a position enabling this and may link learning in the course directly with professional tasks in the data centre.

An important prerequisite to start learning is motivation and learning skills. It is very important and will be shortly addressed during the first face-to-face tutorial at the start of the course. This also includes time planning and time management skills – the resource which must be re-allocated for learning from other daily activities. The potential learner must consider this change in his/her lifestyle.

Good command of English language is important and will enable the learner to benefit from the recommended bibliography and other information resources.

1.5 COURSE STRUCTURE

Chapters
Workshops

The course *Green Sustainable Data Centres* consists of eight *Chapters* and in basic option there are planned three residential *Workshops*: at the beginning of the course, in the middle and the final workshop as examination at the end. Course topics contained in Chapters are advised to study in prescribed sequence. The last - Chapter 8 'Greening by IT' is treated as an

Optional

optional. There also could be the option, that learner (self-learner) can study just one Chapter of his or her interest.

The structure of the course can be found in Table 1.

If you like to finish the course in about 110-120 hours, you should only study the obligatory material and make the obligatory assignments.

1.6 COURSE PLAN

The course is planned to be studied in a period of three or four months (12 – 15 weeks). The learner's workload in this course is evaluated with 5 ECTS. This workload may differ greatly for each individual learner depending on his/her previous experience. The model schedule for the course and workload for learner in the Course is given in Table 1. The Course schedule is very tight allowing just one week learning for each Chapter and it creates problems in a case of any delay. Therefore every institution can adapt and update this course for their needs, accordingly changing the list of activities, content and the schedule. For example, additional week can be given to learner for preparation of the Homework, receiving a feedback from the tutor and presenting an improved version.

Roadshow
Workshop

One *Roadshow Workshop* is planned in the course where all learners meet in some advanced data centre. Depending on opportunities of course providers even 2-3 Roadshow Workshops can be introduced in the course schedule. In the case of difficulties this Roadshow Workshop could be omitted from the Course.

It is expected that course materials are available in the virtual learning environment. The Course structure and learning environment should

Communication
and consultations

allow c*ommunication and consultations* with tutors and among learners as well.

4

TABLE 1   Model schedule of the Course

Week	Topic	Electronic Workbook	Workload (hours)
1	Introduction to programme - Workshop	Study Guide	6
2	Introduction to Green IT	Chapter 1	12
3	Data Centre Facilities	Chapter 2	8
4	IT Equipment	Chapter 3	6
5	Operating systems & Virtualisation	Chapter 4	6
	Homework 1		3
6	Measurement and Control	Chapter 5	12
7	Data Centre Infrastructure Management	Chapter 6	12
	Homework 2		5
8	Roadshow Workshop	Checklist and data centre visit	10
9	Legal and Regulatory frameworks	Chapter 7	10
10	Greening by IT	Chapter 8	10
	Homework 3		5
11&12	*Course project/*Case studies		12
13	Final Workshop with presentations		8
			125 total

As mentioned before, this is a model schedule and each organisation can adjust the above schedule according to their needs and conditions. In the column 'Week' it is advised to put an exact date (and place) of the activity, as well as deadline for presenting the Homework.

Before starting the Course, the tutor must check the web links provided in course materials, if they are not valid, they must be changed or omitted from the text.

Reflection tasks

All chapters contain some *reflection tasks* for learners which must be completed. At the end of Chapter the learner will find answers to reflection tasks. There are also 3 Homeworks completing the studies of Chapters 1-4 (first), Chapters 5-6 (second) and Chapters 7-8 (third).

Three Workshops are planned in the Course. The first Workshop is an introduction to the Course with a short presentation of the main content, course structure, activities and graduation requirements. In this Workshop, the learner should be introduced to a virtual learning environment and should undergo training on how to use the functionality of the learning environment. There will also be a learning skills test to evaluate the learners' ability and understanding of the e-learning environment. The second is the Roadshow Workshop, which is expected to take place in an advanced data centre when main Chapters 1-6 are completed.

Final Workshop

The *Final Workshop* is planned at the end of the Course. In this workshop the learner will present his/her Course Project. Before this Workshop learner must prepare the Course Project in a document format and send it to tutor for review.

At the end of the Course it is recommended to collect learner feedback about the content, tasks, homeworks, workshops and overall study process. This information will be very useful for improving the quality of the Course, as this *Green Sustainable Data Centre* course have not been tested in practice yet.

1.7 HOW TO STUDY?

Instructions presented in the Study Guide

For efficient use of the study material, the learner should follow the *instructions presented in the Study Guide*, which will be provided to the learner in the first Workshop and follow an individual guidance from the tutor.

First, he or she must read the course material and complete the proposed tasks. Tasks follow the appropriate subject matter in the Chapter. Please read this information carefully because it is directly related to the allocated task. For performing particular tasks often an appropriate time has been allocated and/or volume of text to be prepared (min/max in number of pages, words etc.) is given.

To motivate the learner there are reflection tasks given in the Chapters, as well as web links to additional reading.

Homework 1

The Chapters 1-4 are considered to be successfully completed, when the *Homework 1* tasks are performed and a positive valuation from the tutor received. Once a learner has received a positive evaluation by the tutor, he or she must then move to the next chapters. In the same way

Homework 2
Homework 3

Homework 2 completes the Chapters 5-6 and the Homework 3 – Chapters 7-8. In essence Homework 2 and *Homework 3* builds up on what was learned and tasks performed in all previous chapters.

Motivated and active learning is a key factor to be successful in this Course. It means that learners must go through all learning stages. First, the learner gains knowledge while reading the text and reflecting upon it. Then he or she performs the assigned Tasks and tries to apply the acquired knowledge in practice. If something is not clear or some problems arise he or she can apply for help to the tutor and other learners in the virtual learning environment. If the learner needs any specific help he or she may contact the tutor via the virtual e-learning environment or using other communication options proposed by the tutor. It is very important to be open when receiving/asking for feedback, to learn from mistakes and to create new knowledge by active engagement.

The reflection tasks will provide learners with initial feedback on how he or she acquired the Chapter content and model answers to these tasks are given at the end of the Chapter. Feedback from the tutor is the next step when the Homework will be received back with comments.

1.8 COURSE GRADUATION DEMANDS

Conditions for receiving certification on successful completion of the Course are summarised in Table 2.

TABLE 2 Grading table for the Course graduation

		Maximum total score	*Min. score to pass*
Participation in 3 Workshops		–	–
3 Homeworks (10 points each)		30	15
Course Project, presentation and defence		70	35
	Total	*100*	*50*

It is compulsory to participate in all 3 Workshops and complete all three Homeworks (evaluated with at least 5 points each from 10). The minimum number of points for graduation of the Course is 50. Only after a successful presentation and defence of the Course Project the learner has fully completed the Course. These conditions and given here as a model option and can be modified by the institution implementing the Course.

2   **Assessment**

To control how the learner is reaching the defined learning objectives and to facilitate active learning several types of assessment tools are introduced in the course: Reflection tasks, Homework and the *Course Project*.

Course Project

There are tasks included in each chapter, but these tasks are not treated as a part of assessment, they mainly act as a tool for active learning. For motivating learners to perform these tasks, they are directly related to content of the Homework and the Course Project.

The Homeworks are at the end of the Chapters 4, 5 and 8. The Homework must be performed according to the tasks given and submitted to the tutor.

One of the main tasks of the tutor is to mark Homework done by the learners. For each Homework there are formulated tasks and institution implementing the Course must develop grading principles and a grading scale. In the final scoring each Homework is evaluated with a maximum of 20 points. There could also be a minimum pass level established. For all Homeworks as a model option is proposed to establish the pass level is 50% of the maximum (5 from 10). Grading principles must be presented to learners at the beginning of the Course.

Individual learner

It must be also noted that Homeworks are expected to be completed by an *individual learner* (or as a teamwork where appropriate), but any plagiarism must be avoided and references must be used where information is taken from other work.

Strengths and weaknesses of the submitted Homework must be commented by the tutor and constructive advice provided to allow for improvement. The tutor's comments on Homework and individual consultations must be helpful to the learner as well as motivating. It is not enough to say – "It is not good. You have to re-do it". It would be much better to say that it is quite good, but still some improvements are needed and directions must be given on how to achieve the goal, objective and/or learning objective. The tutor should award every stage of progress achieved by the learner with positive comments like - "Well done! Very good! Excellent!".

The result of the grading could be pass or resubmit. If the Homework or the Course Project is not meeting the standard requirements, the learner should be provided with sufficient time to make the recommended improvements. The time allocated for resubmission must be clearly stated at the beginning of the Course and a tight course schedule should be taken into consideration. It is essential for the learner to receive an assessed and marked Homework with feedback from the tutor within 3 days of submission. Of course, there always could be exceptional cases which fall out of regular practice and must be agreed individually on a case by case basis.

There are also Workshops which could be treated as a part of assessment and learners are expected to have an active participation in these sessions.

2.1   REFLECTION TASKS

In the text of each chapter there are reflection tasks given to learner. These tasks are for stimulating active learning and are not been assessed by tutor. Answers to these tasks are given at the end of each chapter.

2.2   HOMEWORK 1

Homework 1 completes learning of Chapters 1-4 and some tasks done by learners in these chapters are summarized in this Homework.
1   Explain the difference between 'green', 'sustainable' and 'efficient'. Write down how does these terms relate to the data centre?
2   What are the three most important reasons for trying to make the data centre more sustainable?
3   Find out what is a share of green electricity used in the data centre, the region or country?
4   Describe the data centre:
    – aim, structure, management/staff, services/projects
    – building, lights, security etc.
    – equipment (computers, storage, cooling, networking, etc.)
    – software
    – measurement/control system …
5   From technical specifications find out and describe:
    – CPU used in the data centre servers
    – Racks used in the data centre
    – Networking equipment and techniques used in the data centre
    – Storage equipment used in the data centre
    – Describe in detail the cooling system (elements and techniques used).
6   Describe the energy usage chain of the data centre and how energy consumption is measured?
7   Describe power management system used in the data centre. Is the power management system efficient?
8   Make a draft evaluation on how 'green' and sustainable is the data centre? Are there any plans for improvements in future?

2.3   HOMEWORK 2

Homework 2 completes learning of Chapters 5-6 and is based on tasks performed in these chapters, but some tasks from Chapters 1-4 are also used in this Homework.
Main tasks for the Homework 2 are:
– Plan and perform measurement or collect data in the data centre related to energy efficiency.
– Perform analysis on energy efficiency of the data centre based on obtained data.
1   Describe and document the energy usage chain of the data centre going through the whole energy chain of the data centre. Collect data and list the most energy consuming parts.

2   From the technical specifications of the data centre facilities, IT equipment, power management system described already in Homework 1 evaluate energy efficiency of:
   – CPU used in the data centre servers
   – Racks used in the data centre
   – Networking equipment and techniques used in the data centre
   – Storage equipment used in the data centre;
   – Cooling system elements and techniques used
   – Power management system used in the data centre.

3   Study the output of the PDU (Power Distribution Unit) measurements, temperature measurements. How will you gather these? Where should they ideally be placed?

4   Does this give you a complete picture whether or not the IT equipment is well configured?

5   Combine the findings of previous task with the power management settings and performance readouts.

6   What is the most important metric for IT equipment? How can you calculate this, even if you are running different applications in a virtual cluster?

7   Why is there a sudden spike in power? How will you resolve this in short term? In the long term?

8   Besides meter data, what other sources of data can be advantageous in understanding energy data usage? Please point at least two.

9   Calculate the PUE of the data centre and turn it into a useful metric. Explain which information you need to turn the PUE calculation into a useful metric.

10 Calculate CADE for the data centre:

$$CADE = AU_{fac} \times EE_{fac} \times AU_{IT} \times EE_{IT}$$

where AU_{fac} is facility utilization, EE_{fac} is facility energy efficiency, AU_{IT} is IT utilization and EE_{IT} is IT energy efficiency.

11 How to configure power management to increase efficiency still providing agreed quality of services?

12 How does virtualization software influence power consumption?

13 Use the earlier calculated PUE and data from the energy management and monitoring system at the data centre to calculate the following on the selected racks:
   – The power efficiencies of various servers.
   – The operational costs of the servers.
   – The power capacities of various racks.
   – The carbon footprint of selected racks.
   – The operational headroom (spare capacity) that exists on each rack.
Discuss the metrics you use in this analysis and how they will assist in implementing energy and carbon reductions in the centre.

14 List the three most important contributions to the data centre's energy bill, and identify one way that each one might be addressed.

15 Use the Checklist to compare this data centre with the best practices promoted within 'EU Code of Conduct on Data Centres'. Encourage the implementation of practices in the Data Centre that are not implemented and that do not have implementation date. Endorse practices that do not have the capacity to act.

2.4   HOMEWORK 3

Homework 3 completes learning of overall course and is related to the development of proposal for improvements in the data centre.

1   Propose a scenario in which the servers can be consolidated and estimate the energy savings.

2   Are there any other savings that these metrics can directly or indirectly affect?

3   How can the racks be consolidated (don't exceed 80% maximum power rating of the rack's PDU)? In this consolidation process what are the savings in overall power consumption and in rack space.

4   Make an improvement plan for reducing overall energy consumption.

5   Make a budget plan for the improvements and prioritise them based on price and gained profit. Calculate ROI for the improvement plan.

6   Identify which of the above regulations, directives, codes of conduct and legislation are required for your data centre.

7   For the regulations, directives, codes of conduct and legislation in your answer to the above question, produce an assessment of whether your data centre meets each of them, identifying if this is full, partial or not at all.

8   Government legislation is one of the major drivers being used to "encourage' organisations to operate in a more sustainable manner, and ICT is one of the key elements in many of these initiatives. A variety of national governments have published strategies of some kind: typically a statement of intentions, and a roadmap for changes within an organisation. See links to some examples in footnote[1]. Find a similar strategy document from your own country and give the outlines in one page.

9   The implication is that the roadmap will be followed by others wishing to pursue similar changes. However, the nature and scale of organisations and their working practices are such that a 'one size fits all' solution seems impractical – even before one considers adapting these recommendations outside the business and commercial sectors. Produce your analysis of the likely barriers to adoption of such a strategy in the data centre and develop proposal on how to overcome these barriers.

10 List three advantages and three concerns for the introduction of smart meters to homes. Is an automated temperature monitoring and control system more likely to be effective in a home or work situation? Explain your answer.

11 Is the Greening by ICT concept applicable to the data centre now? How could this approach be used to introduce improvements in the data centre in future?

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1 The United Kingdom This site includes a roadmap, strategy document and a useful list of "potential areas for reduction"

http://www.cabinetoffice.gov.uk/cio/greening_government_ict.aspx

The Australian government has a comprehensive set of strategy documents at

http://www.environment.gov.au/sustainability/government/ictplan/resources.html,

US government's "National Strategy for Electronics Stewardship" is at

http://www.gsa.gov/graphics/admin/National_Strategy_Electronics_Stewardship_2011.pdf,

the Organisation for Economic Co-operation and Development (OECD) has a trans-national approach (http://www.oecd.org/sti/interneteconomy/42825130.pdf)

2.5   COURSE PROJECT

Combine information

The Course project will *combine information*, results, analysis and proposals for development discussed in chapters and Homework. In preparation of the Course project, the learner must summarize knowledge obtained in the course, as well as results obtained while performing the Tasks and Homework.

Task:
Learner must perform a sustainability audit of the data centre and prepare a strategy for update.
1   Describe the data centre (equipment, building, management, measurement/control system etc.) (2 pages) – from Homework 1.
2   Plan and perform measurement (or collect data) in the data centre (2 pages) – from the Homework 2.
3   Analysis (max 4 pages+ appendix) – from Homework 2.
4   Proposals for improvement (2-4 pages) – from Homework 3 (ROI calculation and decision options included).

Format:
Word document (approximately 4000 words).

At the end of the Course the learner should send a written Course project to the tutor and prepare a PowerPoint presentation (10 min.) for the Final Workshop which will also be the Final Assessment.
The Course project will be graded with maximum 100 points according to the Table 3.

TABLE 3   Grading scale for the Final Work

Parts of the Final Work	Maximum score	Min. score to pass
Description of the data centre	20	10
Measurement and data collection results	20	10
Analysis of energy efficiency of the data centre	20	10
Proposal for improvement (including ROI calculation)	20	10
Report (style, language, terminology etc.), presentation and defence	20	10
Total	*100*	*50*

As a model option proposed here is that the grade obtained in the Course project makes up 40% of the total grade in the course. Points obtained in the Course project must be multiplied by 0.7 and this result is added to points obtained in Training session and tutor Marked Assignments (see Table 2).

3   **Workshops**

There are 3 Workshops planned in the course:
– 1st Workshop – Introduction to the course
– 2nd Roadshow Workshop – visit to some advanced data centre
– Final Workshop – Presentation and defence of the Course project.
It is important to have a detailed plan for each Workshop.
If there is no visit planned to the data centre, then it could be omitted
from the course. First introductory Workshop also could be replaced by
online (i.e. Skype) tutorial or very detailed written instructions should
be provided to the learners.

3.1   FIRST WORKSHOP

The first Workshop must be carefully planned, as well as all the course
activities during the whole course.
In thefirst Workshop, learners are introduced to the Course, tutor(s)
and each other. The tutors presents themselves and asks each learner
to present himself/herself, their experience of e-learning and their
expectation(s) from the course.
Main information of the course is presented by the tutor (like in this
Guide):
– motivation to create such course
– to whom this course is intended
– aim and objectives of the course
– prerequisites
– short annotation of the Chapters
– duration of the course and schedule (course plan)
– Tasks, Roadshow Workshop (if planned), Homework, Course project
and grading
– how to study e-learning course
– tutor support
– course delivery options.
It is very important to motivate and encourage course participants to
become active learners from the very beginning. The learning objectives
must be discussed and agreed with learners.
The tutor must encourage learners to plan their time for learning. On
average 10-12 hours per week must be devoted to this particular course
during the period of the course, approximately a 3 month period. For
adults having a number of commitments, it may difficult to find free
time for learning. For some learners with weaker learning skills, it may
take especially more time in regards to the first Chapters as there are
many reflection tasks to complete and links to additional reading.
The tutor must ask learners to plan learning time for the first chapters
at the beginning and follow the plan strictly. In addition it would be
beneficial to advise learners to take notes (or create a log) on how much
time has been spent/committed on learning, how much time is needed
for each chapter and the time taken to complete each task. It will allow
the learner to be more efficient in future planning based on his/her own
experience. The learner should also be advised not to leave learning to
very end of the stated deadline for delivering the Homework. It is better
to complete the Homework earlier, if possible, and allow additional time
for improvements after receiving tutor's feedback in the case a re-
submission is required.

Learners should be introduced to the e-learning environment. It is very important to remove any barriers or lack of confidence when working within a learning environment. To encourage learners and make them aware some practical tasks may be offered to them - log into virtual learning environment, adjust personal information, socialization etc. Definitive tasks should be given during this first tutorial and for the first study week for the learner to fulfil. One of such tasks should be related to testing the learners learning skills. It could be a serious barrier for those learners who have experienced a long break in their 'learner's' career. If they do not have work experience related to acquiring new knowledge, then 'sharpening' of their learning skills may be crucial to become a successful learner in the course.

3.2   ROADSHOW WORKSHOP

Such Workshop is planned for learners to meet in an advanced data centre, become introduced with technologies available, meet with experts from the field etc.
In planning the event it must be considered what added value will this Workshop bring to learners? What can add to knowledge and skills presence in another Data Centre and meeting other learners?
It could be a test of equipment and measurement techniques used in the advanced data centre. It could be exchange of good practice among learners. Very valuable can be a lecture of a high level expert followed by open discussion.
Visitors will be provided with a Checklist (Annex of this Study Guide) to compare this data centre with the best practices promoted within 'EU Code of Conduct on Data Centres '.
There is a model programme on topics to be addressed during the visit in the data centre.
1   Data centre location from an energy-efficiency point of view.
2   Building specifications.
3   Computer room. In this point it is necessary to analyse:
    – Network. topology and communication protocols.
    – Main Distribution Area (MDA), generally racks that contain the network equipment and primary interface between the data centre and the outside voice and data feeds.
    – Horizontal Distribution Area (HDA). Horizontal cabling between servers and the LAN, SAN, etc.
    – Equipment Distribution Area (EDA) typically made up of parallel rows of adjacent server racks.
    – Zone Distribution Area (ZDA) is a consolidation point in the horizontal cabling system.
    – Location of racks in the room.
    – Hot & Cold aisles.
    – Power and telecommunication cables.
4   IT equipment & Racks, equipment layout in the computer room.
    A proper equipment layout also involves consideration of:
    – Power distribution planning.
    – Cooling planning.
    – Data cabling planning.
    – Future growth and equipment planning.
5   Security, Disaster Planning & fire stopping.

6 Data Centre electrical systems.
   – Estimate computer room power requirements.
   – Estimate the target class reliability ranking.
7 Data Centre cooling.
   – Estimate computer room cooling requirements.
   – Study the relative merits of overhead, floor, and liquid rack-
   oriented cooling architectures.
   – Estimate the convenience of CAC (Cold Aisle Containment) or HAC
   (Hot Aisle Containment).
8 Green data centre Design. Steps for improving data centre Efficiency:
   – Equipment retirement planning.
   – Implementing server virtualization.
   – Designing efficient lighting systems.
   – Right-sizing UPS systems.
   – Employing server power management.
   – Employing outside air and water economizers.
   – Improving under-floor air delivery efficiency.
   – Using supplemental cooling.
9 Building Automation, Monitoring and Control systems.
10 Commissioning and Maintenance.

3.3   FINAL FACE –TO-FACE MEETING

The Final Workshop is devoted to presentations and discussion of the
Course project and final assessment. For this event each learner has to
prepare PowerPoint presentation of 10 minutes containing the main
results of the Course project:
– description of the data centre
– Measurement and data collection results
– Analysis of energy efficiency of the Date Centre
– Proposal for improvement (including ROI calculation).
The learner must be able to present results of his/her Course project and
answer questions. Style of presentation and answers to questions are
taken into account in final grading.

We wish you a pleasant learning and successful tutoring!