CSA GRADE 5 THESIS

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Environmental Issues, Energy Efficiency & Commissioning

Contents

Introduction

The purpose of this thesis is to examine the link between environmental issues, energy efficiency & commissioning / commissioning management. It will investigate to what degree one affects the other and whether additional services can be provided by commissioning specialists in order to help improve the energy efficiency of buildings.

The thesis will commence by summarising findings regarding the increased awareness & focus on the need to reduce energy expenditure as dictated by the latest legislative energy efficiency initiatives. This leads into the main body of the thesis which looks at the impact of this legislation on the building services industry and particularly commissioning and commissioning management. The impact of effective commissioning & commissioning management on energy efficiency will be evaluated via a direct comparison of the results when firstly sufficient allocation of funds and competency to the commissioning process are provided and also when insufficient allocation of funds and competency to the commissioning process are provided.

Findings will be summarised regarding whether buildings should be checked regularly for energy efficiency and what involvement the commissioning specialist could have with this. The question of whether commissioning companies can do more to help maximise a building's energy efficiency will be considered.

Throughout the thesis the term 'commissioning' has been used to refer to various aspects of building engineering services commissioning works, these including; air & water balancing, HVAC plant commissioning and building management systems controls commissioning.

The conclusion will summarise all the findings and items discussed in the thesis.

Section 1 Current Environmental & Energy Efficiency Initiatives and Legislation.

1.0 Overview

Over recent years the subject of energy efficiency has gained greater significance. Concerns are being expressed globally over the earth's dwindling energy sources and the global threat of environmental pollution. Scientific evidence of the Earth's climate being affected by greenhouse gas emissions is gathering apace, according to Dr. Clive Beggs the Earth's climate has warmed by almost 0.7 °C since the end of the nineteenth century and the pace of this warming will continue to increase. If greenhouse gas levels within the Earths atmosphere rise too high the consequent additional warming could threaten the sustainability of our planet as a whole.

The gas which contributes most towards overall global warming is CO_2 (i.e. in excess of 50%), though other CFC gases play a significant role. This perceived threat of global climate change has been the driving force behind intergovernmental summits which took place late in the twentieth century. The summits collectively produced protocols which set targets for reducing ozone depleting and greenhouse gas emissions. These protocols have forced governments to reappraise policies on energy supply and consumption.

The UK Government is committed to reducing emissions of CO_2 which in turn has impacted on industry and businesses to reduce energy usage. Apparently over half of all energy consumed is used in buildings, making the design, commissioning and energy management of facilities within industrial, commercial and residential buildings vital. To enforce these ideas the Government is introducing a package of measures to encourage the improved usage of energy and thus reduce carbon emissions. A summary showing some of the latest legislative initiatives and regulations is shown below:

1.1 Energy Efficiency Legislation

Year Introduced	Legislation Title	Legislation Brief Description
1997	Kyoto Treaty	This treaty was formed when 141 countries who are responsible for generating 55% of the worlds greenhouse gases agreed to reduce this output by 5.2% by 2012
1998	The Energy Charter Treaty	The Energy Charter Treaty was signed in December 1994 and entered into legal force in April 1998. To date the Treaty has been signed or agreed to by fifty-one states. One of its key objectives being the promotion of energy efficiency, and attempts to minimise the environmental impact of energy production and use. The treaty is a legally binding agreement and is the only one of its kind requiring cooperation between different countries in the energy sector.

2002	UK Buildings regulations Part L2	In April 2002 the UK Buildings regulations brought into force part L2 conservation of fuel and power in buildings other than dwellings. This document giving practical guidance and requirements for building structures and building engineering services
From 2007 (phased)	F-Gas Regulations	The key objective of these regulations is the reduction of F-gas emissions from refrigerant (as covered in the Kyoto protocol). To achieve this, the EU regulations concentrate on personnel competency and also the containment, recovery and use of f-gases in refrigerant. From July 2007 tighter guidelines regarding the repair, maintenance and leak testing are detailed. From 1-1-2010 it is illegal to use virgin HCFC's as part of service/maintenance works and from 1-1-2015 this prohibition will also apply to recycled and reclaimed HCFC's.
From 2007 (phased)	Energy Performance of Buildings Regulations	This document relates to the regular inspection of all air conditioning systems with rated outputs of over 12kW at intervals not greater than 5 years or whenever a building is sold, leased or let. The inspection and reporting criteria being based on the Chartered Institute of Building Services Engineers (CIBSE) publication TM44: 2007 titled 'Inspection of Air Conditioning Systems'
April 2010	CRC Energy Efficiency Scheme, (2010)	Introduced by the Government Department of Energy & Climate Change, this legislation will become mandatory and is a climate change and energy efficiency scheme which aims to reduce emissions of CO_2 as set out in the April 2008 Climate Change Act. The government estimates that approximately 15,000 companies will have to record and monitor their energy usage and approximately 5000 larger companies will also have to purchase allowances from the government to cover their CO_2 usage, at the end of the year a league table will be produced depending on companies energy efficiency performance. The revenue accrued from the CO_2 allowances purchased is then awarded back to the best performers

1.2 Section 1 Summary

With the introduction of ever more stringent government legislation on energy efficiency, businesses are coming under increasing pressure to improve their energy efficiency. Clearly there are sound reasons for reducing energy consumption, not only will the environment benefit but also running costs will be reduced for the building managers.

Clearly there is a real demand to continually improve and reduce energy usage in buildings with building services playing a major role in this. Items discussed in this thesis may in the future become compulsory checks as legislation continues to become ever more mindful of ways to improve energy efficiency and hence reduce CO_2 emissions.

Section 2 Impact of an Effective Commissioning Process on Energy Efficiency

2.0 Overview

In the construction industry often sufficient funds are not allocated to the commissioning process, all too often this is managed solely by the construction contractor or the building services contractor and corners are sometimes cut in order to attempt to save money. Below I have investigated the pros and cons of sufficient funds and competency being allocated to the commissioning process, i.e. What is the impact of reducing the commissioning management time on the running costs / efficiency for the building over its lifespan?

2.1 Result of Insufficient Resources being allocated to the Commissioning Process

2.1.1 There will be no specialist personnel appointed as the commissioning manager, the commissioning will likely be managed by the services contactor probably with the bare minimum being accomplished.

2.1.2 No 'up front' commissionability study completed resulting in more problems being encountered during commissioning – some that may not be resolvable at a later stage in the project, potentially decreasing systems efficiency

2.1.3 Insufficient detail and time allocated for air & water balancing on the programme resulting in the commissioning engineers working against impossible deadlines

2.1.4 Poor O&M manuals produced making it extremely difficult for the building occupiers to fully understand the systems and how they should operate

2.1.5 Client training either not carried out or not adequately completed

2.1.6 Handover process not fully managed, systems not fully commissioned resulting in inefficient systems for the remainder of the buildings life

2.2 Advantages of Sufficient Resources being Allocated to the Commissioning Process

2.2.1 A specialist commissioning manager will be appointed meaning that the items listed below will be undertaken and communicated back in commissioning meetings and through the usual lines of communication. If an independent commissioning manager (ICM) is appointed working directly for the client additional benefits can be attained. The ICM will be able to report impartially to all parties, improving communication and problems discovered can be reported immediately and freely. Additionally the client has the reassurance that the ICM is coordinating and witnessing the commissioning independently hence should not be influenced by other parties.

2.2.2 A Commissionability study will be completed which should enable better commissioned results and value engineering to be carried out, hence reducing energy usage

2.2.3 A detailed commissioning programme will be produced meaning that sufficient time will be allocated to the commissioning works resulting in better commissioned systems & reduced energy usage

2.2.4 The liaison between mechanical (including all equipment commissioning), electrical and controls will be better managed resulting in better communication and transition of information.

2.2.5 A competent commissioning company will be appointed meaning that the correct good practice procedures should be followed

2.2.6 The commissioning manager will witness the commissioning results ensuring that all are satisfactory & running to design parameters.

2.2.7 Comprehensive O&M documents will be produced – aiding the building occupiers to fully understand the systems installed and how to operate them

2.2.8 The client training process will be fully coordinated and completed resulting in better trained maintenance staff, hopefully resulting in better maintained systems and less energy usage.

2.2.9 The handover process will be managed ensuring that all systems are commissioned fully and results documented thus ensuring that no badly or part commissioned systems exist which would have a poor efficiency.

2.3 Section 2 Summary

As highlighted by the above pros and cons it can be seen that if sufficient funds, resources and competency are allocated to the commissioning process not only should the systems be commissioned on time and to a higher standard but real benefits should result regarding the building's energy usage over its lifespan. Additional expenditure incurred during the construction phase appointing a commissioning management specialist along with competent commissioning engineers should be paid back & more through energy usage savings over the life of the building.

Section 3 Should Buildings be Checked Regularly for Energy Efficiency?

3.0 Overview

Through the research carried out and summarised in section 1 of this thesis it is easy to see that ever increasing emphasis is being placed on the energy efficiency of buildings and their services. For the larger corporations, particularly those that will be affected by the CRC Energy Efficiency Scheme, (2010) financial incentives are received for the best performers. This may motivate the managers / owners of such companies to instigate energy efficiency checks on their buildings and services. These checks could be likened to an MOT for a car and could be checked regularly, such checks could include the following

3.1 Example Checklist for the Building 'MOT'

Energy Efficiency Check	Brief Description of How Implemented
Increase staff awareness with regards to ways that energy consumption can be reduced	Depending on the premises being assessed this may include increased awareness regarding the following as an example: correct operation of doors, windows and blinds, use of additional heaters, which systems serve which areas & switching off plant when not required to run, alteration of controls set points, effect of equipment running un-necessarily and energy wastage
Checks of occupancy times and plant running hours	Have the plant running time and occupancy times been maximised for energy efficiency? If there are out of hours workers are they positioned close together and served by the same plant or does centralised plant adjust so that only the occupied areas are served?
Heating and cooling set points	Check whether any adjustments can be undertaken in order to reduce heating and increase cooling set points. Are dead bands set between the heating and cooling set points? If possible check BMS trend log data to ensure that plant is not trying to heat and cool at the same time.
Is the building fabric being adequately maintained to minimise heat losses / gains	For example are loft or other insulation sufficient and in good condition, soft furnishings blinds and curtains in good working order? Seal strips and draught proofing for windows and doors in good condition? Door closers operating? Automatic doors or windows operational?

Thermal Imaging of building fabric	Specialist thermal imaging camera detects weaknesses or missing building insulation which could lead to air leakage and hence excessive heat loss or gains and higher energy usage
Analyse CIBSE building log book energy usage data	Are fuel meter readings being recorded in the building energy log book and compared with the design teams estimates and benchmark figures? If the design intent / benchmark figures are being exceeded can this be investigated and explained?
Can additional fuel usage data be gathered?	This is achieved by the installation of temporary electrical monitoring and energy metering of equipment & services in order to assess the energy usage, the figures can then be compared with design estimates and the worst efficient systems reviewed in more detail to see how improvements can be made.
Is the Plant being adequately maintained?	As examples are ventilation filters and drive belts checked and changed as required? Water system strainers regularly cleaned and control sensors and valves maintained in good working order?
Plant operating as when originally commissioned?	Commissioning spot checks to ensure that specific fan power ratings (SFP) are the same as when commissioned. How do the ratings compare with recommended industry guidelines? Could cost effective improvements be made to the systems?
Are air conditioning energy assessments being carried out as required by Energy Performance of Buildings (England and Wales) Regulations 2007?	If so are suggestions and recommendations as stated in the inspections being adopted in order to increase the energy efficiency?
Electrical Lighting Efficiency	Are high efficiency lamps being utilised? Could these be improved / replaced? Are unoccupied areas lit unnecessarily? Could additional controls / sensors be installed that will result in savings?
Heating Plant Sizing and Efficiency	The size of the plant could be checked in view of the space served, also does it have adequate staging to maximise efficiency despite a varying load? Is the space sufficiently zone controlled and sensor locations acceptable?

Comprehensive Update of Commissioning Documents following re-commissioning work	When systems are modified and / or re-commissioned following fit out works often the existing commissioning records and O&M documents are not fully updated. This causes confusion and the client to be referring to incorrect data. The accuracy of the record data could be checked as part of the checks to ensure that the commissioning and O&M data is being properly updated.
Controls Trend Log Data Analysis	Controls trend logging could be undertaken and the performance of the plant reported on. As an example the following could be checked: Are water, air & specialist systems controlling to the correct set point? Any marked deviations over the period logged? How do space temperature and humidity readings compare with the design intent for those rooms? Are fans, pumps and specialist equipment running at correct frequencies / speed settings? Any marked deviations over the period?

3.2 Section 3 Summary

There are no doubt many other checks which could be undertaken, the above list illustrates that the commissioning engineer with some specific additional training in certain areas could carryout or manage (where a specialist is required) the necessary energy efficiency checks and the 'building energy MOT'.

It may become compulsory in the near future to carryout the checks on a regular basis as additional legislation is introduced to try and reduce further our CO_2 output. If carried out correctly potential savings from observations reported should far outweigh the cost of the surveys and the cost of the remedial works over a specified 'pay back period'.

Section 4 Could Commissioning Specialists do more to Help Maximise a Buildings Energy Efficiency?

4.0 Overview

The scope of works for commissioning companies (other than carrying out the air & water balancing) does not usually include any provision for giving advice on improving a building's energy efficiency. Although the primary responsibility for this rests with the design consultant and the subsequent building manager, I have examined if the commissioning specialists could have any valuable additional input.

I have researched 6 areas to see whether the experience and knowledge of the commissioning specialist could be put to more use in this regard. It is noteworthy that greater benefit will result to the project the earlier that the commissioning manager is appointed. If the commissioning manager is appointed maybe at the same time or prior to the main contractor this will allow sufficient time for the required changes and refinements to be made before the construction phase commences. See the areas examined below:

4.1 Commissionability Study and Energy Efficiency

4.1.1 A good commissionability study will include comments in order to improve the systems commissionability and should contain value engineering comments where possible. In addition to this could an energy efficiency study in view of the design intent also be completed? To achieve this and maybe following some additional training in some instances the commissioning manager could review items such as the following;

4.1.2 The design specific fan power ratings, this should also then be calculated once the air balancing is completed to see the actual specific fan power.

4.1.3 Is plant speed controlled where this would be beneficial?

4.1.4 Ensure that only the required amount of valves and commissioning stations etc are going to be installed

4.1.5 Where the scope of the project permits give advice regarding fan & pump selection, this could be derived from past experience of commissioning and evaluating performance

4.1.6 Review the practicality of the mechanical systems controls operation and comment regarding if the systems can be better zone controlled or whether set back could be achieved during time of low occupancy.

4.1.7 Can CO_2 sensors & temperature/humidity sensors be utilised to control the parameters within the conditioned space, the CO_2 sensor could be linked to the fresh air intake volume so that only the required amount of fresh air will be introduced into the space, hence when not required for free cooling the fresh air intake volume can be minimised and the maximum amount of air re-circulated. Also when the CO_2, temperature and humidity parameters are all met the ventilation system air volume output could reduce where this is practicable. From past experience the positioning of the sensors could also be reviewed as to whether they would facilitate efficient operation.

4.1.8 Where the scope of the project permits design aspects to be commented on by the commissioning manager, the following may be reviewed and discussed with the design consultant: Are all possible energy saving measures such as heat recovery being utilised? Are all possible low energy cooling plant such as adiabatic coolers to be installed? Review the general size of the plant and rule of thumb guidelines i.e. ventilation systems versus minimum fresh air requirements, air change rates or cooling loads (whichever is applicable).

4.1.9 Is staging of heating and cooling plant achievable and will it function efficiently in practice?

4.2 Site Inspections

4.2.1 Commissioning managers should already carryout site inspections but energy efficiency is usually not really considered during these inspections. Although the primary responsibility rests with the consultant and the contractor for the installation of the systems, where the project scope permits and particularly when the commissioning manager is working directly for the client, the following could be reviewed and commented on:

4.2.2 Has the contractor installed in a way to 'cut corners' as appose to good practice and in a way to maximise energy efficiency? Also where coordination clashes exist between trades, has a quick fix approach been utilised which would decrease the energy efficiency or has a properly engineered solution been installed? Have energy efficiency cost savings identified during the commissionability review been interpreted and implemented correctly on site?

4.2.3 Due to the commissioning managers detailed knowledge of how poor quality installations affect the commissioning of a system and hence the energy efficiency, when appropriate the above site inspection observations could further enhance the long term energy efficient operation of the plant.

4.3 Client Training

The commissioning manager could help to ensure that sufficient training is being given to the client's personnel or facilities management company so that the systems can be operated correctly and all possible energy saving measures are communicated fully.

4.4 Building Energy Monitoring – Log Book

The data contained within the log books could be checked by the commissioning manager to ensure that:

4.4.1 The data entered is accurate including systems method of operation

4.4.2 Are fuel meter readings being recorded in the building energy log book and compared with the design team estimates and benchmark figures? Where the design intent / benchmark is being exceeded can this be investigated and explained?

4.5 Building Leakage Testing

The commissioning manager should have a good knowledge and understanding of building fabric integrity with regards to air leakage. This knowledge being accrued through past experience of room and ductwork leakage testing / witnessing and plenums air integrity testing and inspections. This knowledge could be utilised for the building leakage test & gives an advantage over other contractors with regards to carrying out building fabric inspections for areas of leakage, observations would be reported to the building contractor for implementing. In this way the commissioning specialist will help the project team to achieve a good pass mark, improving the buildings energy efficient performance in the process.

4.6 Post commissioning energy efficiency Review

Currently, following a project being commissioned, the commissioning manager / company issue the accepted commissioning reports and no evaluation of the results for energy efficiency are usually carried out. In this area the commissioning company could do more by offering to assess the results post commissioning with respect to the energy efficiency achieved. As an example of items to be checked, system specific fan power level could be calculated and compared to the designers/manufacturers intent, reasons for not achieving this investigated. Fan and pump curves evaluated at part and full load and compared with efficiency figures published. These additional works would help to identify if a problem exists affecting the plants efficiency and also provide learning for future projects with a view to continuing to improve the energy efficient performance of the building services.

4.7 Section 4 Summary

In view of the findings stated above when 6 No. areas were reviewed it is evident that the commissioning specialist can do more to help improve a building's energy efficiency. In most cases, with maximising a building's energy efficiency in mind additional checks and works can be carried out by the commissioning manager in order to add value to the project and potentially result in energy savings for the building managers. As stated the effectiveness of the commissioning manager is increased the earlier that they are appointed, it is important that sufficient time exists for required changes and refinements to be made before the construction phase commences.

Section 5 Conclusion

The research conducted within section 1 revealed that businesses are coming under increasing pressure mainly from the Government to improve their energy efficiency, clearly there are sound reasons for reducing energy consumption. Not only will the environment benefit but also running costs will be reduced for the building owners, this being exemplified for larger businesses where from April 2010 they are required to purchase allowances from the government to cover their CO_2 usage with the revenue accrued at the end of each year being awarded back to the best performers.

Section 2 reviewed the impact on the buildings energy efficiency when sufficient and then by contrast when insufficient: funds, resources and competency are allocated to the commissioning process. The comparisons conducted showed that when sufficient time, money and resources are allowed, not only should the systems be commissioned on time and to a higher standard but real benefits will result regarding the buildings energy usage over its lifespan. Additional expenditure incurred during the construction phase paying for specialist commissioning management and competent commissioning engineers rather than cutting corners should be paid back & more through energy usage savings over the life of the building.

Section 3 evaluated whether an 'MOT' for buildings could result in energy efficiency savings and if the commissioning manager could carry out this role. The findings revealed that a significant number of 'MOT' energy efficiency checks could be conducted and that with some specific additional training the commissioning manager could carry out or manage these checks.

Section 4 reviewed 6 No. areas of commissioning, namely: commissionability, site inspections, training, building energy log book, building leakage testing and a post commissioning review. Highlighted in each were instances where the commissioning specialist can do more to help improve a building's energy efficiency. In most cases, with maximising a building's energy efficiency in mind additional checks and works can be carried out by the commissioning manager in order to add value to the project and potentially result in energy savings for the building manager. As stated, the effectiveness of the commissioning manager is increased the earlier that they are appointed, it is important that sufficient time exists for required changes and refinements to be made before the construction phase commences.

Some of the energy efficiency checks highlighted in this report that are not currently compulsory may become so in the near future as additional legislation is introduced to try and reduce further our CO_2 output. If carried out correctly potential savings from observations reported should far outweigh the cost of the surveys and the cost of the remedial works over a specified 'pay back period'

Section 6 Reference Work Acknowledgement

- The Energy Charter Treaty (1994)
- UK Building regulations Part L2 (2002)
- CRC Energy Efficiency Scheme, (2010) by the Government department of Energy & Climate change
- OPSI, The energy performance of buildings, (certificates and inspections) regulations 2007
- IEA Energy conservation in buildings & community systems, various annex reports/studies
- CIBSE Code F
- BSRIA technical note; Thermal Imaging of building fabric
- HMGOV – Improving the energy efficiency of our homes and buildings
- Energy consumption guide 19, Energy use in offices
- Past HNC (building services engineering) course notes
- CIBSE TM31; building energy log books
- BSRIA, building leakage testing
- Energy: Management, Supply & Conservation (by Dr, Clive Beggs)
- BSRIA guidance note 13/97: oversized cooling plant & pumps