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Deliverable D2.1 Assessment of national building codes, EPBD implementation and standards identified.

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BRE will compare and analyse the national building codes from European countries within the project, with specific reference to the Energy Performance Building Directive implementation, in order to evaluate the possible relevance of refurbishment technologies as a means of energy saving and energy consumption reduction, and in general, the contribution of energy related objectives. This task is envisioned as primarily a desk-top study since some comparison work has already taken place, particularly post-implementation of EPBD. Due to the issues of translation of documents, both time required and technical understanding, the primary source will be pre-existing English language analysis and translations. This will be supplemented by data from project partners where possible to make the work as comprehensive as possible while still being practical to implement. It is anticipated that primary sources of information would include Concerted Action (CA) EPBD, The Buildings Performance Institute Europe, previous pan European projects and so on. The analysis will be performed at a national rather than regional or local level data due to the inherent variability of such legislation. Related standards such as, grid connection, electrical and mechanical equipment, etc. will be identified by ANC. In all cases the analysis will try to identify key variations and overall trends in the approaches taken by different counties.

The Deliverable is D2.1 Assessment of national building codes, EPBD implementation and standards identified.</td></tr>
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Table of contents

1. Publishable executive summary 7

2. Introduction........9

2.1 Purpose and target group........9

2.2 Related standards such as, grid connection, electrical and mechanical equipment, were identified by ANCODARQ. Contributions of partners 9

2.3 Baseline 10

2.4 Relations to other activities........10

3. Building codes and the EPBD 12

3.1 National building codes 12

3.2 Energy Performance Building Directive (EPBD) 15

4. Best practice specifications 18

4.1 Introduction 18

4.2 EU Green Public Procurement (GPP) criteria 18

4.3 Eco-design Directive (2009/125/EC)........19

4.4 UK's Enhanced Capital Allowance (ECA) scheme........19

4.5 UK's Government Buying Standards (formerly known as Buy Sustainable Quick Wins)........19

4.6 Building Controls 20

4.7 Building Controls and zoning 21

4.8 Daylighting standards 22

4.8.1 Daylighting Standards........ 23

4.8.2 Daylighting Guides........ 23

4.9 Other energy and sustainability standards........23

5. Renewable Energy Systems (RES) 25

5.1 Introduction to equipment standards........25

5.2 Photovoltaic Panels........25

5.3 Wind Energy........27

5.3.1 Type Testing 30

5.3.2 Danish Type Certification System........ 30

5.3.3 Dutch Type Certification System 31

5.3.4 Prototype and Provisional Certification........ 31

5.4 Heat pumps........31

5.4.1 EHPA participating countries 32

5.5 Inverters 34

6. Energy auditing 38

6.1 The value of an energy audit 38

6.2 Energy audit standards........38

6.3 Building energy audit standard 39

7. Sector best practice guidance........41

8. Conclusions 43

8.1 Summary of achievements 43

8.2 Relation to continued developments 43
8.3 Other conclusions and lessons learned 43

9. Acronyms and terms 45

10. References 48

11. Appendices 51

Appendix 1: Data Collection Template (D2.1-A1) 53

Appendix 2: Data Collection - Austria (D2.1-A2) 57

Appendix 3: Data Collection – Germany (D2.1-A3) 63

Appendix 4: Data Collection – Hungary (D2.1-A4) 72

Appendix 5: Data Collection – Italy (D2.1-A5) 81

Appendix 6: Data Collection – Portugal (D2.1-A6) 92

Appendix 7: Data Collection – Spain (D2.1-A7) 100

Appendix 8: Data Collection – Turkey (D2.1-A8) 111

Appendix 9: Data Collection – UK (D2.1-A9) 118

Appendix 10: Data Collection – Poland (D2.1-A10) 136

Appendix 11: Data Collection – Croatia (D2.1-A11) 152

Appendix 12: Technologies on the UK's Energy Technology List (ETL) (D2.1-A12) 160

Appendix 13: ECA criteria for Building Environment Zone Controls (D2.1-A13) 163

Appendix 14: BREEAM and LEED daylighting credits (D2.1-A14) 170

Appendix 15: Product Certification Scheme Requirements: Solar Photovoltaic Modules (D2.1-A15) 172

1. PUBLISHABLE EXECUTIVE SUMMARY

This study reviews how the building codes of the different European countries within the EcoShopping consortium take into account energy efficiency, Renewable Energy Systems (RES) and in particular, the energy efficiency improvements of envelopes, lighting and HVAC systems of existing non-domestic buildings.

The report identifies that building regulations for the non-domestic building sector and their associated codes lay down minimum levels of performance; they do not attempt to prompt best practice. However, the building codes laid down the minimum performance ("backstop") requirements for building fabric elements and building services; the exception being true renewables, i.e. solar, hydro and wind based technologies, where there were generally no performance criteria. The building codes approach the energy performance of non-domestic building holistically where the overall performance of the building as designed is calculated by the use of approved software. This gives an asset rating which is then deemed as a pass or fail when compared to the performance level required by the individual building code, normally in terms of a target KWhr/m^2/annum.

Best practice performance criteria have been identified for the majority of technology areas which should be used when considering this technology as part of a new build or refurbishment of a non- domestic building; such as EU Green Public Procurement (GPP) criteria and the UK's Enhanced Capital Allowance (ECA) scheme and its Energy Technology List (ETL).

The report recognises that the control of energy in non-domestic buildings is generally poor, despite the availability of a range of tried and tested systems incorporating both mature and innovative technologies. The installation of HVAC zone controls, optimising controllers (for Wet Heating Systems) and lighting controls is encouraged by the building codes, but their specifications are basic. As controls are one of the most effective solutions in realising energy savings, they should always be part of a refurbishment and EN 15232 should be used as the methodology for estimating their effect.

Best practice guidance for daylighting in non-domestic buildings has also been identified along with the need to carry out an energy audit first in order to identify the most appropriate technology areas for any refurbishment.

For a case study such as this it is essential that the methodologies are comparable with those already in use and that technologies match or exceed best practice criteria already published. In addition, producing auditable numbers is essential to showing transparency in how the energy savings claimed are justified.

Best practice guidance on low carbon refurbishment of non-domestic buildings has also been identified; this covers both the refurbishment process and the use of renewable technologies. The guidance is structured around a roadmap for the refurbishment process, identifying the key intervention points during the preparation, design, construction and use phases of the project.

However, refurbishment is not treated consistently and for major works it is suggested the EU GPP criteria of an 20% improvement on the building regulations for new build is aimed for or at least the same performance as the minimum new build criteria, as laid out in the building codes, is reached.

If this is not technically feasible a minimum performance increase, such as achieving a final rating in the top quartile of energy performance should be considered. The top quartile level defined by analysing the database of Energy Performance Certificate (EPC) ratings within the country in which the non-domestic buidling is siituated.

2. INTRODUCTION

2.1 Purpose and target group

The aim of this report is to analyse how the non-domestic building codes of the different European countries within the EcoShopping consortium take into account energy efficiency, Renewable Energy Systems (RES) and in particular, the energy efficiency improvements of envelopes, lighting and HVAC systems of existing buildings.

This report compares and analyses the national building codes for non-domestic buildings from European countries (Austria, Croatia, Germany, Hungary, Italy, Poland, Portugal, Spain and the UK) within the project, with specific reference to the Energy Performance Building Directive (EPBD) implementation and its current recast [1].
The purpose of this analysis is to evaluate how refurbishment technologies contribute to energy saving and consumption reduction. This is in the context of considering the energy related objectives of the overall project.

The primary sources of information in this analysis were:

- The inputs to EPBD concerted action [2];
- The International Energy Agency (IEA) Sustainable Buildings Centre BEEP database entries on building codes [3].

The second data source (taking for example the entries for Turkey [4]) was found to be bit light on detail and it was decided that more detailed information, for example, regarding u-values and plant efficiencies would be required.

This is a desk-top study with the analysis performed at a national rather than regional or local level data. Due to the resource and time allocated and technical understanding, the primary sources were pre-existing English language analyses and existing translated documents. This was supplemented by data from project partners to make the work as comprehensive as possible.

2.2 Related standards such as, grid connection, electrical and mechanical equipment, were identified by ANCODARQ. Contributions of partners

As mentioned in 2.1 ANCODARQ identified and analysed related standards such as, grid connection, electrical and mechanical equipment.

The initial analysis of the data sources identified data gaps, such as the lack of detail in the BEEP database. To fill these gaps a data collection template (see Appendix 1) was disseminated amongst the following partners for them to populate:

- Austria - Georg Siegel, Austrian Institute of Technology (AIT);
- Croatia – Vedran Sesar, Novamina;
- Germany - Sebastian Frankl, GeoClimaDesign AG;
- Hungary - Kinga Horváth, EnergoSys Inc.;
- Italy - Adriana Bernardi, CNR-ISAC;

- Poland - Emil Lezak, IZNAB;
- Portugal - André Oliveira, ISA;
- Spain - Jon Martínez Fontecha, Solintel;
- Turkey - Arif Hepbasli, Yaşar University; and
- UK - Andy Lewry, BRE.

The data collected from the partners is contained in Appendices 2-11 inclusive.

2.3 Baseline

This deliverable is at the start of the EcoShopping project with the aim of informing the partners of the currently state of the art specifications, with respect to non-domestic buildings, for:

- Building envelopes;
- HVAC and lighting systems; and
- Renewable Energy Systems (RES).

This report reviews the data collected from the other partners (see Appendices 2-11) and investigates the best practice specifications contained within:

- EU Green Public Procurement (GPP) criteria [5].
- The Eco-Design Directive (2009/125/EC) [6].
- UK's Enhanced Capital Allowance (ECA) scheme and its Energy Technology List (ETL) [7].
- UK's Government Buying Standards (formerly known as Buy Sustainable Quick Wins) [8].
- UK Feed-in Tariff (FIT) for generating your electricity on-site (e.g. with solar panels or a wind turbine) [9].
- Other pan-European renewable technology standards and initiatives.

Consideration is also given to the Energy Performance Building Directive (EPBD) implementation and its current recast [1]. Implementation is through the concerted action initiative [2] on which BRE currently represents the UK government. BRE also has links with the EU GPP [5] and UK Government Buying Standards [8], having advised on the build environment specifications. In addition BRE has advised the Carbon Trust (managers of the ECA scheme) on best practice specifications for the technology areas on the ETL [7].

2.4 Relations to other activities

This deliverable is at the start of the EcoShopping project and therefore does not have inputs from other tasks within the project.

It aims to inform the partners of the current state-of-the-art specifications and best practice with respect to non-domestic buildings for:

- Building envelopes;
- HVAC and lighting systems; and
- Renewable Energy Systems (RES).

In addition it examines non-domestic building code compliance software and that software used to produce Energy Performance Certificates (EPCs) for the non-domestic part of the EPBD. This is with a view on how this software, which normally produces an asset rating, can be used estimate the potential savings at the design stage.

The asset rating is a measure of building quality: the higher the rating the worse the building is, and the greater the opportunity to reduce carbon emissions and improve the building itself. However, the asset rating provides no information about how the building is operated in practice [10]. An asset rating models the theoretical, as-designed energy efficiency of a particular building, based on the performance potential of the building itself (the fabric) and its services (such as heating, ventilation and lighting),. The building quality (provided by the asset rating) has a large impact on the total emissions, but does not explain all emissions. Other factors such as unregulated loads (e.g. IT, plug-in appliances) or building user behavior also create emissions, which are reflected in the operational rating.

The operational rating records the actual energy use in a building over the course of a year, and benchmarks it against buildings of similar type.

Therefore, to understand and manage the energy use in a building, both ratings are required as they show different aspects of a building's total energy performance [11].

This is an essential part of understanding the energy usage of any non-domestic building [12] along with the organisational review. One area that often 'falls between the cracks' is an overall review of the organisation and its managerial aspects [13]. A common cause of failure to implement recommendations is the disconnect between the operational aspects of an organisation and its management; these human issues also need to be identified and highlighted. This is an essential prerequisite, in order to determine the degree and type of measures that are acceptable and can be taken on board by the target organisation.

The report also considers sustainability ratings, for non-domestic buildings, in terms of whole building performance and best practice.

3. BUILDING CODES AND THE EPBD

3.1 National building codes

In general terms the National building codes, for non-domestic buildings, all take the same approach in that they set:

- Minimum (or backstop) requirements for:
    - **Fabric elements** (doors, windows, roofs, floors, walls etc.) – normally in terms of U-values and in some cases Km (Kappa-m) are used. For example in Appendix 3 for Germany all the major building elements have limiting U-value and those containing glazing have transmittance values as well.
    - For **building services** a variety of metrics are used with the most common being for heating - The Effective Heat Generating Seasonal Efficiency; whilst for cooling a combination of Seasonal Energy Efficiency Ratio (SEER) and nominal energy efficiency ratio (EER) for the cooling generator. For example the UK has all its services and their backstop performance values in a separate Non-Domestic Building Services Compliance Guide [14] – see Appendix 9. Another approach has been to group all the services providing conditioning together (e.g. Poland – Appendix 10) and give them an overall performance target in KWhr/m^2. However this approach is a half-way house in that it does not deal with the specification of individual pieces of kit, neither does it deal with the performance of the building as a whole.
    - For **controls** minimum functionality is specified and none of the building codes, except the UK which was recently updated in November 2013, reference the new European standard BS EN 15232:2012 [15], which will be discussed in the next section.
- Climate zones are defined if there is sufficient variation over a country, for example Italy (Appendix 6) has six climatic zones, each zone with their own set of minimum u-values for building fabric elements.
- In addition to the climatic zones overheating calculations and conditions are included in several of the codes (for Hungary in Appendix 4), which are essential in minimising the peak service load and thus the energy efficiency of the building.
- For **Renewable Energy Systems** there are no minimum performance requirements but the contribution of the technology to the reduction of carbon emissions is recognised; normally through a calculation methodology. Some countries have a minimum renewable contribution, for example Spain (see Appendix 7) has a minimum solar contribution for hot sanitary water and minimum photovoltaic contribution for electric power.
- In the majority of cases the building code requires the calculation of an **overall energy performance (an asset rating)** which is compared to a minimum performance level. The building has to pass this test to be compliant. This calculation is either done at the design stage or at handover, or both. Both would seem to be the most sensible where the design is checked to be compliant and so is the building as-built; thus ensuring what is designed is delivered. This can be terms of primary energy or estimated usage or both; for example Hungary (Appendix 4) have Total primary energy: [kWh/m^2/annum] where maximum permitted values are set, in consideration of A/V ratio and function (residential, office, educational, other) of the building. ("A" is the sum of the surfaces (walls + windows + roof + floor) around the heated air volume, and "V" is the heated air volume). A more refined approach would be where both primary energy (that supplied to building

including renewables) and energy usage (that used in servicing the building) are considered separately.

- This overall energy performance (an asset rating) is normally made more strigent with every new version of the non-domestic building code thus driving minimum standards up over a period of time.

The weakness of an approach based on minimum requirements is that it does not encourage best practice in terms of the technologies used and their individual performance. However, other policy vehicles such as market transformation programmes, financial incentives, and public procurement programmes, have been used in several European countries to drive improvement in the sustainability of non-domestic buildings and their components whilst reducing their environmental impact, including energy usage.

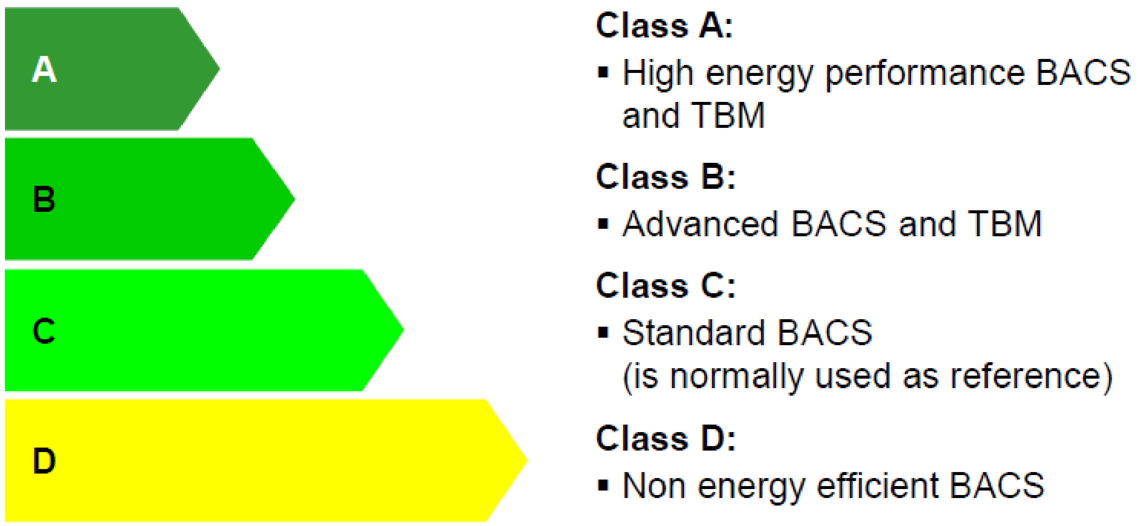
An advantage of having compliance software is that suggested technologies can be modelled to determine their potential energy saving potential. However, not all technologies can be modelled this way because the software normally assumes “standard conditions”, i.e. all buildings of the same type have the same hours of occupancy and occupancy density.

An example is high energy performance controls systems which improve the energy performance of non-domestic buildings by advanced control functions, e.g. adaptive cooling set points and ventilation related to the number of occupants. The performance of these and simpler controls can be assessed by BS EN 15232:2012 [15] which has a series of classes describing the energy performance – see Figure 1.

Typical occupancy patterns are provided in BS EN 15232 for a range of non-domestic building types; it defines classes of energy efficient controls which can obtain that degree of control.

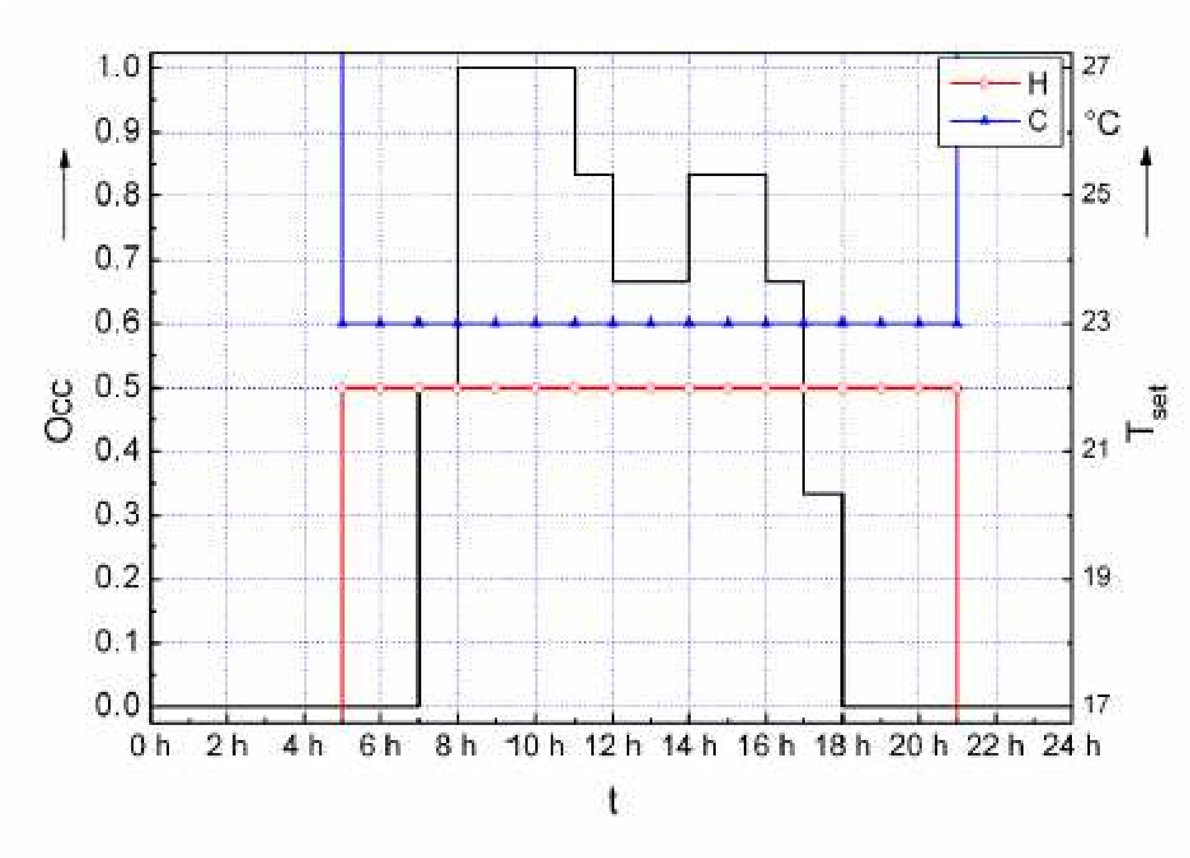
Figure 2 shows the standard operational characteristics of buildings – where there is a small difference between heating and cooling temperature set point. The operation of all HVAC systems starts two hours before occupancy and finishes three hours after occupied period is ended. This control set up is not considered to be energy efficient as there is no need to maintain comfort conditions for three hours after occupancy.

Figure 1: Energy performance classes



Note: Building Automation and Controls Systems (BACS) and Technical Building Management Systems (TBM) in the UK are known as Building Management System (BMS) and Building Energy Management System (BEMS) respectively.

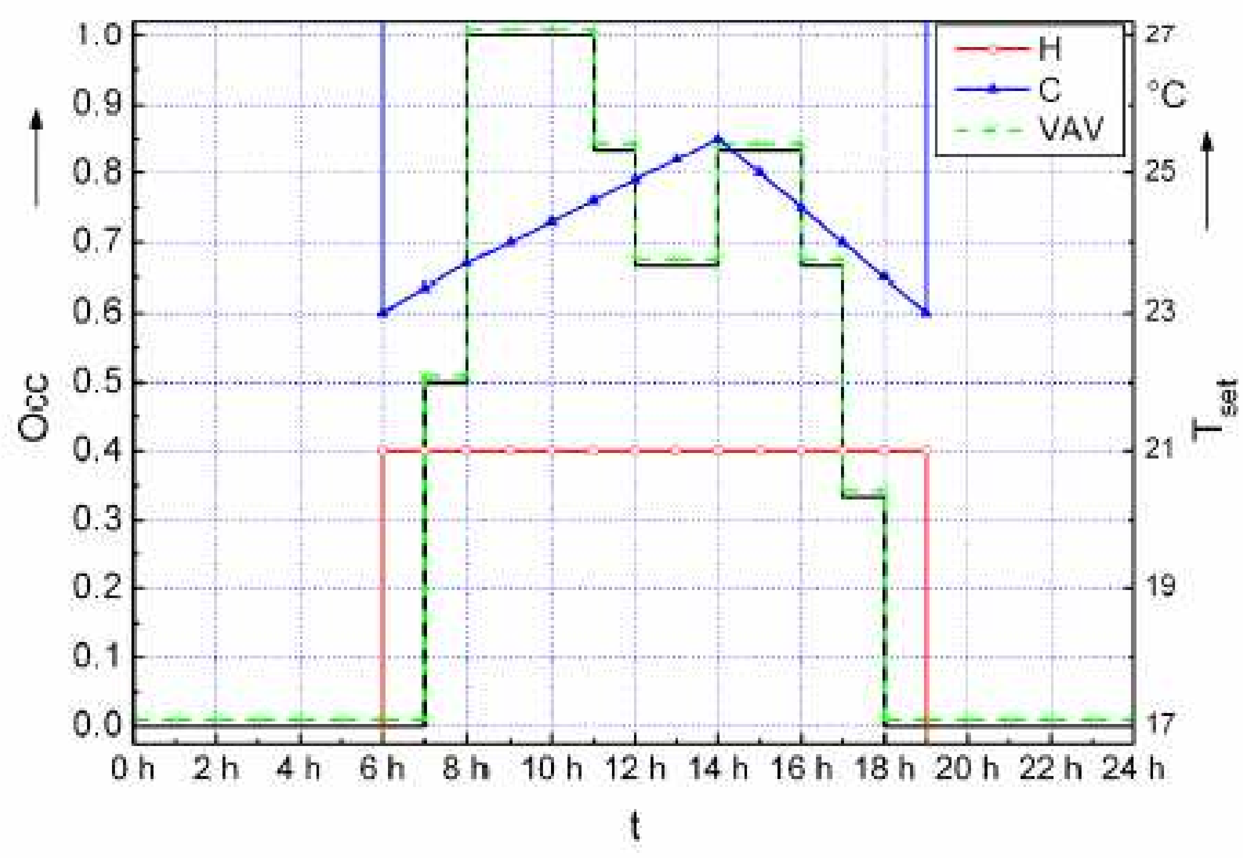
Figure 2: Class C - Standard operational characteristics of buildings



This is typical of control packages defined under the building codes and does not optimise the energy performance of the building.

Figure 3 shows how a high energy performance controls systems improves the energy performance by advanced control functions, e.g. adaptive cooling set points and ventilation related to the number of occupants. A **Programmable BEMS** would normally be required to realise the potential savings from a Class A control system.

Figure 3: Class A – High energy performance controls systems



In order to model and estimate the potential savings from control systems Dynamic Simulation Models (DSMs) are required.

3.2 Energy Performance Building Directive (EPBD)

In some cases the software producing the EPC is the same as that used for building code compliance which means that the results are comparable in terms of the rating. Unfortunately, this not always the case especially when the EPC is an operational rating, based on meter readings, where direct comparison is not possible; an exception is in the UK where the Green Deal tool can be used to join up the asset and operational ratings of non-domestic buildings [11].

In addition the recast of the EPBD has further requirements:

- From Article 2 of the Recast:

10. 'major renovation' means the renovation of a building where:

(a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or

(b) more than 25 % of the surface of the building envelope undergoes renovation;

Member States may choose to apply option (a) or (b).

- Article 7 however, leaves the door open for elemental requirements

Member States shall take the necessary measures to ensure that when buildings undergo major renovation, the energy performance of the building or the renovated part thereof is upgraded in order to meet minimum energy performance requirements set in accordance with Article 4 in so far as this is technically, functionally and economically feasible.

Those requirements shall be applied to the renovated building or building unit as a whole. Additionally or alternatively, requirements may be applied to the renovated building elements.

- Article 4 says that the requirements shall be cost-optimal.

The implementation of these requirements has yet to be clarified and as a result it is unclear whether the national building codes for non-domestic buildings are compliant with the EPBD.

The other weakness with the Energy Performance Certification is that unlike other products no attempt has so far been made to drive the market upward. With other products the lower classes have gradually been phased out over a period of time; for example for domestic appliances, such as washing machines, the only appliances now commonly available are A and A* rated appliances,

The only member state (MS) to move in this direction is the UK where Landlords of commercial premises will be unable to let properties that fall below a set level of energy efficiency unless they make certain improvements. The level of energy efficiency will be demonstrated by the property's EPC and the intention is for this to be set at EPC rating 'E'. The rule is to be brought into force by 1 April 2018 by enacting it through the Energy Act of 2011 [16].

4. BEST PRACTICE SPECIFICATIONS

4.1 Introduction

This can be defined, for non-domestic buildings and their associated elements, on a building or product basis. There are several initiatives both at pan-European and national level that attempt to deal with this issue. Section 3 established that the non-domestic building codes only give the minimum requirements for compliance and do not attempt to maximise the energy saving potential of the building.

The best approach to achieve this would be to:

1. Specify the building elements at a best practice level;
2. Set an overall energy target for the building.

The next sections deal with best practice specifications with non-domestic buildings and their associated elements such as fabric and services.

4.2 EU Green Public Procurement (GPP) criteria

The basic concept of GPP relies on having clear, verifiable, justifiable and ambitious environmental criteria for products and services, based on a life-cycle approach and scientific evidence base [5].

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The GPP approach is to propose two types of criteria for each sector covered:

- The core criteria are those suitable for use by any contracting authority across the Member States and address the key environmental impacts. They are designed to be used with minimum additional verification effort or cost increases.
- The comprehensive criteria are for those who wish to purchase the best environmental products available on the market. These may require additional verification effort or a slight increase in cost compared to other products with the same functionality.

The relevant sectors covered are:

- Construction
- Thermal insulation
- Hard floor-coverings
- Wall Panels
- Indoor lighting

And of interest may be:

- Sanitary tapware
- Street lighting and traffic signals
- Office IT equipment
- Electricity

The main criteria of interest here is that for **construction** where overall energy demand of building aims to be x% lower than that defined in the national legislation. It is recommended to aim for at least 20% lower than the existing national standard demands. This gives an overall target for any refurbishment project that is both realistic and achievable.

4.3 Eco-design Directive (2009/125/EC)

The Eco-Design Directive provides EU-wide rules for improving the environmental performance of energy related products (ERPs) through eco-design. It will increasingly require minimum energy performance criteria from a range of technologies used in buildings [6].The majority of criteria are still in the discussion stage and the majority of final product performance specifications have yet to be published.

4.4 UK's Enhanced Capital Allowance (ECA) scheme

The ECA scheme is a tax break which supports investments in certain energy saving equipment, against the taxable profits of the period of investment. For a product to be eligible for ECAs it must meet specific energy saving eligibility criteria. The scheme is underpinned by the Energy Technology List (ETL) [7], which currently has criteria for 17 technology areas and 60 sub-technologies (see Appendix 12). The eligibility criteria for each category are reviewed each year and updated to reflect technological and market developments. New technology categories can be added to the scheme each year, following approval by the Department of Energy and Climate Change (DECC), Her Majesty's Revenue and Customs (HMRC) and the Treasury.

Other European countries, for example France and the Netherlands, have similar schemes, in fact the UK scheme was originally based on the Dutch Tax scheme model. However, UK tax law requires that every qualifying technology to be defined in precise detail so that there cannot be any claims outside the terms of reference of the scheme.

This has resulted in the specifications within the ETL becoming the most comprehensive source of best practice specifications, in Europe, for energy efficient technologies. If the Ecoshopping project decides to use any of these technologies in its refurbishment, the ETL criteria should be used as the basis for specifying them. However, even a list such as this is not entirely inclusive; and because it is product based, some technologies are not included. These include for example cladding systems and advanced control systems such as Demand Control Ventilation (DCV).

4.5 UK's Government Buying Standards (formerly known as Buy Sustainable Quick Wins)

These contain official specifications that all UK government buyers must follow when procuring a range of products [8]. These specifications pre-date EU GPP and as a result the list is more comprehensive. In addition, recent technical reviews and consequent amendments have ensured these standards are equvalent or additional to any requirements laid down by EU GPP.

Product groups of interest are:

- Buildings – covering a range of construction products
    - Air conditioning units
    - Boilers
    - Central heating systems

- o CHP
- o Condensing units
- o Light bulbs
- o Lighting control gear
- o Lighting systems
- o Motors and drives
- o Paints and vanishes
- o Rain water harvesting equipment
- o Windows

- Construction projects – new builds and refurbishments

  - o Government Buying Standards use appropriate environmental assessment methods, such as BRE Environmental Assessment Method (BREEAM) [17], to ensure more sustainable buildings. These assessment methods tend to provide a holistic approach to sustainability in new-build construction and major refurbishment.
  - o For new build BREEAM excellent is required which in terms of energy standards is 25% beter than that required by the buidkling regulations.
  - o For existing buildings the UK Government has made a commitment to procure only buildings in the top quartile of energy performance. The top quartile level is to be redefined each year, by analysing the database of Energy Performance Certificate (EPC) ratings, in order to ensure that it remains accurate and up to date. For **2010**, the Department for Communities and Local Government (CLG) has calculated that the level is **68 (a low C rating)**. This means that departments **must procure buildings with an EPC rating of 68 or less** in order to be compliant with the top quartile commitment throughout 2010.

Others to note are:

- Water using products
  - o Showers
  - o Taps
  - o Toilets

The technology area specifications such as HVAC and lighting equipment use the ETL criteria. The most interesting specifications here are those for windows and environmental assessment methods because they are the first to deal with a fabric element and whole building performance.

4.6 Building Controls

The control of energy in non-domestic buildings is generally poor, despite the availability of a range of tried and tested systems incorporating both mature and innovative technologies. The installation of HVAC zone controls, optimising controllers (for Wet Heating Systems) and lighting controls is encouraged by the building codes, but their specifications are basic. As a result specifications are often limited to the minimum requirements and superior technologies, such as pre-programmed packaged Building Energy Management Systems (BEMS) and Demand Control Ventilation (DCV), are rarely taken off the shelf.

The author of this report is in the process of publishing a new guide - ***Understanding the choices for building controls*** [18]. This provides simple explanations of the technology, what it can do, where and why it can and should be used - the pros and cons, and how to get to an effective solution in practice.

Controls are one of the most effective solutions in realising energy savings and section 3.1 introduces BS EN 15232 as the methodology for estimating their effect.

Alongside this section 4.4 introduces the Energy Technology List (ETL) which currently has criteria for:

- Heating, Ventilation and Air Conditioning (HVAC) controls (now Building Environment Zone Controls (see Appendix 12);
- Hot Water Systems Optimising controls (now Heating Management Controllers);
- Lighting controls; and
- Variable Speed Drives (VSDs).

Building Environment Zone Controls criteria described above and in Appendix 13 represents good practice when all the criteria are imposed. The criteria above fall slightly short of best practice in that summer/winter change over functionality and a requirement for 365 day programming, as defined in BS EN 15500 [19], have not been included. Joining these together would represent best practice and a specification based on this would probably meet the requirements of Class B of BS EN 15232:2012, a step up from the building codes but this still falling short of the most efficient operation of a building.

Lighting controls are also included but are technology specific; the specification covers products that are specifically designed to switch electric lighting on or off, and/or to dim its output. In addition to the functionality covered by the Building Environment Zone Controls described above, lighting controls cover presence detection and daylight detection – with and without dimming.

The result is that this could be used as an off the shelf specification for the building control systems.

4.7 Building Controls and zoning

The way a non-domestic building is subdivided into zones will influence the predictions of energy performance and how you set up the control of the building. Therefore, the zoning rules must be applied when assessing a non-domestic building for controls. The end result of the zoning process should be a set of zones where each is distinguished from all others in contact with it by differences in one or more of the following:

- The activity attached to it;
- The HVAC system which serves it;
- The lighting system within it;
- The access to daylight (through windows or rooflights).

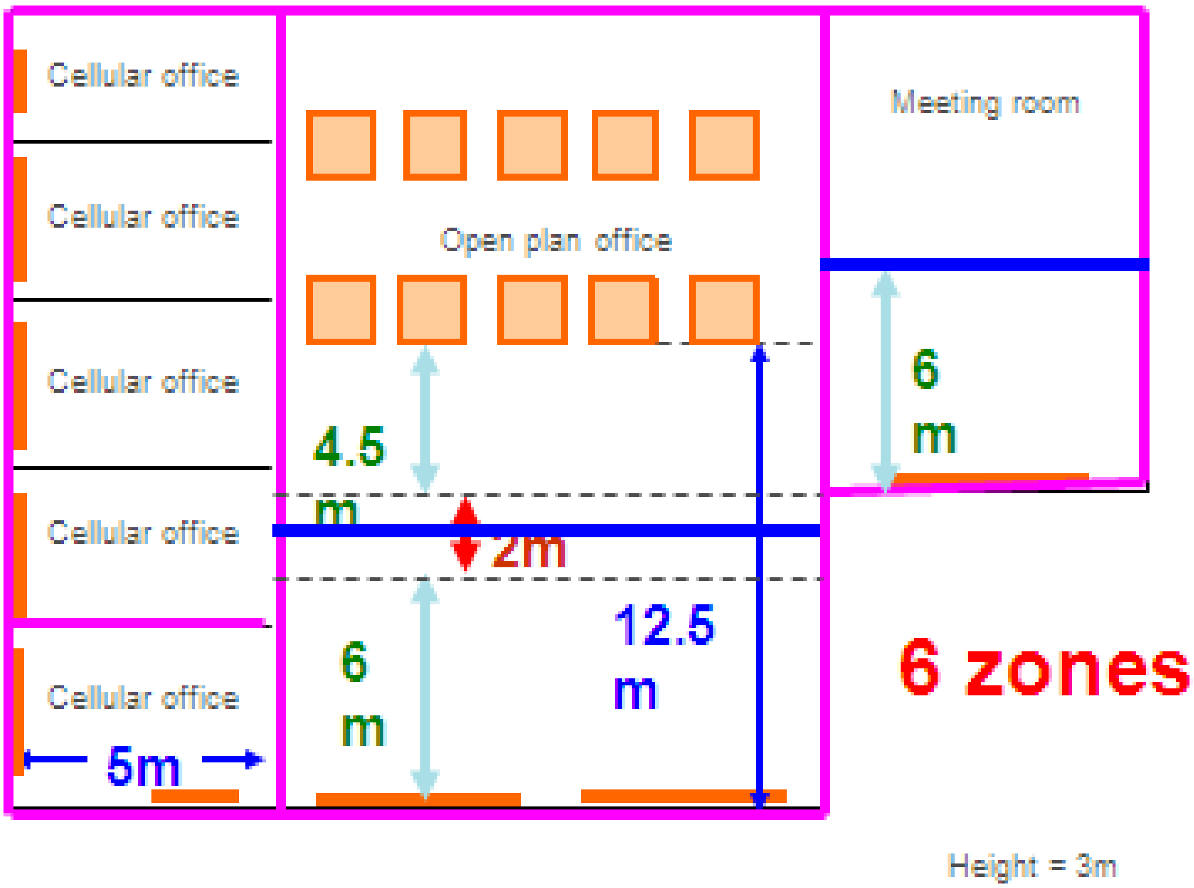
To this end, the suggested zoning process within a given floor plate is as follows:

1. Divide the floor into separate physical areas, bounded by physical boundaries, such as structural walls or other permanent elements.
2. If any part of an area is served by a different HVAC or lighting system, create a separate area bounded by the extent of those services.
3. If any part of an area has a different activity taking place in it, create a separate area for each activity.
4. Divide each resulting area into “zones”, each receiving significantly different amounts of daylight, defined by boundaries which are:

- At a distance of 6m from an external wall containing at least 20% glazing;
- At a distance of 1.5 room heights beyond the edge of an array of rooflights if the area of the rooflights is at least 10% of the floor area;
- If any resulting zone is less than 3m wide, absorb it within surrounding zones;
- If any resulting zones overlap, use your discretion to allocate the overlap to one or more of the zones.

An example of this approach is given in Figure 4. Once the zoning has been carried out consideration can be given to placement of sensors (temperature, occupancy and light levels) with a view to controlling these zones in terms of the services provided.

Figure 4: an example of a small office zoned by activity and then daylighting



4.8 Daylighting standards

Daylight openings are regulated in some countries; however, the nature of the requirements is relatively unsophisticated and generally do not provide an appropriate amount of daylighting. The requirements for the size of daylight openings are not directly comparable among all the countries because the about of ambient light depends on the climatic conditions [20].

Directive 89/654/EEC - workplace requirements [21] require sufficient natural light and be equipped with artificial lighting adequate for the protection of worker's safety and health.

However, this does not seem to be reflected in the regulations ascertaining to buildings where there are no minimum daylight standards.

4.8.1 Daylighting Standards

The only comprehensive standard, for non-domestic buildings, was BS 8206-2 2008 Code of Practice for daylighting [22]. This standard gives recommendations regarding design for daylight in buildings. It includes recommendations on the design of electric lighting when used in conjunction with daylight.

BS 8206-2 describes good practice in daylighting design and presents criteria intended to enhance the well-being and satisfaction of people in buildings, recognizing that the aims of good lighting go beyond achieving minimum illumination for task performance.

This revision of BS 8206-2 has been prepared to take account of the publication of BS EN 12464-1 [23] and BS EN 15193 [24]. In particular, some of the manual calculations that appeared in the 1992 edition have been omitted and a new annex on climate-based daylight modeling has been added along with a new clause on daylighting and health.

Simple graphical and numerical methods are given for testing whether the criteria are satisfied, but these are not exclusive and computer methods may be used in practice. Sunlight and skylight data are given.

In addition, BREEAM or Leadership in Energy & Environmental Design (LEED) methodologies both take into account several daylighting requirements; details of their credits can be found in Appendix 14.

4.8.2 Daylighting Guides

The UK Chartered Institute of Building Services Engineers (CIBSE), Society of Light and Lighting (SLL) guide LG10 [25] on Daylighting and window design aims to design windows for the provision of daylight in order to avoid causing problems with glare, noise intrusion, summertime overheating and excessive use of energy. This guide gives the designer a means of identifying the important factors and methods for solving some of the problems which inevitably occur. Sections include: the role of window in building design; types of design; and daylighting calculation.

More Guidance is given in:

- Site layout planning for daylight and sunlight: a guide to good practice [26];
- The essential guide to retail lighting: Achieving effective and energy-efficient lighting [27].

4.9 Other energy and sustainability standards

Task 2.4 proposes to use building performance rating method in Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 using a computer simulation model for the whole building project. The proposal is to use this for energy performance optimisation but this could lead to conflicts with the results from European based standards and software.

The main reasons being:

- Building Energy Modelling software use local climate and weather files in their calculations and therefore the software specific to that country will give a much more accurate answer.

- American standards are not usually suitable for the European market because they have different testing regimes and performance criteria which are normally not transferrable to European standards.
- American HVAC standards are normally limited to air based systems – i.e. systems that move air (both heated and cooled) to condition space within a building. In general, water based systems (for example where heat is transmitted from a boiler to heat emitters such as radiators) are not covered by standards from the US but are typically used in Europe.

There is also a proposal to use LEED (Leadership in Energy & Environmental Design) which is a US green building tool that provides third-party verification of green buildings. There are a significant number of LEED rated buildings across Europe; for use in the European market, construction practices and climate zones methodology and tool compliant to BS EN 15643-2:2011 [28] and BS EN 15804:2012 [29] would seem most appropriate.

5. Renewable Energy Systems (RES)

5.1 Introduction to equipment standards

The building codes and regulations for each of the countries mainly deal with the interface of the building and the grid. What is missing is best practice specifications for the renewable technologies themselves and the only comprehensive set identified by the research are those supporting the UK Feed-in Tariff (FIT) for generating your electricity on-site [9]. It contains technology requirements for:

- Solar thermal systems;
- Solar PV systems;
- Small and micro wind turbines;
- Heat pump systems;
- Biomass systems;
- Roof mounting kits;
- CHP;
- Micro-hydro systems;
- Bespoke Building Integrated Photovoltaic Products.

These give full product specifications to the current EN and ISO standards. An example of the product certification scheme requirements for solar photovoltaic modules is given in Appendix 15.

Other specifications were identified by the research and the individual technology areas are discussed in the following sections.

5.2 Photovoltaic Panels

Photovoltaic (PV) modules and photovoltaic installations represent electrical equipment and the fulfillment of test specifications, the conformity assessment and the CE-marking are obligatory for such components and equipment.

The Low-Voltage (LV) **Directive 2006/95/EG** [30], is mandatory for PV-modules with voltages above 75 V DC. However, the scope of the European directive relating Electromagnetic Compatibility (EMC) is not applicable in its present form for the modules acting as electromagnetic passive components.

This directive does not apply to equipment where the inherent nature of the physical characteristics is such that:

a) it is incapable of generating or contributing to electromagnetic emissions which exceed a level allowing radio and telecommunication equipment and other equipment to operate as intended; and
b) it will operate without unacceptable degradation in the presence of the electromagnetic disturbance normally consequent upon its intended use. (*EMC (**E**lectro**M**agnetic **C**ompatibility) Directive 2004/108/EC*EMC-directive, article 1, clause 3 [31]).

Guidance on the implementation of this directive is available [32].

However complete PV-Installations (modules, power converter etc.) need to take into both directives. If movable parts are also present, the EC-Machinery Directive 2006/42/EC may also have to be taken into account [33].

The product quality and the safety performance are particular important properties of PV-modules.

Requirements for such PV-products can be classified against the following requirements:

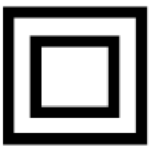
1. Type requirements on PV-modules such as
   - **EN 61215:2005 -** Crystalline silicon terrestrial photovoltaic (PV) modules
   - **EN 61646:2008 -** Thin-film terrestrial photovoltaic (PV) modules
2. Safety requirements such as
   - **EN 61730:2007 -** Photovoltaic (PV) module safety qualification
3. Additional Requirements such as
   - **EN 50380:2003 -** Datasheet and nameplate information for photovoltaic modules

CE-Marking is not a symbol for the independent testing of a product, the manufacturer self-assesses conformity with the requirements of the relevant directives. The European Union has given a guide for the application and realization of the directives [34].

The Low Voltage **Directive 2006/95/EG** [30], is valid for electrical equipment with rated voltages between 50 V and 1000 V AC respectively 75 V and 1500 V DC. This directive is, along with the listed product standards dealing with safety, key to the CE-Marking of PV-Modules.

A basic aspect for the safe operation of PV-modules and equipment is electric shock protection. Compliance with safety class II demands becomes of great importance particularly for modules destined for high system voltages up to 1000 V.

The compliance of safety class II requirements is documented by the corresponding symbol:



The International Electrotechnical Commission (IEC) is the organisation responsible for worldwide standardization. The "Global Approval Program for Photovoltaics" describes a certification procedure based on reliable IECEE-rules (IECEE – IEC System for Conformity Testing and Certification of Electrical Equipment). In this way certified products are marked with the following symbol:

The TÜV Rheinland Group assigns the test symbol "TÜV" [35]. Precondition for the obtainment of this mark is among the type testing the periodic inspection of the fabrication.

The performance PV standards, named **IEC 61215** (Ed. 2 – 2005) and **IEC 61646** (Ed.2 – 2008), set specific test sequences, conditions and requirements for the design qualification of a PV module.

The design qualification is deemed to represent the PV module's performance capability under prolonged exposure to standard climates (defined in **IEC 60721-2-1**). A brief description of the tests follows: [36]

- Visual inspection: is typically a diagnostic check.
- Maximum power (Pmax): is typically a performance parameter.
- Insulation resistance: is an electrical safety test.
- Wet leakage current test: is an electrical safety test, too.
- Temperature coefficients: is a performance parameter.
- Nominal Operating Cell Temperature (NOCT): is a performance parameter.
- Outdoor exposure: is an irradiance test.
- Hot-spot endurance: is a thermal/diagnostic test.
- Bypass diode: is a thermal test.
- UV preconditioning: is an irradiance test.
- Thermal cycling TC200 (200 cycles): is an environmental test.
- Humidity-freeze: is an environmental test.
- Robustness of terminations: is a mechanical test.
- Damp-heat DH1000 (1000 hours): is an environmental test.
- Mechanical load test
- Hail impact: is a mechanical test.
- Light-soaking: irradiance

In addition, there are several other standards that address the safety aspects for a module, such as ETL and UL1703 for US market, MCS (Microgeneration Certification Scheme – see section 5.1) for England, CSA for Canada, JET for Japan, SAA for Australia, Inmetro for Brazil.

5.3 Wind Energy

A number of standards relevant to the design, testing, and operation of wind turbines have been published or are in the process of being published.

This section provides a summary of wind turbine-related standards and how they are applied through the certification process. Then, it considers the application of the key design standard IEC 61400 [37]. Closely related to standards are technical specifications; these are similar to standards, but are considered to be best practice recommendations rather than requirements.

Until recently, standards and technical specifications were developed country by country, or by such entities as Germanischer Lloyd (GL) or Det Norske Veritas (DNV) [38]. The lead in wind turbine standards is now being taken by the International Electrotechnical Commission (IEC). The most important standards that are in use or being developed are listed in the Table 1. Note that some of these are not yet official international (IEC) standards. Some other useful, but non-IEC, standards and guidelines are listed in Table 2.

Table 1: Wind turbine-related IEC standards

Source/Number	Title
IEC WT01	IEC System for Conformity Testing and Certification of Wind Turbines Rules and Procedures
IEC 61400-1	Wind Turbines – Part 1: Design Requirements, edition 2
IEC 61400-2	Wind Turbines – Part 2: Safety Requirements for Small Wind Turbines
IEC 61400-3	Wind Turbines – Part 3: Design Requirements for Offshore Wind Turbines
ISO/IEC 81400-4	Wind Turbines – Part 4: Gearboxes for Turbines from 40 kW to 2 MW
IEC 61400-11 TS	Wind Turbines – Part 11: Acoustic Emission Measurement Techniques
IEC 61400-12	Wind Turbines – Part 12: Power Performance Measurements of Electricity Producing Wind Turbines
IEC 61400-13 TS	Wind Turbines – Part 13: Measurement of Mechanical Loads
IEC 61400-14	Wind Turbines – Part 14: Declaration of Apparent Sound Power Levels and Tonality Value of Wind Turbines
IEC 61400-21	Wind Turbines – Part 21: Power Quality Measurements
IEC 61400-22 TS	Wind Turbines – Part 22: Conformity Testing and Certification of Wind Turbines
IEC 61400-23 TS	Wind Turbines – Part 23: Full-scale Structural Testing of Rotor Blades
IEC 61400-24 TR	Wind Turbines – Part 24: Lightning Protection
IEC 61400-25	Wind Turbines – Part 25: Communications for Monitoring and Control of Wind Turbines

Table 2: Other wind turbine-related standards

Germanischer Lloyd	Regulations for the Certification of Wind

	Energy Conversion Systems
Danish Energy Agency DS-472	Code of Practice for Loads and Safety of Wind Turbine Construction
DNV	Guidelines for the Design of Wind Turbines, 2nd edition
DNV-OS-J101	Design of Offshore Wind Turbine Structures
DNV-OS-J102	Design and Manufacture of Wind Turbine Blades

All of standards referred to in Tables 1 and 2 have some relevance to wind turbine design, although some are more directly relevant than others.

The most important IEC standard is IEC 61400-1 (IEC, 2005a). It deals explicitly with design requirements. It applies particularly to larger, land-based turbines, but it is relevant to smaller turbines and offshore turbines as well. IEC 61400-1 will be discussed in more detail in the next section.

IEC 61400-2 (IEC, 2005b) is, as its name implies, concerned with small turbines. IEC 61400-3 (IEC, 2008b) applies to offshore wind turbines. It is consistent with IEC 61400-1 and focuses particularly on those design issues of relevance (such as waves, ocean currents, etc.) not considered in IEC 61400-1.

ISO/IEC 81400-4 (ISO, 2004) is concerned specifically with the design of wind turbine gearboxes.

IEC 61400-11 TS (IEC, 2006a) deals with acoustic emissions from wind turbines. This technical specification is indirectly relevant to design, since it would be used in evaluating, for example, the noise emission of a prototype. After the evaluation, it is possible that the design would be modified in a subsequent iteration to reduce noise emissions.

IEC 61400-12 (IEC, 2005c) is concerned with power performance measurements.

IEC 61400-13 TS (IEC, 2001a) concerns the measurement of mechanical loads. As with IEC 61400-11, design modifications could be made after the performance testing of a prototype in accordance with IEC 61400-12 and IEC 61400-13 TS. It may be presumed that the testing undertaken in this process would help identify areas where structural design changes might be made.

IEC 61400-14 (IEC, 2004) is concerned with the sound emitted from a wind turbine. It would be used in conjunction with IEC 61400-11 TS.

IEC 61400-21 (IEC, 2008a) is concerned with power quality measurements. This standard has most relevance for the electrical and electronic components of a wind turbine.

IEC 61400-22 TS (IEC, 2008c) is a technical specification for certification.

IEC 61400-23 TS (IEC, 2001b) concerns testing of wind turbine blades. Blades could be tested before the complete prototype is built. Results from blade tests could result in modifications to the blades' structural design.

IEC 61400-24 TR (IEC, 2002) is a technical report concerned with lightning protection. It is relevant to certain details of the wind turbine's design, specifically those that are particularly likely to be adversely affected by lightning.

Finally, IEC 61400-25 (IEC, 2006b) is concerned with monitoring and control of wind turbines, and is relevant to the associated aspects of the design.

The first two documents that appear in Table 2 (GL, 2003; DEA, 1992) are particularly concerned with the certification of wind turbines, but have indirect implications for the turbine design.

The third document (DNV, 2006) is directly relevant to the design process.

The fourth document listed, DNV-OS-J101 (DNV, 2007), is a preliminary offshore turbine design standard, and may be superseded once IEC 61400-3 is finalized.

The fifth document listed, DNV-OS-J102 (DNV, 2006), is concerned with the design of wind turbine blades.

It may be noted that there are many other standards that are relevant to the design of wind turbines. These standards are typically referred to where applicable. For example, IEC 61400-1 includes references to a number of other IEC standards that are of broader scope than wind turbines, as well as International Standard Organization (ISO) standards. One example of another IEC standard is IEC 60204-1: 1997: Safety of Machinery – Electrical Equipment of Machines – Part 1: General requirements.

Similarly, an example of an ISO standard is ISO 4354: 1997: Wind Actions on Structures. Development of the wind turbine gearbox standard (ISO, 2004) is a joint ISO/IEC activity. [39].

5.3.1 Type Testing

The Type Testing module comprises the following elements:

- Safety and Function Tests
- Load Measurements
- Power Performance Measurements
- Blade Tests
- Other Tests including Gearbox Field Test

The Type Testing elements shall be carried out by accredited testing laboratories in accordance to IEC/ISO 17020 or IEC/ISO 17025.

5.3.2 Danish Type Certification System

The Danish Type Certification system is defined in Executive Order BEK no. 651 of 26/06/2008 'Bekendtgørelse om teknisk godkendelsesordning for konstruktion, fremstilling, opstilling, vedligeholdelse og service af vindmøller'. This system is based on the international