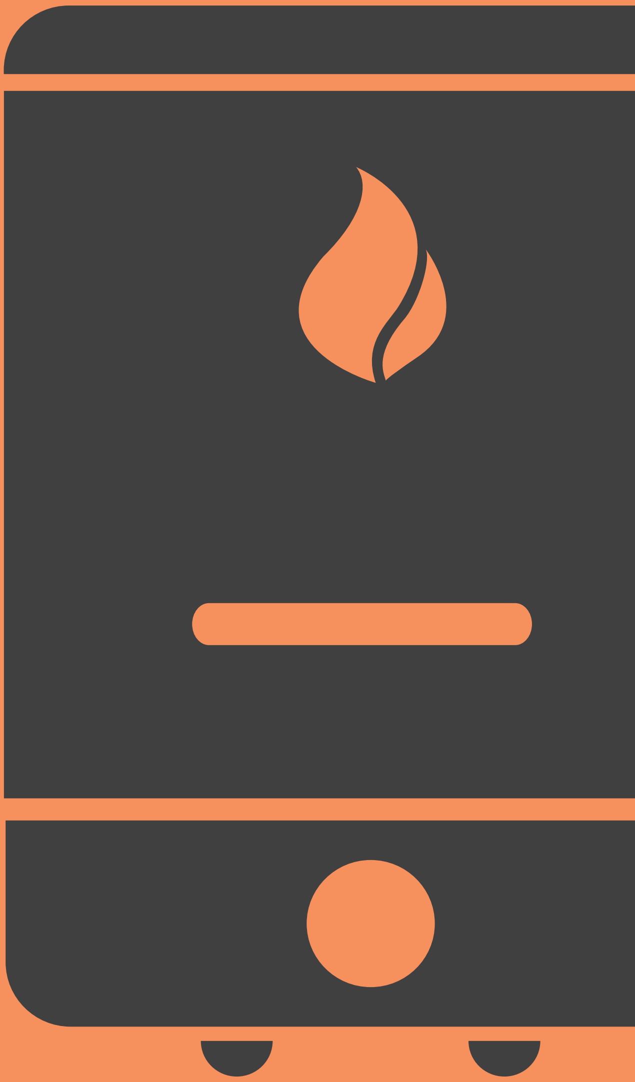
Invest Northern Ireland

Biomass

A Best Practice Guide for businesses in Northern Ireland



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Pictured: Wood Pellet Biomass System, Manor House Hotel, Enniskillen and Valley Hotel, Fivemiletown

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2.0 Purpose of the Guide

Over the last 10 years the use of biomass has expanded rapidly in Northern Ireland. This has brought design, procurement, operational and regulatory challenges. In many circumstances the rapid growth in associated design and operational experience, has ensured that, broadly speaking, the bulk of installations function satisfactorily and biomass has become an established element of the fuel mix in Northern Ireland. However, solid fuel boilers and particularly biomass are operated differently to oil and gas boilers, and combinations of inadequate installation and operational expertise have resulted in some plant failures and potentially dangerous situations – all of which could have been avoided if the existing regulatory structure had been observed.

This guide explains, concisely, the basic guiding principles for procuring a biomass system. The guide is primarily intended for hot water plant but the principles are, by and large, relevant to steam plant and thermal oil plant. The guide is not intended for small-scale room heaters or domestic stoves and it is likewise not intended to cover power generation or combined heat and power systems which are inherently more complex.

Who is this guide for?

This guide is intended for designers, owners, operators and users. It sets out the basic best practice and principles associated with design.

The guide defines the parties considered to be duty holders under current UK law and sets out the basic legal duties of care for each of these duty holders.

What is the scope of this guide?

This guide covers aspects of feasibility, design, supply and operation of an on-site biomass system. The guide does not cover the cultivation or harvesting of biomass. It focuses on best and legal best practice.

This guide provides a detailed explanation of some of the fundamental aspects of biomass installation and operation.

How to use this guidance

The guide is split into stand-alone sections that may be read in isolation or in sequence. If read in sequence the document follows the procedure that should be adopted to develop a successful biomass project. However, guidance on specific matters may be obtained by reference to the relevant section.

Additional sources of guidance

A lot of guidance for biomass has been published over the last few years. Not all of this guidance is correct or accurate and in some cases existing guidance does not adequately address the legal framework and legal duties of care that are applicable in most circumstances.

3.0 Overview of Biomass

3.1

What is biomass?

Biomass is organic matter used as a fuel generally the term is taken to mean something that is of vegetable as opposed to animal origin. However, animal oils or by products, such as fish oil or meat and bone meal would also be classed as biomass. In the context of this guide we are addressing fuels of solid, vegetable biomass origin.

3.2

Where does biomass come from?

There are four basic biomass fuel groups:

1. Crops grown for energy production which could include:
   - Miscanthus
   - Short Rotation Coppiced Willow.
2. Forestry and related residues such as:
   - Virgin wood grown for fuel
   - Harvest residues
   - Sawmill residues.
3. Agricultural residues such as:
   - Straw, animal bedding, wheat stalk
   - Food waste
   - Rice/Grain husks.
4. Industrial waste and co-products:
   - Spent grains
   - Waste wood.

3.3

Is biomass sustainable?

The short answer is no – it is inconceivable that a modern, power hungry, human race can fuel its future on biomass (at least not without a vast reduction in population). Whilst in certain geographical locations biomass may be sustainable, globally this is impossible. A fast growing softwood species might produce a sustainable harvest of 10 oven dried tonnes of wood per hectare per annum. That wood will have a net energy content of approximately 17.76GJ/tonne or in other words the energy content recovered sustainably would be approximately 50,000kWh the equivalent of 4,760 litres of heating oil.

Considered on a larger scale a small process steam boiler of say 7,500kg/hr and operated at 50% capacity for 40hrs week will consume 3.7million kWh of fuel or the equivalent of 74 hectares of sustainably managed forest. It is therefore reasonably easy to see that biomass is not globally sustainable.[1]

3.4

Is biomass expensive?

Biomass fuel is currently relatively inexpensive. Wood chip at 30% moisture content currently costs approximately 2.6p/kWh, which is considerably less than typical gas prices in Northern Ireland. Wood pellet fuels are more expensive at typically 4p/kWh but are still very much cheaper than LPG or 28secs oil. However, the capital cost of biomass equipment is typically 10 times the cost of conventional plant.

To encourage the use of biomass, the Government has introduced a tiered revenue support scheme called the Renewable Heat Incentive (RHI). This scheme is explained fully in the section entitled The renewable Heat Incentive. The scheme provides a revenue payment for heat used. Without the revenue support scheme, biomass is unlikely to be viable commercial option. However, with the revenue support scheme in place, biomass represents a credible commercial opportunity with life cycle cost benefit over conventional fossil fuels.

3.5

Biomass source and type

The type and source of the biomass fuel is important for many reasons, not least the way in which the fuel is legally defined. Across Europe, the provisions of the Industrial Emissions Directive 2013 have subsumed numerous preceding directives and regulations and now stipulate how waste will be classified and how it must be burned. In many cases waste wood and other wastes are a very important local source of fuel – but it is not legal to simply burn waste wood in a biomass boiler unless those wastes comply with very specific legal provisions.

Equally, the mineral content of the biomass will be dictated by the source and the handling. The mineral content (non combustible content) and metal salt content, for example sodium and potassium salts, will vary with biomass species and can adversely affect the combustion qualities of the fuel. In a few cases this can be problematic.

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[1] This is not simply a mathematical certainty it is the view of some more senior and chartered environmentalists in the UK.

3.6
Why should I use biomass?

The local sustainable use of biomass arguably reduces long-term carbon emissions and thus reduces the greenhouse gas concentration in the atmosphere. Although carbon dioxide is released, there is very little, if any, sulphur content and thus sulphur contributions to acid rain are reduced.

3.7
Biomass standards

This guide deals with plant which is designed to burn wood, chipped wood, pelletised wood and waste wood. As there is such a wide variation in wood and because it really can have quite significant effects on combustion, emissions and the physical fouling or other detrimental effect to combustion appliances, the biomass industry has introduced fuel standards. In Europe, the European Union set up a technical committee TC335, which has evolved or adopted a suite of national and self-developed standards that cover everything from tree type to mineral content, fuel chip size to the diameter of logs. This set of standards is often impossible to apply practically or to police. However pelletised fuels are easier to test, standards are easier to enforce and it is easier to certify the manufacturers and suppliers.

Biomass standards are important but the supply of biomass is unlike that of oil or gas and much more like that of coal. Historically, the massive variation in coal types dictated that the boiler and grate were designed for the locally available or specifically imported coal type and not the other way around. As biomass becomes more prevalent, the same difficulties are being encountered. Standards help to alleviate these difficulties.

4.0 Basic Feasibility

4.1

Have I sufficient space for a biomass boiler and fuel storage?

A biomass boiler is significantly larger than the gas or oil equivalent. For example, a boiler of 30–50kW (the size of boiler necessary to heat a large house) will be very much larger than the oil or gas fired equivalent. Figure 1 illustrates the case.

Figure 1 Comparative size

At the small end of the scale, a large house might consume 7–10 tonnes of wood pellets per annum. A proprietary externalised pellet store of 5m^3 will likely be more than adequate, with one or two deliveries a year.

On the other hand, an industrial boiler plant capable of perhaps 2–500kW of thermal output might consume more than 200 tonnes of fuel per annum and require a total fuel volume in excess of 650m^3. Allowing for a practical delivery regime, that might require a fuel store footprint of 36m^2 and deliveries at fortnightly intervals.

Although pellets are more expensive they can offer sensible fuel management solutions in that they can sometimes be stored separately from the boiler.

Because biomass systems generally are less flexible in terms of operation than gas or oil boilers it is helpful from all operational perspectives to operate the biomass boiler at a stable output and to buffer load changes with water storage. The size of the water storage required reflects the operational flexibility of the boiler and selected fuel, and the variation in heat load – this is discussed further in the following sections of this guidance. However, the thermal storage required can be very significant and space has to be available to use a biomass system.

In assessing the feasibility of biomass it is important to understand the significantly larger space requirements for fuel storage, the boiler and for the thermal storage.

4.2

Is an affordable fuel supply available?

If there is no fuel supply, there is no biomass project. In Northern Ireland there is a good supply of biomass pellet and a less established supply of wood chip – although the latter can be obtained from sawmills and suppliers. The website **http://www.biomassenergyni.com** has a useful list of suppliers.

Figure 10, later in this guide, compares fuel costs.

4.3

Is there a commercial case for biomass?

Having established that there is enough space for biomass and that there is a fuel supply available, it is necessary (before too much detailed work is undertaken) to establish a basic commercial case.

Depending on your organisation's investment criterion, the commercial case may be considered as a simple payback where the capital cost of the project is offset by the fuel savings and revenue support payments (net of any maintenance and power costs), or as a life cycle operational comparison.

The main problem with life cycle comparisons is predicting the future costs of oil, gas, wood chip, inflation, market discount rates and other extraneous factors. There is a large amount of prediction involved.

Payback inherently reflects risk (exposure to large capital outlay) and the rate of return on investment. There is, therefore, good reason for using simple payback. However, a life cycle investment appraisal is useful for comparison purposes.

Financial appraisal is dealt with in detail later in this report. It is important to make an early assessment of the commercial case to prevent abortive work at the outset.

4.4

Is it actually practical to deliver fuel to site?

Some consideration must also be given to how exactly a biomass system might be integrated on a site. In the section of this guide entitled Fuels and Fuel Handling, the issues surrounding fuel selection, handling and storage are addressed. Not only must there be space to locate the boiler and fuel storage but it has to be possible to deliver the fuel to site.

At this stage you should make an assessment of how fuel delivery will be achieved and ensure that it can be carried out safely.

Practical considerations might include vehicle manoeuvre space, overhead power lines, site security during delivery, pedestrian restriction, noise and times of delivery.

The Carbon Trust publication, Biomass heating: a practical guide for potential users, contains additional information on fuel delivery and storage.

4.5

Is it possible to integrate biomass technically and economically?

In assessing biomass it is essential to consider:

- How will the biomass system be integrated and controlled?
- Are there technically (and commercially) better alternatives?

To integrate biomass and receive revenue support currently requires integration with a wet heating system (piped hot water and radiators or similar). The biomass system will have to be compatible with existing heating systems – except for a new build where the heating systems can be designed around the biomass system.

Where the biomass system is to be integrated with existing systems, the load profile, peak demands, heat up times, thermal response of the building, the existing controls and other factors must be considered.

Having assessed fuel and availability, the boiler type must be selected based on size, fuel, location and other factors.

4.6

Statutory compliance and emissions regulations

There are numerous legal requirements that apply to the operation of a solid fuel appliance, whether industrial or a domestic boiler. The feasibility study should comprehensively address these issues.

If the biomass boiler is to be located in a new building or relocated within an existing building, planning permission will probably be required. The exception to this will be a large industrial site where there is no requirement to stipulate specific process activity. However, the erection of a large or tall chimney may still be subject to planning permission. Consultation with the local planning office is best – refer also to the attached flow chart in Appendix A.

The intended installation of a boiler/solid fuel appliance will be subject to the provisions of the building regulations. In the domestic context this is mandatory and will relate to the actual performance of the boiler plant. In the industrial context the building regulations will largely be superseded by the raft of design and health and safety legislation in the UK. Refer to the health and safety section in this guide.

The system must comply with emissions regulations. If the intended area is a smoke control area then the appliance (and the fuel) must be certified for use in a smoke control area. Regardless of the area, the operation of a combustion appliance burning more than 45kg/hr fuel must comply with the Clean Air Act 1993. The Clean Air Act is under review and the revised Act will likely impose much more prescriptive and onerous emissions performance targets for biomass. The feasibility study should take account of this fact. On industrial sites and for small-scale plant, for example, less than 20MW, the emissions will be governed by the provisions of the Industrial Emissions Directive and any existing constraints imposed by the Industrial Pollution Prevention and Control Directive on the site. Note that all emissions legislation addresses nuisance. The local authority or the Northern Ireland Environment Agency can intervene to effect remedy if nuisance is caused – even if technically, emission limit values are met. There is little point in complying with emission minima if you are aware that nuisance will be caused. The minimum chimney height for Clean Air Act compliance only will be dictated by the HMIP 1993 Guidelines on Discharge Stack Heights for Polluting Emission. Technical Guidance Note D1 (Dispersion).

You must comply with emission limits to obtain RHI payments. The requirement for compliance with RHI minima limits of 30g/GJ particulate matter and 150g/GJ oxides of nitrogen expressed as nitrogen dioxide was implemented in September 2013.

Additional guidance is available from

http://www.carbontrust.com/media/31667/ctg012_biomass_heating.pdf

5.0 Procurement

In the UK (and Europe) the provision of plant and equipment is subject to legislation that governs the design of the equipment, its safe function and ultimately the provision of a safe system of work. The design, supply and operation of such equipment is subject to a raft of legislation designed to ensure that, in so far as is practical, the end user is safe from harm. There is a basic premise of competency underpinning this legislation requiring competent design and installation.

Purchasing a biomass boiler is a significant investment and this section of this guide is devoted to the process of procurement. It sets out some basic steps for ensuring that the system built provides efficient and trouble-free operation.

The basic steps for assessing feasibility were set out in section 3 of this guide. A feasibility study is an essential part of understanding whether biomass can be incorporated on any site.

5.1
Who should undertake a feasibility study?

Carrying out a feasibility study that does not involve design beyond basic economic evaluation is not subject to the Construction (Design and Management) (Northern Ireland) (CDM) Regulations 2007 in the UK. Consequently many companies could offer to carry out a feasibility study. However, selecting a party with demonstrable competence is important.

Competence is defined as a mix of theoretical and practical knowledge of the subject, explained as:

- Sufficient knowledge of the tasks to be undertaken and the risks involved;
- The experience and ability to carry out their duties in relation to the project, to recognise their limitations and take appropriate action to prevent harm to those carrying out construction work, or those affected by the operation and use of the plant.

Most competent contractors will be capable of providing all aspects of the feasibility study – including basic financial analysis and the assessments required. The contractor must be competent to conduct design and installation – that is a legal requirement.

It is also a legal requirement that, as a prospective purchaser/operator, you make reasonable effort to ensure that the contractor is competent. This might be evidenced by requiring the contractor to provide a statement of competence, by their capacity to comply with the construction and design regulations and by visiting or examining the contractor's previous installations.

An engineer, an architect or a consultant might, equally, be employed to undertake a feasibility study and conceptual design, but there is the same requirement for competency. It is a legal requirement of the designer to advise the client (purchaser) of their legal obligations under CDM and other regulations.

Likewise the competency of the consultant should be determined, in so far as practical, by consideration of feasibilities, designs or installations for which the consultant was directly responsible.

As a purchaser you have a legal obligation (in so far as is practical) to ensure that the parties you appoint are competent.

Feasibility

Feasibility is discussed in the preceding section of guidance.

5.2
Design and installation

The route selected for design and installation depends on the size of the project. For most smaller installations the Sale of Goods and Services Act 1982) - generally sufficient for contractual protection. Under this Act, if the boiler fails to operate as offered or is subject to an unacceptable degree of breakdown or failure, the contractor could be required, under contract, to remedy, replace, or refund the purchaser. For larger and more complex projects a slightly more complex procurement route and developed terms and conditions of contract will be appropriate.

There are numerous potential contractual arrangements but by far the most common is a turnkey system provision. Unless the purchaser has very specific design skills and is willing to accept the legal responsibilities derived from the CDM 2007 Regulations, then this turnkey approach is the best. The design may still be influenced by the purchaser but the contractor is accepting the turnkey responsibilities. Actually the law requires the contractor to liaise with the purchaser to ensure safe design and site safety.

If on handover the purchaser is intent on operating the plant, then it is incumbent on them to ensure the safety of employees. In turn, this requires that the design, however evolved, and the eventual installation, have been fully assessed and deemed safe by a competent party.

The installer should CE mark the system having conducted electrical safety checks and having conducted a PUWER (Provision and Use of Work Equipment Regulations) assessment to ensure the plant complies with the provision and use of work equipment regulations.

Suitable terms and conditions of contract

5.3
Small and technically simple projects

For most small installations it is typically the contractor that provides the purchaser with a design and installs the system. The contractor is duty bound to meet the legal provisions for design and machinery and equipment standards in the UK, and is required to provide an assessment ensuring the system supplied is safe and fit for purpose.

In commercial non domestic projects, and in limited circumstance, the purchaser may conduct the design and subsequently instruct installation works. However, if the purchaser undertakes the design, he has a legal duty of care as designer with incumbent legal obligations. In-house design and build, or in-house design with third party supply and installation, is not a common or recommended alternative – not least because of the shared responsibilities for reliability and performance.

The installation would have to comply with planning, building control, emissions constraints and other regulatory requirements otherwise the contractor would not have complied with their legal duties of care as defined for a designer. It is important to realise that, whilst it is essential to have procured all planning, building permits etc, some of these will likely require input from a prospective contractor, for example, for chimney height. Where practical, all legally required permitting should be in place before contracting to install. Some contractors will not be aware of their duties of care as designers and this would raise a question mark over their competence.

However, generally the contractor would work to their own standard terms and conditions of contract. These should be read with care to ensure they are acceptable. Notwithstanding any offer of works, performance and reliability will constitute part of the contract made with the contractor. It is therefore essential that as much information as possible regarding fuel, boiler and reliability are established in the letter of offer, for example:

- A full description of the system and its intended function
- The maintenance requirements and the cost of maintenance
- The hours of operation
- The availability
- The fuel
- The fuel quality and methods of establishing fuel quality
- The definition of any allied service works
- The full scope of works under the contract
- The programme of works
- The procedure for disputes
- Details of the guarantees
- A detailed explanation of warranted performance.

The Sale of Goods and Services Act 1982 is a very powerful piece of legislation and it has been used on more than one occasion to have a biomass contractor replace several tens of thousands of pounds worth of equipment. Although there is a reasonable expectation of what a boiler is intended to do, it is easier to enforce remedy if important characteristics are documented as part of the offer – forming part of the contract.

It is important to note that a good letter of offer will protect both the purchaser and the contractor.

5.4
Larger public or private sector projects

As projects become larger (financially) and more complex there may be merit in commissioning third party conceptual and developed designs with a formal specification. This route for development is routinely used throughout the UK for larger projects where the purchaser appoints a third party to perform feasibility, design, specification, tender review and, subsequently, project management, for the purchaser. Historically, this party might have been known as the purchaser's engineer who would provide third party impartial advice. The formal role of purchaser's engineer has all but been subsumed by the provisions of the CDM Regulations 2007. These complex and far reaching regulations place onerous duties of care on all parties including the purchaser.

Notwithstanding this, there is often merit in commissioning an independent third party to provide feasibility, specification and subsequently project management.

Larger projects are inherently still subject to basic consumer laws in the UK but for larger projects it would be typical to develop a set of custom terms and conditions of contract which were somewhat more exacting in definition of plant and contractual performance.

These terms and conditions might typically address:

- General provisions of the contract
- The way in which the contract will be administrated
- Staff and labour, plant, materials and workmanship
- Issues pertaining to commencement, delays and suspension, tests on completion, employer's taking over, defects liability, tests after completion
- Measurement and evaluation or variations and adjustments, contract price and payment terms and schedules
- Termination by employer, suspension and termination by contractor, defaults
- Risk and responsibility, insurance
- Force majeure, acts of God etc
- Procedures for claims, disputes and arbitration.

In the UK the FIDEC (International Federation of Consulting Engineers) model form contracts are used extensively. For most biomass installations the FIDEC short form of contract (Green Book) will be satisfactory. For more complex projects involving extensive multidisciplinary works the FIDEC Yellow Book contract may be more appropriate.

The Institute of Mechanical Engineers also produces what is called Model Form 1, which can also be used for larger and generally more complex projects.

Both of these model forms incorporate standard terms and conditions of contract that have been evolved to provide improved protection. Typically these conditions will allow the rejection of the works in part or in whole if performance cannot be met with mechanism to recover the monies paid through bonds or other stipulated means. The standard forms of contract are typically modified to incorporate special conditions that will allow adaptation for the specific project, the specific client, the financial terms and the performance guarantees.

How will the biomass system be integrated and controlled?

5.5

Conceptual design and project specification

By client choice, or typically for larger or more complex projects, the client's engineer or architect might typically draw up a technical specification and terms and conditions of contract. Together with the form of contract, any warranties and guarantees, bonds and payment schedule these will form the contract documentation.

Contract Type	Recommended Model Form of Contract
Smaller straightforward projects	Green Book (FIDEC Short Form Contract)
Employer/Purchaser /Client's design	Red Book (Conditions of Contract for Construction)
Contractor's design and build	Yellow Book (Plant and Design Build)
Contractor's design, build, own and operate	Gold Book (Design, Build and Operate Projects)
EPC wraps and turnkey projects	Silver Book (EPC/Turnkey Projects)

Figure 2 Conditions of contract

The model forms discussed treat the contractor and the client fairly and are designed to eliminate risk, confusion and conflict, in so far as is possible.

Designers must be competent – this is a legal requirement. For larger and more complex projects it may be beneficial to employ a skilled architect or engineer to provide a design and a specification. If the appointed third party provides a design, then the contract might typically be let as a supply and install contract. Much of the responsibility for correct operation and function would then lie with the architect or engineer.

An improved situation can usually be obtained where the architect or engineer provides the basic feasibility and evolves a conceptual design (observing legal requirements and interactions for the design) and where subsequently a design and build contractor is used to develop and detail the design and install the equipment. Here the architect or engineer may produce a semi prescriptive design and build specification that affords the contractor the largest degree of design innovation and latitude whilst stipulating basic project conceptual minima, performance expectations and design standards.

5.6
Contractual protection

For the majority of projects and particularly where an experienced contractor is used, simple terms and conditions of contract, a developed and clear letter of offer and the Sale of Goods and Services Act 1982 will suffice.

Where the project is complex, of significant financial value, or where there could be contractual complication, it may be necessary to put in place additional contractual protection. For example, a bond may be put in place to cover the costs of plant replacement or remedial works should the contractor default or where the plant cannot be accepted in accordance with the terms and conditions of contract because it does not meet specified performance standards.

In addition to a bond, which may extend through the contract period until the works are taken over and the purchaser becomes the legal owner, there may also be clauses which specify damages for underperformance thereafter. These would be limited to demonstrable liquidated damages.

The standard terms and conditions of contract will require the contractor to have in place third party liability and employers liability insurance and very often to insure the works and materials – usually until handover. For larger or complex projects the purchaser might also consider an ‘all risks’ insurance policy, which will afford additional recourse if the contractor defaults or if the plant underperforms.

5.7
Safe systems of work

The purchaser as an employer has a legal duty of care to ensure that plant and equipment and in particular complex machinery (a biomass system legally constitutes a complex machine) is safe to use and operate.

At the very minimum, the purchaser should expect and require:

- The supplier of a biomass system to be inspected for electrical safety and the installation to be certified as complying with the wiring regulations;
- That the contractor providing the biomass system has undertaken diligent design, ensured that the plant constitutes a safe system of work and has conducted a competent inspection and ensured the plant complies with the Provision and Use of Work Equipment Regulations (Northern Ireland) 1999
- That the entire system (not simply individual component parts) should have been assessed as above and CE marked.

6.0 Health and Safety

This is the most important element of good practice guidance. To date in the UK health and safety in the design of biomass systems has demonstrably not been observed. This is evidenced by fatalities, near misses and property damage from an increasing number of accidents.

Health and safety is governed by law and the process of design evaluation for safety often results in simplified and technically robust design. In many cases designing out hazards may cost a little money up front but will reduce operational and maintenance (O&M) costs in the future.

The legal requirement for best practice in design is, to the best of our knowledge, not adequately addressed in any contemporary biomass guidance with the exception of the Combustion Engineering Association's Health and Safety Guidance which was funded by the Carbon Trust and is available for download from www.cea.org.uk.

6.1
The Principal Legal Provisions

The Health and Safety at Work (Northern Ireland) Order 1978

The intention of this legislation is to secure the health, safety and welfare of persons at work and persons other than persons at work against risks to health or safety arising out of or in connection with the activities of persons at work! That includes the operation of a biomass boiler and all allied fuel handling, fuel delivery, emissions control, ash removal systems and so on. The Order sets out the:

- Duties of the employer
- Duties of the employee
- Duties of the designer/manufacturer:

Specifically, the Order requires the designer/supplier (and this can also be interpreted as the system integrator) to ensure, so far as is reasonably practicable, that the article is so designed and constructed that it will be safe and without risks to health at all times when it is being set, used, cleaned or maintained by a person at work.

Likewise the employer must take all reasonable precautions to ensure the safety of their employees. Employees must not be negligent or contribute to risk.

In simple terms the Health and Safety at Work (Northern Ireland) Regulations 2000 (HASAW) requires all parties to ensure health and safety is incorporated in the design. The phrase 'in so far as reasonably practical' may be interpreted as meaning that all parties have undertaken a robust and competent hazard analysis, eliminated as many hazards as possible through design, and have reduced risk to being as low as reasonably possible.

Note that a manufacturer, supplier or systems integrator has broadly similar duties of care in selling, supplying or installing any equipment to a domestic market.

The Management of Health and Safety at Work (Northern Ireland) Regulations 2000

These Regulations set out more specifically the duties of care of the employer (likely the owner of a biomass system). The Regulations place a duty of care on the employer to have ensured the safety of employees.

In practical terms that means ensuring safe systems of work by eliminating hazard, where possible, and assessing the risk of residual hazard harming employees.

That means ensuring that the biomass system is safe and complies with the Provision and Use of Work Equipment Regulations (Northern Ireland) 1999.

The Construction (Design and Management) Regulations (Northern Ireland) 2007

The Construction (Design and Management) Regulations 2007 are intended to ensure a safe system of work and they apply as much to design as they do to construction. The CDM Regulations place a duty of care for responsible and safe design.

A designer is defined in CDM and is really just about anyone involved in the process of project development beyond basic feasibility and initial pricing.

Many of the potential problems with biomass can be addressed by the application of common sense. Huge lifting roofs for chip or pellet stores for example, must be designed for all environmental eventualities and must be provided with fail safe latching mechanisms.

6.2
Underpinning regulation and best practice

The core enabling legislation and management of safety regulations are underpinned with a raft of regulations that would apply specifically to biomass design. See Figure 3 for examples.

6.3
Approved Codes of Practice for Design (Best Practice)

The regulations governing safety of design, installation and operation in the UK identified in Figure 3 (these are examples only and this is not an exhaustive list) are underpinned by what are referred to as ACOPS or approved codes of practice. These are written by industry experts for the Health and Safety Executives (HSEs) and provide the interpretation of what is minimum best practice.

There is an ACOP for most principal regulations, so for example the Lifting Equipment and Lifting Operations Regulations 1999 might apply to bag delivery of biomass by crane. The ACOP L113 would provide the HSE interpretation of good practice.

When a plant is designed, it is imperative that these regulations and the underpinning ACOPs are observed. Failure to design, install or operate in compliance with specific legal instruction is clearly an offence. Failure to comply with what is considered best practice is not an offence, but the documents constitute the legal basis for any case or claim arising and it is extremely difficult to justify departure from best practice in the event of failure or injury.

Note that these and other ACOPs are available free from the HSE website at **http://www.hse.gov.uk/pubns/books/index-legal-ref.htm**

Example Regulation	Applies to the design, construction and operation of:
The Confined Spaces Regulations (Northern Ireland) 1999	Biomass fuel stores, fuel handling, delivery, pellet storage, silos
The Pressure Systems Safety Regulations (Northern Ireland) 2004	Boiler plant and particularly the potential for over temperature and pressure
The Work at Height Regulations (Northern Ireland) 2007	Loading fuel, underground storage, fuel hoppers
LOLER (Lifting Operations and Lifting Equipment Regulations)1999	Loading fuel, underground storage, fuel hoppers, craned deliveries
Control of Asbestos Regulations (Northern Ireland) 2012	May be relevant for gasket materials and door seals on imported stoves, ovens, water heaters and biomass boilers
Control of Substances Hazardous to Health (COSHH) Regulations (Northern Ireland) 2003	Applies to fuel storage, fuels handling, ash handling, cleaning, water treatment chemicals
The Provision and Use of Work Equipment Regulations (Northern Ireland) 1999	Applies to whole system assessment, applies to individual component assessment
Explosive Atmospheres Regulations (DSEAR) (NI) 2003	Applies to pellet storage and boiler operation, dusty environments
The Manual Handling Regulations (NI) 1992	Applies to ash bin handling, fuel handling, other heavy equipment, water treatment chemicals

Figure 3 Basic H&S legislation

Example Regulation	Relevant ACOP	General ACOP
The Pressure Systems Safety Regulations (Northern Ireland) 2004	L122	L80, L81, L134, L137, L144
The Work at Height Regulations (Northern Ireland) 2007		
LOLER (Lifting Operations and Lifting Equipment Regulations) 1999	L113	
Control of Asbestos Regulations (Northern Ireland) 2012	L127	
COSHH Regulations (Northern Ireland) 2003	Control of substances hazardous to health (Fifth edition) L5 2005	
The Provision and Use of Work Equipment Regulations (Northern Ireland) 1999	L22, L24	
Explosive Atmospheres Regulations (DSEAR) (NI) 2003		
The Manual Handling Regulations (NI) 1992	L23	
The Confined Spaces Regulations 1999	L101	
The Management of Health and Safety at Work (MHSAW) Regulations 2000	L21	

Figure 4 Approved Codes of Practice

6.4
The duties of the designer

Considering and summarising specifically the duties of a designer under the CDM Regulations 2007, the designer must:

- Not commence design work unless the client is aware of his duties under the CDM Regulations
- Avoid foreseeable risks to any person:
- Constructing
- Operating
- Maintaining
- De-commissioning
- Design taking into account the requirements of the HASAW, MHSAW and the workplace Health Safety & Welfare Regulations.
- Provide with the design, sufficient information about aspects of the design of the structure, its construction or its maintenance to assist clients, other designers and contractors to comply with their duties under the CDM Regulations.

6.5
Who is legally a designer?

Anyone who has the capacity to materially influence design is legally a designer – that might include

Architect	Functional and building use - ease of construction and maintenance, Ergnomics
Building Services Engineer	Functional control, safety interlocking, safety systems
Civil Engineer	Ground conditions, physical influences
Structural Engineer	Adverse or emergency conditions, containment
Mechanical Engineer	Functional control, safety interlocking safety systems
Surveyors	Value engineering may compromise safety
Design and build Contractors	Product knowledge, CE marking, site specific application
Anybody with the authority to specify or alter	Regulatory authorities also
The Client where he influences design	Client led value engineering or cost cutting
Environmental Engineers	Emission dispersion modelling, Environmental impact assessment

Figure 5 Legally Designers

A designer may categorically not rely on the manufacturer's instructions as providing a safe or relevant safe system of work. It is a duty of care of the designer to have ensured that manufacturer's operational and maintenance instructions are relevant, appropriate and adapted, amended or written given the specific utilisation and application of the equipment concerned.

Designing to a known standard does not guarantee a safe system of work. Appropriate risk assessment is expected. It is thus not sufficient in a risk assessment to simply note that a system complies with a known standard unless that standard is a safety standard.

6.6
What is the difference between a hazard and risk?

Very simply a hazard is something that is always present. In the case of a biomass boiler, high temperatures present a hazard. Risk is the possibility of that hazard causing harm.

It is not possible to design out all hazards – rotating machinery may be a hazard but the augers are required to transfer fuel. However, the risk of harm being caused by the auger can be reduced to the practical minimum by:

Physical control measures

- Preventing the access of unauthorised personnel
- Ensuring that fall shafts and auger entries are physically guarded to prevent the insertion of limbs
- Using trip switches to isolate augers if access panels are opened
- Using wire trips where appropriate
- Providing inverted reversible drives
- Providing emergency stop buttons
- Fitting local lockable isolators
- Fitting visible isolation detection

Procedural control measures

- Requiring permitted maintenance procedures
- Requiring electrical lock off for maintenance
- Testing electrical lock off before the commencement of work
- Providing comprehensive training

6.7
How is safe design accomplished?

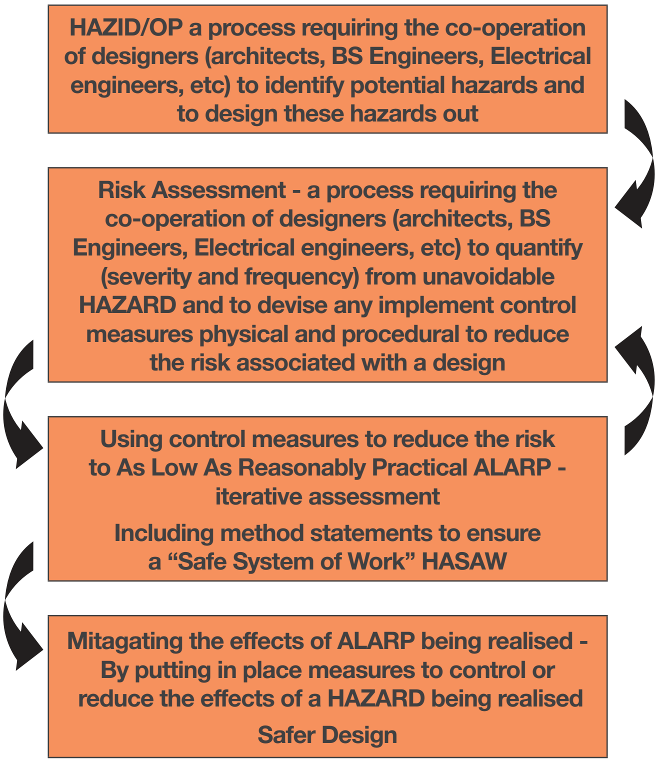
If we were to now consider a typical biomass system we might encounter hazards in the:

- Fuel delivery
- Fuel storage
- Combustion
- Emission control
- Steam or hot water generation
- Heat distribution equipment
- Ash handling
- Water treatment.

The premise of legislation in the UK is to avoid hazard by designing it out and replacing unsafe with safer at all stages of design.

That process requires structured and robust hazard analysis, elimination and subsequent risk assessment to assess the severity and likelihood of any remaining risk being realised. The process must be adapted to suit the scale of the project – so small, less complex projects will require relatively simple hazard identification and risk assessment.

The process is easily explained in Figure 6.



HAZID/OP a process requiring the co-operation of designers (architects, BS Engineers, Electrical engineers, etc) to identify potential hazards and to design these hazards out

Risk Assessment - a process requiring the co-operation of designers (architects, BS Engineers, Electrical engineers, etc) to quantify (severity and frequency) from unavoidable HAZARD and to devise any implement control measures physical and procedural to reduce the risk associated with a design

Using control measures to reduce the risk to As Low As Reasonably Practical ALARP - iterative assessment

Including method statements to ensure a "Safe System of Work" HASAW

Mitagating the effects of ALARP being realised - By putting in place measures to control or reduce the effects of a HAZARD being realised

Safer Design

Figure 6 The process of risk management

7.0 Fuels and Fuel Handling

7.1

What forms of wood fuel are there?

Wood fuel is supplied in many forms, from baled forest brash to pelletised core wood. Commercial wood fuels generally are supplied in three forms – as logs, as chips or as pellets. It may also be possible to secure supplies of wood waste such as joinery or sawmill off cuts as strip wood, sawdust or block.

All of these fuels have differing handling and combustion characteristics. Sawdust and particularly course softwood dust is especially hard to handle and charge to a boiler. However, there are specialist designs for these fuels. This guidance focuses on two key fuel types, namely chipped wood and pellets.

7.2

How does biomass burn?

Wood, like any other solid fuel, burns by initially thermally decomposing – a combination of gasification and pyrolysis. The volatile components, gases and tars driven off during this initial stage of combustion, produce heat as they ignite and burn which continues the process. When the wood has reached sufficient temperature all the volatiles are burned off and the remaining carbon is burned in oxygen to produce carbon dioxide.

The combustion of a solid fuel relies initially on this pyrolysis and gasification and if the wood is very wet it will also be necessary to use some heat to dry the fuel. That heat has to be continuously stored and recovered from the furnace and for very wet fuels (more than 30% wet weight) the furnace has to have a substantial thermal inertia requiring a lot of heat storing refractory. For very dry fuels, for example pellets, the amount of energy required for drying is low and refractory is only required to prevent heat transfer to the structural components of the boiler and for retaining safe external temperatures.

The process of combustion is one of thermal decomposition and oxidation, the latter being exothermic. The process of combusting a solid fuel is somewhat different to that of an oil or a gas, for unlike a liquid or gaseous fuel, the fuel cannot be readily mixed with air and the transfer of heat between particles or components of fuel is less predictable. In liquid fuels, for example, the flame front around a droplet can be modelled and the rate of heat transfer to an adjacent droplet can be calculated.

A solid biomass fuel burns by first thermally decomposing to produce volatiles that are driven off from the surface and then ignite and burn around the solid particle. The heat released continues this process. Solid carbon and mineral contents may glow or oxidise with a very homogeneous and exothermic conversion of carbon to carbon monoxide and then to carbon dioxide in an oxidising air flow, with correct air management that has the potential to reach extremes of temperature. The combustion of volatiles is essentially that of a gas or vapour.

Biomass and particularly wood, has relatively low carbon content and high volatiles content.

Unfortunately the char produced as a biomass particle is burned typically acts as an insulator preventing heat transfer from biomass particle to biomass particle. Finer particle size improves combustion to an extent – but when the particle size is reduced to 2–3mm the bulk density increases and the inter-particulate space reduces and the material becomes difficult to burn.

In simplest terms it is difficult to set light to a tree with a match and it is equally difficult to set fire to a pile of sawdust. However, kindling will produce a sustainable fire with a match. The mechanics of the actual combustion process are important in understanding how to burn this specific fuel. Most biomass fuels will benefit from either mechanical agitation or partial fluidisation with a combustion airflow – this in addition to providing the air required to burn off the volatilised components.

The process of combustion takes place in three phases. Considered elementally these processes occur sequentially, however the process occurs over different timescales for different elements of the fuel charge and at different locations in the fuel bed. Although there is a logical process flow, these processes of combustion are occurring simultaneously.

Drying – The fuel charged to the boiler will almost certainly have physically bound (surface and trapped) moisture content. This must be dried from the fuel before combustion takes place. Water boils at 100ºC and where significant quantities of wet fuel are charged, the temperature in the furnace may temporarily reduce with associated smoking as the fuel dries. This is often the opposite of what was intended by charging the fuel. The drying airflow need not have a high oxygen content and may be usefully circulated from another part of the furnace.

After the fuel has dried, the processes of pyrolysis and gasification take place releasing a range of liquid, vapour and gaseous intermediates, including tars, creosotes and furfurals. If combustion is not completed these are visible as smoke.

The fuel is finally reduced to char – a form of largely carbon and inorganic ash constituents which decomposes with oxygen to produce carbon monoxide and carbon dioxide. The carbon burn out produces some radiant heat. However, much of the radiant heat produced must be reinvested in drying and pyrolysis within the combustion space and is not usually recovered for useful heating in the biomass boiler – for example, it maintains furnace space temperature.

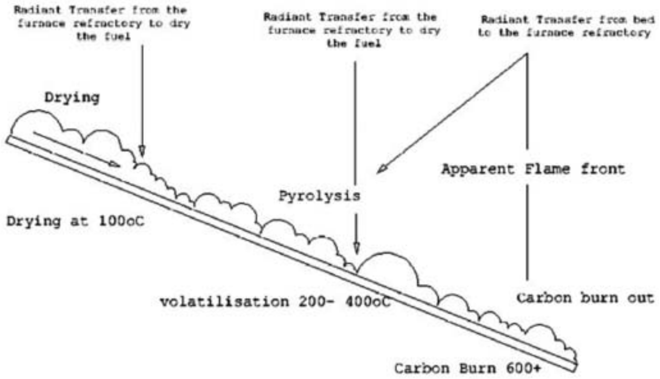


Figure 7 The process of biomass combustion

The bulk of the heat produced and usefully recovered is from the subsequent combustion of the vapours and gases produced by the enforced volatilisation of the fuel. The limit of this is usually associated with a visible flame front. The heat is then removed by passing the hot gases of combustion through the heat recovery tubes of a boiler. The primary mode of useful heat transfer is therefore forced convection. So some of the heat generated by the combustion process is re-invested in the processes of drying and pyrolysing and is thus consumed to sustain the fire.

Once wood chars, the heat transfer from flames to the wood reduces and the amount of gas driven off reduces. To keep the fuel burning it is sometimes necessary to agitate or turn the fuel to maintain the exposure of unburned surfaces. This can be achieved by agitating or moving the grate, which also has the benefit of moving ash. Moving grates are best for wetter fuels and offer versatility – but likewise they may be used for dry pellet fuels.

Figure 8 The step grate

So for wetter fuels thermal properties of the furnace dictate the responsiveness of the furnace and it follows that wetter fuels offer less load following flexibility than dry fuels. Fuel choice dictates the type of equipment that will be used to burn biomass and the flexibility of the system. Wetter fuels require a larger refractory mass and the fuel must usually be agitated. Dry fuels such as wood chips of less than 30% moisture content may typically be burned in a pile (although moving grates offer many other advantages) and offer much higher flexibility in terms of load following, turn down and system integration.

Logically, it follows that wet fuels are better suited to large stable load profiles whilst dry fuels, offering greater flexibility are suitable for smaller less stable loads. This is discussed in more detail in subsequent sections of the guide.

7.3
Is biomass easy to burn?

The short answer is yes. However, the correct fuel, equipment and commissioning is required. The bulk of combustion problems arises from two key issues, namely:

- Clinkering or slagging
- Heat exchanger or chimney fouling.

Heat exchanger fouling generally results from one of two principal mechanisms. The first is the condensation of tars and other heavy volatiles on the relatively cold heat exchange surfaces or flue linings.

This is more likely to happen with wet fuel, poor combustion control and intermittent loads where the furnace is starved of air to reduce output. To a great extent these problems can be eliminated by selecting the correct fuel for the load, sizing the boiler plant appropriately, and buffering the load so as to allow the biomass plant to run efficiently at higher fire rates. Of course, this is not always possible, so good routine cleaning and maintenance are part of the equation.

The gases evolved during combustion will burn at an extremely high temperature and if sufficiently high the mineral content of the ash will soften and clinker will form; as the ash continues to melt a liquid slag will form. The formation of clinker and particularly slag will cause damage to the grate, refractory lining and ash removal systems, quickly preventing the proper operation of the boiler plant.

In clean wood fuels the presence of lignin (naturally present at higher concentrations in the bark) contributes to reduced mineral melting softening and melting points. Contamination with silica and other soil borne products may cause excessive wear in handling and combustion plant and the volatilisation of metal salts at high furnace temperatures (potassium and sodium salts) will cause rapid heat exchanger corrosion.

To eliminate some of these problems refer to European standards for wood fuel.

7.4
What standards are there?

Wood fuel has been used across Europe for many years and national standards have been evolved to describe such attributes as size, moisture content, fines content, and mineral content. The European Union set up a technical committee TC335 which has evolved or adopted a suite of national and self developed standards that cover everything from tree type to mineral content, fuel chip size to the diameter of logs. Although some fuel suppliers, particularly pellet suppliers, conform to standards, the supply of wood chip remains less conforming. So care must be taken to ensure, in so far as is practical, that the fuel meets your requirements.

The CEN/TC 335 adopted a range of standards. The CEN TS/ 14961:2010/12 (Parts 1 through 6) standard provides a definition (For wood chip briquette and pellet fuels) of:

- The origin of the material
- The size of the material
- The physically bound water content
- The ash content.

The suite of other CEN/TC adopted standards provides a means of defining ash characteristics, chlorine content, bulk densities and many other interesting factors, but the overarching 14961 provides basic parameters which most fuel suppliers can comprehend and provides a basis for classification and standardisation. For most fresh wood derived products this is adequate.

In the context of wood pellets there is also the EnPlus standard – EnPlus is simply a trade mark owned by the European Biomass Association. The ENplus standard meets CEN/TS EN 14961-2 and additional stricter criteria. The quality standard assures low emissions and high energy value. For all practical purposes CEN/TS EN 14961 is quite adequate.

The size, moisture content, fines content and mineral content are all relevant and important to the fuel choice and the boiler or furnace choice as is discussed in the subsequent sections of this guide.

7.5
What is the best fuel to burn?

Fuel availability – to a large extent this is dictated by what fuel is available! You may not have the choice. In Northern Ireland there is a stable supply of wood pellets and a growing supply of fresh wood chip from various suppliers. A smaller amount of Grade A or clean recycled wood is available.

Plant size – the physical size of the boiler/furnace is also relevant for, as previously described, the smaller boilers rely on very consistent fuel quality for stable operation. The physical space available for storage or site fuel storage and delivery restriction will have bearing on the best type of fuel.

Emissions restrictions – will also dictate the type of fuel that you can burn. For smoke control areas, the fuel must be certified as suitable for a smoke control area. Generally fresh wood pellets and fresh wood chip are certified for these areas.

Financial incentive – may influence what you burn to qualify for the Renewable Heat Incentive (RHI). Biomass boilers <20MW will shortly require a certificate from a test house accredited to ISO 17025 for tests to prove emissions compliance. The certificate must show that the boiler can comply with emissions limits of 30g/GJ net for total particulate matter (PM) and 150g/GJ net for NOx – the RHI emissions certificate. This will prevent most straw burning and many waste wood burning plants from receiving the RHI.

Space restriction and storage options – will almost certainly influence fuel choice. If the boiler can only be located inside a building and there is little space for fuel storage, a sensible option may be pellets. However, if the boiler can be located outside the building and there is adequate space for fuel tipping it might be more cost effective to use chips.

Fuel cost – this reflects the effort involved in preparation of wood chip that is dried to 30% moisture content and of homogeneous size. It is easy to burn but the supplier has incurred processing cost and this will be reflected in the cost. Pellets are really easy to handle but have a relatively high production cost so are more expensive.

7.6
What is the energy content of the fuel?

The energy content of fuel is the single most misunderstood aspect of biomass and it is worth expanding on this aspect to give the reader a sound understanding.

In referring to a fuel's energy content the terms net and gross calorific value (CV) are routinely used. Gross CV refers to all of the chemical energy in the fuel that will be released by combustion. It is the sum of all exothermic (heat producing) reactions.

Wood is a complex structure of organic polymers. These polymers consist largely of carbon and hydrogen. When the wood is burned (even when the wood is bone dry) the hydrogen forms steam which has high energy content. In most circumstances that steam is exhausted from the boiler and is often apparent as steam in the flue emission.

Generally it is not possible to recover the heat produced when the hydrogen in the fuel burns because this produces water vapour (steam) and the heat is removed from the furnace. Hydrogen related losses reduce the energy that can be effectively or practically recovered from the furnace. If these losses are deducted from the gross CV a more practical assessment of the fuel's useful energy is obtained. This is called the net CV.

The difference between net and gross CV is the amount of energy produced as steam or water vapour and is solely dependent on the hydrogen content of the fuel.

Often of course the wood fuel also contains water within the cell structure or as surface moisture. In fact, fresh wood chip may contain up to 60% water by wet weight. This water is also driven off as steam and, just like boiling a kettle, a large amount of energy is used to boil and evaporate this water. If the energy required to boil the water is also taken into account then this further reduces the energy that is practically available for useful heating in the boiler.

The useful energy in a bone dry fuel is the net CV. From this deduct the energy required to boil any water that is trapped in the chip. The remaining energy is termed 'net as received' and is the gross energy net of hydrogen and water losses. This is abbreviated as NAR CV. The wetter the fuel, the lower the NAR CV.

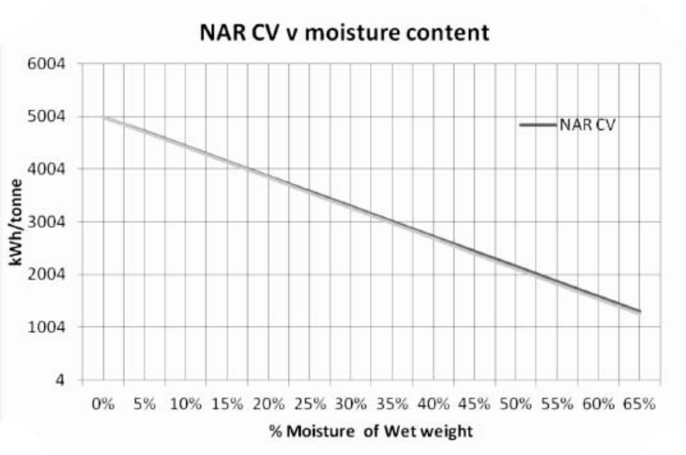


Figure 9 How moisture content affects calorific value

This is important because it affects the energy content per unit weight and it will affect the design of the boiler as previously described. Net CV is calculated as the gross CV less the evaporation energy at a specific reference temperature, normally 25ºC (but sometimes 22ºC and 15ºC are used).

Although net CV is much more useful in understanding how much useful heat will be released to the furnace, the physical water vapour will generally be evaporated at 100ºC (because most furnaces operate at atmospheric pressure) and indeed hydrogen fuel content will form water as superheated steam. These factors reduce the practical amount of heat recoverable below that of the net CV or NAR by a small margin. For most furnaces operating with an exhaust gas temperature of in and around 200ºC Figure 9 can be used to evaluate the NAR and the net recoverable energy.

The calorific value of wood varies with species but the approximate gross calorific value is 19.3GJ/tonne on a dry gross basis and approximately 18GJ/tonne on a dry net basis.

When you purchase wood fuel, the chips and pellets are usually sold by the tonne and not by the energy content. It is therefore essential to understand the energy content relative to moisture content. Figure 10 will help you compare wood fuels at different moisture contents.

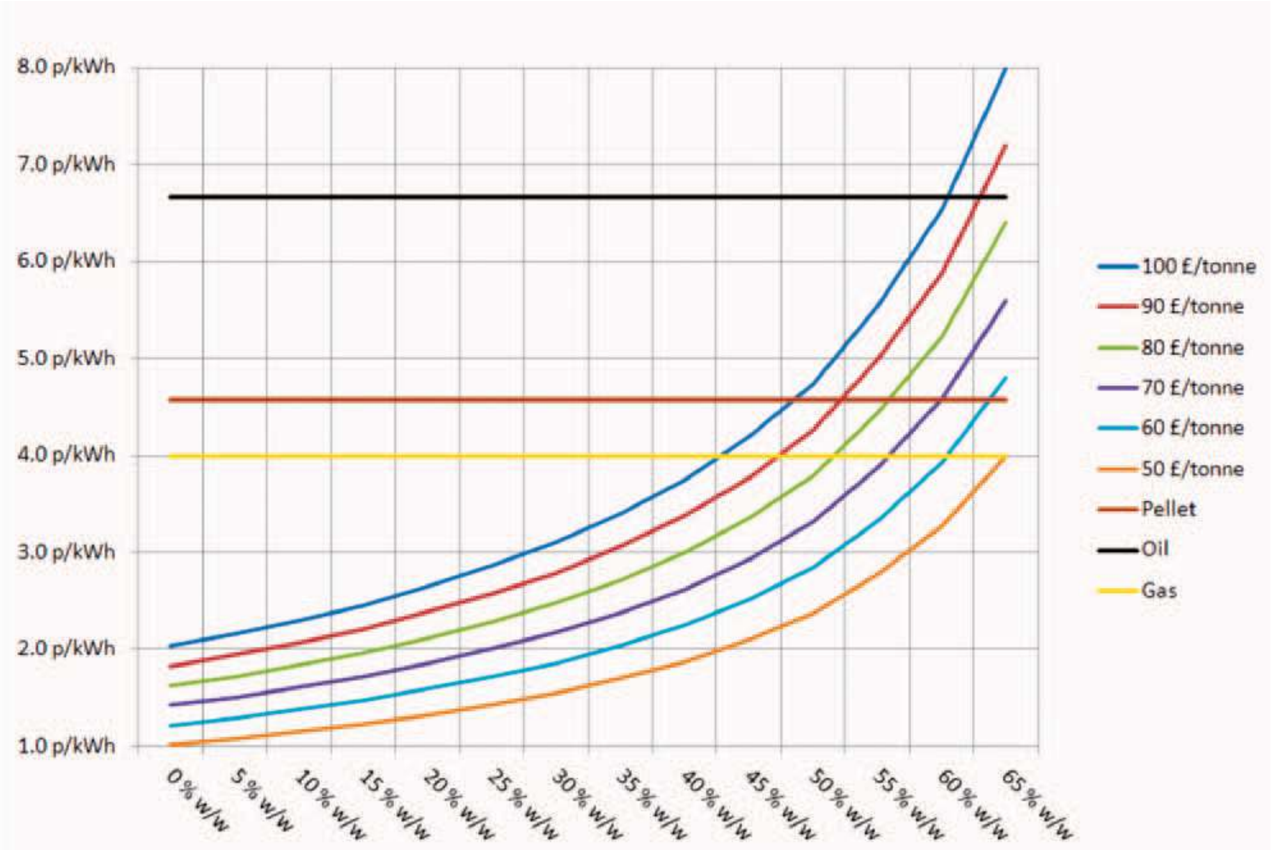


Figure 10 Comparing fuel costs

Figure 10 shows that buying a tonne of wood chips at 50% moisture content for £50/tonne would be the same price per kWh as a tonne of wood chips at 30% and £80/ tonne.

Pellet wood fuel – meeting CEN/TS EN 14961 or EnPlus standard – will have an energy content of not less than 16.5GJ/tonne or 4,583kWh/tonne (more generally 4,800 kWh/tonne) and pellets at £220 are super-imposed to allow comparison of pellet prices with wood chip.

	£100.00 /tonne	**£90.00 /tonne**	**£80.00 /tonne**	**£70.00 /tonne**	**£60.00 /tonne**	**£50.00 /tonne**
0%	2.0	1.8	1.6	1.4	1.2	1.0
5%	2.2	1.9	1.7	1.5	1.3	1.1
10%	2.3	2.1	1.8	1.6	1.4	1.1
15%	2.4	2.2	2.0	1.7	1.5	1.2
20%	2.6	2.4	2.1	1.9	1.6	1.3
25%	2.9	2.6	2.3	2.0	1.7	1.4
30%	3.1	2.8	2.5	2.2	1.9	1.6
35%	3.4	3.1	2.7	2.4	2.0	1.7
40%	3.8	3.4	3.0	2.6	2.3	1.9
45%	4.2	3.8	3.3	2.9	2.5	2.1
50%	4.7	4.3	3.8	3.3	2.8	2.4
55%	5.5	5.0	4.4	3.9	3.3	2.8
60%	6.5	5.9	5.2	4.6	3.9	3.3
65%	8.0	7.2	6.4	5.6	4.8	4.0

Figure 11 Fuel Cost Calculator (p/kWh)

7.7
How do I compare the energy content with oil or gas?

Gas oil has approximately 10.5kWh/litre and currently costs 70p/litre or very approximately 6.6p/kWh. Heating oil or kerosene has approximately 10.2kWh/litre and costs approximately 62p/litre or 6.07p/kWh.

7.8
How should I purchase biomass fuel?

If you are buying pellets and these are certified to CEN/TS EN 14961 or EnPlus standard then there is some certainty about what is being purchased. However, it is important to ensure that the fuel has not absorbed water for this will quickly degrade it. Committing to biomass requires a significant investment in the boiler plant and it is important that, having made that investment, the fuel price continues to provide a competitive margin over oil or gas.

Converting to biomass is to an extent protected by the provision of the RHI, but pellet supply is not as regulated as gas and it is important to protect against price rises. So price indexing is important.

Price indexing is simply a mechanism that limits the price increase that the supplier can apply over the contract term to cover inflationary increases. Biomass offers an alternative to oil and gas and it is therefore logical to set the inflationary index against these alternates and part potentially against the Retail Price Index. Using crude and gas spot price indices is largely unrelated in both geography and time frame to the price in Northern Ireland.

A solely CPI based arrangement may be acceptable, or a fixed and agreed annual percentage increase may be acceptable.

It is important to base the indexing mechanism on indices that can be readily identified and checked and that are relevant. For example the CPI reflects a basket of inflationary indices and is easily determined from the Government’s web site. It is relatively simple to get three quotes for oil supply or indeed quotes for gas price. Whilst other formal guidance suggests the use of crude indexing and spot gas prices, these do not often reflect what will actually prevail in Northern Ireland.

Given that water makes such a large difference to the potential recoverable energy content it is important to understand what you are actually buying. The fuel delivered should be tested, but determining moisture content is not as easy as it might seem. For large purchases the most reliable method of testing the moisture content is to take several samples (agreed as representative) and to oven dry these until there is no further weight loss. The moisture content can then be determined accurately and price adjustment made.

For smaller samples and ready reckoning then a capacitive moisture meter may be used. However, it is important to realise that most handheld probe type meters are not sufficiently accurate and a calibrated capacitive meter is required.

Some further guidance on contracts and contract templates may be obtained from **http://www.carbontrust.com/resources/guides/renewable-energy-technologies/biomass-heating-tools-and-guidance#biomass-templates**

7.9
How is wood fuel delivered?

Fuel delivery and storage are the two most troublesome aspects of biomass. Delivery is troublesome because it generally entails the movement of heavy vehicles, manoeuvre in restricted space or operations that would fall under the Lifting Operations and Lifting Equipment Regulations 1999. Storage has allied fire, explosion, and health risks and most fuel stores will fall under the provisions of the Confined Spaces Regulations 1999. Refer to the **http://www.cea.org.uk** guidance downloads.

Wood chip can be tipped or delivered by push trailer either onto hard standing and subsequently moved, or tipped directly into a fuel hopper or underground fuel store. Vitally there are safety implications associated with these operations and we refer you to the CEA guidance.

For smaller wood chip deliveries there is the potential for bulk bag delivery. Polypropylene bulk bags of 1m^3 or larger can be used and the contents emptied directly into the fuel hopper using bottom tied bags.

Wood chips can be mechanically conveyed via auger, chain paddle or elevator conveyor. However, extended routes are undesirable because of the potential for blockage. Pneumatic transfer of wood chip is possible but noisy, very time consuming and not recommended.

The shape and size of the wood chip is important. If the fuel is chipped fresh wood, then the chip size is homogeneous and handling in auger, chain paddle and so on can be effected generally without much difficulty. If the wood is shredded, recycled wood, it splinters and contains longer shards and is irregularly shaped which will cause auger blockage – chain paddle is always recommended in these circumstances. Shredded waste wood typically contains a large fines percentage and this gives rise to a significant dust and mechanical abrasion problem.

Pellets may be delivered by simple tipper, pneumatically blown, vacuumed, bagged or other. The opportunities for pellet delivery are far superior and pneumatic transfer can be achieved over some considerable distance efficiently, typically up to 20m where site access is restricted. Where pellet storage cannot be located beside the boiler plant it can be located remotely and the pellets transferred from a larger remote store to a boiler day bin. This can be fully automated.

The pneumatic transfer of pellets generates static charge. Wood dust can explode under some concentrations and the delivery of wood pellets requires careful electrical earthing and design. In practice this is simple to achieve but important not to overlook.

Lifting lids or roofs and underground storage are all possible and architecturally very satisfying but lifting lids will slam shut in the wind, high level access will be dangerous in wet and windy weather, underground storage will flood and may also present a work at height risk. This must be considered in the design of the delivery system.

Once a fuel is selected and storage is assessed (refer to the earlier section on feasibility) the most important factor is to ensure the simplicity and safety of the delivery system (refer to the section of this guide on health and safety in design). It is a legal requirement that the designer consults with the fuel supplier and the end user and determines a safe system of fuel delivery.

7.10
How do I store wood fuel?

There is a wide range of options for fuel storage. Where wood chip is used for smaller installations, a metal hopper with auger extraction and internal agitation may be used. With fresh wood chip, the propensity for bridging is very much reduced but this sort of arrangement is unsuitable for shredded waste woods. Such hoppers are really only suitable for above ground solutions of relatively low volume – for example less than 10m^3. Tipped delivery is difficult unless the tipping trailer is higher than the delivery point, the store is built in to rising ground or there is a ramp access. Although ramps and other such mechanisms have been used widely, the safety of these arrangements for a reversing truck is questionable and a full design risk assessment and PUWER assessment is legally required. Delivery by bag and crane can be accomplished safely for smaller volumes – however, again it is essential that safe delivery procedures are evolved.

For larger chip storage options the construction of a shed or silo is probably required. The most common arrangements for chipped storage incorporate swept floors and walking floors to remove the chip.

In the swept floor a rotating head with sweeping arms is submerged beneath the fuel pile. The arms are rotated by low ratio gear box and the circular sweep motion of the arms beneath the pile agitates and moves fuel to an extraction slot in the floor of the fuel store and into a primary transfer auger which removes the fuel. Swept floors are generally suitable for large fresh wood chip boilers but unsuitable for shredded waste wood.

Figure 12 A swept floor

Figure 13 A walking floor

With a walking floor a series of reciprocating combs are driven back and forth under the fuel pile and as the combs return from the driven position these will push or pull fuel toward and into a cross auger which removes the fuel to the boiler. This arrangement is far superior for large fuel stores and for fuels which are non homogenous such as waste wood or refuse derived fuels. However, walking floors are extremely versatile and are used even at very small scale.

Underground storage does provide ease of delivery – however, if components of the extraction system fail it can be expensive and awkward to dig the fuel out in order to access those components. The risk of fire and the method of fire fighting must be considered. Chips and pellets can be stored underground – pellets using specialised waterproof containers. Consideration must be given to flooding and other water ingress as this causes severe operational problems.

All types of fuel storage present hazards. Large piles of wood fuel are of course a fire hazard and suitable locations for the fuel storage must be considered carefully, not solely from the perspective of easy delivery but from that of fire hazard.

The bulk density of the fuel may change very significantly with varying moisture content and consideration must be given to the dead weights and dynamic loads that will be posed by the fuel and the delivery or extraction of the fuel. A store designed for wood chip will not necessarily carry the weight of the same volume of pellets because there is a significant difference in bulk density and imposed lateral load.

The fuel storage will very likely be connected to the combustion appliance and as such there is a risk under varying ambient pressure conditions for the back draft of carbon monoxide. (Biomass boilers will operate at times with carbon monoxide levels in excess of 100 times those of a gas or oil fired boiler.) In all circumstances unauthorised and unsupervised entry to a fuel store must be prohibited and reasonable precautions taken to prevent such entry. Entry into any fuel store (an enclosed space connected to a combustion appliance) must be undertaken after ventilation and risk assessment, in accordance with the provisions of the Confined Spaces Regulations, and in observance of the supervisory and escape procedures defined therein.

Wood dust is an explosion hazard and a COSHH hazard. The Dangerous Substances and Explosive Atmospheres Regulations 2003 (DSEAR) apply to the storage of wood pellets and to arrangements where dust accumulation could present an explosive atmosphere. Special provisions for pellet storage are required.

You should always refer to the **http://www.cea.org.uk guidance downloads**

7.11
What size of wood fuel store do I need?

The size of fuel store will often be dictated by the space that is available on site. If there is insufficient space it may be impractical to opt for biomass – remember that many sites in urban areas were designed around piped fuel or convenient oil storage. The physical space required for storage can be considerable; at relatively low bulk densities a tonne of wood chip may occupy $3.5m^3$ and deliver the equivalent of 300 litres of oil, so taking up much more than 10 times the space required for oil. Notwithstanding the site restrictions that might apply to storage, consideration must be given to the frequency of delivery. Whilst it is acceptable to have oil delivered perhaps even fortnightly for some commercial buildings it is likely that solid fuel delivery will generate more dust and noise and frequent deliveries will not be as acceptable.

Where practical, the fuel store should be sized to limit the number of deliveries, particularly the winter deliveries that might be irregular or weather dependent.

Because bulk delivery is always cheaper, best practice will be to weigh the advantage of reduced delivery times with reduced cost, against the physical difficulties of large scale storage and delivery (and allied risks of fire etc). In practical terms it might be appropriate to hold a maximum of three or four weeks of storage for peak consumption periods where on-site space allows.

7.12
Health and safety in fuel delivery

Considering fuel delivery alone:

- Can the delivery vehicles arrive and discharge fuel safely?
- Are there overhead power wires?
- Does the driver know where pedestrians are and are they safely excluded from the delivery site?
- If an underground store is used, is the truck prevented from reversing into the hole?
- If a ramp is used what has been done to stop the truck slipping of the side of the ramp?
- Have adverse weather conditions been considered?
- Has the change in the delivery vehicle's centre of gravity been considered?

In most cases biomass is going to require some traffic and delivery consideration. The impact on off-site traffic flow may have to be considered and certainly the safety of the operation on site must be considered.

Common sense would tell you not to locate a fuel hopper under an 11kV power line where the delivery is by bulk bags and a lorry mounted crane – yet it has been done.

In some cases fuel can be transferred pneumatically. Pellet deliveries require special consideration. To keep the pellets in fluid and mobile for pneumatic deliveries, the air velocity will be approximately 15 to 30ms-1.

Even with short transfer systems there will be some dust generated –cellulosic dust. That dust will present a health hazard and potentially an explosion hazard. All available indications are that a suspension of more than $39g/m^3$ may be ignited to provide a very rapid conflagration or indeed explosion. Several pellet plants have been lost and there have been instances of pellet store explosion.

Pellet dust has a high explosion index value (Kst value). This means wood dust presents an explosion risk. Fine sanded hardwood dust presents a significantly greater problem than rough soft wood dust. The origin and size of the dust are relevant. Dry sawdust is a problem and pellet dust is likely to be a problem – but the larger fines associated with wood chips are much less likely to cause a problem. A risk assessment is the best way of identifying any problem.

The delivery system must be earthed and provided with equipotential bonding to prevent the risk of spark from static accumulation.

The delivery truck must be earthed to the delivery system.

Pellets delivered should be arrested by impact absorbing rubber sheet or plate and not blown against a hard wall to cause fracture and dust.

7.13
Health and safety in fuel storage

Most fuel stores will constitute a confined space. Certainly underground stores and containerised fuel storage solutions are categorically confined spaces.

A confined space need not be completely enclosed like a hopper or a silo – it is simply a substantially enclosed space where hazardous conditions might arise.

No one should enter a fuel store without:

- Good reason
- Being authorised
- Having ensured it is safe to do so.

For detail you should refer to the provisions of the Confined Spaces Regulations 1999.

Moreover, access to a fuel storage area should be secured and noticed. Inadvertent access must be reasonably prevented.

In many instances the fuel store is connected to the biomass boiler via one or more auger pipes. Under certain draft and fire conditions is it quite possible for combustion gases to leak back to the fuel store.

The process of combusting wood has an intermediate step of carbon monoxide production. Although complete and theoretical combustion should not be allied to particularly high levels of carbon monoxide, high values can readily be produced at low fire, for example, values greatly in excess of 3000ppm.

Regulation 5	**Confined Spaces Regulations “Arrangements for Rescue”**
Concentration	**Symptoms**
35 ppm (0.0035%)	Headache and dizziness within six to eight hours of constant exposure
100 ppm (0.01%)	Slight headache in two to three hours
200 ppm (0.02%)	Slight headache within two to three hours; loss of judgment
400 ppm (0.04%)	Frontal headache within one to two hours
800 ppm (0.08%)	Dizziness, nausea, and convulsions within 45 min; insensible within 2 hours
1,600 ppm (0.16%)	Headache, tachycardia, dizziness, and nausea within 20 min; death in less than 2 hours
3,200 ppm (0.32%)	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400 ppm (0.64%)	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800 ppm (1.28%)	Unconsciousness after 2-3 breaths. Death in less than three minutes.

Figure 14 The toxicity of carbon monoxide

Gas leakage, evidenced by the smell of wood smoke or traces of smoke sometimes is the usual cause of carbon monoxide build up.

However, there is a more insidious and less well known, but equally fatal, cause of carbon monoxide and methane build up and that is the decomposition of fatty acids (aliphatic acids) in the lignin which produce carbon monoxide and methane based products, which will constitute a severe health hazard and could constitute an explosion hazard.

Regular maintenance is required inside fuel stores. How is that to be achieved safely? The answer is by following proper and evaluated procedures.

1	Define the confined space category
2	Identify the person in charge
3	Ensure a safe system of work
4	Pre entry checks
5	Formal training
6	Ensure the provision of PPE
7	Emergency and rescue arrangements in place

Figure 15 Confined spaces prerequisites

Pre entry checks would include:

	Confined Spaces Regulations “Arrangements for Rescue”
1	Communications procedures
2	Team composition
3	Equipment and PPE
4	Ventilation
5	Barriers
6	Warning signs
7	Mechanical and electrical isolation
8	Atmosphere checks
9	Training checks

Figure 16 Confined spaces arrangements for rescue

Entry into large contained pellet storage will require carbon monoxide detection, pre-ventilation and rescue procedures to be in place.

The application of common sense is required - AND if you are operating a solid fuel boiler, carbon monoxide detection in the store and the boiler house is good practice – but always in addition to good ventilation.

Since we have already raised the issue of dust explosion and the potential for the presence of combustible gases, it is appropriate to consider this in the use of fixed and portable electrical equipment.

Pellet stores can potentially produce large volumes of very fine dry dust and this accumulates over time. There is a higher risk of explosion and you should refer to existing HSE guidance on explosive dusts which references wood dust and a Kst of approximately 130.

Again the formal application of common sense by risk assessment is appropriate.

The provisions of the Machinery Safety Directive, Provision and Use of Work Equipment Regulations and the Supply of Machinery (Safety) Regulations 2008 and the related HSE guidance dictate the requirements for the safety of equipment.

The transfer augers are very powerful and cannot make a distinction between chips and a hand. All mechanical systems should be interlocked to access doors. All systems should be electrically isolated and locked and verified as inoperable, (particularly if neutral connections are not switched) to ensure maintenance safety.

Full written and risk evaluated procedures must be produced and adhered to. Equipment that starts intermittently is particularly high risk because persons may be tempted to intervene whilst the equipment appears dormant. The use of machinery guards, interlocks, infra red and safety wires must be considered.

However, the fundamental requirement is to design to mitigate risk to the lowest practical level.

8.0 Boilers and Grates

The variety of boiler designs is perhaps only matched by the number of fuels that could be burned in them. In this guidance we have had to make some generalisations. The size ranges given are not definitive and in all cases a careful evaluation would be required.

In section 4.0 of this guide the relationship between the moisture content of the fuel and refractory mass is discussed. The wetter the fuel the more refractory mass is required and the bigger and more expensive (typically) the boiler becomes.

It is possible to run very small boilers on wood chips, but generally at the small scale these chips have to be very dry – less than 30% moisture content. At or below 50kW the cost of a wood chip boiler installation cannot usually compete with a pellet boiler, which in practice is usually the best solution. Boilers of this size are typically used for semi urban applications that require tight emissions compliance, and pellet firing is really the practical option for biomass. For those seeking a small boiler it is worth noting that many manufacturers produce a standard wood chip boiler with the option for a 'pellet head' – a system for burning pellets within a standard chip or log boiler. Sometimes this solution will offer a very low cost option.

Above 50kW and below 100kW there may be circumstances where the capital costs of a wood chip installation (and all the allied handling, storage etc), or where there is a locally available chip supply, allow wood chip to compete with pellet firing. However, in most circumstances pellet firing will offer the most competitive operation.

At or above 100kW wood chip will become increasingly competitive. The technology required to mass burn pellets is similar to that for wood chip and the relatively low cost of wood chip as a fuel becomes attractive.

What type of boiler and grate is best?

8.1
Fixed grates

Solid fuels are burned on a grate within a hearth or furnace. The grate simply allows the fuel to be piled while the combustion process takes place. The grate is usually made of some heat resisting cast iron alloy which has superior resistance to fracture and deformation on heating. In small wood chip boilers using dry fuel the grate will be fixed, and typically fuel will be fed onto that grate from a stoker auger or ram. The grate must allow appropriate airflow to the fuel pile and the separation of ash – so the geometry or spacing of grate bars will vary to accommodate these factors.

A fixed grate might, in relatively small boilers, be under fed. In other words the fuel is augered up through the middle of a grate and, as fuel burns on that pile and new fuel is charged, the ash is driven to the external periphery of the grate. That motion, induced by a combination of combustion and the introduction of new fuel, effectively agitates the fuel pile and ensures proper combustion. However, many slightly more advanced designs incorporate a fixed sloping grate or even a fixed stepped grate to assist in an orderly fuel exposure.

Generally fixed grates may be used for dry boilers of relatively small size.

8.2
Reciprocating grates

At typically larger scale, for example 200kW and above, and particularly for larger chip sizes and wetter fuels, it may be necessary to provide active agitation. This is because the grate area is much larger, the fuel pile is generally deeper, and ensuring stable combustion becomes a little more complex. Agitation is often achieved using a reciprocating grate. In these designs, the grate is periodically agitated to move the fuel. As the fuel is moved fresh unburned material is exposed and is properly combusted.

The most common of these is a reciprocating step grate, which operates in a very similar manner to a 'penny falls'. A series of alternate moving and fixed steps reciprocate to shuffle fuel down a step grate from the charging end to ensure full combustion.

Figure 17 Reciprocating hearth

Generally reciprocating step grates are better for wetter fuels (more than 30% moisture) and larger boilers. To put this in perspective, however, there are excellent efficient 200kW fixed step grate boilers capable of burning 30%+ moisture content fuel.

8.3
Pellet hearths and pellet boilers

Wood pellets are very dry, with a moisture content of typically less than 10%. They are also dense, with densities ranging over 675kg/tonne. It is possible to pile burn pellets, burn them on a step grate or indeed on a reciprocating grate. However, as the pelletised calorific value is so high and very little, if any, energy is required for drying, most BSEN 14962 compliant pellets can be burned in a stainless or inconel hearth pot. The pellets are typically circulated in the pot or are subject to a cyclonic air flow which agitates and provides combustion air. Pellets are added at programmed intervals to sustain combustion. This arrangement, or something similar, is the basis for most advanced pellet boilers.

Refractory mass is really not required for anything other than structural protection of the boiler and the boiler can therefore be relatively small. Moreover, the ignition sequence can easily be started by blowing air over an electric element to ignite the pellets in the airstream. Because the boiler has low thermal inertia and because the operation can easily be automated, the pellet boiler offers the best in flexibility, turn down and load following. In theory a good pellet boiler does not require to be operated with thermal storage – however, good practice suggests that a thermal store will reduce the physical peak capacity of the boiler required (that would be true of oil and gas boilers).

It is therefore difficult to surpass pellet fired operations for flexibility, turn down, physical size, efficiency, and emissions. It is for these reasons that they are so valuable in the smaller scale application.

8.4
Pellet heads

Pellet heads offer some opportunity where a multi-fuel operation or a low cost conversion is required, or where simply the combination offers a reduced capital cost. A pellet head is essentially a pot hearth and combustion air fan with augured pellet supply that can be added into an existing biomass boiler (usually a smaller boiler up to 100kW).

Figure 18 Pellet heads

8.5
Summary

In summary, if the boiler is very small it is almost always the case that a pellet boiler will provide the best all round solution.

- If the boiler is to be 100kW or less, a pellet boiler will be the best option, but the economic case for dry (<30% moisture content) wood chip would have to be evaluated carefully if dry wood chip can be obtained.
- If the boiler is larger than 100kW–200kW and dry wood chip is available then some fixed hearth designs, for example a shallow fixed step, will combust this material well.
- If the boiler is bigger than say 200kW or the fuel is wetter (>30% moisture content) then some form of reciprocating grate will likely offer the best solution.

8.6
Combustion related health and safety issues

In an oil or gas boiler the risk of combustion space explosion is substantially reduced by the incorporation of controls that purge the boiler prior to ignition and check that ignition is maintained as a precursor to fuel flow.

These controls are commonplace and work well.

In a solid fuel boiler the determination of combustion conditions is much harder. Partially combusting the fuel produces an explosive pyrolysis gas. If the correct oxygen conditions are met, that can have undesirable consequences – a very rapid flash over, deflagration or in some circumstances very rapid deflagration or even detonation.

Solid fuel operations may often give rise to pops and bangs as pyrolysis mixes ignite over the bed – particularly at low rates of fire.

Over fuelling the boiler i.e. charging excessive amounts of wood which will smoulder on a hot bed – particularly at periods of low load, start up or shutdown – has the potential to produce a higher risk situation.

In some cases automatic draft control can improve the situation – but equally can exacerbate it. As a rule, draft control and the maintenance of a negative pressure in the boiler is desirable.

On no account should a boiler door or access be opened to determine operation if a fault or poor combustion conditions are expected. The admittance of air may be sufficient to cause ignition and deflagration. Appropriate operator training is required and in this case the manufacturer’s instructions should be followed.

Opening a boiler door whilst any form of combustion is taking place is very dangerous and certainly on larger chip and pellet boilers should be prohibited. There may be circumstances where a trained commissioning engineer operates the boiler otherwise.

Some boilers, particularly log boilers, require a loading door to be opened to charge logs – generally these are smaller domestic boilers. The operating instructions are often minimal and sometimes not in English. Opening a door to any combustion space is usually extremely dangerous and these smaller log boilers should be treated with great caution.

In most cases interlocks will be fitted to prevent such interference. Under no circumstances should such interlocks and safety controls be circumvented.

In the event of known over fuelling, or suspected malfunction, the operators should have, and adhere to, a published set of procedures. These should incorporate any necessary emergency procedures to be followed and importantly the contact numbers for management and emergency service as required.

9.0 Sizing a Biomass Boiler

In some respects the size of a biomass boiler will be dictated by the amount of money that can be recovered by the RHI. Because plant of less than 99kW will receive 6.3p/kWh for every unit of heat produced and plants above this will receive 1.5p/kWh, the economic pressure influences boiler sizing. This leads to undersizing and far from optimal installation in some cases. The situation is further confused by the fact that the current rules allow two smaller boilers to serve the same premises so long as these serve separate hydraulic circuits. Thus 396kW of biomass installation could qualify for revenue support at 6.3p/kWh if the boilers served four hydraulically separate circuits. Of course the cost of four smaller boilers in relation to the revenue generated from load may not be worthwhile, but the situation might be beneficial for some installations.

9.1
Demand duration curves

In designing a heating system the physical size of the boiler plant is selected to offset the worst case (design) fabric heat loss and the design air infiltration loss. These loads depend on the fabric thermal properties and the air change rate (mechanically or naturally induced). The boiler can be sized accordingly with additional margin for heating up the building. To clarify, if the boiler was only sized to meet the design (peak heat load), it would simply be able to offset these steady state losses in the worst weather conditions. But if those conditions were prevailing on a Monday morning the boiler might never really be able to raise the temperature of the building to an acceptable level. So conventional boiler sizing dictates size based on design conditions plus a start-up margin for intermittent heating operations.

In practice the design conditions (usually 21°C/0-3°C) are rarely met, and even during heat up, conventional sizing techniques result in boilers that are very much oversized for most of their operational requirements. If the demand duration curve (a plot of demand v hours incurred) were to be plotted for most heating applications, a curve as illustrated in Figure 19 might be very typical.

In practice, a boiler sized at 50–60% of peak demand will be able to displace 80–90% of the total site consumption, subject to satisfactory turn down being achieved. That should be evident from the chart but can be estimated for most sites using a degree day analysis.

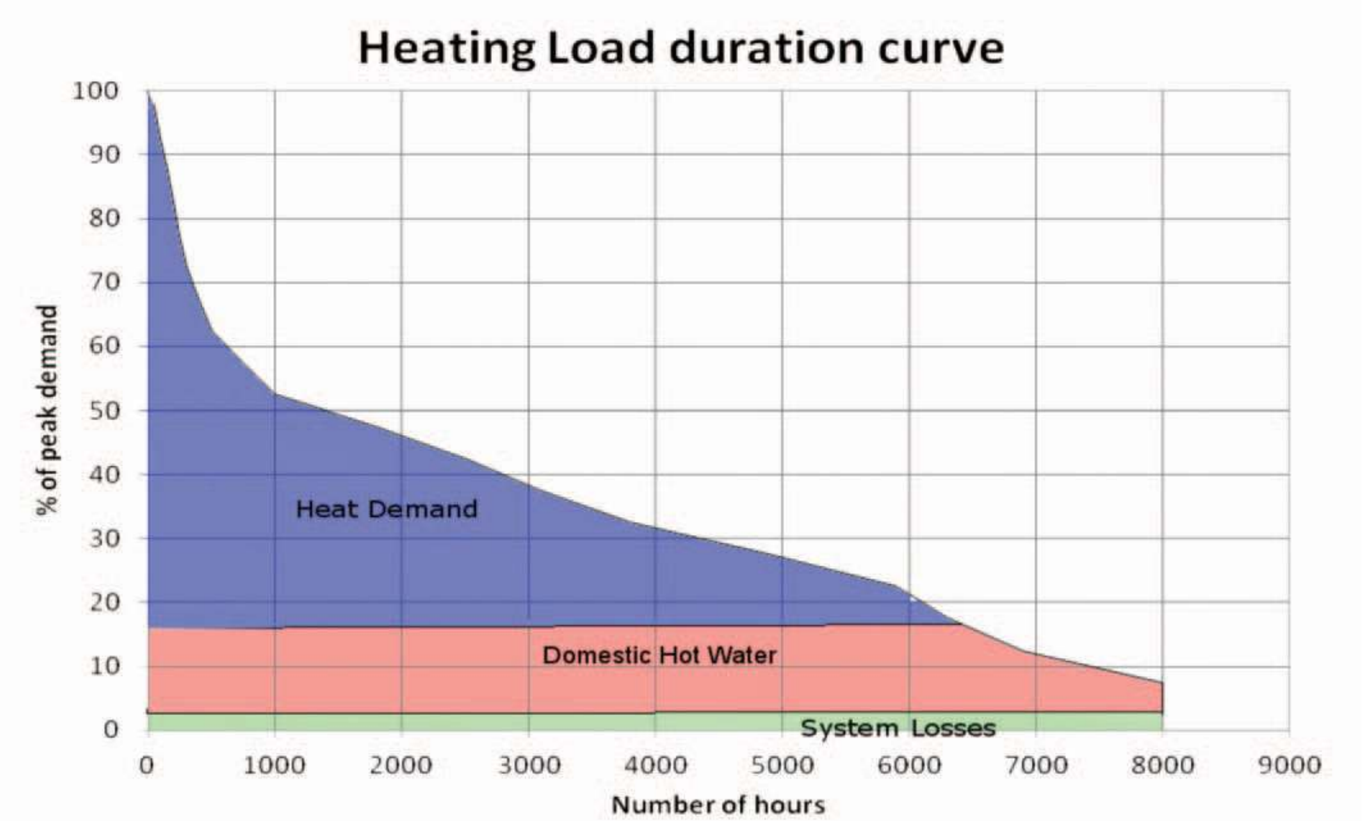


Figure 19 Load duration curves

The existing plant will also have been sized to accommodate what is termed the 'fast start margin' – an additional capacity over design that allows a larger than design heat output to be achieved when, at the start of an intermittent heating period, the room temperature is low, for example, 10ºC. This over capacity depends on the average ambient and the thermal weight of the building. It is commonly the case that a margin of 20–30% is added to the design demand above. Where the building is intermittently heated it is important that this margin is allowed for, because otherwise, in colder weather, the building will not (possibly never) reach design temperature very quickly. The heat input must exceed the losses in order for there to be a temperature rise.

This method of plant sizing results in a boiler that will, under part load and steady state conditions, be well oversized for the actual demand. The result will be that it cannot turn down sufficiently to meet part load condition (or, in the case of a gas boiler, short cycles continuously unless a loop led demand system is employed to govern burner firing). In a conventional arrangement the installed plant will typically operate at less than 40% of installed capacity for nearly 70% of the operational hours. This situation is wasteful of energy if the boiler is a simple oil or gas fired boiler with Hi/Lo/off burner because at low load, which prevails most of the time, the burner cycles wastefully. However, modular gas premix boilers solve this problem almost completely.

9.2
Sizing biomass boilers

Biomass boilers have limited turn down (33% on chips and 25% on pellets) and certainly when fired on wood chip cannot be turned off instantly. Likewise the response to increasing demand can be very slow. The answer is to store heat and allow the boiler to operate at almost constant thermal output. This is less important with pellet boilers, which do offer a higher degree of flexibility, but is good practice to include heat storage.

Typically then, and for conventional space heating applications, a biomass boiler should be sized at close to 60% of the design demand. This is a rule of thumb and ideally the demand duration curve should be established to size this accurately. Be aware that it is not possible for a supplier or designer to calculate what the extent of displacement will be without conducting this analysis.

9.3
Sizing thermal storage

The easy way to think of thermal storage is as a car battery. Under most circumstances the demands on that battery are low and it is trickle charged whilst driving. When the car is started the alternator output is simply not sufficient to meet the peak current flow but supplements a short term drain to get the car started. A similar concept may be applied to the biomass heating system.

If the biomass boiler is sized at 60% of design peak head load then there will be circumstances when the heating system will have to meet 100% of that load and (if the temperature is to rise) the fast start margin. It is important to understand that the fast start margin has to be included in that demand figure. The fast start margin and acceptable rate of rise of temperature depends very much on the thermal weight (inertia) of a building. Heavy old stone buildings take longer to heat up and cool down, light weight modern constructions heat up quickly. A building services design should be conducted to determine the design heat loss, the required rate of rise of temperature and accordingly the margin of thermal input required to effect that rate of rise of temperature.

So, if the design heat loss plus the fast start margin had been assessed as 100kW and this gave an acceptable rate of rise of temperature under the worst heat loss condition, the biomass boiler would be sized at 60kW and the design flow and return temperature difference for the wet heating system would be 11ºC (82ºC/71ºC). Using surplus capacity at night or at times of low demand throughout the day, the biomass boiler can service no or low demand whilst simultaneously heating water in the thermal store. The heat stored can then be released during periods of peak demand (start up demand) to supplement the boiler output. So if, for example, 100kW will bring the building to temperature in one hour from cold start, the thermal store would have to be able to provide an additional 40kW for one hour (or 40kWh or 144,000KJ) and as the design temperature difference is 11ºC and the specific heat capacity of water is 4.19kJ/kg/ºC then approximately 3,000 litres of thermal storage would be required (in this case 50litres/kW of biomass boiler capacity). During the peak demand period, the thermal store is depleted at a rate of 100kW.

Typical design is arranged as illustrated in Figure 20 where the boiler services a thermal store and the load in turn is serviced by the thermal storage.

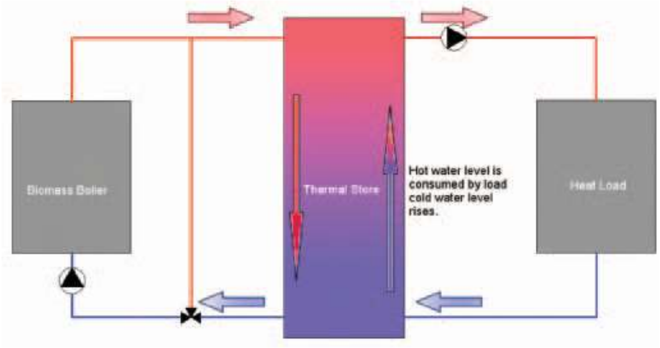


Figure 20 Simple use of thermal storage

The thermal store is designed to stratify the hot water and during the peak flow period the flow around the heat load on the right would be sufficient to dissipate 100kW. Because the maximum output of the boiler is only 60kW, the cold water level in the thermal store will rise.

However, sizing thermal storage is a little more complex than this, because to a large extent it depends on the start up, time and modulation flexibility of the biomass boiler. Flexibility rather than capacity for turn down is the important factor. Most biomass boilers can turn down perhaps to 30% of maximum output on a dry fuel but if it takes 30 minutes to change fire rate up or down then there is a very significant inertia that has to be considered.

If the thermal store is fully charged then the biomass boiler will have shut down. When in the morning the peak heat up demand or hot water demand is incurred the thermal store will be depleted by the load pumps. The load will initially be met by depleting the thermal store but there will be a period where there is no useful contribution from the biomass boiler for it must first be brought up to temperature. The thermal storage must therefore have sufficient capacity to cover full peak demand over that dead band. That is dependent on the operational flexibility of the boiler.

However, the trigger temperature (the return temperature at which the boiler is asked to fire) is key in determining the useful and timely contribution of the biomass boiler. This is not so much a problem with biomass boilers but rather with slower response wood chip boilers where fuel must be augered onto a grate, ignited and then a fire established.

As a rule of thumb, for typical heating applications the boiler can be sized at 60% of peak load and the thermal storage at somewhere between 30 and 50 litres/per kW of boiler output. However, it is important to stress that if you undersize the thermal storage, the system will be depleted before the boiler can contribute. The thermal storage should be sized to meet the peak flow for the time it will take the biomass to reach temperature and give support and then for the difference of peak load less the biomass output for any remaining time of peak output.

Clearly the operation of a supplementary gas or oil fired boiler can be used to reduce the amount of storage required where the integration of large thermal storage causes difficulty.

It is stressed that:

- The acceptable rate of rise of temperature for any given building must be calculated. The schedule of heating times can be adjusted to afford longer acceptable heat up times and reduced start margins.
- If the biomass boiler is the sole boiler, a margin over the design heat loss must be allowed (fast start margin) in calculating the thermal demand. Simply calculating the design heat loss and using this figure as the design peak demand will not afford sufficient margin to raise the temperature of the building quickly.
- If the biomass boiler is supplemented with a gas or oil fired top up then the same strategy for optimum biomass boiler size may be used, but the storage volume can be reduced if larger storage proves inconvenient.
- Care should be taken to ensure that in sizing the boiler as explained, the demand duration is sufficiently steep to afford sufficient excess biomass capacity to charge the thermal store.

9.4

Integrating and controlling the biomass boiler

In a few simplistic systems the stratification in the thermal store is used to trigger the boiler operation. With a thermocouple near the top of the thermal store and one at the bottom of the thermal store, the boiler will fire when cold water reaches the top of the storage vessel and stop when the warm water has (despite any load circulation) reached the bottom of the thermal storage. It is a simple on/off arrangement with two extremes of thermal storage (fully charged or none). If the reduced temperature sensed by the uppermost thermocouple is used to trigger boiler firing, the disadvantage of this situation is that the store will deplete before the boiler is fired and makes useful contribution to peak loads, and there will be a period of significantly reduced thermal output.

An alternative arrangement will use a preset reduction in return temperature to trigger firing – for a reducing return temperature is indicative of store depletion and increased load.

However, in a typical arrangement the depletion of the thermal storage can be monitored with thermocouples installed over the height of the vessel. In this way a reduced return temperature (indicating significant load and thus the cooling of the lower regions of the thermal storage) will be detected early by the lowest thermocouple and the biomass boiler can be fired early to arrest the rate of depletion during peak demand periods.

The arrangement is illustrated in Figure 21.

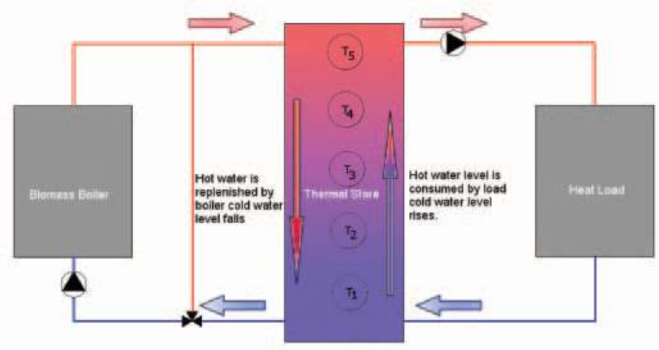


Figure 21 Improved control using thermal storage

In practice, most modern high end pellet and wood chip boiler controllers offer integrated controls. They are designed to operate with this type of storage arrangement and provide summer/winter settings to effect improved boiler start up in relation to drops in return temperature.

Minimising the draw off from the thermal storage will maximise the temperature difference imposed by the load, and good practice would be to include (where possible) a mixed flow load circuit to reduce draw off at peak demands. If the biomass boiler is operated at a relatively high temperature and larger temperature difference then the load circuit flow and temperature difference can be blended down to the typical 82/71, or indeed lower flow and return temperatures if the load circuit is weather compensated.

The arrangement is illustrated in Figure 22.

However, this may be impractical if domestic hot water circuits constitute part of the load, as minimum flow temperatures must be maintained for the prevention of legionella infection.

9.5
Pressure systems safety implications

The operation of boilers in the UK is governed by the Pressure Equipment Directive (PED), the Pressure Systems Safety Regulations (PSSR) 2000 and the Pressure Equipment Regulations (PER).

The provisions for the design and inspection of pressure equipment are well known and pressure equipment produced in Germany, Denmark, Austria, Slovenia and some other countries is subject to similar, if not more onerous, design and material specifications. However, importing a CE marked boiler does not mean the system is CE conformant.

Where biomass systems are directly connected (refer to the preceding diagrams), the net static head at any part of the system must be sufficient to maintain the water at below the saturation temperature. Failure to do so will result in the potential for boiling and the production of flash steam where the pressure is reduced, for example at the highest elevations of the heating system or at the pump inlet. If the biomass system is to be operated at higher temperatures with existing equipment it will almost certainly be necessary to increase the system pressure in an open vented system. This is achieved by raising the height of the feed and expansion tank or, in a closed system, by adjusting the set point of the pressurisation unit.

The boiler must be equipped with a safety valve that in the event of over temperature will prevent over pressure by venting water and steam. The minimum legally permitted size of discharge in the UK is 20mm but the valve size should be selected in accordance with the manufacturer’s instructions or as otherwise calculated to prevent over pressure of more than 10%.

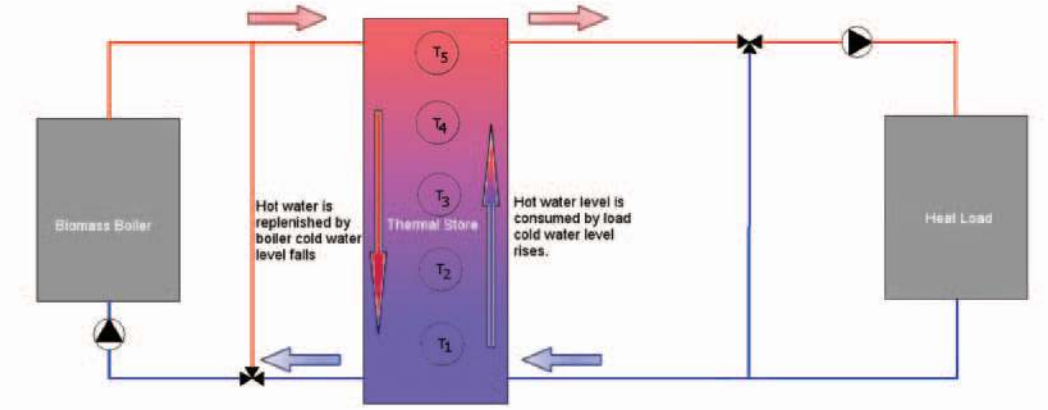


Figure 22 Mitigating primary flows in the biomass circuit

The discharge pipe work must be vented safely outside the boiler room at a location where there is no risk of injury to a third party. The discharge cannot be valved or obstructed in any way.

If the boiler is fitted with a low water system pressure operational inhibit switch, then this should be used.

Where biomass boilers have significant thermal inertia, particularly wood chip boilers, then a control system to prevent over temperature should ensure shutdown. Likewise there should be heat dissipation by a controlled method, for example, forced dissipation through the load, the provision of a heat dump, or the provision of indirect cooling to ensure that under no circumstance temperatures achieved can result in steam production and subsequent over pressure.

Generally the PSSR is intended to apply to hot water systems operating at or above 100ºC. This obviously applies to Medium and High Temperature water, thermal oil and steam systems. However, the regulations apply to systems that could become pressurised and it is worth remembering that it may be necessary to operate some hot water systems at over 0.5bar to retain a sufficient anti-flash margin. In the event that margin is lost, the content will turn to steam.

This has implications for the design of many high thermal inertia boilers and/or higher temperature water boilers as adequate provision must be made in the event of power failure, where special provision (including the use of back-up electrical supply) may be required. A risk assessment is appropriate.

The conventional pump and safety valve over capacities may not be adequate and standby power may be required.

10.0 Emissions Regulation

Wood is a mix of cellulose, hemi cellulose and lignin (a complex polymer largely based on phenol orientated monomers). The thermal decomposition of wood (pyrolysis and gasification) as described in section 6.0 of this guide, results in the production of a wide range of organic compounds. If not fully combusted these compounds are emitted as smoke, tar and vapours and will pose a health risk.

These organic compounds are principally what are termed aromatic compounds including dioxins (a colloquial term used to refer to di benzo dioxins and di benzo difurans). The combustion of biomass has the propensity to produce a range of poly aromatic compounds. Partial or incomplete combustion will produce a range of products including, potentially, dioxins, unless the combustion is very carefully controlled.

True dioxin, a benzene ring with two oxygen atoms, is not a stable compound and not particularly toxic. Therefore, the combustion of clean wood or biomass is less likely to result in the production of more dangerous ‘halogenated dioxins’ unless there is contamination present, such as driftwood. However, this does not mean that wood smoke is in any way safe as it contains a wide range of other harmful and carcinogenic intermediates.

Of particular concern are halogenated dioxins. If there were any chlorine contamination of the fuel (food waste, salt, brine driftwood) then there is the risk that polyphenol or dioxin or furan based compounds become chlorinated, producing poly chlorinated phenols and poly chlorinated bi-phenols. These are stable compounds that can react with DNA to promote adverse human immune responses. These products are lipophilic and accumulate in the food chain.

In addition to the volatiles, tars and carbon monoxide there will be fly ash – fine particles of non combustible mineral content which has been lifted from the combustion space and entrained in the flue gas. Fly ash drawn into the flue gas stream from the fire bed has a complex role to play in the condensation of polyaromatics and the formation of halogenated compounds. The issue of particulate is therefore of increasing concern and emission restrictions for biomass will undoubtedly increase. (For additional information refer to www.elementconsultants.co.uk). The particulate will lodge in the lungs of the individual inhaling the particulate where the payload of condensed particulate is delivered.

As the fuel is burned the volatile content is consumed and under perfect combustion conditions, these volatiles are burned to produce carbon dioxide and water vapour. However, even with the best technology, that is virtually impossible. A biomass boiler (and particularly wood chip boilers) have the potential under some operational circumstances to produce very high levels of carbon monoxide (10–100 times that typically produced by a gas fired boiler) and accordingly the flue gases can be very dangerous.

Note that the absence of visible smoke does not preclude the production of dangerous emissions! Currently available guidance acknowledges the risks from wood smoke but is largely dismissive and in some cases inaccurate.

To control the likely emissions from biomass an increasingly complex regulatory structure is evolving to address the fuel origin and quality, and the combustion emissions.

10.1
Emission regulation

Regulation is extremely complicated and depends on the type of fuel and the appliance.

10.2
Definitions of waste and clean biomass

Although all wood is biomass, the first distinction to make is the distinction between waste wood and wood considered to be clean biomass. Waste is a by product of a main production activity. A sawmill will produce waste and a joiner’s workshop will produce waste. In the UK, if waste is to be thermally treated, this must be done in accordance with the provisions of the Waste Incineration Directive (WID) (subsumed by the Industrial Emissions Directive) unless it is specifically exempted.

Sawmill wastes are exempted from the WID. Grade A wood wastes (those that are untreated, and that refers to any paints varnishes, coatings, glues or treatments of any kind) are exempt from WID but will be subject to environmental permitting and emissions constraints imposed by process guidance notes.

The situation is best explained by the flow chart given in Appendix A to this guidance.

10.3
Smoke control areas

If the plant is to be built in a smoke control area (refer to **http://smokecontrol.defra.gov.uk**) then the biomass equipment for a specific fuel must be certified. The best method of determining whether you are in a smoke control area or not is to contact the relevant council Environmental Health Department.

Plant which is certified for smoke control areas has been tested and deemed as efficient and sufficiently pollution free in operation.

10.4
Local air quality management

European air quality legislation dictates that all UK local authorities have to review and assess air quality, measure pollution and predict how it will change in the next few years. The purpose is to meet the EU ambient air quality targets.

If a local authority finds any places where the objectives are not likely to be achieved, it must declare an Air Quality Management Area. All applications for exempted appliances must be approved. Larger and non approved appliances burning virgin wood may still be rejected if the local authority cannot meet its air quality target or can demonstrate that the addition of biomass will risk it not achieving its air quality management targets.

The local authority will then put together a plan to improve the air quality – a Local Air Quality Action Plan.

10.5
Clean Air Act

The Clean Air Act 1993 is a culmination of nuisance legislation. It is important to note that when chimney height reference is given in this context, that a nominal height might be calculated using the Chimney Height Technical Guidance Note D1. However, the chimney height must not cause nuisance.

10.6
Planning

Planning is required for most installations where there is a new build, where there is a change of use or where the visual appearance of a building will be changed. Definitive guidance cannot be given because the range of situations is so varied.

In all cases you should contact your local planning department.

10.7
Building control

In all cases building control is required. Small domestic appliances require a building warrant to ensure that the appliance meets safe installation standards as set out in Part J of the Building Regulations Northern Ireland and the accompanying technical guidance notes. Large biomass power stations will have internal components, fire escapes, emergency lighting, safe evacuation distances, safe stair sizes, building materials and so on, which will all be subject to building control.

10.8
Health and safety associated with flue gas emissions

Continuous exposure to high concentrations of wood smoke would also pose a severe health risk and it is important to ensure that the chimney (regardless of compliance with the Clean Air Act 1993, local air quality management and D1 calculations) is sufficiently high to disperse the smoke properly. Compliance with a standard does not constitute safe design unless that standard is a safety standard. Compliance with the apparent legal minima for dispersal does not necessarily constitute safe design and the arrangement may easily fall foul of other nuisance or health and safety legislation.

11.0 Ash Production and Handling

When a fuel is burned the mineral content remains as ash. If the fuel is not burned properly, the ash will contain a mixture of organic contaminants.

Bottom ash is the ash remaining on the grate – it is usually subject to extremely high temperatures and thus contains a low organic content. Bottom ash from clean biomass is generally less dangerous than fly ash. Separated bottom ash should be disposed of to landfill subject to waste acceptance criteria.

Fly ash is the ash blown off the grate or that particulate resulting from volatilised metals and metal salts derived from the biomass. Separated fly ash, where tested and found to be contaminated, should be disposed of as hazardous waste.

Ash is a waste. Fly ash, even from clean biomass will contain various toxic materials and where mixed into bottom ash will contaminate the bottom ash. Waste is subject to waste control legislation unless derogation for alternate use as a product is given.

The current position in Northern Ireland is that ash is a waste and should be landfilled subject to meeting the waste acceptance criteria.

11.1
Health and safety in ash handling

Ash is essentially the non combustible mineral content of the biomass – or at least that is what it should be.

In practice, and particularly with poorly controlled and smaller biomass systems, the ash has a high residual organic content. Largely charcoal, that content could be 5% or much more. Sometimes the ash is visibly dark.

The tiny particulate in the ash is a COSHH hazard and ash handling should be subject to appropriate method statement and personal protective equipment. Ash should only be handled cold with an appropriate dust mask.

Ash bins should have locking lids and safety warnings. Opening the bin lids can cause deflagration and serious injury.

The ash will potentially contain some harmful and potentially carcinogenic compounds if there is a high carbon content. However, most of these will breakdown in ultraviolet light (day light). All ashes should be disposed of to landfill or hazardous landfill sites.

The weight of the ash bin must be considered (as well as the temperature of the ash) and a safe system of work compliant with the provisions of the manual handling regulations, and COSHH must be developed.

12.0 The Renewable Heat Incentive

12.1
Revenue support

The Northern Ireland Renewable Heat Incentive (RHI) is a DETI scheme that provides financial support to non-domestic renewable heat generators (in the context of this guide – biomass boilers). The Renewable Heat Incentive Scheme Regulations (Northern Ireland) 2012 provide for an annually inflation adjusted payment for those qualifying under the scheme.

The aim of the Northern Ireland RHI was to increase the uptake of renewable heat to 10% by 2020 (baseline position of 1.7% in 2010). The 10% target for renewable heat equates to 1.6TWh (or an additional 1.3TWh when considering existing levels). This target was included in the Strategic Energy Framework and an interim target of 4% renewable heat by 2015 has been included in the Programme for Government.

The RHI compensates investors for the additional costs of renewable heat compared to traditional fossil fuel systems. The costs involved (including capital, financing, barrier, fuel and operating) were evaluated to provide a revenue support – a p/kWh support rate for heat produced by biomass. The methodology used by Government was intended to underpin a minimum 12% rate of return on investment – clearly that varies with installation.

12.2
What size of plant is supported?

Small biomass plants are disproportionately expensive (largely because the preceding capital grant schemes and currently the RHI have driven the cost of the mostly imported equipment to extreme levels).

Boilers of less than 1MW total thermal output may be eligible for RHI funding. There is no support above this.

Payments are made for accredited installations for non domestic, metered heat supplied to an eligible process. The current tariff structure is shown in Figure 23.

12.3
Who is eligible?

Currently only non-domestic sectors are supported. The non-domestic segment includes businesses, the public sector, charities and not-for-profit organisations, and industry.

A non-domestic installation is a renewable heat unit that supplies heat to anything from large-scale industrial heating to small business and community heating projects. This includes small businesses, hospitals, schools and so on, as well as district heating schemes (one boiler serving multiple homes).

Size range	NI RHI tariff (pence per kWh)	Length of tariff
Less than 20 kWth	6.6p/kWh	20 Years
20kWth and above up to but not exceeding 100kWth	6.3p/kWh	20 Years
100kWth and above up to but not exceeding 1000kWth	1.5p/kWh	20 Years

Figure 23 Summary boiler solutions at 1st April 2014

12.4
What help is available for domestic users?

The Northern Ireland, Renewable Heat Premium Payment (RHPP) scheme is a Government support scheme to help domestic householders install renewable heating and hot water systems in their homes.

Domestic applicants may apply for a voucher which will be issued if their application is successful. When the qualifying technology has been installed the voucher can be exchanged for grant money. In the case of a qualifying biomass installation that is currently worth £2,500.

- The property must be situated in Northern Ireland.
- The property must be a permanent residential building which is occupied for most of the year – it cannot be a second home or holiday home. Mobile homes, caravans, house boats and systems which are only to heat swimming pools are not eligible.
- The applicant must be the owner of the property, or, if privately rented, the renter must have permission from the owner of the property to install the renewable technology.
- If the property is joint-owned, all owners must agree to the installation.
- The property should already be installed with all basic energy efficiency measures. For instance, it should have loft insulation up to 250mm and cavity wall insulation where practical. If it is not practicable to install some of these (for instance, a house with solid walls cannot have cavity wall insulation) then there is no need to take such measures.
- All relevant permissions for the installation, including planning permission and Building Control approval must have been obtained.

12.5
How do I apply for the Renewable Heat Incentive?

Detailed guidance is available from the OFGEM website at **https://www.ofgem.gov.uk/environmental-programmes/renewable-heat-incentive-rhi/northern-ireland-renewable-heat-incentive**

13.0 ESC - Energy Services Contracts

13.1

What are energy services contracts?

The term energy services contract (ESC) describes arrangements by which an organisation may ‘contract out’ the provision of its energy services to an Energy Services Company (ESCo). These agreements allow an organisation to transfer the responsibility of ensuring cost-effective procurement, security of supply and meeting end user needs.

This transfer of responsibility generally requires services to be delivered through contracts that are specified in terms of required outputs. For example, the contract may specify the energy provision in terms of what is required to maintain a process or to ensure that a satisfactory working environment is achieved.

This feature differentiates ESCs from more traditional forms of energy procurement, although in the context of biomass, the ESC model most typically relates to supply side management only – fuel, boiler, operation, heat.

In order to meet the contract demands, ensuring efficiency, sustainability and continuity of supply throughout the term of contract, it will often be necessary for the ESCo to invest in new plant and equipment, for example the new biomass boiler. Such investments, which may involve significant capital, typically take place at the beginning of the contract period and are often a key incentive for both public and private sector clients.

13.2

What are the benefits of ESCs?

The benefits to be obtained from ESCs include:

The provision of capital funding – A biomass system is generally an expensive undertaking. A specialist contractor can fund the replacement boiler and any new systems required. During periods of budgetary restrictions, corporate funds may be directed to core business activities rather than investing in energy plant.

Improved budgeting and cost control – A potentially large capital spend and irregular maintenance costs are transformed and borne as revenue costs. This facilitates improved long term planning and budgeting. Revenue payments can be structured to meet cash flow requirements on an annual basis. Fuel costs where incorporated in the agreement may be indexed against the RPI and alternate fossil fuel options so as to afford a continued life cycle business benefit.

Reduced energy costs – A specialist contractor can assess how energy savings can be made and develop the most appropriate and energy efficient solution. The contractor can also negotiate fuel purchase strategies tailored to individual sites. These can be more cost effective, flexible and appropriate than central fuel purchasing.

Transferred risk – By taking responsibility for fuel procurement, supply, operation and underwriting the performance of site services, an ESCo contractor takes on risks that might otherwise be borne by the purchaser. The degree of risk transfer is both flexible and negotiable.

Subject to very well written contract conditions, a long-term partnership will provide the contractor with the incentive to invest for the maximum savings and so increase the benefits to both partners. This will also stimulate continuing investment in plant during the contract.

Improved management resources – A specialist contractor will take care of all day-to-day plant operation and maintenance activities. This releases the client’s management and staff to concentrate on the organisation’s core activities and focus on strategic energy issues.

Health and safety management – Through managing design, operation and maintenance activities, contractors can take on many of the duties of complying with environmental targets or current legislation, and will be responsible for potential risks such as emissions, spillages, and hazards.

13.3

What does a typical ESC involve?

An ESC can be flexible (in fact a good contract will allow flexibility). In practice the arrangement is similar to buying a car on hire purchase, but with distinct benefits beyond simply capital funding. However, the cost of capital and management etc must be recovered by the ESCo.

Typically, and in the context of a biomass boiler, the scope might include the design, supply, installation and the operation of the biomass boiler with the service provision being heat or steam. The fuel procurement may be included or excluded from the agreement as required and the same issues apply to fuel pricing as are dealt with elsewhere in this guidance.

The most developed arrangements will be DBFO (Design Build Finance and Operate) Contracts including:

- The ESCo will design and install any new and energy efficient plant required.
- The ESCo will finance the construction of the biomass plant and improvement of the existing energy plant as required.
- The ESCo will then operate and maintain the facility for an agreed period.
- The ESCo will negotiate and arrange the competitive supply of fuel and power and sell useful energy on to the client.
- The ESCo will manage the plant specified energy or environmental performance targets.

In practice, that requires some careful and robust performance specification and cost indexing as described elsewhere in this guidance. However, if the correct balance is struck then there is genuine and cost-effective risk transfer for both parties. However, it is essential to get good independent legal advice before entering into an ESC.

Contract terms of 10 to 25 years would not be uncommon for this type of contract. The contract must be sufficiently flexible to protect both parties.

In some arrangements, where the asset is clearly leased as simply an operational lease, the asset may be treated as being owned by the ESCo and not the client. This may have commercial benefit for one or other or both depending on financial circumstance. If the contract is defined with eventual asset transfer then it will be treated as a finance lease and will appear on the purchaser's balance sheet despite there being no capital investment. The commercial benefits or otherwise have to be considered very carefully.

13.4
Where can I get additional guidance?

Generally the term ESC is used to describe a much wider range of services than simple boiler design, supply and installation. In the USA, for example, ESC Contracting often incorporates a full facilities management and demand side management role. There is currently very little independent guidance that is specifically relevant for biomass. However, general guidance might be determined from the following link:

http://www.euesco.org/fileadmin/euesco_daten/pdfs/euESCO_response_concerning_EPC.pdf

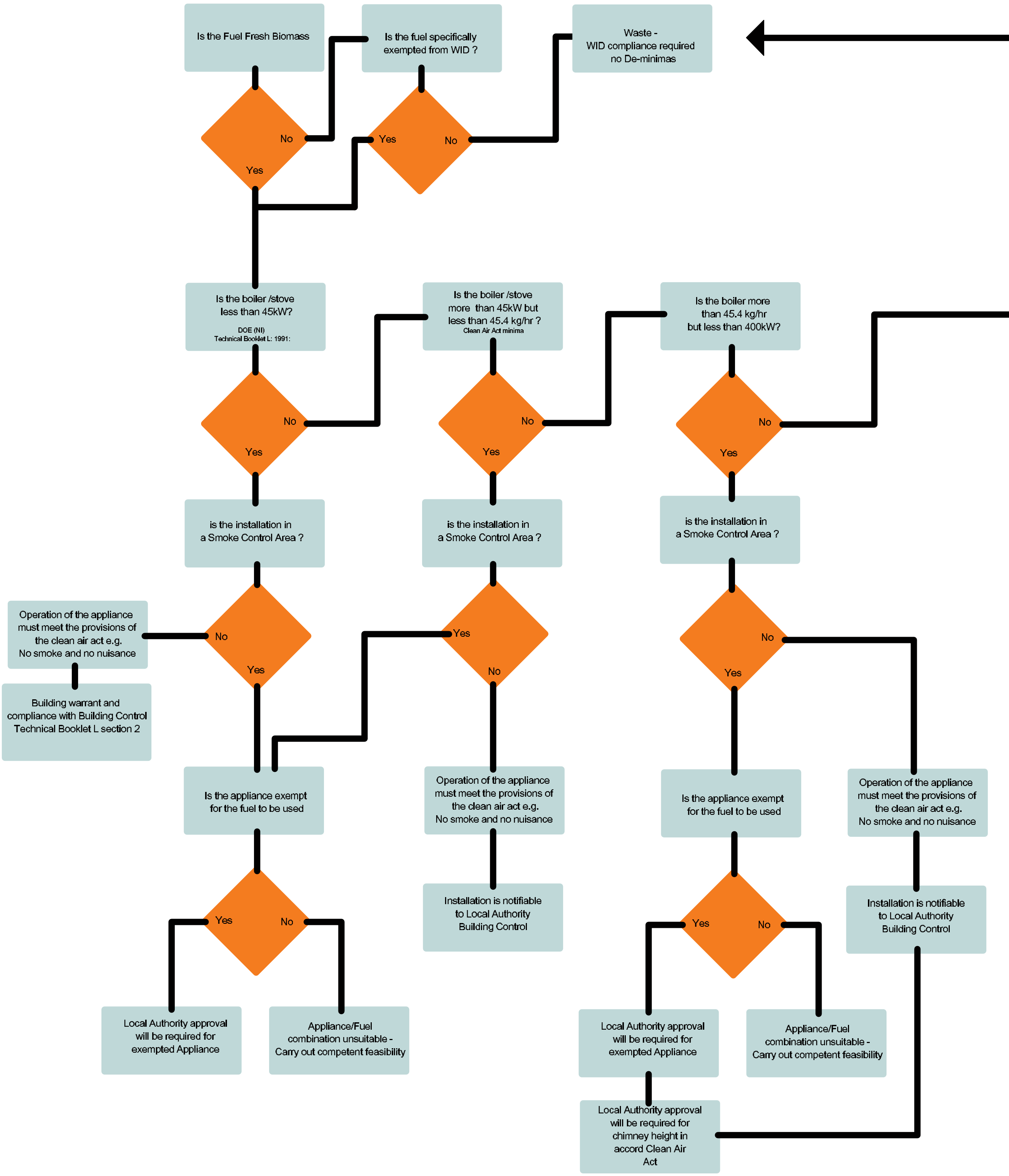
or

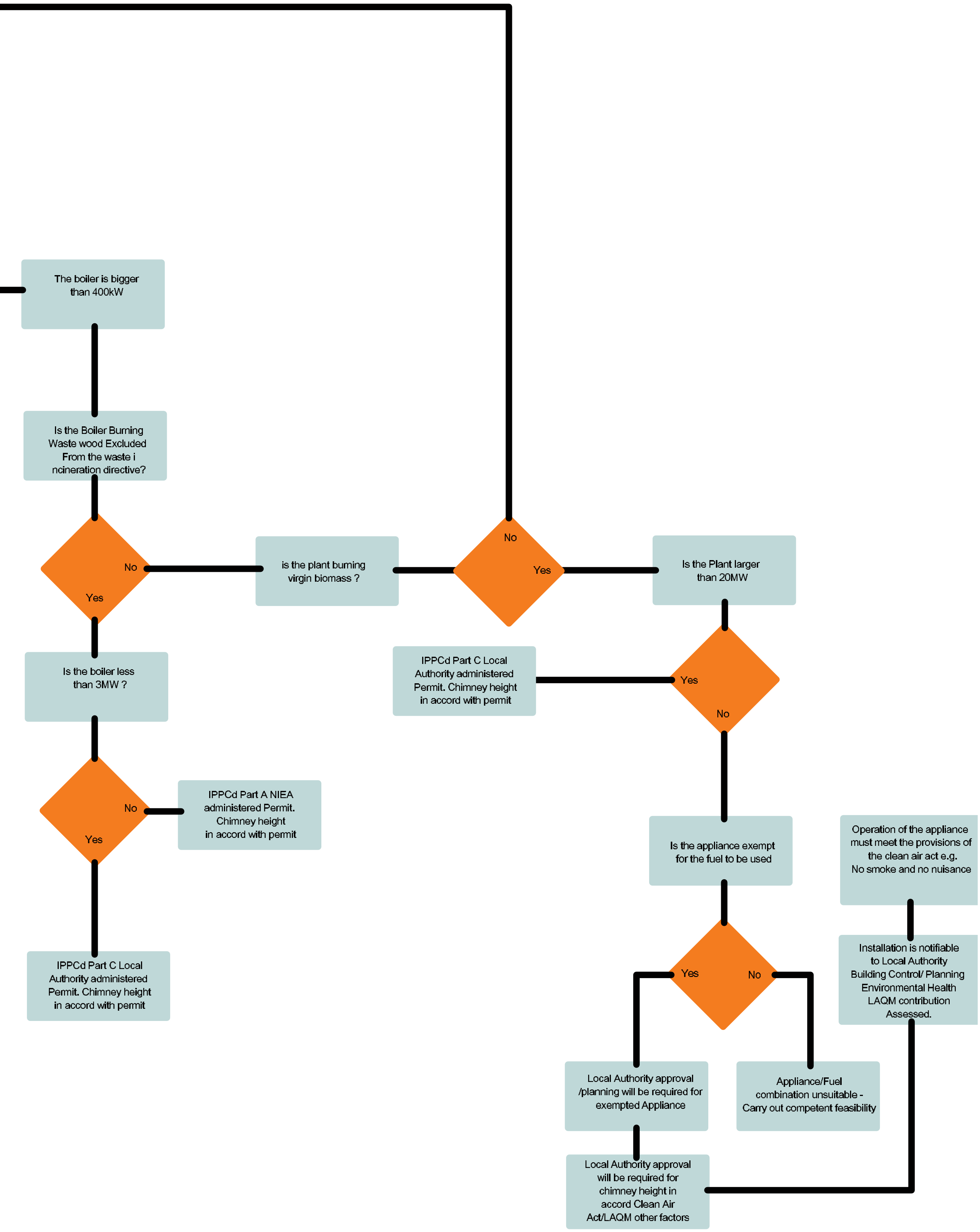
http://www.carbontrust.com/media/88611/ctg073-biomass-contracting-guide.pdf

Additional and specific Information can be solicited directly from Invest Northern Ireland business advisers.

14.0 References and Additional Guidance

Appendix A
A simplified guide to regulatory provision




The boiler is bigger than 400kW
Is the Boiler Burning Waste wood Excluded From the waste incineration directive?
No
Yes
is the plant burning virgin biomass ?
No
Yes
Is the Plant larger than 20MW
Is the boiler less than 3MW ?
IPPCd Part C Local Authority administered Permit. Chimney height in accord with permit
Yes
No
No
Yes
IPPCd Part A NIEA administered Permit. Chimney height in accord with permit
Is the appliance exempt for the fuel to be used
Operation of the appliance must meet the provisions of the clean air act e.g. No smoke and no nuisance
Installation is notifiable to Local Authority Building Control/ Planning Environmental Health LAQM contribution Assessed.
Yes
No
IPPCd Part C Local Authority administered Permit. Chimney height in accord with permit
Local Authority approval /planning will be required for exempted Appliance
Appliance/Fuel combination unsuitable - Carry out competent feasibility
Local Authority approval will be required for chimney height in accord Clean Air Act/LAQM other factors

Publishers	**Title**	**Length of tariff**
Ofgem	https://www.ofgem.gov.uk/environmental-programmes/renewable-heat-incentive-rhi/northern-ireland-renewable-heat-incentive	RHI application guidance
The Carbon Trust	Biomass heating - A practical guide for potential users	A guide for potential users of biomass heating equipment covering details of the technology and advice on procurement and operation.
The Carbon Trust	Contracting Guide	Gives guidance on contracts for biomass installations.
The Carbon Trust	Fuel procurement guide	Provides advice on setting up a biomass fuel supply.
The Carbon Trust	Health and safety guide	Published by the Combustion Engineering Association.
The Biomass Energy Centre	http://www.biomassenergycentre.org.uk	Various useful links
The Biomass Energy Centre	Biomass Feasibility Study	Short guide to feasibility

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