FORESIGHTING REPORT

Torrefied Biomass

A foresighting study into the business case for pellets from torrefied biomass as a new solid fuel source

For Members only

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V1.0

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ITI ENERGY INTRODUCTION

ITI Energy is one of three operating groups that make up ITI Scotland. Together with ITI Techmedia and ITI Life Sciences, we will be investing in excess of £450 million over ten years in research and development. Publicly funded, but 100% commercially driven, our collective aim is to create new technologies and stimulate business growth in Scotland.

ITI Energy will select and invest in programmes based on assessing future market needs, identifying technology opportunities, and responding to ideas, initiatives and proposals from the research and business communities. We will use our £150 million funding to commission and direct applied research projects in collaboration with partners from industry, academia and finance.

Throughout this process, we will protect the Intellectual Property (IP) that our investments generate, enhancing its competitive positioning, and helping to bring the resultant technology to market.

Participation in our activities and projects is open to all businesses and research organisations, regardless of where they are located. We are based in Aberdeen, but our scope and vision is global. We closely follow research activities in other countries, and welcome involvement and collaboration from overseas. Our success depends on being able to develop new technologies that address market needs around the world.

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BACKGROUND

Wood pellets are made by compressing dry saw-dust. They are a well specified solid fuel, with higher energy density and easier to handle than wood chips. They are used essentially for space heating, being competitive with heating oil at $ 60 /bbl oil price, and more recently as a fuel for co-firing in coal power plants, in particular to reduce CO_2 emissions.

The world production of wood pellets exceeded 7 Mt in 2005, equivalent to a market of € 1 billon. Sweden and Canada each produce over 1 Mt/yr. Denmark and Austria, where early policy incentives were provided, produce about 0.5 Mt/yr each. Production in the UK is about 0.1 Mt/yr and the potential for Scotland is reported to be about 0.3 Mt/yr.

Although volumes are still, small trans-atlantic and pan-european trade has developed over the last few years to supply wood pellets as fuel for co-firing in power generation plants in North-West Europe. This has been driven by pressure to reduce CO_2 emissions. There is the potential for this market to grow substantially provided that CO_2 pricing is favourable.

Co-firing of a wide variety of solid and liquid biomass materials in coal power plant has been the subject of many studies and trials over the past 20 years, with some early commercialisation now taking place. A recent DTI study (*) has looked into the economics of co-firing various bio-mass fuels including wood pellets. In particular, the study highlighted that

- *The co-firing of a range of biomass materials, at low co-firing ratios has been successfully introduced to coal-fired power stations in Britain, and the impacts on the performance, integrity and environmental performance of the plants have been small.*

- *In order for coal plant to operate at higher co-firing ratios, coal power plant operators will need to invest in new equipment for the direct co-firing of biomass materials.*

- *In most cases, the facilities for the reception, storage and handling of the biomass have to be upgraded substantially, or new facilities have to be installed, to cater for the significant increase in the biomass throughput*

Although wood pellets are reasonably easy to handle compared to many other solid biomass materials, they still have the following disadvantages in comparison to coal:

- high fibre content, which creates a bottleneck in the co-milling process with coal, reducing the overall co-firing ratio % potential
- hydrophilic material, would need to be kept dry during both off-site and on-site transport, storage and handling operations
- energy density, as received, is relatively low compared to internationally traded steam-coal
- limited supply – 7 Mt/yr compared to some 200 Mt/yr coal traded over the Atlantic – as feedstock is saw-dust, itself a co-product of saw-mill and furniture industry.

Making pellets from torrefied biomass, including sustainably grown wood or wood residues, rather than saw dust could resolve many of these issues. Indeed torrified material has physical and combustion properties closer to coal.

Torrefied biomass is the name given to the product of a process that involves heating biomass at 250 – 300 deg C for around one hour, leading to partial decomposition of the biomass polymeric structure. The resulting material is brittle and hydrophobic, can be easily stored, handled and milled without significant deterioration in quality. The torrefied material can also be pelletised, bringing its energy density closer to coal.

Because of a potentially huge sustainable supply and physical similarity to coal as a solid fuel, with no sulphur and virtually no ash, torrefied pellets (TOP) could become the future fuel of choice for space heating and co-firing with coal for power generation, provided the fuel can be produced and delivered at a competitive price.

This study investigates how to turn this vision into reality and briefly highlights potential opportunities for Scotland in this context. The work was directed and managed by ITI Energy with contributions from Energy Research Centre of the Netherlands (ECN), The University of Aberdeen, and Renfrew-based Mitsui Babcock.

(*) The Economics of co-firing , report URN 06/1959, July 2006

Wood pellets

Torrefied Wood pellets

1. INTRODUCTION

Torrefaction is a low temperature thermal process applied to biomass materials to modify their properties for further processing. The torrefaction process involves drying and heating the biomass to temperatures in the range 250-300ºC in the absence of air and at atmospheric pressure, for a period of around one hour. Under these conditions, the biomass polymeric structures undergo partial decomposition, with the release of volatile components, to produce a solid product, with very different physical properties from those of the original biomass. The torrefied material is dry, brittle and hydrophobic and the gross calorific value is a little higher than that of the parent biomass, on a dry basis.

The torrefied material can be stored for long periods of time without significant deterioration in quality, and is much easier to mill than the parent biomass. The torrefied material can be turned into pellets to increase the bulk density, and to reduce the tendency to generate dust in storage, transportation and handling. Pellets made through that combined “torrefaction and pelletisation” are called TOP pellets Their basic properties is compared with wood, torrefied biomass and conventional wood pellets are shown in Table 1.

Table 1. Properties of wood, torrefied biomass, wood pellets and TOP pellets

Properties	Unit	Wood	Torrefied Biomass	Wood Pellets	TOP Pellets
Moisture Content	**% wt**	35	3	7-10	1-5
Calorific Value (LHV)					
As received	**MJ/kg**	10.5	19.9	15.6-16.2	19.9-21.6
Dry	**MJ/kg**	17.7	20.4	17.7	20.4-22.7
Mass density (bulk)	**kg/m^3**	550	230	500-650	750-850
Energy density (bulk)	**GJ/m^3**	5.8	4.6	7.8-10.5	14.9-18.4
Pellet strength		-	-	Good	Very good
Dust formation		Moderate	High	Limited	Limited
Hygroscopic nature		Water uptake	Hydrophobic	Swelling Water uptake	Low swelling Hydrophobic
Biological degradation		Possible	Impossible	Possible	Impossible
Seasonal variations		High	Low	Moderate	Low
Handling properties		Normal	Normal	Good	Good

There is also the prospect that a relatively wide range of biomass materials can be used as feedstocks for the production of a fairly consistent torrefied product, the so-called Multiple Input-Specific Output (MISO) concept. For these reasons, torrefied biomass has significant advantages over the parent biomass materials as a boiler fuel, and particularly for firing or co-firing in coal-fired boiler plants, as a carbon neutral fuel.

2. TORREFACTION OF BIOMASS

The torrefaction process operates at temperatures between 250 and 300 °C under atmospheric pressure, in the absence of oxygen and at relatively low particle heating rates (< 50 °C/min). During the process, the biomass partly decomposes releasing a range of combustible volatile materials. In the process, around 70% of the mass, on a dry basis, is retained as a solid product, which contains around 90% of the initial energy content.

The typical mass and energy balance for the torrefaction of dry biomass is shown in Figure 1.

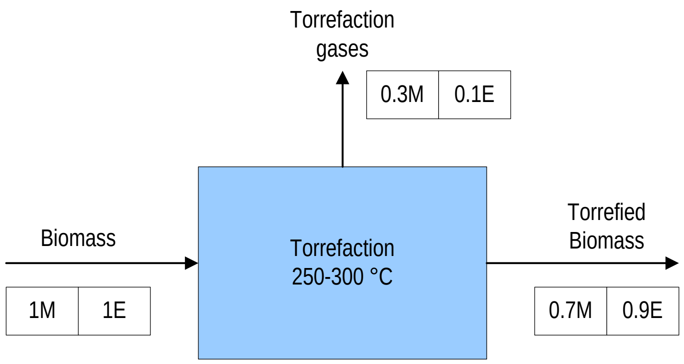


Figure 1. Typical mass and energy balance of the torrefaction process (Symbols: E = energy unit, M = mass unit)

Woody and herbaceous biomass materials comprise three main polymeric structures: cellulose, hemicellulose and lignin. During the torrefaction process a large number of different reaction pathways can be identified. For practical purposes, these can be grouped into a small number of principal reaction regimes, as illustrated in Figure 2.

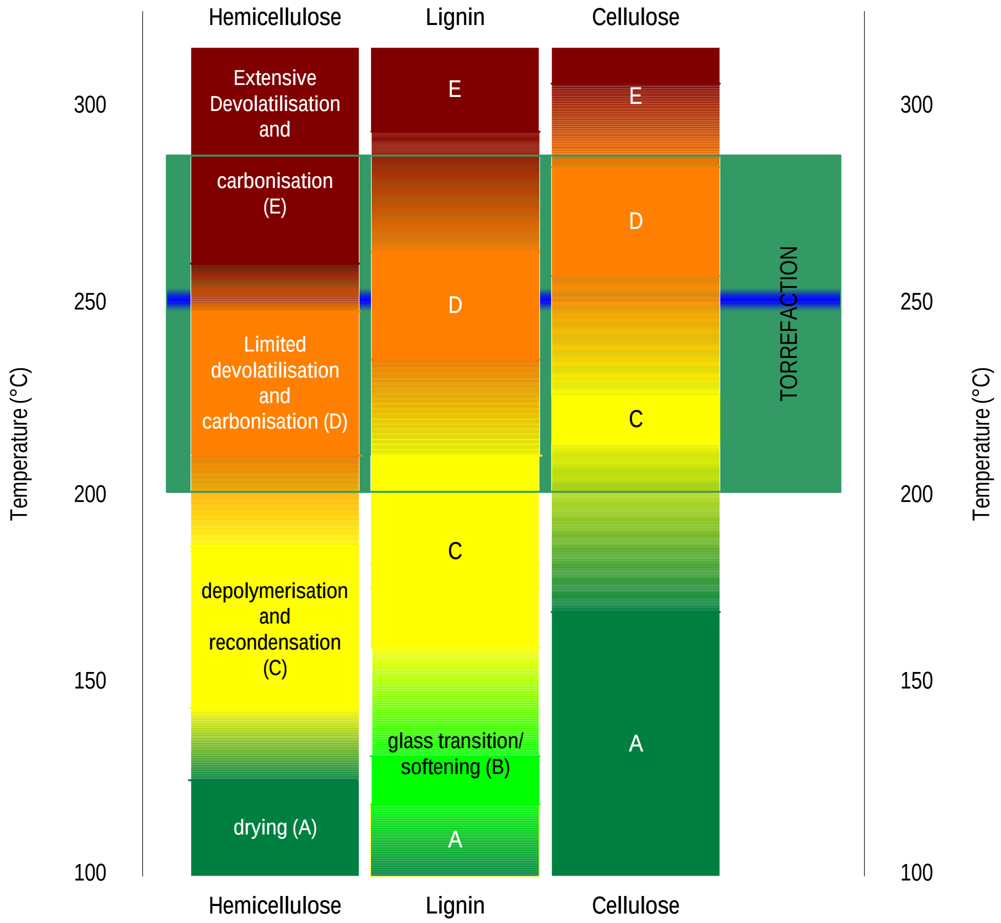


Figure 2. **The main physico-chemical processes that occur during the heating of lignocellulosic materials under torrefaction conditions**

For each of the principal polymeric species, similar decomposition regimes can be defined according to the temperature range:

- Range A — the biomass is dried.
- Range B — softening of the lignin
- Range C — depolymerisation occurs and the shortened polymers condense within the solid structure.
- Range D — limited devolatilisation and carbonisation of the intact polymers and the solid structures formed in the temperature regimes C.
- Range E — extensive devolatilisation and carbonisation of the polymers, and, of the solid products that were formed in regime D.

In general, the hemicellulose is the most reactive polymer, followed by the lignin, and cellulose is the most thermostable. At temperatures less than 250°C, the principal reaction is the limited devolatilisation and carbonisation of the hemicellulose. There is minor decomposition of lignin and cellulose, which does not lead to a significant mass loss. At temperatures in excess of 250°C, the process becomes more vigorous as hemicellulose decomposes into volatiles and a char-like solid product, and lignin and cellulose show limited devolatilisation and carbonisation.

The transitions from one regime to another occur gradually with increasing temperature. For hemicellulose, the transitions occur over a narrow temperature range whereas those for lignin and cellulose occur over a wider temperature range. The exact transition temperature depends on the type and properties of the biomass, and mineral material can act as a catalyst. In torrefaction, the devolatilisation and carbonisation processes occur relatively slowly and the reactivity of hemicellulose very much depends on its molecular structure.

A large number of reaction products are formed during torrefaction. The yields depend on the torrefaction conditions (temperature and time) and on the biomass properties. The products are classified, based on their physical state at room temperature (Figure 3).

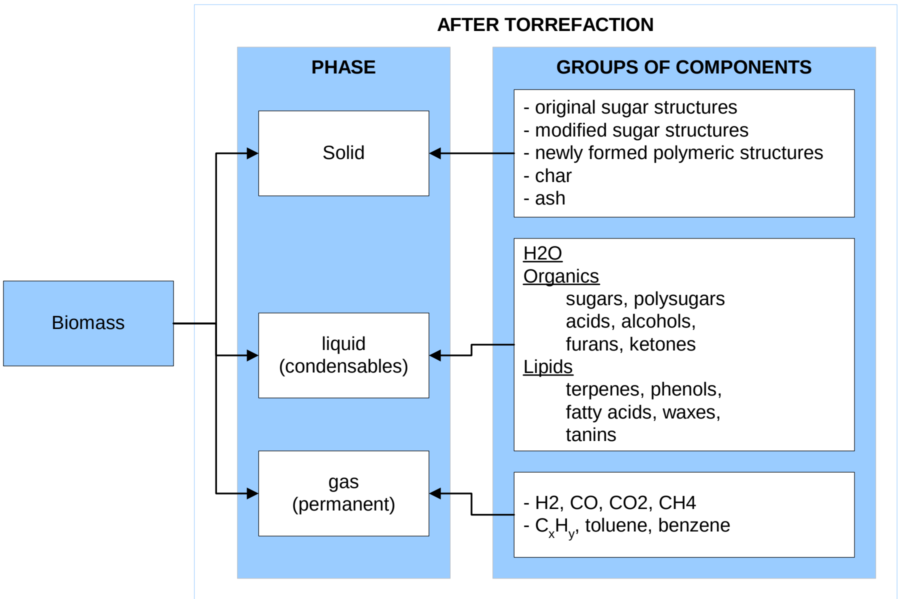


Figure 3. The principal products formed during the torrefaction of biomass

3. ECN TORREFACTION TECHNOLOGY

In the 1980's, at time of high oil price, a demonstration plant for the torrefaction of wood, was built and operated by Pechiney in France to produce material for metallurgical industry. This plant, built around a rotary kiln as torrefaction reactor, was used as a base to evaluate the technology. The total production cost (TPC) of the Pechiney process was estimated at 100 €/t product (without feedstock costs) and were dominated by reactor costs. Including feedstock costs, the TPC was 150-180 €/t product. It is clear that torrefaction products, based on this process, cannot compete with wood pellets with a delivered cost of 120 €/t.

The focus of the ECN research was to reduce the costs of torrefaction to create an economically viable business case for the co-firing market. Optimisation of the process design targeted:

- Minimisation of reactor residence time
- Optimisation of process conditions to improve the grindability of the product and the process thermal efficiency
- Development of compact reactor technology with high heat transfer rate and accurate temperature control
- Establishment of high energy efficiency through heat integration
- Energy densification through the combination of torrefaction and pelletisation

The central element of the technology is a directly heated moving bed torrefaction reactor in which biomass is heated using the recycled torrefaction gases (torgas). Tar is not expected to be an issue for firing the torgas. The recycle consists of re-pressurisation of the torgas to compensate for pressure drop losses in the recycle-loop and of the heating of the recycle gas to deliver the required heat demand in the torrefaction reactor. The heating of the torrefaction reactor is indirect to prevent the ingress of oxygen from the flue gas to the torrefaction reactor.

A generalised process flow diagram of the ECN Torrefaction process is presented in Figure 4.

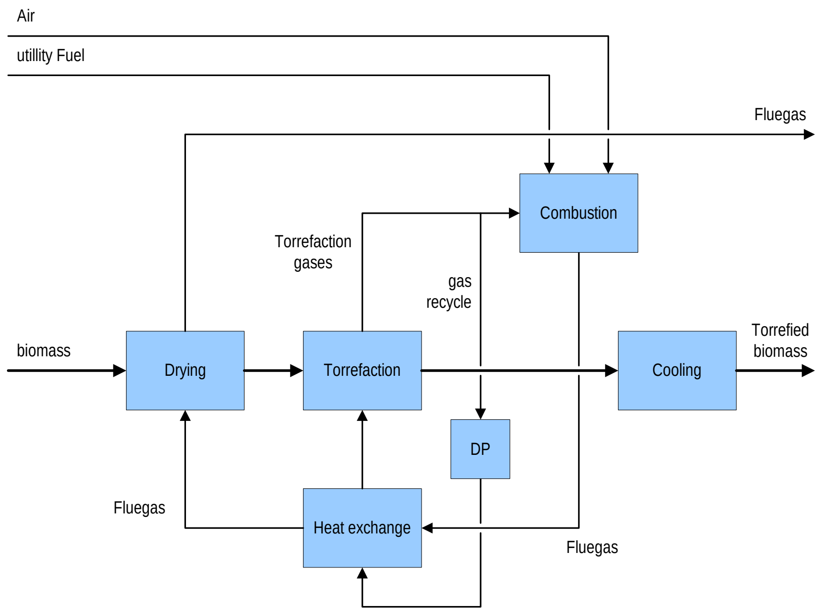


Figure 4. Basic concept directly-heated torrefaction

For biomass feedstock is wetter than 15% moisture content, an external dryer is required. This lowers the heat requirement of the torrefaction process, reduces the recycle flow rate, and permits the combustion of the torgas that otherwise would be too wet. Typically a rotary drum dryer, in which the biomass is dried in direct contact with hot flue gas, is employed. The heat generated by combustion of the torgas is used for both torrefaction and drying of the biomass. A support fuel is employed to balance the process thermally and to provide stability and control of the combustion process.

A moving bed reactor has been selected for the torrefaction unit as it provides a low cost option, as well as high heating and feed rates. Consequently it is also very compact.

The ECN moving bed reactor is not a standard unit, but has significant innovations with respect to:

- **Feedstock flexibility**. It can process a wide variety of biomass without needing to change the basic principles of the reactor.
- **Temperature control**. The torrefaction temperature in the reactor is the most crucial parameter, and must be controlled with high accuracy.
- **Feasibility of the integral process**. The reactor design enables the use of state-of-the-art technology for all other operations than torrefaction. This minimises both the investment costs and the technological risks.

The technology concept is proven at bench scale and a pilot plant is scheduled to be commissioned at the end of 2006. The plant will enable to test various feedstock and validate design data for a commercial plants with capacity ranging from 20 to100 kt/a.

4. COMBINED TORREFACTION AND PELLETISATION

A conventional biomass pelletisation process typically consists of drying and size reduction prior to densification. After densification the hot pellets are cooled. Steam conditioning of the biomass is commonly applied to enhance the densification process through the softening of the fibres.

Torrefaction typically involves pre-drying the biomass, torrefaction and product cooling. The TOP process combines torrefaction and pelletisation. Torrefaction is introduced as a functional unit after drying and before size reduction (Figure 5). The production costs for conventional and TOP pelletisation are similar.

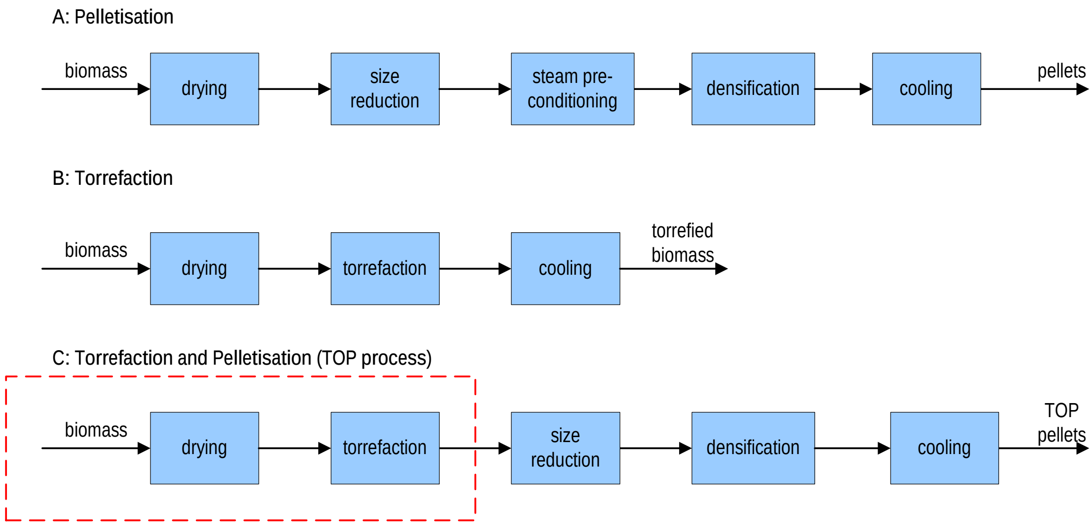


Figure 5. Combination of torrefaction with pelletisation - the TOP process

5. PROCESS SIMULATIONS AND ECONOMICS

A process simulation tool developed by ECN was used to quantify the mass and energy balances, the key process characteristics and the primary economics of the torrefaction based TOP process. The model includes flow sheet calculations of drying, torrefaction, cooling, grinding and pelletisation, and includes the performance characteristics of the key items of equipment.

The simulations were solved using experimentally-derived product distributions to determine the mass and energy balance. On this basis, the main plant items were specified. The specific requirements for the biomass dryer and the torrefaction unit were developed in detail.

On the basis of both the mass and energy balance, and equipment design, the Total Capital Investment (TCI) and the Total Production Costs (TPC) were estimated. The model solves the balances for a given thermal output (MWth) by changing the feedstock capacity. From this main balance all other conditions were estimated by an iterative procedure. A summary of the main process design specifications applied in the design and simulation of the process for the study work are shown in Table 3.

Table 3. General plant design specifications

TECHNICAL						
Item	**unit**	**value**		**Item**	**unit**	**Value**
Desired Production rate	MWth	47		**Ambient temperature**	ºC	20
On-stream period	hour/a	8,000				
Target market product		co-firing				
ECONOMICS				**UTILITY COST**		
Item	**unit**	**value**		**Item**	**unit**	**value**
Interest on financing	%	5.0		**Electricity**	€ct/kWe	6.5
Depreciation period	year	10		**Natural gas**	€ct/Nm^3	16.0
Project lifetime	year	10				
Tax-rate	%	30				

For the current study the plant capacity was set to an energy output of 47 MW_{th}. This corresponds to the output of a typical wood pellet production plant of 80,000 t/a (10 t/hr pellet production, 8000 hr/a, pellets have a calorific value of 17 MJ/kg). The on-stream time is set to 8,000 hr per annum, which is typical for a fully operational and commercial plant.

The process produces TOP pellets for the co-firing market which are sold to the power stations. A 5% interest rate and a project lifetime of 10 years, equal to the depreciation period of the plant were used in the analysis. The tax-rate is set to 30%. The utility costs reflects current market price for Northern Europe.

The biomass feedstocks used in the process simulations are shown in Table 4. The biggest difference between these raw materials is their moisture content and bulk density.

Table 4. Feedstock specifications

Case	Feedstock	Shape (mm x mm x mm)	MC (wt%)	Bulk density (kg/m^3)
1	Wet Softwood	Chips (15x30x40)	50	250
2	Wet Softwood	Chips (15x30x40)	35	220
3	Open-air dried wood	Chips (15x30x40)	25	200

The principal differences in the mass and energy balance of each feedstock are caused by the large difference in moisture content, and this will also affect the process economics. A summary of the main outcomes of the process simulations and the general mass and energy balance of the torrefaction process for Case 1 are shown in Table 5 and Figure 6.

The key results of the economic evaluations are shown in Table 6. The Total Capital Investment for Case 1 is estimated at around M€ 7.2. For Cases 2 and 3 the investment costs of the dryer are reduced in line with the reduced feedstock moisture contents.

Table 5. Main results of the cost estimations

ITEM	UNIT	VALUE	VALUE	VALUE
Calculation	**(code)**	**Case 1**	**Case 2**	**Case 3**
Total Capital Investment	M€	7.2	6.5	6.1
Working capital	M€	0.6	0.6	0.6
Project contingency	M€	0.6	0.5	0.5
Total processing costs (TPC)	€/t	50	37	34
	€/GJ	2.4	1.8	1.6
TPC breakdown (main items)				
Feedstock	€/t	-	-	-
Depreciation+financing	€/t	13.9	11.9	11.1
maintenance	€/t	2.1	1.8	1.7
Personnel	€/t	8.1	7.6	7.6
Support fuel	€/t	7.7	2.6	2.6
Electricity	€/t	7.7	4.6	3.1
Other	€/t	10.1	8.4	7.8

The Total Processing Costs (TPC) increase with the increasing feedstock moisture content, from 34 €/t product (Case 3) to 50 €/t product (Case 1).

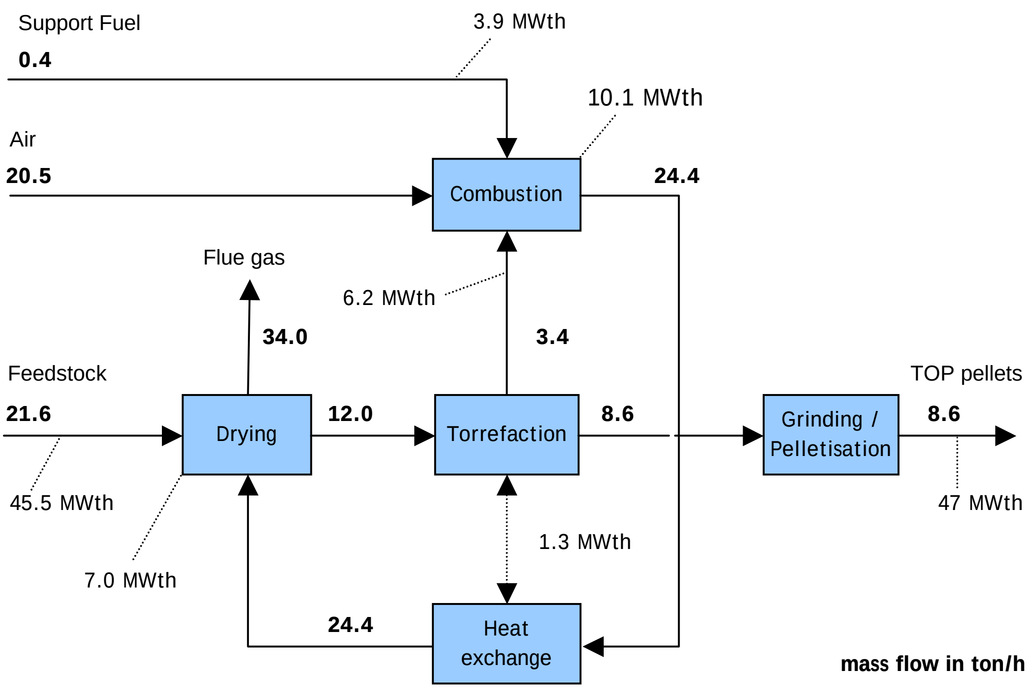


Figure 6. General Mass and Energy Balance for Case 1

Table 6 Summary of the Outcomes of the Process Modelling.

ITEM	UNIT	VALUE	VALUE	VALUE
Calculation	**(code)**	**Case 1**	**Case 2**	**Case 3**
Feedstock	type	Softwood-chips	Softwood-chips	Softwood-chips
Moisture content	% weight	50%	35%	25%
Net Calorific value	GJ/t	7.6	10.3	12.5
Bulk density	kg/m^3	250	220	200
Energy density	GJ/m^3	1.9	2.3	2.5
Product	type	Pellets (TOP)	Pellets (TOP)	Pellets (TOP)
Moisture content	% weight	3.0%	3.0%	3.0%
Net Calorific value	GJ/t	19.2	18.2	18.1
Bulk density	kg/m^3	750	750	750
Energy density	GJ/m^3	14.4	13.7	13.6
PLANT CAPACITY				
on-stream time	hour/a	8,000	8,000	8,000
Feedstock	MWth	46.7	48.9	48.2
	t/a	177,457	136,280	111,327
	m^3/a	709,828	619,454	556,637
Pellets	MWth	47.2	47.2	47.2
	t/a	70,700	74,600	75,200
	m^3/a	94,267	99,467	100,267
UNIT RATIOS	UNIT/t pr			
feedstock	t	2.51	1.83	1.48
electricity	kWh	117.7	70.5	47.7
support fuel	Nm^3	48.4	16.2	16.5
air	Nm^3	1,807	863	503
water	m^3	-	-	-
PLANT PERFORMANCE				
Thermal efficiency	LHV basis	93.4%	93.9%	95.1%
Net efficiency	LHV basis	88.8%	90.9%	93.0%

Economies of Scale

The effects of the scale of operation on the economics were evaluated for Case 3. The capacity of the plant was varied from 23 MW_{th} fuel production to 71 MW_{th} fuel production. The Total Capital Investment varied from M€ 4.7 for the 23 MW_{th} (36.3 kt/a product) plant to M€ 7.9 for the 71 MW_{th} (112 kt/a product) plant. The TPC was decreased from 59 €/t at 23MW_{th} to 30 €/t at 71 MW_{th}.

6. FEEDSTOCK RESOURCES

The ECN process is capable of handling a wide range of biomass materials with moisture contents up to around 50%. For this study, the availability of wood chips generated within the forest products industry has been examined, with the main focus being on Scotland. These materials can be sourced as:

- Forest Residues
- Co-products from the sawmilling industry
- Co-products from wood processing industry
- Produce of short rotation coppice energy plantations

Forest residues are the tops and branches left in the forest following conventional forest harvesting operations. In Britain, conifer forest harvesting follows the Scandinavian shortwood concept where trees are felled, the branches removed and the piece of the stem above 7cm diameter cut and left in the forest. These residues can then be collected, and are usually chipped either in the forest or at landing, and transferred to chip vans for transport to the user. These are relatively expensive operations and so different ways of handling these low density residues are evolving such as compressing the residues in the forest into bales or into composite residue logs (CRL). The latter have recently been shown to be the most cost-effective method for delivery of energy wood in Sweden.

An alternative method is to adopt integrated harvesting systems where whole trees are felled and transported to a point in the forest, where they are processed further. This processing involves removing the branches with flails and chipping the branches. This system has the advantage that it reduces the cost of the fuel chip.

For small and poorly shaped trees where there is no ready commercial market a straightforward solution is to harvest and comminute them in one operation, so-called whole tree harvesting/chipping. In Scotland, a significant number of trees meet these criteria and could form a good proportion of the feedstock, at least in the short to medium term future.

Co-products from the sawmilling industry take the form of chips and sawdust. The majority of the large-scale sawmills in Scotland process coniferous logs, mainly spruce and pine, and their co-products usually flow to the panel board industry for production of chipboard or MDF.

Co-products from the wood processing industry take the form of chips, shavings, saw and sander dust. Bulk supplies will be limited to the Central Belt and from cooperages on Speyside.

Short rotation coppice usually involves harvesting fast growing willow trees and producing either bundles of stems or a comminuted product. The UK co-firing regime was designed to develop market confidence, so that farmers would grow this crop for fuel. However, the costs of producing the chips are still very high. This source is not considered further here.

The Forestry Commission's view of the quantities of woody biomass which may be available for use as fuel in Scotland is shown in Table 7.

Table 7 Available Woodfuel Resource in Scotland

Product	**Annual Available Resource (oven dry tonnes)**
Stemwood (7-14 cm diameter)	70,000
Poor quality stemwood	113,000
Stem tops	14,000
Branches	126,000
Sawmill conversion products	40,000
Aboricultural arisings	10,000
Short rotation coppice	600
Total	**381,000**

7. SUPPLY CHAIN LOGISTICS AND COSTS

Three main cases have been examined to determine the feasibility of producing TOP pellets from different biomass feedstocks at a production level of 80,000 tonnes of pellets per year. A range of feedstocks have been examined, however the main differentiating factor is the moisture content. The 3 cases are shown in Figure 7.

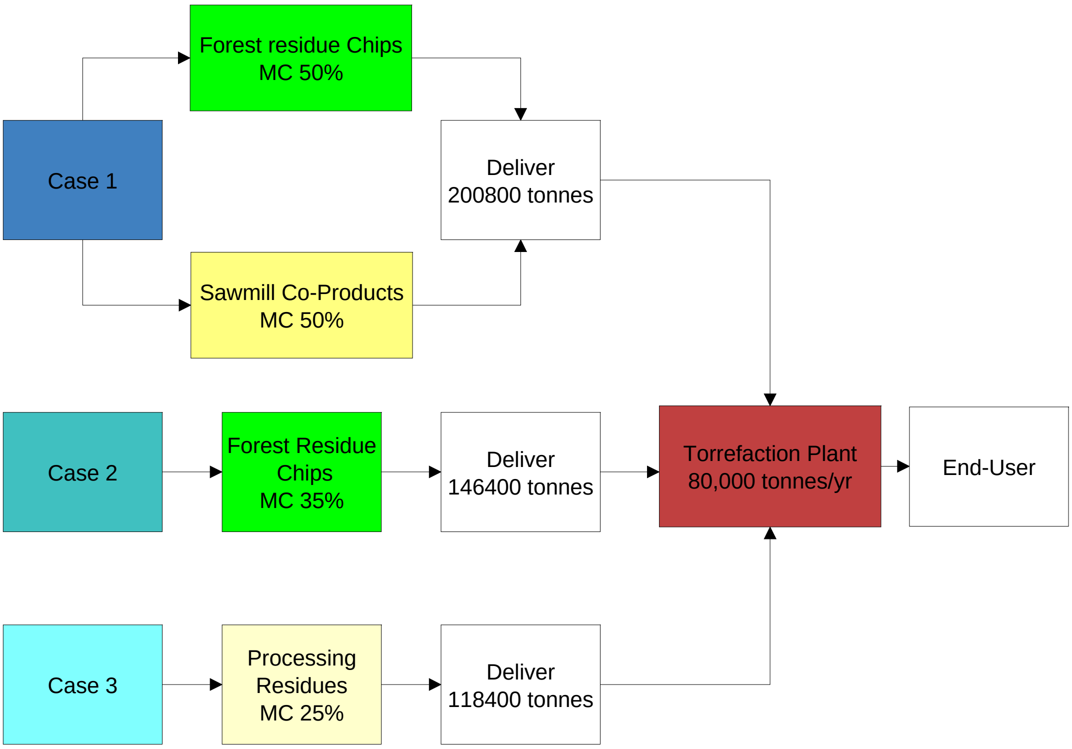


Figure 7 Potential Supply Chain for 80,000 tonnes TOP production per year

The most recent costs for operations were collected from the literature and industrial contacts, and were built into a spreadsheet model to determine the delivered cost of TOP pellets from each of the potential feedstocks. The cost relations are summarised in Table 8 and Figure 8.

Table 8 Feedstock required as a function of source and moisture content

	CASE 1	CASE 2	CASE 3
Feedstock	Softwood	Softwood	Softwood
Source	Forest or Sawmill	Forest	Processing Plant
Form	Chips	Residue Chips	Chips
Moisture Content (%)	50	35%	25%
Bulk Density (kg/m^3)	250	220	200
Net Calorific value (GJ/t)	7.6	10.3	12.5

Feedstock Required per Year	200800	146400	118400
Feedstock required per tonne TOP	2.51	1.83	1.48

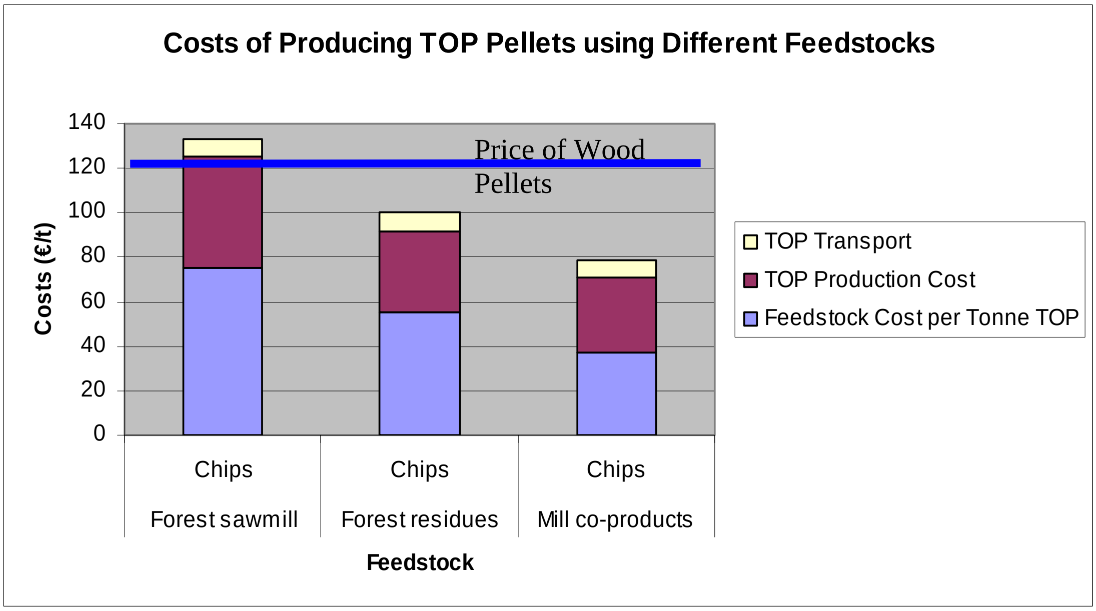


Figure 8. Costs of Producing TOP Pellets Using Different Feedstocks

The delivered economic costs of TOP pellets vary from around 80 €/tonne up to around 133 €/tonne for sawmill chips. On an energy basis this corresponds to about 4 to 6.5 €/GJ, making TOP pellets competitive with wood pellets currently delivered at about 8 €/GJ to certain power stations (Figure 8).

It is considered that a combination of forest residues and sawmill co-products would be required to get near the levels of supply required for feedstocks with a moisture content of 50%. In this case, the plant would need to be located adjacent to a large sawmill. There are three such sawmills in the NE of Scotland. These would appear to offer a significant advantage as the sawmills in the other regions of Scotland with the potential to supply such a plant are already linked with other biomass developments.

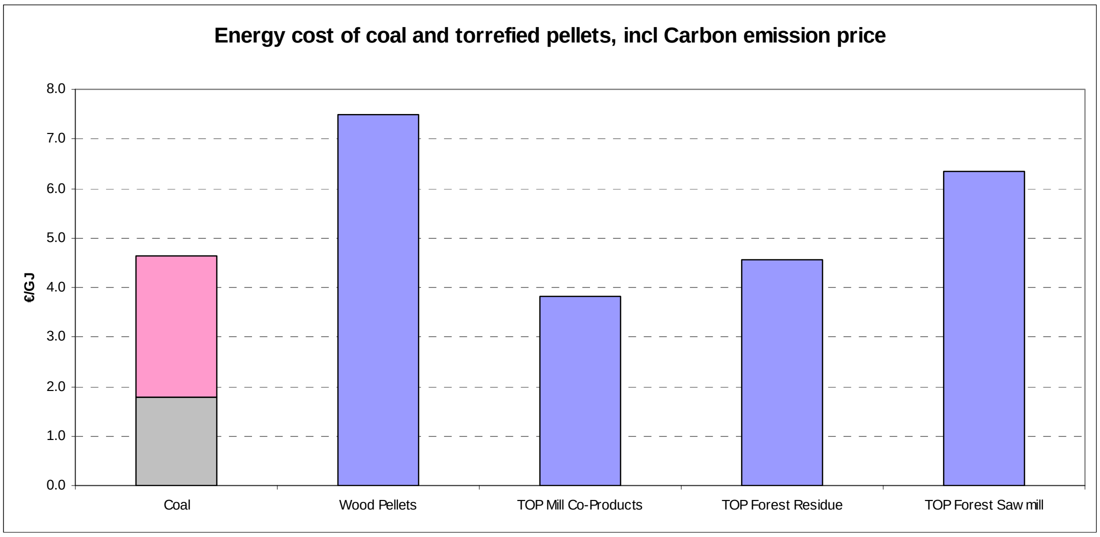
There is some potential to reduce the costs of delivered forest residues by compacting the residues thereby getting a more cost-effective payload for road transport. The delivered costs for forest residues are likely to fall with time as system efficiencies start to develop with experience. In the longer run, integrated harvesting systems and whole tree chipping of small trees may well be required to ensure security of supply and reduce competition for resource from the panel board industries.

The question of economic scale of operation needs to be addressed as the larger the conversion plant the greater the economies of scale for processing but the greater the dis-economies of scale associated with the feedstock supply. The larger the quantity of feedstock required, the wider will be the catchment area, which will impact both on the transport costs and the security of supply.

The competitivity of TOP *versus* imported coal essentially depends on the value attributed to the reduction in CO_2 emissions. Based on bituminous coal from South Africa or East Canada delivered to Europe at a CIF price of 50 €/tonne, TOP from mill co-products become competitive for co-firing in power plants at a carbon emission price of 20 € /tCO_2. TOP from forest residues require 30 €/tCO_2 while high moisture content chips from forest would need 50 € /tCO_2. Over the last 2 years, carbon market price has varied between 10 and 30 € /tCO_2.

As a result of the above, and assuming a power station efficiency of 35%, the station gate fuel cost of TOP, expressed per unit of electricity produced, ranges from 40 to 65 €/MWh or £ 26 – 43 /MWh. This costs range is comparable to, although somewhat lower than, the £ 35 – 50 /MWh presented in the recent DTI report on “Economics of Co-Firing”.

Figure 9. Energy Cost of Coal, Wood Pellets and Torrefied Pellets, including Carbon Emission Price



8. IMPORT – EXPORT CONSIDERATIONS

The power generation companies have been very agile in sourcing biomass fuels for co-firing in quantities and costs that are relevant to their operations. This demonstrates that an international trade in biomass is already operational. It is also clear that significant quantities at appropriate prices are more readily available on the international market than in the domestic market.

Given the high energy density of TOP pellets it would be sensible to manufacture them in the country of origin of the feedstock and export the pellets. They will be much easier to handle and the risks of wetting and decomposition are much reduced with TOP pellets. It can easily be envisaged that lignocellulosic feedstocks could be produced in parts of the world where land and labour costs and population densities are significantly lower than in North West Europe and hence the costs of feedstock delivered to a TOP facility will be lower. There may even be cost reductions in the TOP process and larger plants, perhaps up to 200 kt/year, can be constructed taking advantages of wider catchment areas and economies of scale. The TOP pellets can then be traded on the world market as transport costs by sea-going bulk carriers are significantly cheaper per tonne delivered than road transport which dominates in Europe.

By way of example, in certain parts of Latin America, it is possible to sustainably produce and supply wood to a central processing location for less than 2 €/GJ. Adding a processing cost of 1.5 €/GJ and a shipping cost of 1 € /GJ (20 €/tonne) would lead to a TOP delivered cost in Europe around 4.5 €/GJ, thus competitive with coal for carbon prices of 30 € /tonne. This gives a great opportunity for Scottish businesses linked to this supply chain.

9. RISK AREAS AND SUBJECTS FOR FURTHER DEVELOPMENT WORK

Security of feedstock supply

The ability to contract for a significant portion of the continuous supply of suitable feedstock required for the prospective torrefied fuel production plant, at an appropriate price, and over the proposed period of plant operation, will constitute one of the key assets of a biomass-to-energy project. For biomass projects, this has been one of the key risk areas historically, and any potential lender or investor will take a keen interest in the proposals for management of the feedstock supply risks.

Initially, this issue can be addressed by the performance of a suitable feasibility study on the longer term availability of appropriate feedstock within reasonable transport distances of the proposed site, and preferably from a number of potential suppliers. This should cover any potential threats to the future feedstock supplies and prices, including the competing markets for the proposed feedstock materials.

In the longer term, prior to financial closure, suitable feedstock supply arrangements and contracts will be in place.

The technical, regulatory and commercial risks associated with the torrefaction technology and the proposed torrefied fuel production facility

As described above, the technical and other information about the ECN torrefaction process has been derived from laboratory scale testwork and some desktop process engineering, including the development of process simulation and economic modelling capabilities.

The further technical development of the process will involve the construction and operation of a pilot scale facility by ECN to provide further process data under more realistic conditions, and to provide the information on which to base the detailed design of the key equipment. The focus of the proposed pilot scale testwork is on the design and operation of the moving bed torrefaction unit and associated equipment, since this is the unit process that entails the highest degree of novelty and which has an important influence on the overall process economics.

On completion of the pilot plant test programme, and when the position with respect to the ECN patent cover for the process has been clarified, the performance of an appropriate ‘due diligence’ exercise on the technical and other aspects of the torrefaction technology is proposed.

The proposed torrefaction plant will involve the operation of a direct fired biomass drying unit and a biogas/solid fuel combustor. The appropriate planning agreements, and environmental and other consents for the operation of the plant, will be required. Past experience with dedicated biomass thermal conversion projects indicates that this may be a prolonged and expensive exercise, depending principally on the selection of the site.

At present, the torrefied fuel production costs and the project business plan are entirely dependent on the capital and operating cost estimates provided by ECN on the basis of the process simulation work, and on economic models recently developed for the torrefaction process. Further work in this area, including the development of a more comprehensive business model will be required, when the data from the pilot plant are available.

The projected markets and prices for the torrefied product
The availability of secure supply contracts for the torrefied material covering a significant portion of the product from the proposed plant, at an appropriate price, and over the proposed period of plant operation, will constitute one of the key assets of the project. The sale of the product will provide the only source of future income to project and it is clear that potential lenders and investors will take an interest in the security of this income.

At the present time, the key market is considered to be as a fuel for co-firing in large coal-fired power boilers. The torrefied fuel product, as with the majority of biomass materials, is significantly more expensive than coal, and biomass co-firing activity in Britain is currently dependent on subsidy via the Renewables Obligation or adequate valuation of CO_2 emissions for instance through the EU Emissions Trading Scheme (ETS). The future economics of biomass co-firing and the future competitiveness of the torrefied material as a fuel for co-firing need to be studied in some detail.

Initially, this issue can be addressed by assessing the longer term marketability and competitiveness of the product into the target markets. This should cover any specific advantage of the fuel as well as potential future threats to the future sales of the product, including its competitive position relative to the alternative fuels, particularly for co-firing. It may also be prudent to consider alternative markets for the torrefied materials, such as space heating in the commercial and residential market.

10. WAY FORWARD – ITI ENERGY VISION

As highlighted above, further de-risking work is required prior to planning the construction of a demonstration plant in Scotland. Conceptually, a 20 kT/yr demo plant would supply the local wood pellet market for residential and commercial heating and provide the significant amounts of products for large scale trials in power stations

In this respect, the major actions required over 2007 are:

1. validate the innovative torrefaction reactor developed by ECN, and test it on local Scottish feedstock (e.g. spruce residues)
2. confirm the suitability of torrefied pellets for co-firing with coal in power plants, and for boiler in the residential and commercial markets by a series of trials
3. identify one or several suitable location(s) in Scotland, with adequate supply and logistics
4. evaluate the commercial potential of this new fuel both at local and international level, any credit for carbon emission reduction, and/or other pollutants.
5. bring together a consortium of interested stakeholders from the forestry industry, engineering companies, energy companies (large or small), which would see benefits in participating in a demo plant.

Financial resources required for executing the above actions are currently estimated at about £100k. ITI propose to progress and complete these actions in close cooperation with a group of active members in the relevant areas.

Further information on this foresighting study may be obtained from Georges Dupont Roc, Director, Strategy & Business Development on tel 01224 282630 or email georges.dupontroc@itienergy.com.