



SUBCOAL® CONCEPT PAPER

Clean Coal Technologies 2015 KRAKÓW

Abstract

The Subcoal® concept gives the waste recycling sector and the major energy consuming industries a clear route to recover energy with a material that would otherwise have been disposed by incineration or landfill. Instead the waste streams are refined and converted into a high quality fuel which can replace dirtier fossil fuels such as bituminous coal in existing installations such as power stations. The Subcoal® quality is tailored to each energy consumer resulting in efficient combustion and in many cases reduced emissions to atmosphere.

This gives governments a very useful tool in the management of waste in a safe and sustainable manner and supports energy intensive industries in their efforts to reduce their environmental impact and make a significant improvement to their financial performance at a time when many industries are under threat due to the general economic downturn.

Executive summary

The Subcoal® concept offers a number of opportunities for both non-recyclable paper-plastic waste producers and major fossil fuel consumers. Our concept offers to upgrade the non-recyclable paper-plastic waste streams into a high quality alternative fuel, which can be used in similar ways to bituminous coal or lignite. We do not offer a waste to energy concept, we prefer calling it waste to fuel concept, as we feel we are in a higher segment of the waste hierarchy than incineration or waste to energy facilities. Our focus lies on substituting lignite and/or bituminous coal in existing facilities such as power stations or cement kilns.

The concept for the fuel production was invented in 1998, by the Dutch chemical company DSM¹. A spin-off company called Qlyte first started producing the fuel in 2008, the N+P group has taken over both the intellectual property and the Subcoal® production facility in 2013.

In many countries both waste and energy are on top of the political agenda. For waste the discussion mostly focuses on preventing waste, recycling waste and solutions for waste which cannot be recycled any further. For energy the discussion mostly focuses on renewable energy, the reduction of emissions and the reduction of fossil fuel usage. The link between the two discussions is rarely made, and this is where the Subcoal® concept comes into play.

Subcoal® combines the fact that paper-plastic waste fractions cannot be 100% recycled to new products, with the fact that renewable energy doesn't necessarily have to come from 100% biomass waste fractions such as wood. Converting non-recyclable paper-plastic waste fraction to a pellet which can be used as an alternative to bituminous coal or lignite can offer the solution for millions of tons of waste, which currently end up in landfill or waste incineration plants. You will solve both problems, as the converted "waste" will replace fossil fuels and will thus contribute to a more renewable way of generation energy or heat.

Our input material mostly comes from waste sorting plants or large paper-plastic waste producers such as cardboard mills, in some cases the production line can be implemented in at the site of the waste producer. We offer these companies a technology which will upgrade their waste to a valuable resource. On the other side of the equation we focus on energy consuming industries such as cement kilns or coal fired power stations, which are offered the ability to replace their traditional fuel by a sustainable alternative, in many cases no new dosing and grinding equipment is necessary as Subcoal can be handled by existing equipment. Both the international waste market as well as the international energy consuming industry produce and consume respectively millions of tons of material so the international potential of this concept is huge.

There is little public awareness of the fact that paper-plastic waste fractions already replace millions of tons of bituminous coal and lignite in the cement industry. From this experience it is also known that these kind of fuels actually reduce the emissions such as CO₂ and NO_x plus they offer a significant economical contribution for both producers as end users.

By stimulating the Subcoal® mind-set, governments have a useful tool which can help them in achieving their climate change goals and also solve their problem for sustainable waste management. In our opinion Subcoal® provides the missing link for waste to be re-used and energy to be more sustainable.

¹ Reference to patent numbers are on the last page of this paper.

Introduction to the N+P Group

With over 20 years of experience, the N+P Group is a well-known and respected name in the European field of waste recycling. The company stands out thanks to its highly experienced staff, its straight forward talking and the transparent relationship it has with its customers. N+P is a leader in the field of the industrial recycling of waste residues, coming from various industrial sectors.

The company offers a number of services including:

- Logistic development (supply chain) and coordination
- Operational know-how
- Notifications and permits (TFS procedures)
- Analysis & reporting
- Project management
- Development
- Consultancy

Back in 1993 N+P was one of the first companies to have its own production line for the production of alternative fuels. From this period, the cement industry has always been a major off taker of the high quality alternative fuels which N+P produces. Along with the cement industry, the lime and power industry are also major energy consumers which use alternative fuels produced and/or delivered by N+P.

N+P is currently one of the largest alternative fuel exporting companies operating in the UK. Strategic locations in the UK currently allow a number of different alternative fuels to be shipped to e.g. Latvia, Germany and Portugal. N+P is also one of the biggest alternative fuel suppliers in Europe. The current contract portfolio for alternative fuels is approx. 1.100.000 tonnes per year, mostly in long-term contract with multinationals. Turnover is approx. € 70 million per year, with the whole group moving approx. 2 million tonnes of industrial waste throughout Europe.

Introduction to the Subcoal® technology

The patented Subcoal® technology was developed by the Dutch chemical company DSM. The technology was developed to find a sustainable solution for non-recyclable waste streams, which would otherwise end up in landfill or be incinerated. It is of no discussion that waste should always be prevented or recycled to new products, but a significant amount of waste is still currently not recyclable at the moment. Key to this technology was the conversion of paper-plastic waste streams, to a sustainable alternative fuel. The process currently has been developed to take not only paper waste streams but other waste streams e.g. general commercial and industrial wastes. The patents and technology are now owned by N+P's subsidiary Subcoal International B.V. The technology is licensed to Qlyte Operations B.V., which is the first stand-alone Subcoal® production facility in the Netherlands.

The technology consists of a number of different treatment stages, depending on the input waste streams. The waste streams are typically purified with recyclables being collected and removed from the waste streams. A drying step is available if the waste streams are high in moisture content. The material is shredded to the required size and pelletized, typically having a diameter of 8mm and a length of 40mm (with a larger particle size available if required).



The process allows numerous parameters to be controlled, with the process also-guaranteeing stable quality fuel in terms of heat content, together with concentrations of ash, chlorine, heavy metals and moisture. This means we can produce fuels tailored to our customer's demands.

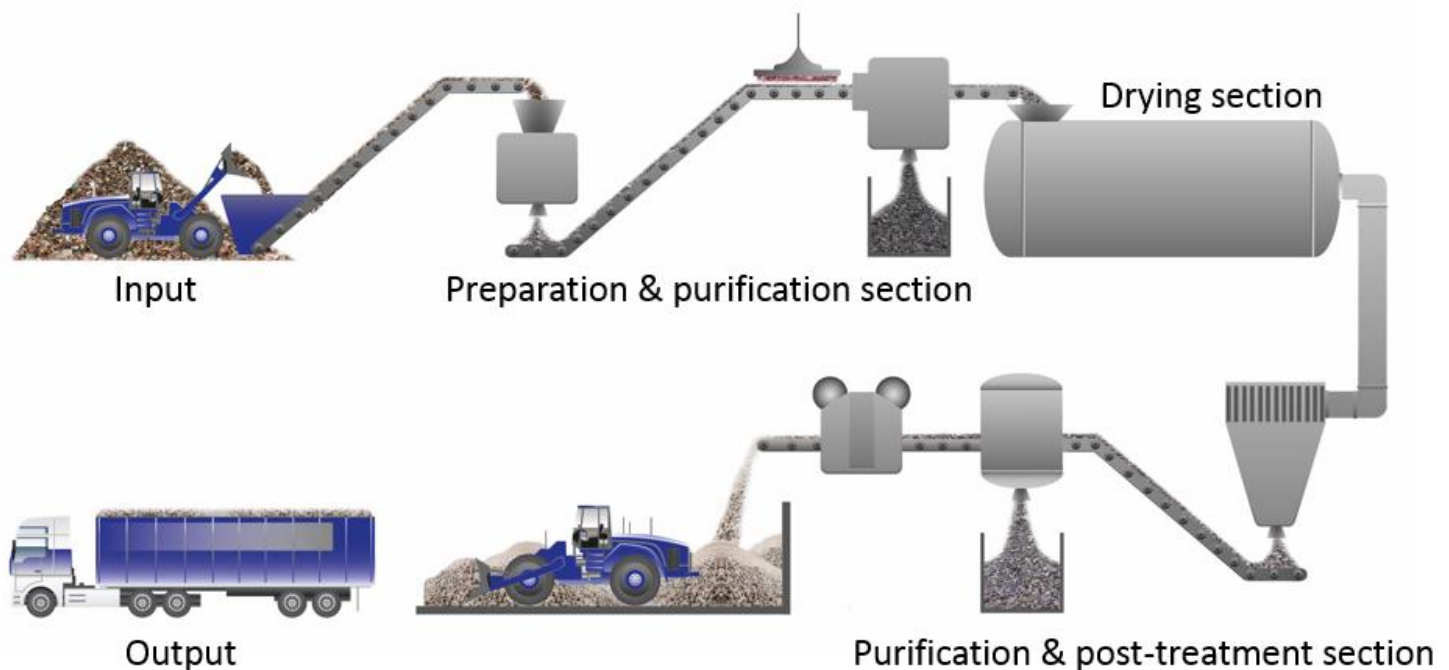
Technical information

Subcoal® typical input waste streams

The typical waste streams which are used to produce Subcoal® are non-recyclable paper-plastic waste fractions, coming from various sources. Mostly commercial waste is used, coming from waste sorting plants where valuable recyclables are removed for further processing. In addition waste coming from paper and cardboard mills as previously stated is very well suited to be processed into an alternative fuel. Household waste is not directly suited to be used in as a raw material, however treated household waste could also be used as well. If household waste is used and diverted from landfill then a further benefit in using Subcoal® would be the reduction of methane gas being emitted to atmosphere from landfill sites. It is well known that methane is a much more harmful gas than CO₂ and so such a development would further improve the environmental credentials of using the Subcoal® concept. It should be noted that the paper-plastic waste streams are known in the market as refuse derived fuel (RDF) and sometimes as solid recovered fuel (SRF).

Subcoal® process

The patented process consists of a number of process steps. The number of steps required to produce a high quality alternative fuel depends on the quality of the input materials which are available. Drying for instance is necessary if the waste streams contain > 15% moisture. In the first phase of production, the material is screened and shredded to a smaller size. The next step is to remove as many impurities as possible, for example ferro and non-ferro material. The material is then fed via a optic separator to remove as much PVC as possible (due to its very high chlorine content), before being shredder to the final size of roughly 30mm. The final step is to pelletize the raw material into the required form, depending on the application this is typically done to a 8mm diameter and about 40mm length.



The unique features of the Subcoal® pellets

The pellet coming from our process has a number of unique features, which gives it its added value. First the density is much higher, compared to other alternative fuels such as SRF (Subcoal® 450 kg/m³ versus SRF 150 kg/m³), saving on transportation costs, plus the higher density has a benefit in certain applications.

Because the material is pelletized, the particle size is greatly reduced. Due to the pressure in the dices (used in the Subcoal® production process) the plastics start melting together, forming a hard and strong pellet. Once ground, typically the pellets have a particle size of less than 5mm. The pellets also show hydrophobic behaviour, thus the pellets do not dissolve in and will not absorb much moisture. In theory this will allow you to store the pellets outside for short periods.

Subcoal® composition versus fossil fuels

Subcoal is used to replace fossil fuels such as bituminous coal, lignite, and petcoke. Due to the patented process to produce Subcoal®, the chemical composition is comparable to bituminous coal and lignite in terms of heating value. Parameters such as heavy metals are comparable to coal, in some cases Subcoal® is even cleaner than fossil fuels.

Subcoal® typical specification

Net calorific value (as received)	: > 20.000 kJ/kg > 9.000 Btu/pound
Ash content	: < 12 W.-%
Moisture	: < 8 W.-% DW
Chlorine	: < 0,8 W.-% DW
Sum heavy metals	: < 800 mg/kg
TOC	: > 50 W.-% DW
Biomass	: > 50 W.-% DW
Volatile matter	: > 60%
Typical physical size (unground)	: Ø 8 mm (length 40 mm)
Typical physical size (ground)	: < 5mm
Density	: 400-450 kg/m ³

Via a number of desk studies as well as case studies at industrial applications, it is proven that Subcoal® has a comparable burnout time as coal- and lignite dust. The percentage of volatile matter is much higher (up to 6 times higher) compared to fossil fuels.

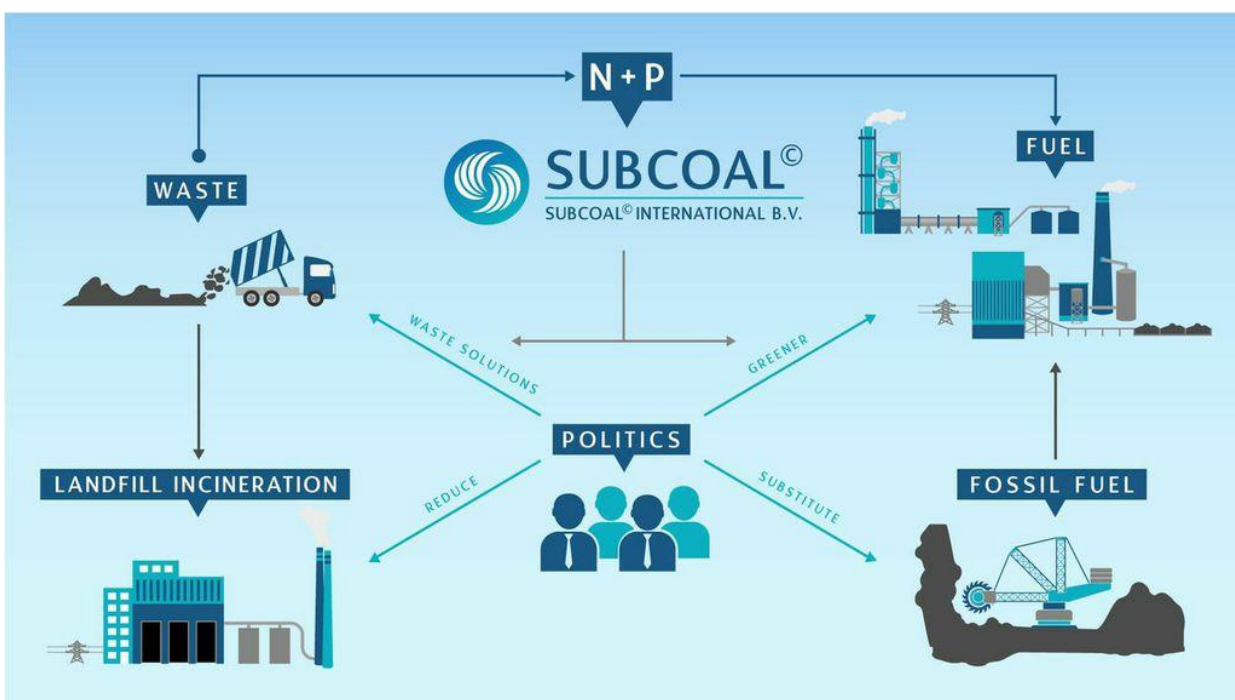
Subcoal® applications

The current applications that are currently using Subcoal® include the cement, lime and power industries. These industries use Subcoal® to substitute their fossil fuels. Depending on the type of installation Subcoal® is almost always ground or co-ground before being dosed to the kiln or boiler. Applications are known to use Subcoal® without grinding as well.

Subcoal® concept

The philosophy behind the Subcoal® concept is that it can solve the missing link between the growing need for waste to be reused and the increasing demand for sustainable alternative fuels by major industrial energy consumers. Every country produces waste. Much of this waste can be recycled, but there are always waste streams which cannot be recycled any further and end up in landfill or waste incineration. This is exactly the type of waste stream which the Subcoal® technology focusses on. The Subcoal® technology offers all the necessary steps to create a high quality alternative fuel and diverts waste streams from landfill or incineration.

Almost every country has energy consuming industries, such as power stations, cement kilns and lime kilns. These industries consume huge amounts of fossil fuels and thus emit large amounts of CO₂ into the atmosphere. Especially in western countries the discussion regarding alternative fuels and the reduction of CO₂ emissions is at the very top of the political agenda. The alternative fuel pellets which are produced using the Subcoal® technology can be used to replace dirty fossil fuels such as bituminous coal and lignite. Due to the high biomass content of the pellets the burning of such alternative fuels will reduce the CO₂ emissions wherever they are burnt.



In addition all major energy consumers are under extreme pressure from the authorities to reduce their emissions of oxides of nitrogen or NO_x. When taking the cement industry as an example it has been demonstrated that the burning of such alternative fuels as Subcoal® improve the combustion process and so reduce the emissions of thermally generated NO_x. There are now many examples where the NO_x emissions reduce by up to 50%. Experience in with coal fired power generators also show reductions in NO_x emissions when burning alternative fuels similar to Subcoal®.

Via the Subcoal® route, waste which normally ends up in landfill or in waste incineration plants is “re-used” in a beneficial manner. Subcoal® recycles waste in the best possible way: use the available energy to the fullest, to replace raw fossil fuel energy. On this fact we distinguish ourselves from waste to energy facilities. A study carried out under the supervision of CE Delft, Delft (the Netherlands Climate analysis Subcoal®, June 2011)² proves that the Subcoal® route is a more sustainable route compared to waste to energy installations, even waste to energy installations with a heat exchange unit. From practical experience we have seen no effects on by-products such as fly ash, gypsum or the final product (clinker or lime) itself.

² Publication number: 11.2483.44

The new generation of coal mines

Following our statement earlier that a significant number of waste streams are non-recyclable in a physical way, we therefore argue that every country sits on its own potential energy mine with high heat content waste materials not being effectively utilised. With the possibilities that the Subcoal® technology offers, we could use a significant percentage of the non-recyclable waste streams as alternatives to fossil fuel such as bituminous coal, lignite and petroleum coke.

Hundreds of millions of tonnes of potential

The possibilities which non-recyclable paper-plastic based waste could offer in the energy sector are largely underrated. In Western Europe there is little awareness of the huge efforts the cement industry has taken to replace an average of 30% of fossil fuels in their kilns. Many kilns in Germany and the United Kingdom operate at 60% thermal substitution of alternative fuels. The global substitution rate at cement kilns is believed to be at only 5%, if we would assume that every kiln can achieve 30% thermal substitution, then it is estimated that almost 200 million tonnes of alternative fuels could be consumed globally by the cement industry alone which is already a proven concept.

“To think in a strategic combination, it is vital that countries find solutions for their waste streams and in addition countries should be as independent as possible in terms of energy supply. Using their own resources, the Subcoal® technology allows countries to prevent waste ending in landfill or waste incineration while on the other hand contributing to a cleaner and more independent and sustainable fuel supply .”

The development of the last 20 years within the cement industry shows the potential of non-recyclable paper-plastic based fuels. This development has been done without any form of government involvement in terms of subsidies. This is a vital point, as it demonstrates that this is a viable solution and has been driven by market forces independent of government support.

Substitute for bituminous coal

An alternative fuel may have comparable chemical aspects when compared to e.g. bituminous coal or lignite however the physical form is much more different. Typically bituminous coal is ground on site before being blown into the boiler or kiln. Almost every alternative fuel which is available in the market, biomass included, needs a separate dosing system and a separate burner to be used. The example given earlier on the cement industry is no exception, millions of euros have been invested in proper dosing equipment to enable kilns to burn various liquid and solid alternative fuels. The cost reduction which alternative fuels bring make these investments easier to bare. The market has for a long time been searching for an alternative fuel which can be used in similar ways to bituminous coal or lignite (dust) as this would significantly reduce additional required investment in order to utilise such fuels. This type of alternative fuel is considered the Holy Grail within the industry. We have proven that Subcoal® is can be co-grinded with bituminous coal in a vertical roller mill³.

³ Alstom Boiler Deutschland research report lab report V 5619; 4.48778

HOLY GRAIL

Subcoal® pellets have proven to be one of the first alternative fuels which can be treated in such a way as bituminous coal, whilst being commercially attractive without the need for governmental subsidies. In other words, existing equipment used for grinding, dosing and burning, are suited to dose the Subcoal® fuel into the boiler or kiln. This means that for example a power station is able to use Subcoal® without any extra investment. In addition Subcoal® can also sold in the ground form to cement kilns, as a substitute for lignite dust.

Public awareness

The cement industry has been a pioneer in the displacement of dirty fossil fuels by cleaner waste derived fuel made from non-recyclable paper, plastics and cardboards. This achievement has been achieved in a low key manner. Due to this, the level of public awareness is low and there is little appreciation that this progress has been achieved without the support of state aid. There is now possibly a need to broadcast this achievement so that more progress can be made in other sectors.



OUR OBJECTIVE

Our objective is to bring awareness to the governments, the waste sector and the energy consuming industries and realize a reduction of CO₂, NO_x and other emissions using the Subcoal® concept. We feel that at this point in time, the general awareness of the possibilities which paper-plastic based alternative fuels can offer is largely underestimated. If all sectors involved are banded together using the Subcoal® concept, countries can very quickly reduce their waste streams and reduce their usage of fossil fuels, a win win situation. The financial benefit which could be achieved in comparison to landfilling, incineration or buying fossil fuels can also be enormous. Next to this, Subcoal® helps to achieve the environmental goals set out in various national, European and worldwide conferences.

What can we offer?

The N+P Group specializes in the realisation of the Subcoal® concept on both the production and application side. With over 20 years of experience, we know our way in the dynamic waste market and the difficulties end users have with using alternative fuels.

We have invented the wheel many years ago and are happy to share our knowledge and experience on both production companies, but also potential alternative fuel users. We have many references where we have either started a new installation to produce fuels, upgraded existing installations, and we also have a lot of references from multinationals using our high quality alternative fuels.

Our companies offer a number of services, which can be tailored to suit every client's needs in a specific project.

- Logistic development (supply chain) and coordination
- Operational know-how
- Notifications and permits (TFS procedures)
- Analysis & reporting
- Project management
- Development
- Consultancy
- Intellectual property

In some cases we can also bring financial parties to the table who have the capability to invest in these kind of projects.

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Patents

Title	EP Patent number
Grindable pellet (granted)	EP-B-2307531
Method of making a pelletized fuel (granted)	EP-B-1083212
Method for firing an industrial furnace using coal or cokes with a secondary fuel (pending)	EP14163780.1
Improved combustibility of a waste plastic based fuel (pending)	EP-A-2129753
Process for drying and purifying a particulate cellulose/plastic waste mixture (granted)	EP-B-2134820
Method for processing a mixture of cellulose/plastic waste particles to form a fuel (pending)	EP-A-2318488