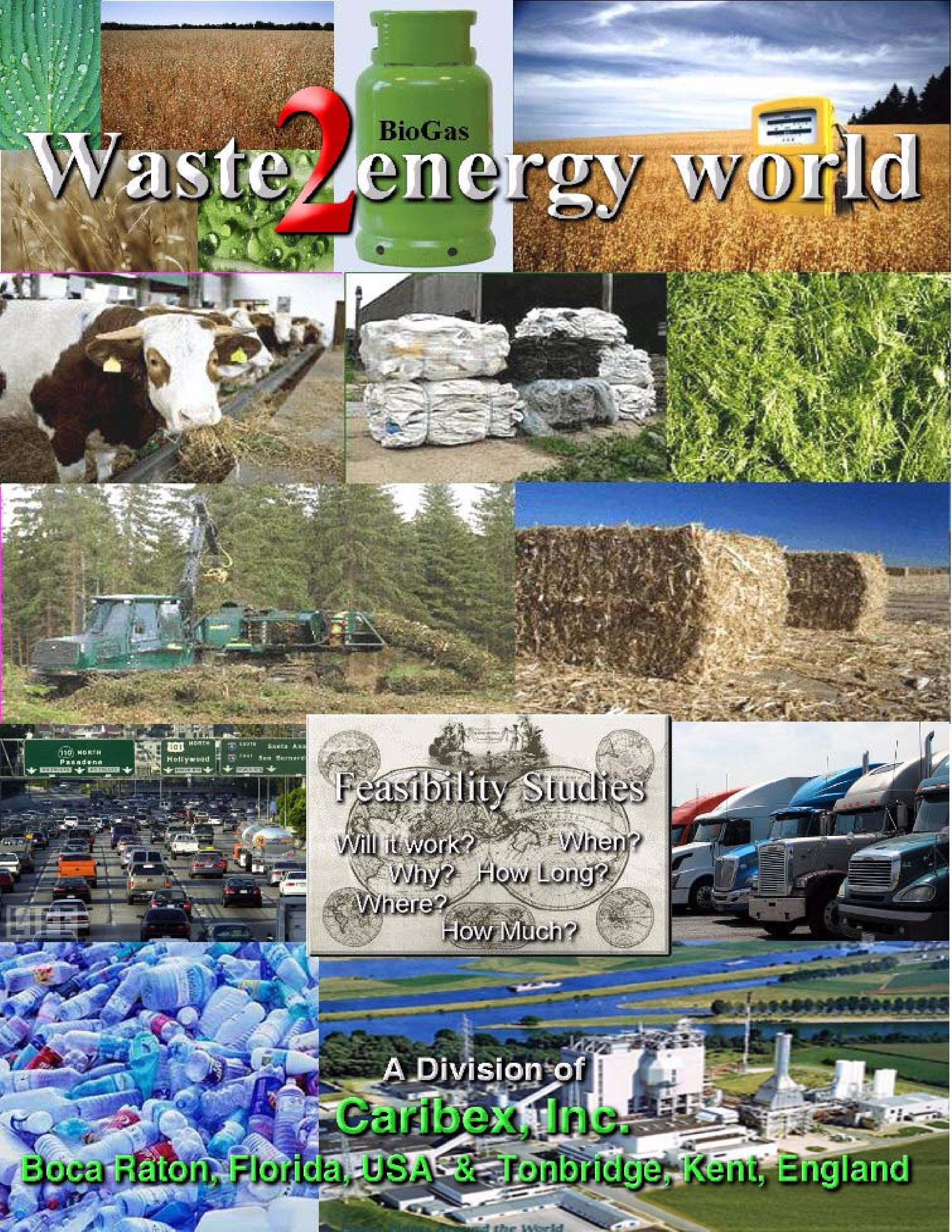
Waste2energy world



A Division of

Caribex, Inc.

Boca Raton, Florida, USA & Tonbridge, Kent, England

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WELCOME TO WASTE 2 ENERGY WORLD

Waste-2-Energy World is a division of Caribex, Inc. We have been undertaking independent feasibility studies and writing advanced business plans since 1974.

We deliver non-biased, independent work studies, feasibility studies and business plans for clients interested in converting municipal, industrial and agricultural waste materials as well as other materials into useful energy.

The disposal of waste materials has, from the earliest civilizations, been a burdensome problem. Today, as urban populations have increased, the problem has become acute. For decades, our only solution has been dumps and landfills, some employing incinerators, composting and many other means, none of which are satisfactory in either the short or long term. These methods of waste disposal are unsanitary, polluting and dangerous.

Waste 2 Energy (W2E) is a consulting company delivering honest feasibility studies that are not beholden or slanted toward any particular manufacturer or technology.

We know that the right kind of system and process for any given community, city or town will vary according to each of their specific requirements, capabilities, needs and expectations.

Every single detail must be taken into careful consideration when planning or suggesting a workable methodology. This is what we do and we do it exceptionally well.

We understand the waste to energy and waste disposal processes and we carefully factor all the realities into our studies to provide solutions that a truly workable and very effective both in the short and long term.

We welcome you to our website and consider our approach to the problem. If you agree that it makes sense, contact us and let's work together to bring the best and most cost effective solution possible to your particular waste to energy problem.

Robert Firth

President,
Waste2Energy World

About Us

Robert Firth and Peter Coleman head up the management team at Caribex. Together, they have written literally hundreds of studies and business plans for clients worldwide.

Robert has 40 years of engineering and management experience while Peter is a licensed business planner from the UK. Both have lived and worked all over the world on a wide variety of projects.

Caribex, the parent company, has focused on aviation related studies while Peter's background includes programming and accounting. The company began its pursuit of waste to energy in 2002 with a pyrolysis project in Egypt.

Since then, the plasma arc technology along with advanced pyrolysis methodology has developed into a worldwide phenomenon such that there is today, scarcely a city, town or municipality that remains unaware of the significant benefits of gasification of MSW (Municipal Solid Waste).

Caribex brings to the table, a wide spectrum of hands-on construction and design experience. Between them, Robert and Peter understand exactly what they are talking about and know the costs and benefits of each of the principal methodologies involved in W2E.

CONSULTING

In addition to Work-studies, feasibility studies and advanced business planning for new waste to energy projects, we also offer a full consulting service for waste disposal and waste to energy projects.

We offer our consultancy in a variety of manners: Not only on a retainer basis but also on a monthly, weekly, daily and even an hourly basis for telephone consultancy.

We advise municipalities as well as private companies and businesses. This consultancy takes many forms and ranges from helping with initial introduction to the technologies and methodology's of waste to energy to consultancy on full projects, from engineering with engineers, contactors, vendors, public forums, delivering feasibility and full advanced business planning and financial modeling.

We understand that in many cases, companies and municipalities not only have their own well-trained and expert staff in place and do not need us to undertake the full-blown project feasibility study. However they sometimes require temporary solutions and expertise to help guide their own in-house team in certain specific aspects of a given task.

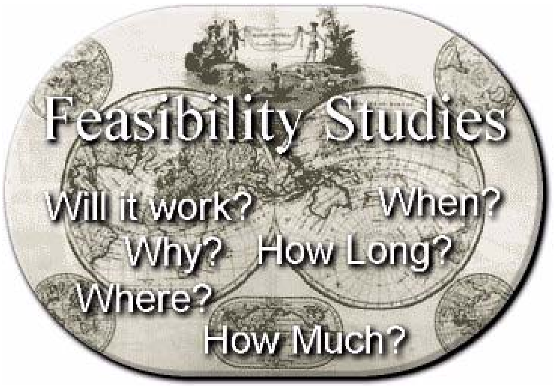
We also understand that, with the terms and charters of some municipalities, agencies and private entities, outside consultancy and expertise is sometimes easier for them than having to go directly to an RFP before they are ready to do so. Thus, initial outside consultancy can often save considerable and unnecessary costs, not only in the overall project but, in the early feasibility, evaluation and reporting stages.

FEASIBILITY STUDIES

Most governments and municipalities as well as larger companies very often lose out on vital information and end up spending hundreds of thousands if not millions of dollars when it comes to alternative energy evaluations.

The reason for this is the feasibility studies they have contracted for are biased.

Many companies supplying alternative energy and waste to energy technology or products will offer "lowball" energy studies and feasibility studies - even offering them free of charge. However, as we all know, in life we all get what we pay for so, beware of freebees!



These vested companies do this simply so they can slant a study toward their own technologies and products. They make the problem fit their specific technology rather than consider and recommend the best technologies to suit the particular situation at hand.

By far, in the largest percentage of projects, the correct solution is almost always a balanced combination of the very best and most economical technologies and products available. The idea is to get the best results for the least expenditure. The end user after all has to live with the repayment of the debt for twenty or more years. Overpayment is not an option!

The only way to avoid this problem is to have a properly researched, study undertaken by a professional, independent company, with no connection to any manufacture or suppliers of the technology. A biased or "slanted" study will usually be flawed, for obvious reasons and ultimately can cost much more than necessary

The Feasibility Study considers:

Aspects of the project such as:

- Is it the intention of the authorities for the new plant to eliminate local landfills or, will the plant be concerned only with the daily delivery of new waste materials?
- What will be the total daily quantity and substance of the materials to be delivered?
- Type of waste:
- Will the waste materials delivered, include industrial, hazardous and agricultural waste to the plant?
- If so, in what frequency and quantity?
- Delivery:
- How, when and by what means will deliveries be made to the facility?
- This is a complicated metric requiring considerable research.
- Future growth:
- The facility needs to consider the future growth of the area (city and regional area) so as to allow for growth (increased input) over a period of twenty years.
- Expected results:
- The study will deliver its findings to the client such that a five-year financial projection will indicate the total overheads expressed by detailed line items for every category of expense contrasted against expected offsetting revenues.
- Revenues will be expressed as a function of generated KWH's or in m3 of SynGas, factored at the desired rates. The figures will indicate break-even operations as well as expressing increasing graduations matching the inputted flows of materials to be gasified.
- Allowances will reflect the capacity of the plant, which will match the expected growth of the serviced areas. Equally, consideration will be given to increasing overheads as well as increases in the cost of the generated power to the local power company(s).
- The client is expected to pay a fee to cover the cost of the Feasibility Study. From this we pay our expenses including, travel, the rental of office space and salaries to local personnel retained to assist in researching and obtaining the data to be used in the study. In general, it is expected that a period of 3 months will be required to deliver the completed study.
- If desired we can provide access to considerable funding. Once the lender has reviewed the Feasibility Study and met with the local officials and developers, funds will be made available (first draw) to the PPC to cover the costs of engaging the design team and beginning drafting detailed construction plans. At this time the client will also draw from the lenders a payment of $150,000 to recoup funds paid for the Study.

- Following the above, Caribex will begin writing the formal Business Plan. In this case, payment would be made from a pre-approved draw reflected in the preliminary budget and again, a period of 3 months is expected for us to deliver the completed plan.
- The Business Plan includes letters of intent from local vendors and contractors based on their review of a set of preliminary site plans and specifications.
- It is the aim of the Business Plan to engage as many local vendors and contractors as possible so as to retain the greatest amount of the construction and materials funding in the local area.

How an independent study can save millions.

So many times we have seen a gasification project study put out to RFP and the winning company will be less than half of most of the others. Why? There has to be a reason. Well there is!

Although there seems to be an immediate saving of 50% on the cost of the study that could be several thousands of dollars in some cases, depending on the size of the project to be studied, it is a very false savings. A biased study giving a solution slanted to a specific technology or supplier can and will be astronomically more expensive in the long run.

To dismiss all other technologies in favor of a one technology fits all bias is totally wrong and in most parts, unethical. Hundreds of thousands of dollars more than necessary are then built into the actual cost of the project itself.

Some biased studies will recommend only Pyrolysis; others will recommend only Plasma arc gasification. However, a pyrolysis plant will do most of the job but will not gasify everything because of the limitation in temperature ranges. A plasma arc plant on the other hand will gasify virtually everything but is exceptionally expensive in dealing with everyday urban waste.

An independent, unbiased study as an example would intelligently inform that a combination of technologies might be more efficient and economical for a specific project. Instead of a one hundred and twenty million dollar plasma arc plant utilizing 18 Inch plasma torches just to handle the volume it might be advisable to have a Fifty-two million dollar pyrolysis plant for the bulk and a much smaller thirty million dollar plasma arc plant with 4 inch torches to handle the non gasified contaminates from the pyrolysis plant and all other hazardous waste as a separate entity. The two plants could then supply their combined produced syngas to the same gas turbines for the production and generation of power.

Just by taking the best of each technology and combining them, as on the above example project, it would not only produce the clean energy from waste, clean up all contaminates, recycle all energy (BTU's) locked up in dumps and land fills, but also save up to fifty eight million dollars in the process.

A Forty Million Dollar ($40,000,000.00) saving on the plant design, engineering and construction cost while giving the same waste to energy efficiency and for the sake of having an unbiased study as opposed to one that would be biased to any one specific technology or supplier.

An independent unbiased study can also make recommendations and observations for other ideas and properties that could also help with specific project. For example: Materials and concrete recycling contaminate destruction and clean distilled water production from waste.

BUSINESS PLANS

A Business Plan is a detailed blueprint for building a given company. A business plan contains all that the Feasibility study has plus specific time-lines, detailed budgets with monthly and seasonal forecasts, letters of intent, resumes of staff, background, competition, strengths & weaknesses, work sheets and a full notations, appendix and all related and required documents that will be referenced as the company is being developed.

A well-written business plan will show what revenues can be expected and when to expect them, what overheads and expenses will need to be paid and exactly when they will be due. It will also show staffing levels and salaries along with costs of employment, sales levels with monthly and seasonal trends, setup costs, building/office costs, utility and telephone costs, legal, insurance and accounting costs, office furniture and supplies costs and a myriad of other cost projections as well as legal requirements and conformation to regulations.

In addition to the revenue projections and costs, the business plan will feature sections on demographics, objectives, expansion plans, contingency exercises, product and services market introductions, regulatory requirements and the laws of City, State and Federal governments relating to the business / project and much more. A well-written business plan can help maximize potential and minimize overheads, liabilities and risk associated with any project.

Over the years we have written many feasibility studies and business plans for new and expanding airline operators. We have started several airlines from scratch and are able to offer hands-on assistance and support from day one until the project is complete.

What does a Business Plan show and why do your need one?

First, let’s imagine that you are planning on building a valuable W2E project. What is the first thing you want to know? Of course, can the project reach its projected revenues? Can it succeed and remain in operation functioning as intended.

These are the practical every day considerations of any management team.

For any new project the single document that means the difference between a positive or negative outcome is 100% , the Business Plan. If the plan is well and truly written and the lender and his advisors can see clearly in acceptable format, exactly how the facility is going to operate, make the loan repayments and avoid default, that project is far ahead.

The plan has to show, in clear understandable terminology and acceptable, recognizable format, a minimum of a five-year, month by month financial projection reflecting every possible overhead contrasted against variable revenues.

The plan has to introduce the key officers and staff and contain detailed resumes of the principals. The plan has to show in detail how the facility will serve its proposed markets and allow the readers to see that the management team indeed understands the mechanics of the business.

An W2E project is exactly equal to the sum of its parts and no more. The plan must show how the facility intends to operate and maintain the technology, where and how it will be maintained and a detailed list of equipment that will be provided. There needs be comments and description of spares, tooling and storage.

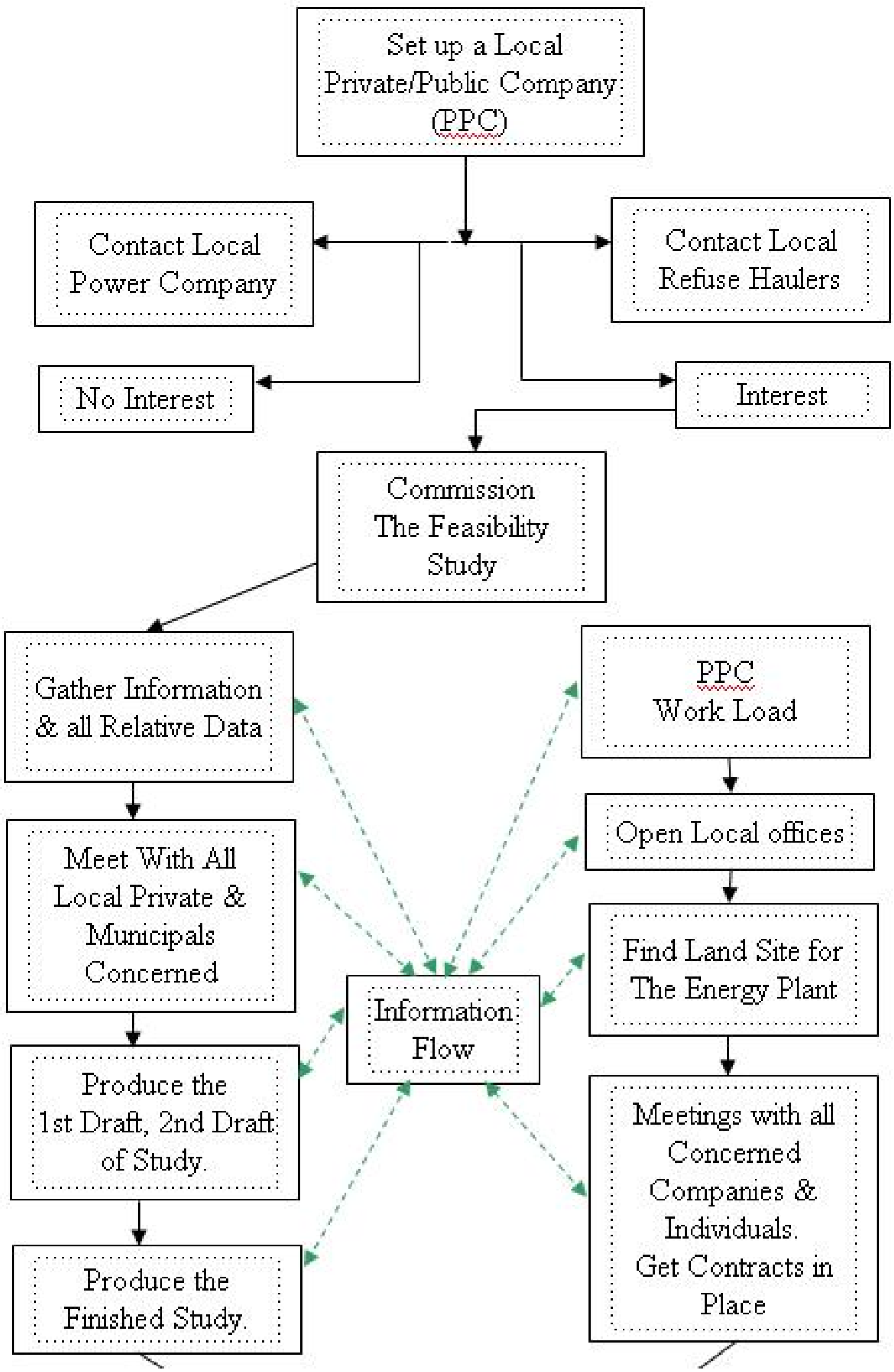
The plan needs to show exactly where the facility will be located and how the operating team will be retained and trained along what each level of staff and management will be paid. There has to be a very detailed set of projections indicating the number of employees that you will have to retain both initially and as the operations grows.

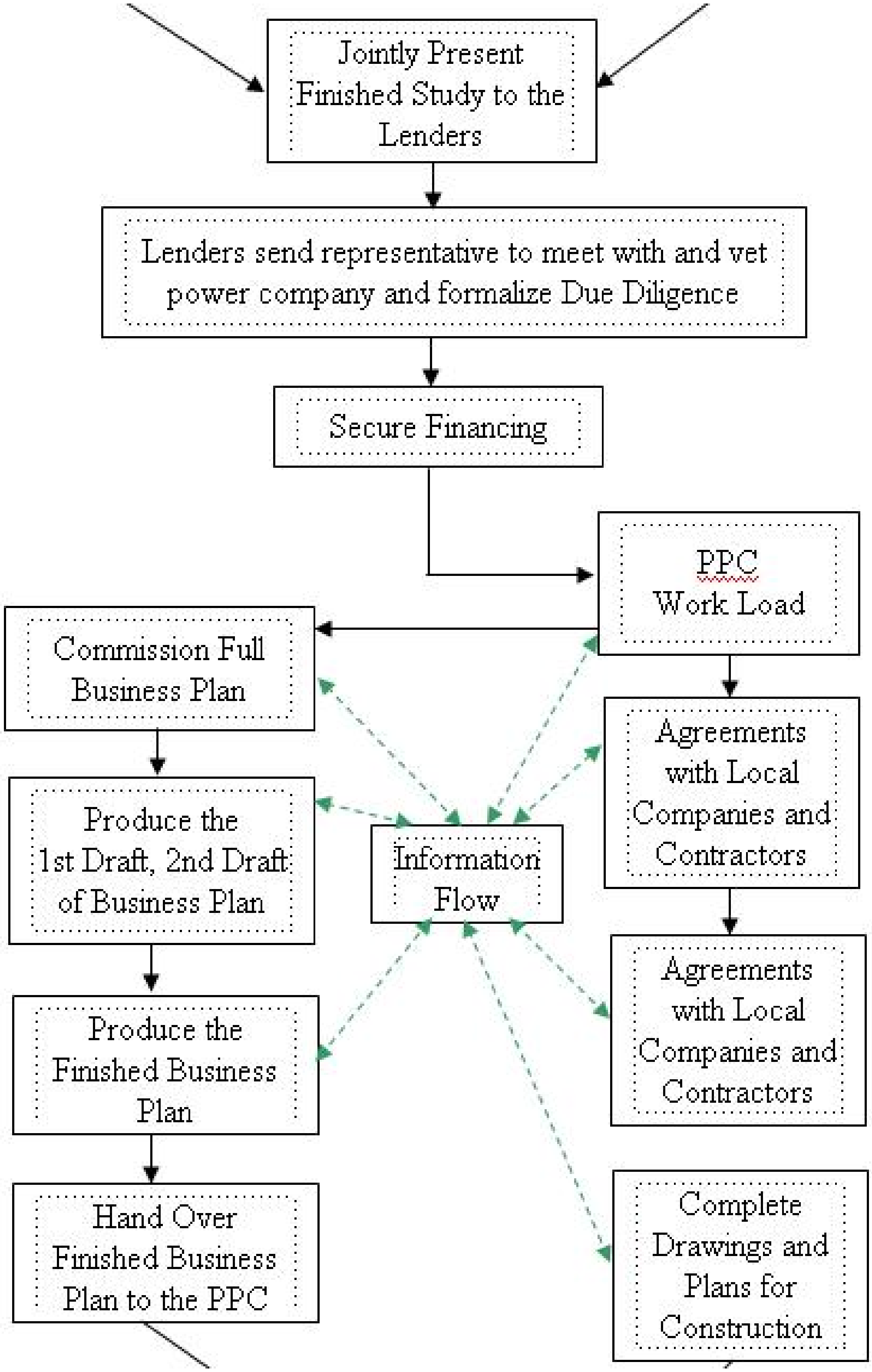
You will have to have letters of intent included in the appendix from all the relevant parties. For example, the appendices will require letters from the various civil authorities under which the plant will be operating indicating that they have reviewed and are in accord with the plans. A letter from an insurance broker is often an additional requirement. In fact, for every statement in the plan there has to be back- up documentation in the appendix.

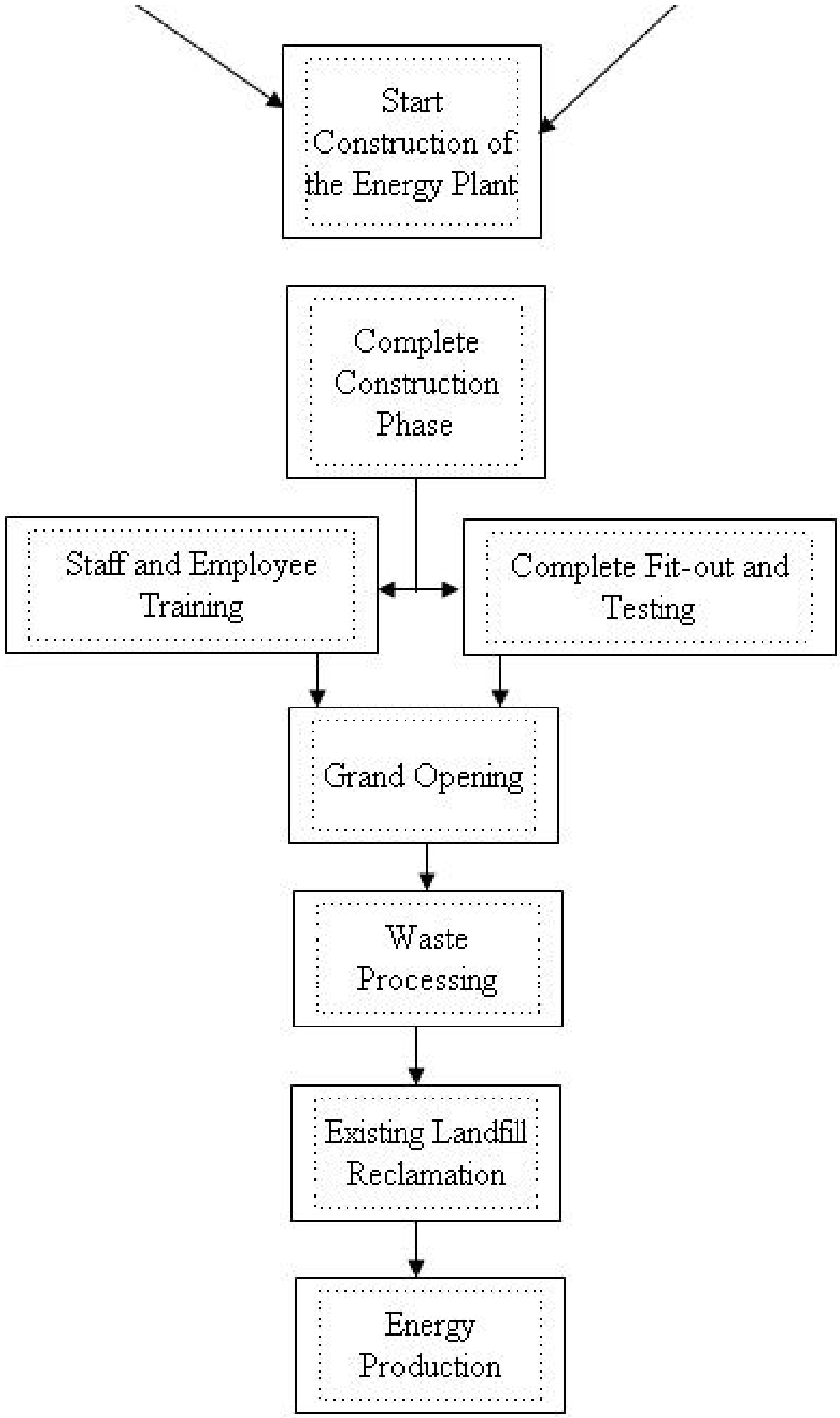
The plan has to detail every single area of the new company so that lenders and bankers can have confidence that the management team does, in fact, have a very clear idea of exactly what is required for success. Absent a plan that reflects all of the above, the project will have little or no chance of being judged loan worthy. Remember, there are literally and easily at least 250 of hours of detailed number crunching work in any Business Plan that is worth the name. We are a work for fee company. We ask for 50% of our fees in advance with the balance on delivery based on a detailed performance agreement.

There are only a few companies in the world actually capable of doing what we do and we are the only one who have actually done what we tell others how to. All of our personnel are lifetime hands-on professionals not college kids hired by a New York consulting company. A poorly written Business Plan is valueless and will not be given consideration in the real world.

FULL PROJECT FLOWCHART




Jointly Present Finished Study to the Lenders
Lenders send representative to meet with and vet power company and formalize Due Diligence
Secure Financing
PPC Work Load
Commission Full Business Plan
Produce the 1st Draft, 2nd Draft of Business Plan
Information Flow
Agreements with Local Companies and Contractors
Agreements with Local Companies and Contractors
Produce the Finished Business Plan
Hand Over Finished Business Plan to the PPC
Complete Drawings and Plans for Construction


Start Construction of the Energy Plant
Complete Construction Phase
Staff and Employee Training
Complete Fit-out and Testing
Grand Opening
Waste Processing
Existing Landfill Reclamation
Energy Production

PROJECT FINANCING

FINANCING WASTE TO ENERGY POWER PLANTS

CARIBEX is able to offer 100% financing for these projects via loan programs through various lenders.

These loans need to meet certain criteria like any other financial transactions of this nature and are based on each project independently.

The lenders have strong interests in funding "green" projects and are offering 20-year loans tailored to fit the requirements of each specific facility.

The lenders are not requiring initial down payments or up front soft costs of any kind. The interest rate is within the normal commercial % of interest and is offered without pre-payment penalties.

The lender does ask that they have an opportunity to review a professional feasibility study however prior to any contact. Once viewed, they will normally issue a conditional commitment letter in advance of the full due diligence.

Once they have reviewed the study the process begins with a scheduled inspection by the lenders representative who will visit the municipality / client. Meeting with the sponsors, city officials and, if the facility is to deliver electric power, the local utility company who will purchase the power produced by the new plant.

In addition, the inspector will also meet with the various government officials and companies who will be delivering the waste materials, as each of them will pay "tipping" fees" for deliveries. The plant receives revenues from only two principal sources, the sale of power (electricity and or synthetic gas) and fees from tipping and disposal of municipal waste.

The lender is required to ensure that the sources of revenue for the plant meet reasonable guidelines. The lender will also require guarantees from the facility owners whether it is a PPC (Public Private Corporation) or a private Utility or indeed a municipality.

It is the purpose of the Feasibility Study to determine the size (capacity) and approximate cost of the plant. This, of course, is a function of the waste materials to be processed. In delivering the study we dispatch specialists to make these determinations (metrics), which are based on surveys and various sources of information provided by local officials.

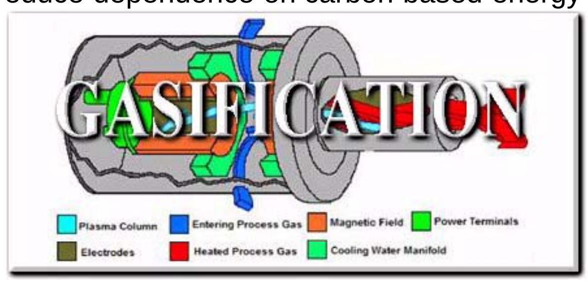
TECHNOLOGIES

INCINERATION

This is an old and polluting technology used to simply burn household trash and waste. Incineration produces a limited amount of heat that is normally used to heat boilers to produce steam to drive steam turbines to generate limited amounts of electricity. This technology is no longer considered a viable alternative. Many of these old facilities are being upgraded to gasification facilities.

GASIFICATION

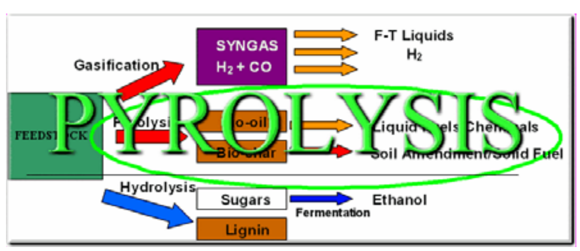
This is clearly thought to be the way of the future in both terms of efficiency and the environment. Gasification is a flexible and clean energy technology that can turn a variety of feedstock into energy, helping to reduce dependence on carbon based energy sources providing a clean alternative source of electricity, fertilizers, fuels, and other useful by-products. Gasification converts almost any material into a useable and efficient gas (syngas). The syngas can be used to produce electricity directly, via gas turbines or used to produce liquid fuels, bio fuels, a substitute for natural gas (SNG), or hydrogen. There are more than 140 gasification plants operating worldwide. Nineteen of those plants are located in the United States. Worldwide gasification capacity is projected to grow 70% by 2015, with 80% of that growth occurring in Asia.



There are many companies producing gasification technologies. There are two main types of gasification; Pyrolysis and Plasma Arc.

PYROLYSIS

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F). The word is coined from the Greek-derived elements pyr "fire" and lysis "separating". Pyrolysis is a special case of thermolysis, and is most commonly used for organic materials. The Pyrolysis or gasification of wood, which starts at 200–300 °C (390–570 °F), and occurs naturally for example when vegetation comes into contact with lava in volcanic eruptions. In general, pyrolysis of organic substances produces gas and liquids leaving a solid residue richer in carbon content. Extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization.



PLASMA or PLASMA ARC

Plasma arc gasification is a waste treatment technology that uses very powerful electrical energy creating extremely high temperatures by an electric arc. This is like a continuous lightning bolt and instantly breaks down all material into elemental gas and limited solid waste (slag), in a device called a plasma converter.

The process has been intended to be a net generator of electricity, depending upon the composition of input wastes, and to dramatically reduce the volumes of waste sent to landfills. Relatively high voltage, high current electricity is passed between two electrodes, spaced apart, creating an electrical arc. Inert gas under pressure is passed through the arc into a sealed container of waste material, reaching temperatures as high as 25,000 °F (13,900 °C) in the arc column. The temperature a few feet from the torch can be as high as 5,000–8,000 °F (2,760–4,427 °C).

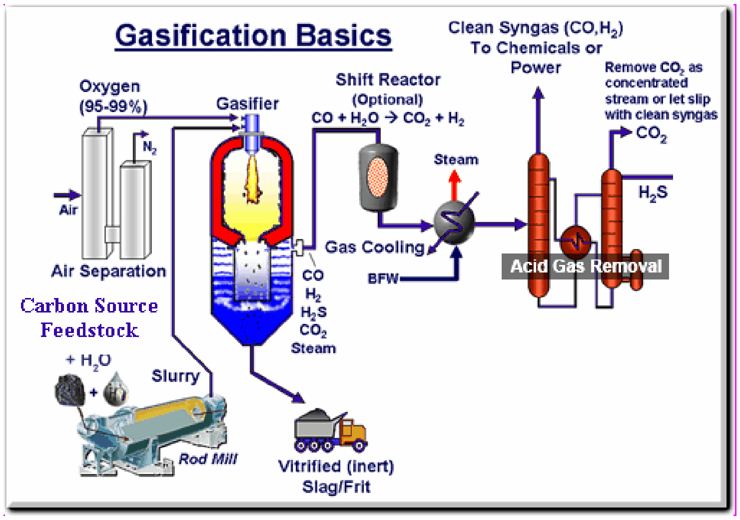
At these temperatures, most types of waste are broken into basic elemental components in a gaseous form, and complex molecules are separated into individual atoms. The reactor operates at a slightly negative pressure, meaning that the feed system is complemented by a gaseous removal system, and later a solid removal system. Depending on the input waste (plastics tend to be high in hydrogen and carbon), gas from the plasma containment can be removed as syngas.

Information with thanks to the "Gasification Technologies Council"

GASIFICATION

Gasification is an environmental friendly solution to an environmental problem

The world is facing rapid growth in energy demand, persistently high-energy prices, and a challenge to reduce carbon dioxide emissions from power generation and manufacturing. No single technology or resource can solve the problem, but gasification can be part of the solution along with renewable power sources such as wind and energy efficiency programs.



Gasification can enhance the world energy portfolio while creating fewer air emissions, using less water, and generating less waste than most traditional energy technologies. Whether used for power generation, for production of substitute natural gas, or for production of a large number of energy intensive products, gasification has significant environmental benefits over conventional technologies.

- Gasification provides significant environmental benefits
- Gasification plants produce significantly lower quantities of air pollutants.
- Gasification can reduce the environmental impact of waste disposal because it can use waste products as feedstock, generating valuable products from materials that would otherwise be disposed as wastes.
- Gasification byproducts are non-hazardous and are readily marketable.
- Gasification plants use significantly less water than traditional coal-based power generation, and can be designed so they recycle their process water, discharging none into the surrounding environment.
- Carbon dioxide (CO2) can be captured from an industrial gasification plant using commercially proven technologies. In fact, since 2000, the Great Plains Substitute Natural Gas plant in North Dakota has been capturing the same amount of CO2 as a 400 MW coal power plant would produce and sending that CO2 via pipeline to Canada for Enhanced Oil Recovery.
- Gasification offers the cleanest, most efficient means of producing electricity from coal and the lowest cost option for capturing CO2 from power generation, according to the U.S. Department of Energy.

ECONOMIC BENEFITS

- Gasification can compete effectively in high-price energy environments to provide power and products.
- Gasification can be used to turn lower-priced feedstock, such as petcoke and coal, into very valuable products like electricity, substitute natural gas, fuels, chemicals, and fertilizers. For example, a chemical plant can gasify petcoke or high sulfur coal instead of using high-priced natural gas, thereby reducing its operating costs.

- While a gasification power plant is capital intensive (like any very large manufacturing plant), its operating costs are potentially lower than conventional processes or coal-fired plants because gasification plants are more efficient and require less back-end pollution control equipment. With continued research and development efforts and commercial operating experience, the cost of these units will continue to decrease.
- Gasification offers wide fuel flexibility. A gasification plant can vary the mix of solid feedstock, or run on gas or liquid feedstock—giving it more freedom to adjust to the price and availability of its feedstock.
- The ability to produce a number of high-value products at the same time (polygeneration) also helps a facility offset its capital and operating costs. In addition, the principal gasification byproducts (sulfur and slag) are readily marketable. For example, sulfur can be used as a fertilizer and slag can be used in roadbed construction or in roofing materials.
- A state-of-the-art gasification power plant with commercially available technology can perform with efficiency in a range of 38-41 percent. Technology improvements now in advanced testing will boost efficiency to significantly higher levels.
- Gasification can increase domestic investment and jobs in manufacturing industries that have recently been in decline because of high energy costs.
- Many predict that coal-based power plants and other manufacturing facilities will be required to capture and store CO2, or participate in a carbon cap and trade market. In this scenario, gasification projects will have a cost advantage over conventional technologies. While CO2 capture and sequestration will increase the cost of all forms of power generation, an IGCC plant can capture and compress CO2 at one-half the cost of a traditional pulverized coal plant. Other gasification-based options, including production of motor fuels, chemicals, fertilizers, or hydrogen, to name a few, have even lower carbon capture and compression costs. This will provide a significant economic and environmental benefit in a carbon-constrained world. (See Carbon Capture & Compression Costs.)
- Gasification can replace volatile natural gas as a fuel or a feedstock. Read more.
- Gasification is being used around the world. Read more about gasification economics in practice.

PRODUCTS AND APPLICATIONS

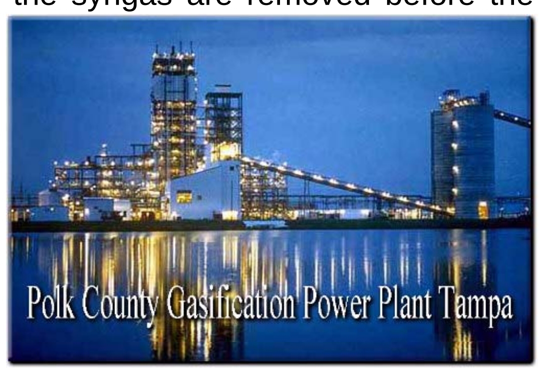
Chemicals and Fertilizers

Modern gasification has been used in the chemical industry since the 1950s. Typically, the chemical industry uses gasification to produce methanol as well as chemicals, such as ammonia and urea, which form the foundation of nitrogen-based fertilizers. The majority of the operating gasification plants worldwide produce chemicals and fertilizers. And, as natural gas and oil prices continue to increase, the chemical industry is developing additional coal gasification plants to generate these basic chemical building blocks.

Eastman Chemical Company helped advance the use of coal gasification technology for chemicals production in the U.S. Eastman's coal-to-chemicals plant in Kingsport, Tennessee converts Appalachian coals to methanol and acetyl chemicals. The plant began operating in 1983 and has gasified approximately 10 million tons of coal with a 98 to 99 percent on-stream availability rate.

Power Generation with Gasification

Coal can be used as a feedstock to produce electricity via gasification, commonly referred to as Integrated Gasification Combined Cycle (IGCC). This particular coal-to-power technology allows the continued use of coal without the high level of air emissions associated with conventional coal-burning technologies. In gasification power plants, the pollutants in the syngas are removed before the syngas is combusted in the turbines. In contrast, conventional coal combustion technologies capture the pollutants after combustion, which requires cleaning a much larger volume of the exhaust gas. This increases costs, reduces reliability, and generates large volumes of sulfur-laden wastes that must be disposed of in landfills or lagoons.

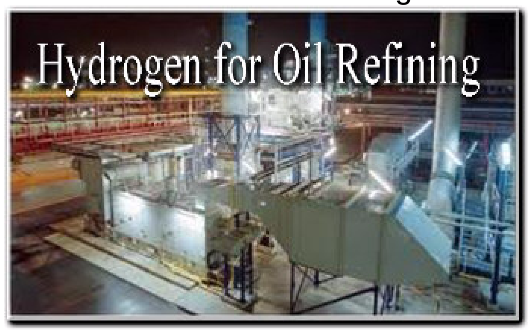


Today, there are 15 gasification-based power plants operating successfully around the world. There are three such plants operating in the United States. Plants in Terre Haute, Indiana and Tampa, Florida provide baseload electric power, and the third, in Delaware City, Delaware provides electricity to a Valero refinery. (See World Gasification-Based Power Generating Capacity)
Substitute Natural Gas

Gasification can also be used to create substitute natural gas (SNG) from coal and other feedstocks, supplementing U.S. natural gas reserves. Using a "methanation" reaction, the coal-based syngas—chiefly carbon monoxide (CO) and hydrogen (H2)—can be profitably converted to methane (CH4). Nearly identical to conventional natural gas, the resulting SNG can be shipped in the U.S. natural gas pipeline system and used to generate electricity, produce chemicals/fertilizers, or heat homes and businesses. SNG will enhance domestic fuel security by displacing imported natural gas that is generally supplied in the form of Liquefied Natural Gas (LNG).

Hydrogen for Oil Refining

Hydrogen, one of the two major components of syngas, is used in the oil refining industry to strip impurities from gasoline, diesel fuel, and jet fuel, thereby producing the clean fuels required by state and federal clean air regulations. Hydrogen is also used to upgrade heavy crude oil. Historically, refineries have utilized natural gas to produce this hydrogen. Now, with the increasing price of natural gas, refineries are looking to alternative feedstocks to produce the needed hydrogen. Refineries can gasify low-value residuals, such as petroleum coke, asphalts, tars, and some oily wastes from the refining process, to generate both the required hydrogen and the power and steam needed to run the refinery.



Transportation Fuels

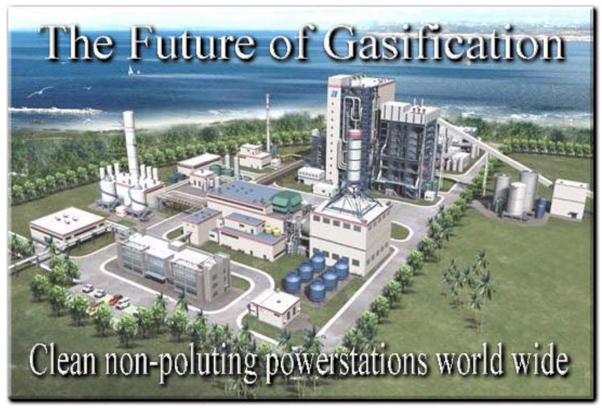
Gasification can be used to produce transportation fuels from oil sands, coal and biomass. Read more about each of these technologies.

GASIFICATION INDUSTRY

Gasification has been reliably used on a commercial scale worldwide for more than 50 years by the chemical, refining, and fertilizer industries and by the electric power industry for more than 35 years. Currently, there are more than 140 gasification plants—with more than 420 gasifiers—operating worldwide. (See Global Syngas Capacity By Region). Nineteen of those gasification plants are located in the United States.

The Future of Gasification

Worldwide gasification capacity is projected to grow 70 percent by 2015, with 80 percent of the growth occurring in Asia. The prime movers behind this expected growth are the chemical, fertilizer, and coal-to-liquids industries in China, oil sands in Canada, polygeneration (hydrogen and power or chemicals) and substitute natural gas in the United States, and refining in Europe.



- The use of gasification is expanding. Several gasification projects are under development to provide steam and hydrogen to upgrade synthetic crude in the oil sands industry in Canada. In addition, the paper industry is exploring how gasification can be used to make their operations more efficient and reduce waste streams.
- A number of factors contribute to a growing interest in gasification, including volatile oil and natural gas prices, more stringent environmental regulations, and a growing consensus that CO2 management will likely be required in power generation and energy production. (See U.S. Energy Prices).
- China is expected to achieve the most rapid growth in gasification worldwide. Since 2004, 29 new gasification plants have been licensed and/or built in China. In contrast, no new gasification plants have begun operation in the United States since 2002.
- The gasification industry is expected to grow significantly in the United States despite a number of challenges, including rising construction costs and uncertainty about policy incentives and regulations.

TRANSPORT FUELS

Transportation Fuels from Oil Sands

The "oil sands" in Alberta, Canada are estimated to contain as much recoverable oil (in the form of bitumen) as the vast oil fields in Saudi Arabia. However, to convert this raw material to saleable products requires mining the oil sands and refining the resulting bitumen to transportation fuels. The mining process involves massive amounts of steam to separate the bitumen from the sands and the refining process demands large quantities of hydrogen to upgrade the "crude oil" to finished products. Residuals from the upgrading process include petcoke, deasphalted bottoms, vacuum residuals, and asphalt/asphaltenes - all of which contain unused energy.

Traditionally, oil sands operators have utilized natural gas to produce the steam and hydrogen needed for the mining, upgrading, and refining processes. However, a number of operators will soon gasify petcoke to supply the necessary steam and hydrogen. Not only will gasification displace expensive natural gas as a feedstock, it will also enable the extraction of useable energy from what is otherwise a very low-value product (petcoke). In addition, black water from the mining and refining processes can be recycled to the gasifiers using a wet feed system, reducing fresh water usage and waste water management costs. (This is not inconsequential, since traditional oil sand operations consume large volumes of water.)

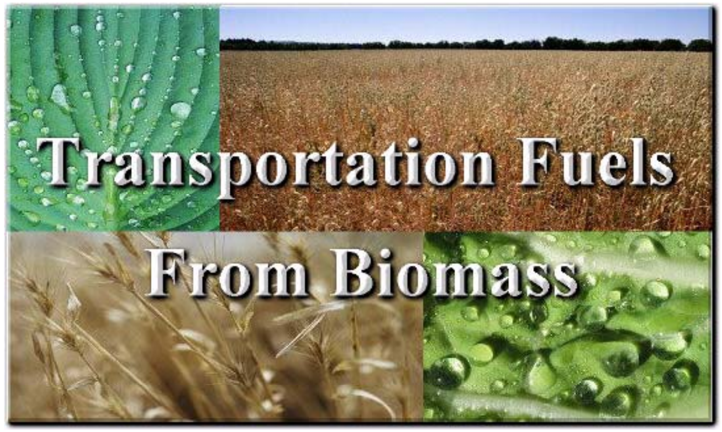
Transportation Fuels from Coal

Gasification is the foundation for converting coal and other solid feedstocks and natural gas into transportation fuels such as gasoline, ultra-clean diesel fuel, jet fuel, naphtha, and synthetic oils. Two basic paths are employed in converting coal to motor fuels via gasification. In the first, the syngas undergoes an additional process, the Fischer-Tropsch (FT) reaction, to convert it to a liquid petroleum product. The FT process, with coal as a feedstock, was invented in the 1920s, was used by Germany during World War II, and has been utilized in South Africa since the 1950s. Today, it is also used in Malaysia and the Middle East with natural gas as the feedstock.

In the second process, so-called Methanol- to-Gasoline (MTG), the syngas is first converted to methanol (a commercially used process) and the methanol is converted to gasoline by reacting it over a bed of catalysts. A commercial MTG plant successfully operated in the 1980s and early 1990s in New Zealand and plants are under development in China and in the U.S.

Transportation Fuels from Biomass

Gasification is also being used as a basis for converting biomass to transportation fuels. Biomass, (such as agricultural waste, switch grass, or wood waste) is converted to a synthesis gas via gasification. The synthesis gas is then passed over various proprietary catalysts and converted to transportation fuels, such as cellulosic ethanol or bio-diesel. Several biomass-to-liquids plants are now under development.



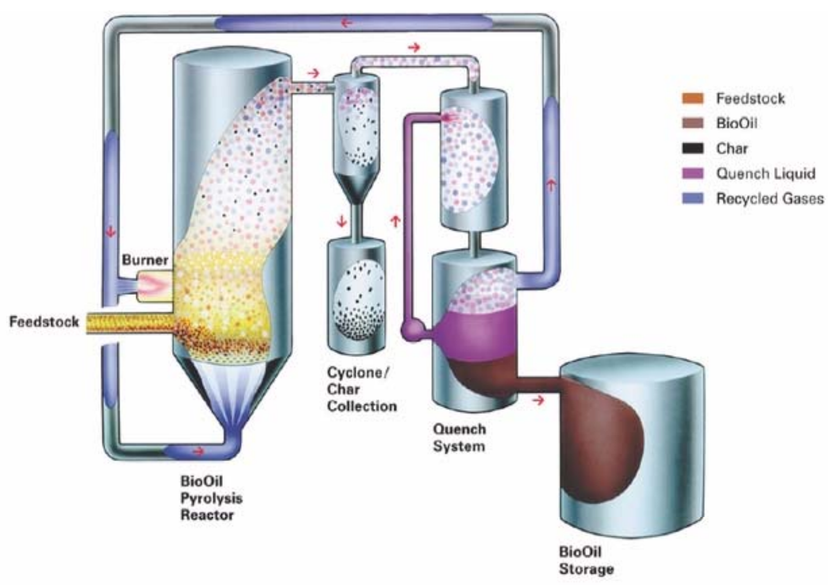
Information with thanks to the "Gasification Technologies Council"

PYROLYSIS GASIFICATION

Simplified depiction of pyrolysis chemistry.

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F). The word is coined from the Greek-derived elements pyr "fire" and lysis "separating".

Pyrolysis is a special case of thermolysis, and is most commonly used for organic materials, being then one of the processes involved in charring. The pyrolysis of wood, which starts at 200–300 °C (390–570 °F),[1] occurs for example in fires or when vegetation comes into contact with lava in volcanic eruptions. In general, pyrolysis of organic substances produces gas and liquid products and leaves a solid residue richer in carbon content. Extreme pyrolysis, which leaves mostly carbon as the residue, is called carbonization.



The process is used heavily in the chemical industry, for example, to produce charcoal, activated carbon, methanol and other chemicals from wood, to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal, to convert biomass into syngas, to turn waste into safely disposable substances, and for transforming medium-weight hydrocarbons from oil into lighter ones like gasoline. These specialized uses of pyrolysis may be called various names, such as dry distillation, destructive distillation, or cracking.

Pyrolysis also plays an important role in several cooking procedures, such as baking, frying, grilling, and caramelizing. And it is a tool of chemical analysis, for example in mass spectrometry and in carbon-14 dating. Indeed, many important chemical substances, such as phosphorus and sulfuric acid, were first obtained by this process. Pyrolysis has been assumed to take place during catagenesis, the conversion of buried organic matter to fossil fuels. It is also the basis of pyrography.

In their embalming process, the ancient Egyptians used a mixture of substances, including methanol, which they obtained from the pyrolysis of wood.

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it does not involve reactions with oxygen, water, or any other reagents. In practice it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs.

The term has also been applied to the decomposition of organic material in the presence of superheated water or steam (hydrous pyrolysis), for example in the steam cracking of oil

Occurrence and uses

Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, like wood, cloth, and paper, municipal waste and also of some kinds of plastic. In a wood fire, the visible flames are not due to combustion of the wood itself, but rather of the gases released by its pyrolysis; whereas the flame-less burning of embers is the combustion of the solid residue (charcoal) left behind by it. Thus, the pyrolysis of common materials like wood, plastic, and clothing is extremely important for fire safety and fire fighting.

Cooking

Pyrolysis occurs whenever food is exposed to high enough temperatures in a dry environment, such as roasting, baking, toasting, grilling, etc.. It is the chemical process responsible for the formation of the golden-brown crust in foods prepared by those methods.

In normal cooking, the main food components that suffer pyrolysis are carbohydrates (including sugars, starch, and fibre) and proteins. Pyrolysis of fats requires a much higher temperature, and since it produces toxic and flammable products (such as acrolein), it is generally avoided in normal cooking. It may occur, however, when barbecuing fatty meats over hot coals.

Even though cooking is normally carried out in air, the temperatures and environmental conditions are such that there is little or no combustion of the original substances or their decomposition products. In particular, the pyrolysis of proteins and carbohydrates begins at temperatures much lower than the ignition temperature of the solid residue, and the volatile subproducts are too diluted in air to ignite. (In flambé dishes, the flame is due mostly to combustion of the alcohol, while the crust is formed by pyrolysis as in baking.)

Pyrolysis of carbohydrates and proteins require temperatures substantially higher than 100 °C (212 °F), so pyrolysis does not occur as long as free water is present, e.g. in boiling food — not even in a pressure cooker. When heated in the presence of water, carbohydrates and proteins suffer gradual hydrolysis rather than pyrolysis. Indeed, for most foods, pyrolysis is usually confined to the outer layers of food, and only begins after those layers have dried out.

Food pyrolysis temperatures are however lower than the boiling point of lipids, so pyrolysis occurs when frying in vegetable oil or suet, or basting meat in its own fat.

Pyrolysis also plays an essential role in the production of barley tea, coffee, and roasted nuts such as peanuts and almonds. As these consist mostly of dry materials, the process of pyrolysis is not limited to the outermost layers but extends throughout the materials. In all these cases, pyrolysis creates or releases many of the substances that contribute to the flavor, color, and biological properties of the final product. It may also destroy some substances that are toxic, unpleasant in taste, or those that may contribute to spoilage.

Controlled pyrolysis of sugars starting at 170 °C (338 °F) produces caramel, a beige to brown water-soluble product which is widely used in confectionery and (in the form of caramel coloring) as a coloring agent for soft drinks and other industrialized food products.

Solid residue from the pyrolysis of spilled and splattered food creates the brown-black encrustation often seen on cooking vessels, stove tops, and the interior surfaces of ovens.

Charcoal

Pyrolysis has been used since ancient times for turning wood into charcoal in an industrial scale. Besides wood, the process can also use sawdust and other wood waste products.

Charcoal is obtained by heating wood until its complete pyrolysis (carbonization) occurs, leaving only carbon and inorganic ash. In many parts of the world, charcoal is still produced semi-industrially, by burning a pile of wood that has been mostly covered with mud or bricks. The heat generated by burning part of the wood and the volatile byproducts pyrolyzes the rest of the pile. The limited supply of oxygen prevents the charcoal from burning too. A more modern alternative is to heat the wood in an airtight metal vessel, which is much less polluting and allows the volatile products to be condensed.

The original vascular structure of the wood and the pores created by escaping gases combine to produce a light and porous material. By starting with dense wood-like material, such as nutshells or peach stones, one obtains a form of charcoal with particularly fine pores (and hence a much larger pore surface area), called activated carbon, which is used as an adsorbent for a wide range of chemical substances.

Biochar

Residues of incomplete organic pyrolysis, e.g. from cooking fires, are thought to be the key component of the terra preta soils associated with ancient indigenous communities of the Amazon basin. Terra preta is much sought by local farmers for its superior fertility compared to the natural red soil of the region. Efforts are underway to recreate these soils through biochar, the solid residue of pyrolysis of various materials, mostly organic waste.

Biochar improves the soil texture and ecology, increasing its ability to retain fertilizers and release them slowly. It naturally contains many of the micronutrients needed by plants, such as selenium. It is also safer than other "natural" fertilizers such as manure or sewage since it has been disinfected at high temperature, and since it releases its nutrients at a slow rate, it greatly reduces the risk of water table contamination.

Biochar is also being considered for carbon sequestration, with the aim of mitigation of global warming. Because pyrolysis burns the volatile gases, biochar only emits water vapor. By burning the harmful gases, a stabile form of carbon can be sequestered into the ground where it will remain for thousands of years.

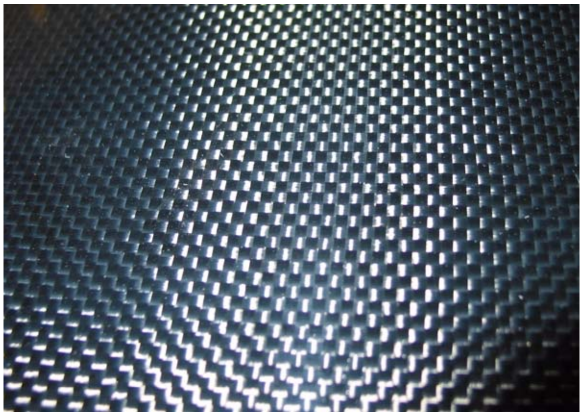
Coke

Pyrolysis is used on a massive scale to turn coal into coke for metallurgy, especially steelmaking. Coke can also be produced from the solid residue left from petroleum refining.

Those starting materials typically contain hydrogen, nitrogen or oxygen atoms combined with carbon into molecules of medium to high molecular weight. The coke-making or "coking" process consists in heating the material in closed vessels to very high temperatures (up to 2,000 °C or 3,600 °F), so that those molecules are broken down into lighter volatile substances, which leave the vessel, and a porous but hard residue that is mostly carbon and inorganic ash. The amount of volatiles varies with the source material, but is typically 25-30% of it by weight.

Carbon fibe

Carbon fibers are filaments of carbon that can be used to make very strong yarns and textiles. Carbon fiber items are often produced by spinning and weaving the desired item from fibers of a suitable polymer, and then pyrolyzing the material at a high temperature (from 1,500–3,000 °C or 2,730–5,430 °F).



The first carbon fibers were made from rayon, but polyacrylonitrile has become the most common starting material

For their first workable electric lamps, Joseph Wilson Swan and Thomas Edison used carbon filaments made by pyrolysis of cotton yarns and bamboo splinters, respectively.

Biofuels

Pyrolysis is the basis of several methods that are being developed for producing fuel from biomass, which may include either crops grown for the purpose or biological waste products from other industries.

Although synthetic diesel fuel cannot yet be produced directly by pyrolysis of organic materials, there is a way to produce similar liquid ("bio-oil") that can be used as a fuel, after the removal of valuable bio-chemicals that can be used as food additives or pharmaceuticals. Higher efficiency is achieved by the so-called flash pyrolysis where finely divided feedstock is quickly heated to between 350 and 500 °C (660 and 930 °F) for less than 2 seconds.

Fuel bio-oil resembling light crude oil can also be produced by hydrous pyrolysis from many kinds of feedstock, including waste from pig and turkey farming, by a process called thermal depolymerization (which may however include other reactions besides pyrolysis).

Plastic waste disposal

Anhydrous pyrolysis can also be used to produce liquid fuel similar to diesel from plastic waste.

Processes

In many industrial applications, the process is done under pressure and at operating temperatures above 430 °C (806 °F). For agricultural waste, for example, typical temperatures are 450 to 550 °C (840 to 1,000 °F).

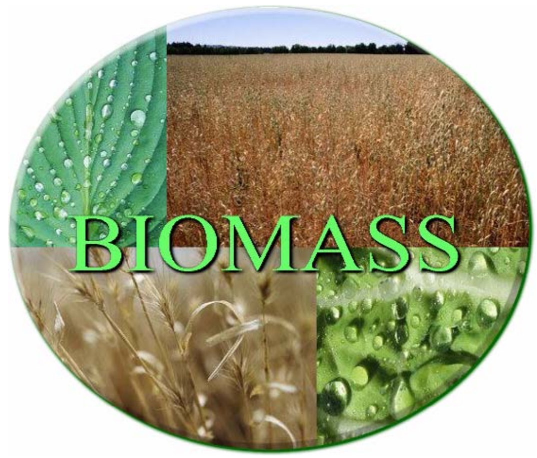
Vacuum pyrolysis

In vacuum pyrolysis, organic material is heated in a vacuum in order to decrease boiling point and avoid adverse chemical reactions. It is used in organic chemistry as a synthetic tool. In flash vacuum thermolysis or FVT, the residence time of the substrate at the working temperature is limited as much as possible, again in order to minimize secondary reactions.

Processes for biomass pyrolysis

Since pyrolysis is endothermic, various methods have been proposed to provide heat to the reacting biomass particles:

- Partial combustion of the biomass products through air injection. This results in poor-quality products.
- Direct heat transfer with a hot gas, ideally product gas that is reheated and recycled. The problem is to provide enough heat with reasonable gas flow-rates.
- Indirect heat transfer with exchange surfaces (wall, tubes). It is difficult to achieve good heat transfer on both sides of the heat exchange surface.
- Direct heat transfer with circulating solids: Solids transfer heat between a burner and a pyrolysis reactor. This is an effective but complex technology.



For flash pyrolysis the biomass must be ground into fine particles and the insulating char layer that forms at the surface of the reacting particles must be continuously removed. The following technologies have been proposed for biomass pyrolysis:

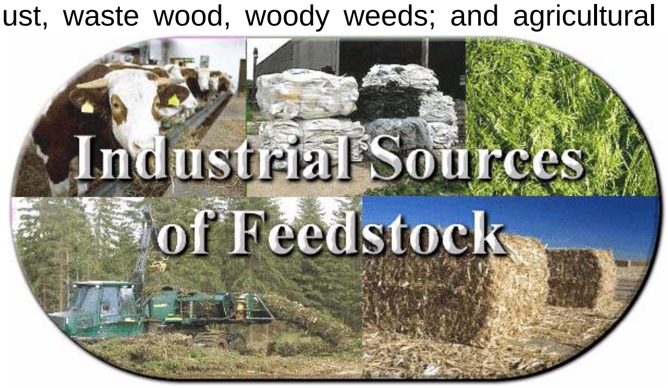
- Fixed beds were used for the traditional production of charcoal. Poor, slow heat transfer resulted in very low liquid yields.
- Augers: This technology is adapted from a Lurgi process for coal gasification. Hot sand and biomass particles are fed at one end of a screw. The screw mixes the sand and biomass and conveys them along. It provides a good control of the biomass residence time. It does not dilute the pyrolysis products with a carrier or fluidizing gas. However, sand must be reheated in a separate vessel, and mechanical reliability is a concern. There is no large-scale commercial implementation.
- Ablative processes: Biomass particles are moved at high speed against a hot metal surface. Ablation of any char forming at the particles surface maintains a high rate of heat transfer. This can be achieved by using a metal surface spinning at high speed within a bed of biomass particles, which may present mechanical reliability problems but prevents any dilution of the products. As an alternative, the particles may be suspended in a carrier gas and introduced at high speed through a cyclone whose wall is heated; the products are diluted with the carrier gas. A problem shared with all ablative processes is that scale-up is made difficult since the ratio of the wall surface to the reactor volume decreases

as the reactor size is increased. There is no large-scale commercial implementation.

- Rotating cone: Pre-heated hot sand and biomass particles are introduced into a rotating cone. Due to the rotation of the cone, the mixture of sand and biomass is transported across the cone surface by centrifugal force. Like other shallow transported-bed reactors relatively fine particles are required to obtain a good liquid yield. There is no large scale commercial implementation.
- Fluidized beds: Biomass particles are introduced into a bed of hot sand fluidized by a gas, which is usually a re-circulated product gas. High heat transfer rates from fluidized sand result in rapid heating of biomass particles. There is some ablation by attrition with the sand particles, but it is not as effective as in the ablative processes. Heat is usually provided by heat exchanger tubes through which hot combustion gas flows. There is some dilution of the products, which makes it more difficult to condense and then remove the bio-oil mist from the gas exiting the condensers. This process has been scaled up by companies such as Dynamotive and Agri-Therm. The main challenges are in improving the quality and consistency of the bio-oil.
- Circulating fluidized beds: Biomass particles are introduced into a circulating fluidized bed of hot sand. Gas, sand and biomass particles move together, with the transport gas usually being a re-circulated product gas, although it may also be a combustion gas. High heat transfer rates from sand ensure rapid heating of biomass particles and ablation is stronger than with regular fluidized beds. A fast separator separates the product gases and vapors from the sand and char particles. The sand particles are reheated in fluidized burner vessel and recycled to the reactor. Although this process can be easily scaled up, it is rather complex and the products are much diluted, which greatly complicates the recovery of the liquid products.

Industrial sources

Many sources of organic matter can be used as feedstock for pyrolosis. Suitable plant material includes: greenwaste,, sawdust, waste wood, woody weeds; and agricultural sources including: nut shells, straw, cotton trash, rice hulls, switch grass; and poultry litter, dairy manure and potentially other manures. Pyrolysis is used as a form of thermal treatment to reduce waste volumes of domestic refuse. Some industrial byproducts are also suitable feedstock including paper sludge and distillers grain



There is also the possibility of integrating with other processes such as mechanical biological treatment and anaerobic digestion.

Industrial products

- syngas (flammable mixture of carbon monoxide and hydrogen): can be produced in sufficient quantities to both provide the energy needed for pyrolysis and some excess production
- solid char that can either be burned for energy or recycled as a fertilizer (biochar).

Fire protection

Destructive fires in buildings will often burn with limited oxygen supply, resulting in pyrolysis reactions. Thus, pyrolysis reaction mechanisms and the pyrolysis properties of materials are important in fire protection engineering for passive fire protection. Pyrolytic carbon is also important to fire investigators as a tool for discovering origin and cause of fires.

From Wikipedia, the free encyclopedia

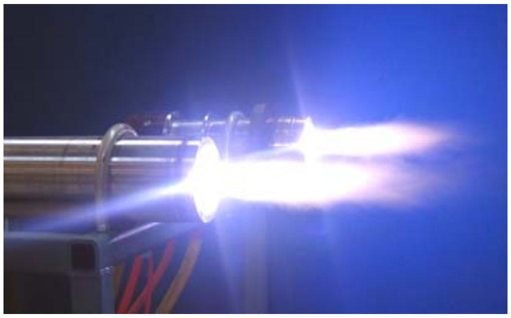
PLASMA or PLASMA ARC GASIFICATION

Some types of gasification use plasma technology, which generates intense heat to initiate and supplement the gasification reactions. Plasma gasification or plasma-assisted gasification can be used to convert carbon-containing materials to synthesis gas that can be used to generate power and other useful products, such as transportation fuels. In an effort to reduce both the economic and environmental costs of managing municipal solid waste, (which includes construction and demolition wastes) a number of cities are working with plasma gasification companies to send their wastes to these facilities.

One city in Japan gasifies its wastes to produce power. In addition, various industries that generate hazardous wastes as part of their manufacturing processes (such as the chemical and refining industries) are examining plasma gasification as a cost-effective means of managing those wastes streams.

Plasma

Plasma is an ionized gas that is formed when an electrical discharge passes through a gas. The resultant flash from lightning is an example of plasma found in nature. Plasma torches and arcs convert electrical energy into intense thermal (heat) energy. Plasma torches and arcs can generate temperatures up to 10,000 degrees Fahrenheit. When used in a gasification plant, plasma torches and arcs generate this intense heat, which initiates and supplements the gasification reactions, and can even increase the rate of those reactions, making gasification more efficient.



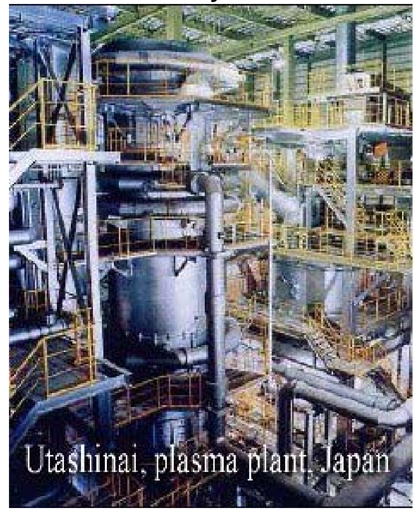
Plasma Gasification

Inside the gasifier, the hot gases from the plasma torch or arc contact the feedstock, such as municipal solid waste, auto shredder wastes, medical waste, biomass or hazardous waste, heating it to more than 3,000 degrees Fahrenheit. This extreme heat maintains the gasification reactions, which break apart the chemical bonds of the feedstock and converts them to a synthesis gas (syngas). The syngas consists primarily of carbon monoxide and hydrogen—the basic building blocks for chemicals, fertilizers, substitute natural gas, and liquid transportation fuels. The syngas can also be sent to gas turbines or reciprocating engines to produce electricity, or combusted to produce steam for a steam turbine-generator.

Because the feedstock reacting within the gasifier are converted into their basic elements, even hazardous waste becomes a useful syngas. Inorganic materials in the feedstock are melted and fused into a glassy-like slag, which is non-hazardous and can be used in a variety of applications, such as roadbed construction and roofing materials.

Commercial Use

Plasma technologies have been used for over 30 years in a variety of industries, including the chemical and metals industries. Historically, the primary use of this technology has been to decompose and destroy hazardous wastes, as well as to melt ash from mass-burn incinerators into a safe, non-leachable slag. Use of the technology as part of the waste-to-energy industry is much newer.



Utashinai, plasma plant, Japan

There are currently plasma gasification plants operating in Japan, Canada and India. For example, a facility in Utashinai, Japan has been in commercial operation since 2001, gasifying municipal solid waste and auto shredder waste to produce electricity. There are a number of proposed plasma gasification plants in the United States.

Benefits of Plasma Gasification

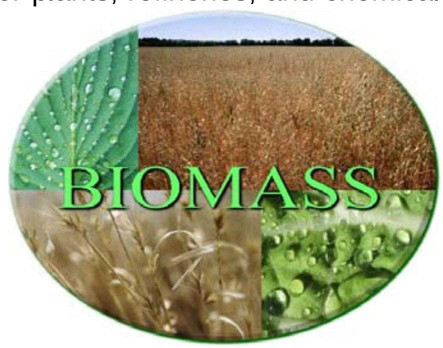
- Plasma gasification provides a number of key benefits:
- It unlocks the greatest amount of energy from waste
- Feedstock can be mixed, such as municipal solid waste, biomass, tires, hazardous waste, and auto shredder waste
- It does not generate methane, a potent greenhouse gas
- It is not incineration and therefore doesn't produce leachable bottom ash or fly ash
- It reduces the need for landfilling of waste
- It produces syngas, which can be combusted in a gas turbine or reciprocating to produce electricity or further processed into chemicals, fertilizers, or transportation fuels—thereby reducing the need for virgin materials to produce these products
- It has exceptionally low environmental emissions

Information with thanks to the "Gasification Technologies Council"

BIOMASS GASIFICATION

Biomass includes a wide range of materials, including energy crops such as switch grass and agricultural all sources such as corn husks, wood pellets, lumbering and timbering wastes, yard wastes, construction and demolition waste, and bio-solids such as sewage sludge. Gasification helps recover the energy locked in these materials and can convert biomass to electricity and products, such as ethanol, methanol, fuels, and fertilizers.

Biomass gasification plants differ somewhat from the large-scale gasification processes typically used in major industrial facilities such as power plants, refineries, and chemical plants, although the differing types of gasification can easily be combined.



Feedstock

Biomass usually contains a high percentage of moisture, which can be 25% (By Weight) in some cases. The presence of high levels of moisture in the biomass reduces the temperature inside the gasifier, which then reduces the efficiency of the gasifier. Therefore, many biomass gasification technologies require that the biomass be dried to reduce the moisture content prior to feeding into the gasifier. This can be an added benefit as the moisture can be taken out and processed into large quantities of deionized (Distilled) water. Pure water.

Air-blown Gasification

Most biomass gasification systems use air instead of oxygen for the gasification reactions. Gasifiers that use oxygen require an air separation unit to provide the gaseous/liquid oxygen; this is usually not cost-effective at the smaller scales used in biomass gasification plants. Air-blown gasifiers use the oxygen in the air for the gasification reactions.

Scale of plants

In general, biomass gasification plants are much smaller than the typical coal or petroleum coke gasification plants used in the power, chemical, fertilizer and refining industries. As such, they are less expensive to build and have a smaller facility "footprint". While a large industrial gasification plant may take up 150 acres of land and process 2,500-15,000 tons per day of feedstock (such as coal or petroleum coke), the smaller biomass plants typically process 25-200 tons of feedstock per day and take up less than 10 acres.

Biomass to Ethanol and Liquid Fuels

Currently, most ethanol is produced from the fermentation of corn. Vast amounts of corn and land, water and fertilizer are needed to produce the ethanol. As more corn is being used, there is an increasing concern about less corn being available for food. Gasifying biomass, such as corn stalks, husks, and cobs, and other agricultural waste products to produce ethanol and synthetic fuels such as diesel and jet fuel can help break this energy-food competition.

Biomass, such as wood pellets, yard and crop wastes, and "energy crops" such as switch grass and waste from pulp and paper mills can be used to produce ethanol and synthetic diesel. The biomass is first gasified to produce the synthetic gas (syngas), and then converted via catalytic processes to these downstream products.

Biomass to Power

Biomass can be used to produce electricity—either blended with traditional feedstocks, such as coal or by itself. Nuon's IGCC plant in Buggenum, Netherlands blends about 30% biomass with coal in their gasification process to produce power.

Cutting Costs, Increasing Energy

Each year, municipalities spend millions of dollars collecting and disposing of wastes, such as yard wastes (grass clippings and leaves) and construction and demolition debris. While some municipalities compost yard wastes, this takes a separate collection by a city, which is an expense many cities just can't afford.

Yard waste and the construction and demolition debris can take up valuable landfill space, shortening the life of a landfill. Many cities face a shortage of landfill space. With gasification, this material is no longer a waste, but a feedstock for a biomass gasifier. Instead of paying to dispose of and manage a waste for years in a landfill, using it as a feedstock reduces disposal costs, landfill space and converts the waste to power and fuels.

Benefits of Biomass Gasification

- Converting waste product into high value energy & products
- Reduced need for landfill space for disposal of solid wastes
- Decreased methane emissions from landfills
- Reduced risk of groundwater contamination from landfills
- Production of ethanol from non-food sources
- Information with thanks to the "Gasification Technologies Council"

WASTE GASIFICATION

Throwing Away Energy

Gasification can convert materials normally considered waste into energy and valuable products. In the U.S. alone thousands of tons of a potential source of energy are collected and thrown away each week. Most of the waste that we discard from our homes and businesses every day - such as non-recyclable plastics, construction debris, used tires, household trash, and sewage - contains energy. Gasification can convert the energy in all of this waste into electric power, substitute natural gas, chemicals, transportation fuels, and fertilizers.

Gasification is Not Incineration

Gasification is not incineration. Incineration is the burning of fuels in an oxygen-rich environment, where the waste material combusts and produces heat and carbon dioxide, along with a variety of other pollutants. Gasification is the conversion of feedstock into their simplest molecules - carbon monoxide, hydrogen and methane forming a syngas which then can be used for generating electricity or producing valuable products.

WASTE RESOURCES

250 Million Tons/Year of Municipal Solid Waste

According to the U.S. Environmental Protection Agency, each year Americans generate about 250 million tons of municipal solid waste (MSW) - about 4.5 pounds per person per day. This MSW includes a wide variety of wastes, including kitchen and yard waste, , electronics, light bulbs, plastics, used tires, and old paint. Despite significant increases in recycling and energy recovery, only about one-third of the total MSW is recovered - leaving the remaining two-thirds (or 135 million tons/year) to be dumped into landfills or incinerated. These figures do not include the 7.2 million dry tons of biosolids from wastewater treatment, much of which is also landfilled or incinerated.

Cities and towns spend millions of dollars per year to collect and dispose of MSW wastes in landfills - using thousands of acres of land. Many states have banned incinerators and a number of states, such as New York, New Jersey, Massachusetts, Connecticut, California and Florida are faced with limited landfill space, forcing them to transport their MSW hundreds of miles for disposal in other states.

In addition to consuming valuable land, the decomposing MSW generates methane, a greenhouse gas, and the leaching wastes may also pose a threat to the groundwater. However, there is an alternative to putting this waste in a landfill - it can be converted through gasification to useful products.

Billions of Tons of Industrial Waste Every Year

American industrial facilities dispose of 7.6 billion tons of industrial solid waste per year. This waste includes plastics and resins, chemicals, pulp and paper. In addition, the debris generated during construction, renovation and demolition of buildings, houses, roads and bridges adds another 136 million tons/year. (source: U.S. EPA)

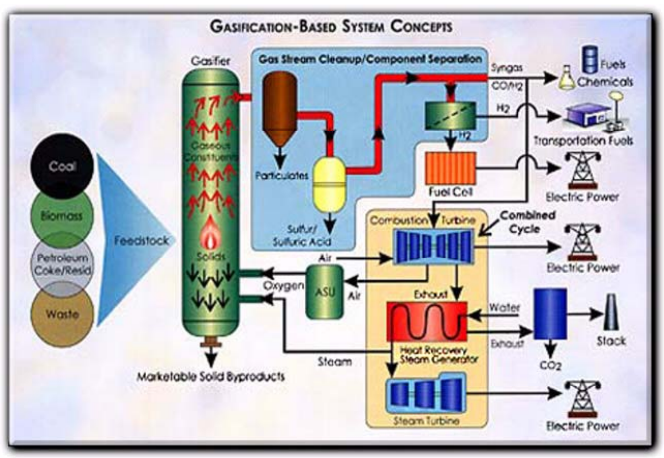
Much of this industrial waste is also suitable for gasification. For example, the construction and demolition waste can be gasified to produce power and products. The non-recyclable industrial plastic wastes can also be gasified.

THE WASTE GASIFICATION PROCESS

From Waste to Energy and Valuable Products

All of this waste contains unused energy. Instead of discarding that energy source, gasification can convert it to electric power and other valuable products, such as chemicals, substitute natural gas, transportation fuels, and fertilizers. On average, waste-to-energy plants that use mass-burn incineration can convert one ton of MSW to about 550 kilowatt-hours of electricity. With gasification technology, one ton of MSW can be used to produce up to 1,000 kilowatt-hours of electricity, a much more efficient and cleaner way to utilize this source of energy. Industrial waste also contains a large source of untapped energy. For example, the energy content of wood construction and demolition waste is about 8,000 Btu/lb and about 10,000 Btu/lb for non-recyclable industrial plastics.

MSW gasification faces a number of challenges. Because MSW can contain such a wide variety of materials, the materials may need to be sorted to eliminate those items that cannot be readily gasified or that would harm the gasification equipment. In addition, the gasification system may need to be designed to handle a variety of different materials because these materials may be gasified at different rates.



Further, one of the important advantages of gasification is that the syngas can be cleaned of contaminants prior to its use, eliminating many of the types of after-the-fact (post-combustion) emission control systems required by incineration plants. Technologies used in waste gasification include conventional gasification systems, as well as plasma arc gasification. Whether generated from conventional gasification or from plasma gasification, the syngas can be used in reciprocating engines or turbines to generate electricity or further processed to produce substitute natural gas, chemicals, fertilizers or transportation fuels, such as ethanol. Read more about the products of gasification.

Gasification Does Not Reduce Recycling Rates

Gasification does not compete with recycling. In fact, it enhances recycling programs. Materials can and should be recycled and conservation should be encouraged. However, many materials, such as metals and glass, must be removed from the MSW stream before it is fed into the gasifier. Pre-gasification feedstock processing systems are added up-front to accomplish the extraction of metals, glass and inorganic materials, resulting in the increased recycling and utilization of materials. In addition, a wide range of plastics cannot be recycled or cannot be recycled any further, and would otherwise end up in a landfill. Such plastics are an excellent, high energy feedstock for gasification.

In addition, not all cities or towns are set up to collect and process recycled materials. And, as populations grow, the amount of waste generated grows. So even as recycling rates increase, the amount of waste is increasing at a greater rate. All of this waste represents lost energy and economic value - which gasification can capture.

ECONOMIC BENEFITS

- Gasifying waste has a number of significant environmental benefits:
- Reduces need for landfill space
- Decreases methane emissions
- Reduces risk of groundwater contamination from landfills
- Extracts useable energy from waste that can be used to produce high value products
- Enhances existing recycling programs
- Reduces use of virgin materials needed to produce these high value products
- Reduces transportation costs for waste that no longer needs to be shipped hundreds of miles for disposal
- Reduces use of fossil fuels
- Information with thanks to the "Gasification Technologies Council"

SAMPLE DATA OF SPOKANE COUNTY
WASTE TO ENERGY FACILITY

Mandatory service area: Spokane County / 430,000 ratepayers

Type of contract: Full service/Operate Wheelabrator / Waste Management

Ownership: City of Spokane

Financing ($110 million): Revenue Bonds - Mandatory debt to entire County

Department of Ecology Grant ($60 million)

Start-up: 1991

Expenses and Revenues for 2009:

Cost of Operation $17.2 million ($62 per ton)

Cost of Ash Disposal $4.1 million ($47 per ton)

Cost of Debt $9 million

TOTAL COSTS $30.3 million

Electricity Revenue $11.4 million

Materials Recovery $0.1 million

NET COST OF OPERATIONS $18.8million ($68 per ton)

REFUSE COMBUSTION:

Operation: 24-hours per day, 7 days per week

Process Lines: 2 @ 400 tons-per-day

Plant maximum daily capacity: 800 tons

Average thru-put: 720 tons per day (365 days per year)

Feed system: 2 overhead refuse cranes with ram feeder

Grate design: Von Roll reciprocating

Combustion temperature: 2500° F

Auxiliary fuel: Natural gas

Waste weight reduction: 65%

Annual Greenhouse Gas Production 600,000,000 Pounds CO_2

CO_2 per MWH 4480 pounds of total CO_2 per Megawatt Hour:

1580 pounds of fossil CO_2 / MWh plus,

2900 pounds of bio CO_2 / MWh

Ash handling system: Semi-dry, vibrating pan conveyor

Materials recovery: 10", aggregate, ferrous

Air Quality Control: Type of equipment: Dry scrubbers-Fabric filters-deNOx (2 units)

Energy Production:

- Type of energy: Electric power
- Steam flow to turbine: 188,000 pph @ 830 psig/825° F
- Heat energy produced: 125 megawatts
- Average sellable electricity output: 16.1 megawatts (141,000 MWh/year, 8760 hours in a year)
- Efficiency: 13%
- Cooling system: Air cooled condenser
- Customer: Puget Sound Power and Light Inc.

Facts & Figures:

- Plant Maximum Capacity: Equals 800 Tons/day, two 400/ton per day boilers.
- Guaranteed capacity: 248,200 Tons/yr., 720 tons/day
- Effective maximum capacity: 275,000 Tons/yr
- Max capacity reached: 1992, excess hauled to Klickitat County

- Electrical output: 26 megawatts maximum - 20 megawatts average - 16 MW sold
- Turbine Speed: 3600 rpm producing 60 Hertz (60 cycles/sec)
- Pit Dimensions & capacity: 140' x 50' x 40'; 40' back wall; 4800 tons
- Receiving floor: 62,000 square ft. or 1.4 acres
- Stack: 175' tall, preformed concrete sections, contains three flues
- Fire Temperature: 2500 degrees F
- Temp/Velocity of exiting stack gases: 250 degrees F, 4000 ft per minute

Construction involved:

- 16,415 cubic yards of concrete
- 198,692 cubic yards soil imported
- 45,251 feet of pipe
- 3,248 Tons of structural steel
- 350,829 feet/66.445 miles of cable
- 10,740 feet/2.3 miles of cable tray
- 2,396 field welds
- Time to construct: 22 months
- First refuse fire: September 6, 1991
- Refuse crane: capacity = 9 tons or 6.5 cubic yards; Typical load = 2-3 tons
- Computer System: Bailey Network 90
- Cost: 110 Million dollars, largest capital project for City of Spokane.
- Ownership: City of Spokane.
- Debt responsibility: City of Spokane & Spokane County & all municipalities

Design, construct, operate and maintain for 20 years at 100% profit margin.

Technology:

- Ash Quantity: 65% reduction by weight of original MSW weight.
- Ash Disposal: Rabanco Regional Landfill, Klickitat County (near Roosevelt, WA).
- Ash Transport: Container capacity 15 tons. Configuration: two containers per load, 30 tons per truck, 8-10 truckloads/day. Intermodal train container, 25-28 ton capacity.
- Iron recovery: 2.5% of original weight of MSW. Iron is not recovered with traditional landfilling.
- Built for expansion: Extended Conveyors; Big pit; Extra flue in stack; Boiler APC turbine needed
- Air Cooled Condenser: Totally dry cooling-6 cells, 150 HP motors
- Tube length: Approximately 100 feet, suspended from structural steel

Bag Houses:

Bag houses contain 3420 bags (1710 per boiler line).

Filtering bags are made of Gore-Tex fabric.

Continuous Emission Monitors: Read every 15 seconds-02, S02, Nox, Opacity, CO, Temperature

Property Area: 52 Acres

Similar technology:

No Waste-to-Energy sites have been built in the U.S. for the last 15 years. Wheelabrator operates 13 other similar old facilities in the U.S. There are over 500 plants in the world, approximately 136 using the same basic technology. More than 20 equal to or larger than 800 TPD.

Regulatory Agencies:

Spokane Air Pollution Control Authority (SCAPCA)

Washington Department of Ecology (WDOE)

Spokane Regional Health District (SRHD).

BTU values:

Garbage = 4,800/pound

Coal = 12,000/pound

Plastic = 14,000/pound

Tires = 16,000/pound

F. A. Q.

Q.. How does Gasification energy output compare to conventional conversion processes?

A.. The advantage of the gasification process is its ability to unlock the greatest amount of energy from waste. As compared to landfill gas capture, (where facilities capture landfill methane emissions and combust the gas for energy), the power output from gasification is many times greater and so much more efficient generating off-setting revenues

Q.. What are environmental operational benefits of W2E Gasification?

A.. Operation of a gasification WTE facility avoids the release of methane that otherwise is emitted when trash decomposes in landfills. Gasification also eliminates the displacement of CO_2 that is emitted when electricity is generated from fossil fuels such as coal.

Q.. What are the advantages of a gasification WTE facility over incineration?

A.. Gasification provides an environmentally friendly and effective means of producing synthesis gas (syngas) and steam to generate electricity and other forms of energy. Gasification reduces greenhouse gas emissions. and eliminates the need for land-fills. Standard Incineration creates bottom ash and fly ash, which is considered a hazardous waste material requiring additional treatment or disposal in special landfills. The high temperature of gasification converts material to a molten slag which, after cooling, can be used as a contaminate free construction aggregate and roadbed material.

Q.. What are the advantages of a WTE facility over landfills?

A.. Gasification facilities can actually reclaim land by eliminating landfills. The content of the landfills to be reclaimed are used as feedstock to produce energy. Compared to landfills a gasification WTE facility has a massively smaller greenhouse gas footprint and harmful air emissions are virtually eliminated. They also eliminate the release of methane that would otherwise be emitted when trash decomposes in landfills.

Q.. What type of data can be expected from an initial study?

A.. A facilities in Spokane county recently publicly released their concept findings, Please see page 41 of this document.

According to Environmental Canada, methane is estimated to have a global warming effect 23 times greater than carbon dioxide.

PARTIAL CLIENT LIST

- 3D Distribution Systems, Inc. U.S.A.
- Action Equipment Ltd. UK & France
- Action Recovery Inc. U.S.A.
- Adtec Alloys Ltd. UK & Channel Is.
- Aeromarine International Inc. U.S.A.
- AeroShare, LLC. Jamiaca.
- African Family Planning Association
- West Africa African Village (PAAP Jobe) Ltd. Africa
- Air Cap U.S.A.
- Air Caribbean Trinidad,
- Alaskan Airways U.S.A.,
- All World Homes Inc. U.S.A.,
- Alimed Labs., Inc. U.S.A.,
- Bank International De Paris (BICI) Europe, Africa,
- Barclays Bank P.L.C. UK, Europe
- Bathurst International UK, West Africa
- Bay Colony Club. U.S.A.
- Blue Moon Bridals & Florists Intl. Ltd. UK
- Boots factory (The) Germany & Austria,
- British Petroleum P.L.C. West Africa,
- Broken Wing Ranches U.S.A.
- Can Air Canada,
- Cantrell and Cockran (C&C) P.L.C. UK,
- Caribbean Airways Barbados,
- Carousel Recovery Inc. U.S.A.
- Central Bank P.L.C. The Gambia
- Charles Cady & Associates (accountant) U.S.A.,
- Clinique Inc. (Cosmetics) U.S.A.,
- Coca Cola Southern Bottlers Ltd. UK,
- Courtenay Garage Co. Ltd. UK,
- C.S.A. Communications, Inc. U.S.A.
- Data Efficiency UK and USA
- Diversity Developments Inc. U.S.A.,
- Evergreen Aviation, USA & Africa
- Gambia Airways Ltd. The Gambia
- GKI, Sunbound U.S.A.,
- Golf 2001, Inc. U.S.A.,
- Gonini Airlines Ltd. Suriname,
- H & L Property Management Inc. U.S.A.,
- Hal Jones & Co. U.S.A.,
- Hattons International Ltd. UK, &. Europe
- International Village. U.S.A.
- Jaco Pastorius project U.S.A.,

- Jamaica Go. Jamaica
- Kololi Village Corporation Ltd. UK, West Africa
- Kouto Wild Life Sanctuary, Africa,
- Liberty Airlines Inc. USA, West Indies
- Lister Chemicals Ltd., Ireland
- Livestock Air Transport Ltd. UK,
- Lloyds Bank P.L.C. UK,
- MacNeil Enterprises Ltd. UK, Italy, Africa
- Mainstream Funding Co. Ltd. U.S.A.,
- Mallory Racing (Titan Group) Ltd. UK, Africa, Europe,
- McKenzie Sales & Export Ltd. M-East, UK, Ireland,
- M.E. Properties Ltd. West Africa,
- Merlin Sports Fishing Ltd. Africa,
- M.E. Services Limited. UK, Europe & Africa,
- Ministry of Defense, UK, The Gambia
- Ministry of Immigration, The Gambia
- Ministry of Tourism, The Gambia,
- Mondo 155 G.M.B.H., Germany,
- Murray Electrical. UK and Spain,
- National Bank of The Gambia. West Africa,
- National Health Institutes of America, Inc. U.S.A.,
- National Westminster Bank P.L.C. UK,
- Nevada International Commodities. Channel Is.,
- Europe Overseas Airways, Belgium,
- Paul M Epstein & Associates U.S.A.,
- Renogade Research and Information, U.S.A.,
- RLD Directory Publishing Inc. U.S.A.,
- S.O.G.E.A. International & Europe, Africa,
- Sakhalinskie Aviatrassy, Sakhalin, Russia,
- Saffideen Trading Co. Ltd., West Africa,
- Save the Children, (GB) West Africa,
- Save the Children (USA) West Africa,
- Shyben A. Madi & Sons Ltd., Africa,
- Spanair, Spain,
- Spantax Airlines, Spain,
- Stephen Betts Refiners/Bullion Ltd. Europe/Africa,
- Tartarstan American Aviation Group. U.S.A. Russia,
- Teachers Whisky (Distillers) Ltd., Scotland,
- Technico Dev & Financing Ltd. UK, East Africa,
- The Harrison Group UK,
- The Henly Group. UK, France, Italy,
- The Mercer Jersey Trust, UK, Europe,
- The Renwick Group of Companies, UK,
- The Vicarage Road Group of Companies. UK,
- Tierra Del Sol, Dominican Republic,
- Transnational Management, Inc. USA

- TravelAlert U.S.A.,
- Tropical Airways U.S.A.,
- USA Hosts Inc. U.S.A.
- US Air U.S.A.,
- United Transnet PLC U.S.A.,
- Vickering Ltd. UK and Europe,
- Vidio Max (Gambia) Ltd. Gambia,
- Virgin, Nigeria. Nigeria & UK
- Wackenhut Security Systems Inc. U.S.A., Africa,
- West Indies Express, U.S.A. Haiti,
- West Of England Commercial, UK,
- Wildlife Ranching and Research Ltd. Kenya, Africa,
- Wynot Ltd. UK, West Africa,
- Mekong Air, Cambodia.

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President

GLOSSARY

Biomass: Generally includes plant materials, such as crops, crop residues, algae, wood waste materials from timbering and lumbering operations, construction and demolition waste, municipal solid waste and sewage sludge (or biosolids). The specific definition of biomass can depend upon state laws or regulations.

Biomass Gasification: The conversion of biomass or biosolids (sewage) into a gas that can be used to produce electricity and products. Biomass gasification differs in several aspects from traditional gasification. The plants are generally smaller in scale, use air instead of oxygen (or use plasma gasification) and require that the biomass be dried before being gasified.

Btu: British thermal unit. Btu is a measure of the heating value of a fuel. It is the amount of heat required to raise one pound of water one degree Fahrenheit at atmospheric pressure. The higher the number of Btu's per pound of feedstock, the higher the heating value. For example, the heating value of bituminous coal is typically 10,000-12,500 Btu per pound, while municipal solid waste is in the range of 4,000-5,500 Btu per pound. Gasifiers are typically designed or rated by the heat input in Btu per hour.

Carbon Capture: Separating out the carbon dioxide (CO2) and concentrating it so that it can be compressed, transported and stored. CO2 capture technologies are commercially proven. Gasification plants manufacturing ammonia, hydrogen, fuels or chemical products routinely capture CO2 as part of their process. See more about CO2 capture on the Gasification and CO2 page.

Combustion: Burning or incineration of a fuel using excess air or oxygen. When carbon-based materials (like coal or biomass) are combusted, the reaction produces carbon dioxide and heat, in addition to criteria air pollutants. Gasification is a different type of process, producing a gas. It is not combustion and provides a less costly means of capturing CO2.

Criteria Air Pollutants: Under the authority of the Clean Air Act, the U.S. Environmental Protection Agency has established ambient air quality standards for common air pollutants, such as carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. EPA regulates these air pollutants on the basis of information (criteria) on the health and/or environmental impacts of these pollutants. Criteria pollutants are the only air pollutants with national ambient air quality standards that define the allowable concentrations of these substances in the air.

Feedstock: The material fed into a gasifier and converted into a synthesis gas (syngas). Any carbon-containing material, (solid, liquid or gas), can be used as a feedstock for a gasifier. Traditional feedstocks include coal and petroleum coke (or other residues of petroleum refining). In addition, biomass, biosolids, municipal solid waste, industrial wastes, and natural gas are used as feedstocks. The feedstock itself is not a "fuel" in gasification, since it is not combusted. Rather, it is converted into a gas (syngas), which has value as hydrogen, or transportation fuels that can then be combusted externally.

Gasification: Gasification is a thermo-chemical process that converts carbon-containing materials, such as coal, petroleum coke (petcoke), biomass, waste, or other materials, with little or no oxygen present and at high temperatures, into a synthesis gas (syngas). The syngas can then be used, to produce electric power, and valuable products such as chemicals, fertilizers, substitute natural gas, hydrogen, steam, and transportation fuels. Gasification is very different from combustion, in that the carbon-containing materials (feedstocks) are not burned or incinerated; they are converted into the syngas. Read more at the Gasification Process page.

Gasifier: A vessel where the gasification reactions take place. In the gasifier, the feedstock reacts with oxygen (or air) and water (or steam) at high temperatures. Temperatures in gasifiers range from 900-3,000 degrees Fahrenheit, depending technologies. Under these conditions, the gasifier breaks apart the chemical bonds of the feedstock, forming syngas.

I**ntegrated Gasification Combined Cycle (IGCC):** An IGCC power plant combines the gasification process with an efficient "combined cycle" power generator (consisting of one or more gas turbines and a steam turbine). Clean syngas is combusted in the gas turbines to generate electricity. The excess heat from the gasification reactions r is then converted into steam. This is combined with steam produced from the gas turbines, and sent to a steam turbine generator to produce additional electricity. Read more at the Products and Applications page.

I**ndustrial gasification:** Large scale gasification operations used by industry, such as the chemical, paper, and fertilizer industries. Typical products from industrial gasification are gases, chemicals, fertilizers, and transportation fuels. Read more at the Products and Applications page.

Municipal solid waste (MSW): Residential and commercial materials that are used and then discarded. These materials include paper, yard waste, food waste, and containers (such as plastic bottles and cans), tires and electronics. MSW may include recyclable materials, depending on the amount of recycling provided by the local government.

Partial oxidation: Partial oxidation is a chemical reaction. It occurs in a limited oxygen environment - in a pressurized vessel with heat, feedstock (such as coal) and limited oxygen creating a syngas consisting primarily of hydrogen and carbon monoxide.

Plasma: Often called the fourth state of matter (the other three are solid, liquid, and gas). Plasma is created when an electrical charge passes through a gas. The resultant "flash" of lightning is an example of plasma found in nature.

Plasma gasification: The use of plasma, generally in the form of a plasma "torch" or "arc" to provide the heat energy needed to initiate a gasification reaction. Plasma torches and arcs can reach temperatures of 5,000 - 10,000 degrees Fahrenheit. The most typical use of plasma gasification is to convert various materials, such as municipal solid waste and hazardous waste, into a clean syngas used to produce electricity and other products.

Slag: A glass-like byproduct of the gasification process. Slag is carbon or inert material such as ash that was not converted to synthesis gas in the gasifier. It is inert, non-hazardous and can be used in roadbed construction, roofing materials and other applications.

Syngas or synthesis gas: The gas produced as the result of the gasification reactions of feedstock, oxygen (or air) and water (or steam). Syngas consists primarily of hydrogen and carbon monoxide. Depending on the type of gasification technology, quantities of nitrogen, methane, carbon dioxide, hydrogen sulfide and water vapor are also present in the syngas. These can be removed and reused using conventional gas cleaning processes.

Waste- to-Energy gasification: The process of using gasification to convert various types of waste streams, such as municipal solid waste, hazardous wastes or other industrial and commercial wastes into a synthesis gas that can be used to produce electricity and other valuable products. This differs from burning or incinerating the waste, which involves combustion, not gasification. Combustion produces carbon dioxide and heat, but not the syngas produced by gasification.

Information with thanks to the "Gasification Technologies Council"