Entech Renewable Energy Solutions Company Profile

ENTECH
RENEWABLE ENERGY SOLUTIONS

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Company Background

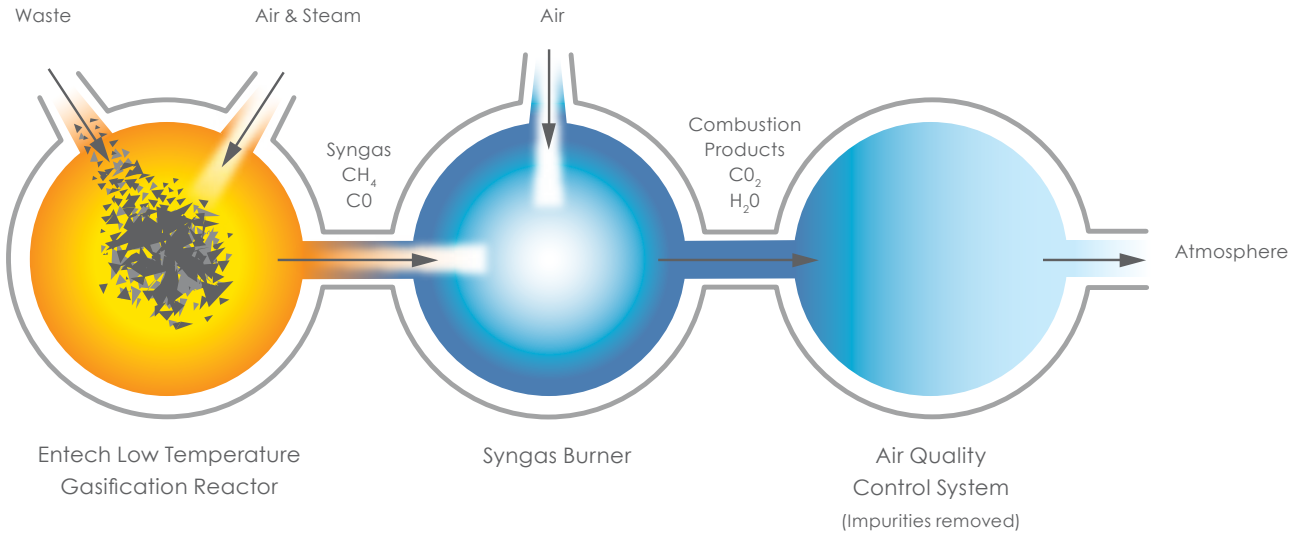
Entech is a leading supplier of modular plant and equipment in the energy from waste market. The Company's technology is advanced low temperature gasification, where carbon in waste products is converted in an oxygen starved environment to an energy rich synthetic gas or "syngas".

Entech has been delivering gasification solutions since 1990 and the Company has evolved to be a leader in the energy from waste market. The features of the Entech gasification solutions can be summarised as:

- Standard plant design that can treat various waste streams.
- Two stage combustion process where waste is converted into a syngas then oxidised in a second stage to release heat energy.
- All plants designed to deliver emissions standards EU WID 2000/76/EC. 46 Projects delivered since 1990 (see reference plant section).
- The Entech gasification technology is classified as an Advanced Conversion Technology (ACT) and the electricity produced from the biomass fraction of the waste qualifies for maximum Renewable Obligation Certificates (ROCs) in Europe or Renewable Energy Certificates (REC) in Australia.
- The process produces an ash with less than 3% carbon content (loss on ignition).
- Modular design allows for local solutions for waste treatment and scale up to larger plants. Solution suitable for 50 – 300,000 tonnes per annum of waste.
- Solution can treat MSW, hazardous waste, clinical waste and liquid waste.
- Highly evolved Plant Operating System software that allows trouble free plant operation with minimal operator interface.
- All plants equipped with continuous emissions monitoring systems (CEMS) to allow on line, real time information on emissions performance.

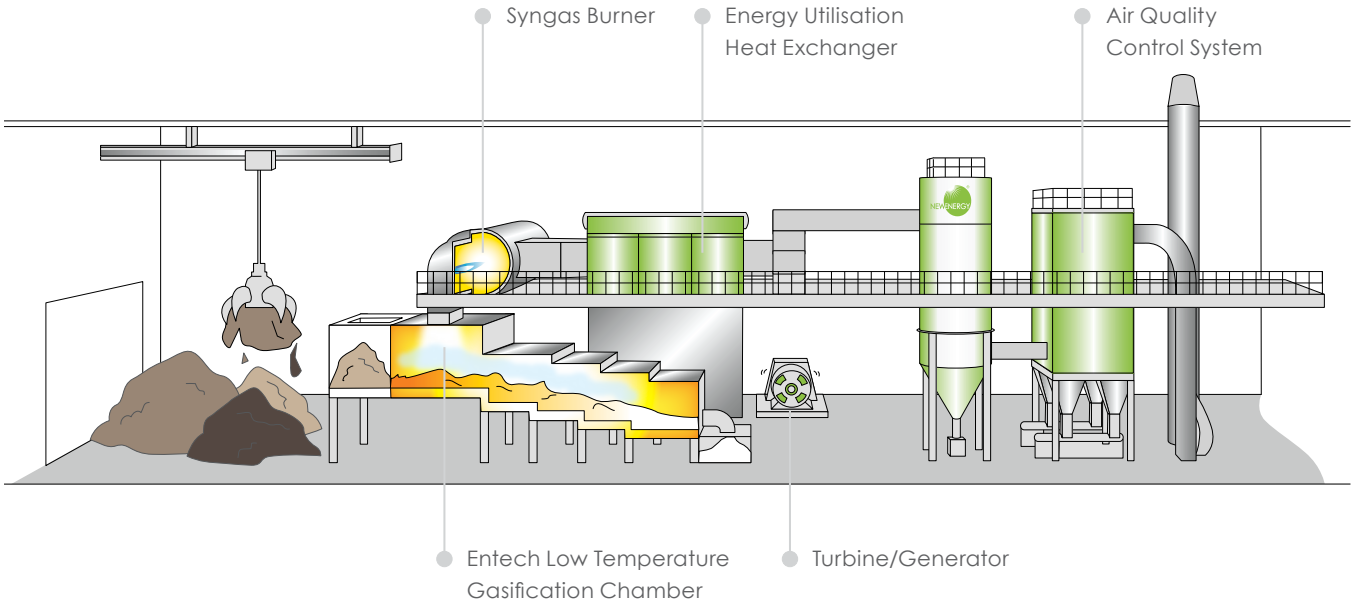
Figure 1: A view inside the Entech gasifier where waste resembles molten lava in the oxygen depleted environment

Technology



The Entech Gasification technology is based on a two stage combustion process. Waste is converted into a gas or syngas in the primary oxygen starved chamber. The syngas, which consists mainly of methane, carbon monoxide and short chain hydrocarbons is then fired in a secondary oxidation chamber or syngas burner. Combusting the organics is their gaseous state allows a very clean and thorough burn, which delivers a superior emissions performance over traditional combustion processes such as incineration.

The information presented below is a description of the Entech Gasification technology:



Gasifier Feeding Stage

The waste is received for gasification and fed into the gasifier feeding device. This feeding device is comprised of a chamber with an air lock design feature. The air lock design feature is essential for ensuring that waste can be fed into the gasifier without losing control of the amount of air in the gasification chamber, and without the release of fugitive emissions.

Low Temperature Gasification Chamber

The gasification chamber receives the waste and heats it to the required ignition temperature. This is done in a sub-stoichiometric environment to ensure the target syngas is produced. The chamber is heated to between 600oC and 875oC, and steam is introduced. The result is the production of syngas with volatile content high in carbon monoxide (CO), methane (CH_4) and short chain hydrocarbons. The gasification reaction is exothermic and self-sustaining, ensuring that all waste subsequently fed into the reactor is heated by the reactor conditions.

The gasification chamber has a retention time of 16 to 24 hours. This is an important design feature because any attempt to shorten this process would reduce the production of syngas. Another important design feature is a patented stoking and churning device. This device uses rams to enter the chamber and slowly turn the waste over to ensure that all waste is exposed and fully converted.
A small component of the initial feedstock, containing the inerts such as silica and metals, is discharged in the form of an ash. The ash is biologically inert and has been subjected to stringent leachate tests, with the results complying with US-EPA standards. Although the ash is suitable for disposal at a Class II landfill, New Energy would seek to find a beneficial use for the ash as a road base, concrete aggregate or as a soil conditioner.

Syngas Firing Stage

The syngas in the gasification chamber rises and is ignited by the syngas burner. The syngas burner is an advanced high efficiency 3-stage low-NO_X gas burner. This technology has been developed by the gas industry and is well proven. The burner is used to fire the downstream steam boiler.

Energy Utilisation Stage

Heat produced from the syngas firing stage provides energy for steam generation in the steam boiler. The steam boiler is purposely ‘over designed’ to ensure maintenance is minimised. A corner-tube design water tube steam boiler is used to produce high pressure steam. This design feature is for a high solids environment, so when applied to an ultra-low solids process, heat transfer efficiency is maximised whilst downtime for cleaning is minimised.

Steam Turbine and Power Generation Stage

The high pressure steam produced in the steam boiler is connected via a manifold to the “Steam Turbine and Power Generation Stage”. The turbine generates 11kV, 3 phase, 50 Hz electrical power. Steam turbine technology is extremely well developed and this particular model would have the following design features.

- Multi-stage turbine with turbo-alternator and automatic voltage regulation (AVR).
- An air/water cooled condenser that recovers steam as a condensate for re-use in the steam circuit.
- A closed loop glycol-based turbine cooling system.

Air Quality Control Stage

The “Air Quality Control Stage” (AQCS) receives the cooled off gas for cleaning. It is important to note that the untreated off-gas is environmentally superior to firing of many conventional fossil fuels. Regardless, cleaning is undertaken to ensure compliance with stringent environmental regulations. This stage of design also ensures that the environmental impact of the plant is minimised. The AQCS design is based on “best available technology” and is well proven in many industries.

Flow Control Stage

The cleaned off-gas exiting the AQCS is induced through a “Duplex Induced Draft Fan System”. The exhaust system is pressure controlled by variable speed fans to ensure that the entire system is under vacuum. Additionally, all feed and discharge orifices are pressure sealed or valve sealed to eliminate the potential escape of fugitive emissions.

Reference Projects

The following Projects have been delivered utilising the Entech low temperature gasification process, utilising the two stage combustion process to:

Project Number	Year	Country	WDF FEED-STOCK	Nominal Throughput T/Day	Nominated MJ/kg	Nominal Output MWt	Availability Days/yr
1016	1990	Hong Kong	MSW	60	10	7.2	313.0
1024	1990	Taiwan	Textile	15	20	3.5	313.0
1032	1990	Australia	Biohazardous	35	25	10.1	313.0
1033	1990	Australia	Biohazardous	15	20	3.5	313.0
1035	1990	Taiwan	Rubber Tyres	10	35	4.2	313.0
1036	1990	Taiwan	Industrial (Textile)	36	15 - 20	7.0	313.0
1037	1991	Taiwan	Industrial (Textile)	5	20	1.2	313.0
1045	1991	Australia	Biohazardous	36	20	7.0	313.0
1062	1992	Taiwan	Industrial (Textile)	5	20	1.2	313.0
1065	1992	Australia	VOC's	840	0.5 - 0.75	7.0	313.0
1067	1992	Taiwan	MSW + Dried Sludge	15	10	1.6	313.0
1070	1992	Taiwan	Biohazardous	15	20	3.5	313.0
1071	1992	Singapore	Biohazardous	15	20	3.5	313.0
1072	1991	Taiwan	MSW	40	10	4.9	313.0
1073	1993	Indonesia	Industrial (Polyethylene By-Products)	5	20	1.2	313.0
1079	1993	Australia	Biomass	5	10	0.6	313.0
1084	1994	Taiwan	MSW	5	10	0.6	313.0
1086	1994	Thailand	Petrochemical (By-Products)	10	30	0.6	313.0
1092	1995	Indonesia	Industrial (Nylon By-Products)	10	20	2.4	313.0
1096	1995	Hong Kong	Industrial (Printed Circuit Boards)	7	28	2.4	313.0
1098	1996	Thailand	Industrial (Industrial Estate)	40	15	7.0	313.0
1101	1996	China	Airport	5	10	0.6	313.0
1106	1996	South Korea	Industrial (LG Engineering Factory)	20	25	5.8	313.0
1109	1996	Australia	MSW	15	10	1.6	313.0
1115	1997	Taiwan	Biohazardous	30	20	7.0	313.0
1117	1997	Indonesia	MSW	30	10	3.5	313.0
1123	1997	Singapore	Biomass	72	2.5 - 7.5	5.8	313.0
1127	1999	Fiji	MSW & Quarantine	11	10	1.2	313.0
1132	2000	PNG	Petrochemical (Slop Oil + Cont. Water)	0-60	0 - 40	4.5	313.0
1134	2000	Malaysia	MSW	60	10	7.2	313.0
1138	2001	Taiwan	Industrial (Nuclear Reactor)	5	10	0.6	313.0
1139	2002	Taiwan	Biohazardous	5	20	1.2	313.0
1142	2002	Taiwan	Industrial (Pharmaceutical By-Products)	15	0 - 40	4.5	313.0
1146	2003	Korea	MSW	30	10	3.5	313.0
1148	2003	PNG	MSW + C&I	40	10	4.5	313.0
1150	2004	Bydgoszcz	Biohazardous	3.5	30 - 40	1.6	313.0
1151	2004	Taiwan	Biohazardous	15	30 - 40	5.8	313.0
1152	2004	Poland	Quarantine	1.5	15 - 20	0.3	313.0
1153	2005	Samoa	Biohazardous	5	20	1.2	313.0
1154	2005	Thailand	Industrial (Industrial Estate)	5.5	25	1.6	313.0
1157	2006	Poland	Quarantine	1	25 - 35	0.4	313.0
1158	2007	Sri Lanka	Quarantine	20	10	2.4	313.0
1162	2008	Malaysia	Biohazardous	24 - 30	35 - 40	14.2	313.0
1164	2012	Poland	Biohazardous	12 - 15	35 - 40	5.8	313.0

Reference Projects Detail

Entech has been delivering low temperature gasification projects since 1990. The heart of the systems has been the two stage combustion process, which leverages off the environmental benefits of extracting the carbon from waste in the form of a syngas and then oxidising the gas utilising a low NOx syngas burner.

Entech has until now been an equipment supplier that has provided turnkey projects for various companies to own and operate. The company is now focusing on build own and operate opportunities, with a number of large projects currently underway internationally by Entech's in partnership with their licensee companies.

The two stage combustion process was initially adopted by clients who wanted superior emissions performance without expensive and complex off gas cleaning equipment. The gasification system offered this and the relatively clean off gasses and superior dioxin performance still remains one of the key features of the technology.

Over time, the design of the gasification system and its control and monitoring systems became more sophisticated to make use of advances in technology. This was particularly true in the area of emissions control systems, computerised process control systems and continuous monitoring of emissions using Continuous Emissions Monitoring Systems (CEMS).

Today all plants are designed to comply with the most stringent and well recognised emissions standard, which is the European Union Directive 2000/76 ('Waste Incineration Directive' or 'WID').

Parameter	Units	EU WID
Dioxin/Furans	mg/Nm^3	0.1
VOC	mg/Nm^3	10
Total Heavy Metal	mg/Nm^3	0.5
Mercury	mg/Nm^3	0.05
Cd & Tl	mg/Nm^3	0.05
Total PM	mg/Nm^3	10
S & compounds	mg/Nm^3	50
N & compounds	mg/Nm^3	200
Cl & compounds	mg/Nm^3	10
F & compounds	mg/Nm^3	1
CO	mg/Nm^3	50

European Union Directive 2000/76 ('Waste Incineration Directive' or 'WID')

Reference Projects

The project reference list is a selected list of projects from the above table. They are presented in reverse date order, showing the latest plants first that are designed to the EU 2000/76 WID emissions standard.

1. Project 1164 Gorzow Poland

Date Installed	2012
Customer	Gorzow Medical Institute
Waste Type	Biohazardous & Hazardous
Country	Poland
Thermal Capacity	5.8MWt
Calorific Value	35MJ/kg
Waste Capacity	15tpd

Figure 2: Gorzow Medical Institute Poland

Plant Bibliography:

The Gorzow gasification plant was commissioned in late 2012 to manage medical and biologically hazardous waste from the Gorzow Medical Institute and surrounding areas. The Institute needed to upgrade existing waste incineration infrastructure to adhere to the new EU regulations, namely the EU 2007/76 WID emissions standards. The Entech gasification system does this whilst providing heat to the entire hospital including autoclaves for sterilisation purposes.

The plant has continuous emissions monitoring which in adherence to the WID Standard. This project has come about following Entech's previous success in installing other projects in Poland.

Figure 3: Entech 5.8MWt Gasification Unit & Controls System

2. Project 1162 Malaysia

Date Installed	2008
Customer	FMS Mediserve
Waste Type	Biohazardous & Hazardous
Country	Malaysia
Thermal Capacity	14.2MWt
Calorific Value	20MJ/kg
Waste Capacity	60tpd

Figure 4: Entech 14.2MWt Gasification Plant

Plant Bibliography:

FMS is a large government owned company in Malaysia that owns and operates many businesses across the country's medical supply chain. The above plant processes much of the medical waste generated in peninsular Malaysia. The plant is designed to comply with the EU 2000/76 WID emissions standards and has CEMS to measure and record all key emissions parameters from the plant on a continuous basis. Heat from the energy recovery system is used to power a large industrial laundry which is located adjacent to the energy from waste facility.

Figure 5: Air Quality Control System

Figure 6: Steam line to adjacent industrial laundry

3. Project 1158 Sri Lanka

Date Installed	2007
Customer	Aviation Authority Sri Lanka
Waste Type	MSW, C & I, Quarantine
Country	Sri Lanka
Thermal Capacity	2.4MWt
Calorific Value	10MJ/kg
Waste Capacity	20tpd

Project Bibliography:

In 2006 the Aviation Authority of Sri Lanka was in the grips of the Asian Bird flu crisis. In response they quarantined all waste coming through the major international airport. The waste, which could best be described as MSW and C& I came from all catering activities at the airport, all waste coming off commercial airliners and from the airport village that supports 1,500 permanent workers.

Figure 7: Duel 2.9MWt Entech Gasifiers

4. Project 1151 Taiwan

Date Installed	2004
Customer	CGMH Hospital
Waste Type	Biohazardous & Hazardous
Country	Taiwan
Thermal Capacity	5.8MWt
Calorific Value	30-40MJ/kg
Waste Capacity	15tpd

Project Bibliography:

Taiwan is an island nation that has long understood the pitfalls of landfilling waste. With a strong recycling market and adoption of thermal technologies, the country has achieved a landfill diversion of over 90%.

Entech has been recognised as a leading supplier of advanced thermal conversion technology and as such has sold many gasification plants into the Taiwanese market. This particular project is for the CGMH Hospital group and has operated successfully since 2004. Medical waste from the district arrives in sealed bags and is introduced to the system without inspection. The flexible nature of the technology enables the plant to treat waste from high CV (waste drugs) through to low CV (food scraps) without altering the configuration of the plant.

This project was the third successful contract Entech has delivered to CGMH emphasising the customers' satisfaction with the technology.

Figure 8: The plant operator monitors operations from the control room

5. Project 1150 Poland

Date Installed	2004
Customer	RCO Investment
Waste Type	Biohazardous & Hazardous
Country	Poland
Thermal Capacity	1.6MWt
Calorific Value	40MJ/kg
Waste Capacity	3.5tpd

Project Bibliography:

A group of private investors and RCO Hospital, an 800 bed leading oncology facility, recognized that waste derived fuel could be utilized to satisfy the hospitals high energy demands. The ENTECH – Renewable Energy System process waste derived fuel from the hospitals own waste, in addition to biohazardous waste collected from other facilities within a 100 kilometer radius.

The result being that RCO Investment Corporation (partially owned by RCO Hospital) sells energy to the hospital at discounted rates below conventional fuels, the hospital's existing boiler room plant is now only adopted as standby and the ENTECH system produces energy equivalent to over 1.0 million litres of fuel oil per year (or around 1.0 million cubic meters of natural gas per year).

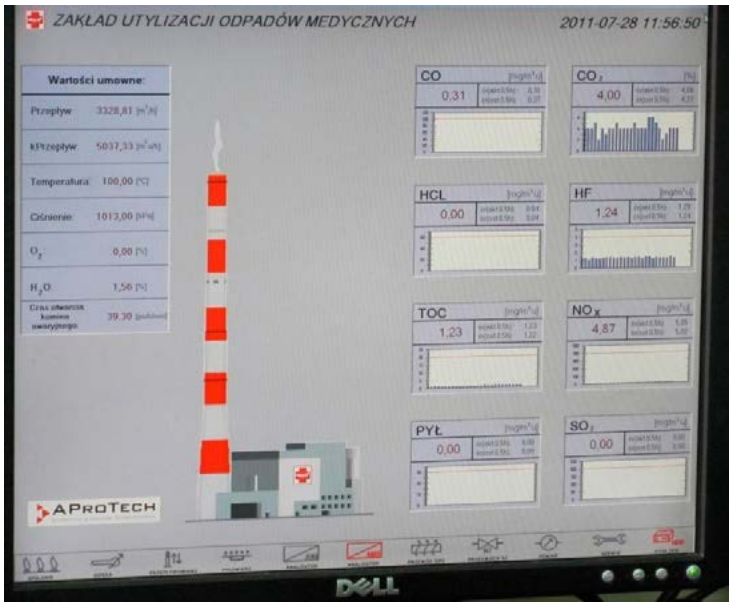


Figure 9: The gasification plant, which is designed to meet EU 2000/76 WID monitors emissions continuously

6. Project 1142 Tiawan

Date Installed	2002
Customer	Sinopharm Corporation
Waste Type	Pharmaceutical By-Products
Country	Taiwan
Thermal Capacity	4.5MWt
Calorific Value	20MJ/kg
Waste Capacity	30tpd

Project Bibliography:

This project showcases Entech's ability to successfully treat liquid waste from pharmaceutical manufacturing for one of Taiwan's largest pharmaceutical companies, Sinopharm Corporation. Mixed solvents are a problematic waste worldwide. The Entech "Liquifire™" system is incorporated into the plant design to atomise the liquid and direct inject into the gasifier. Energy is recovered from the waste and is utilised to power a downstream boiler. The two stage combustion process allows the plant to have excellent emissions performance whilst offsetting the energy needs of the client who utilises the steam in the chemical manufacturing process.

Figure 10: Liquid waste treatment plant utilising Entech's Liquifire and gasification processes.

7. Project 1134 Malaysia

Date Installed	2000
Customer	Genting Group
Waste Type	Municipal Solid Waste
Country	Malaysia
Thermal Capacity	7.2MWt
Calorific Value	10MJ/kg
Waste Capacity	60tpd

Plant Bibliography:

The Genting Group of Malaysia are the leading entertainment and casino group in the country. The Genting Highlands Complex known as the “fun city beyond the clouds” is one of the main tourist precincts in Malaysia. The tourist attraction generates around 60 tonnes of municipal solid waste or MSW per day. Entech was contracted in 2002 to supply the gasification solution to the Group to manage waste in situ and to offset some of the energy demands of the complex. The fossil fuel savings alone represented approximately $2 million saving to the customer.

Figure 11: This picture of the ash from the Genting MSW project is a good example of how metals can be recovered after the low temperature gasification process. High temperature incineration would melt these metals and entrain them in the off gasses, which is not ideal for superior emissions performance

8. Project 1132 Papua New Guinea

Date Installed	2000
Customer	Chevron
Waste Type	Slop Oil/Mud Drillings
Country	PNG
Thermal Capacity	4.5MWt
Calorific Value	0-40MJ/kg
Waste Capacity	10-60tpd

Project Bibliography:

Chevron Corporation is one of the most environmentally aware and responsible companies in the World. All Chevron projects are delivered within the confines of their own mandated environmental management systems (EMS). In 2000 Chevron embarked on an on shore oil and gas production facility in PNG. They sought a solution to treat the by-products of the drilling process including slop oil, mud drillings and contaminated water. Entech was selected because of the Entech gasifiers ability to handle all these by-products with a standard plant configuration and minimal operator interface. The project delivered emission standards acceptable to Chevron based on compliance to US EPA standards.

Figure 12: An Entech 4.5MWt gasifier operating in PNG for Chevron

9. Project 1127 Fiji

Date Installed	1999
Customer	Airports Fiji Ltd
Waste Type	Municipal Solid Waste
Country	Fiji
Thermal Capacity	1.2MWt
Calorific Value	10MJ/kg
Waste Capacity	11tpd

Project Bibliography:

Fiji is an island nation with a pristine natural environment. Quarantine control through major airports is a major concern of the local government. In 1999 Entech was commissioned to install an Entech Gasifier to destruct waste that was either declared or seized as part of customs operations at the airport. Fiji does not have a suitable manufacturing industry to allow construction of the Entech solution in country. One of the advantages of the modular configuration of the Entech technology is the ability to deliver skid mounted solutions to remote projects. This project also reinforces the well developed plant operating system that allows unskilled plant operators to successfully operate the equipment.

Figure 13: The Entech gasifiers can be factory tested and skid mounted to allow minimal site installation work

10. Project 1123 Singapore

Date Installed	1997
Customer	Singapore Foods Ltd
Waste Type	Animal Processing By-Products
Country	Singapore
Thermal Capacity	5.8MWt
Calorific Value	7MJ/kg
Waste Capacity	72tpd

Project Bibliography:

Singapore Food industries are one of the country's largest suppliers of meat and bone meal products. Since the breakout of diseases such as BSE or Mad Cows Disease the management of waste by-products from the industry has been closely controlled. Entech was contracted in 1997 to provide a safe and environmentally friendly waste disposal option that broke the potential "contamination chain" and controlled the spread of serious disease. The Entech gasification process also provided a significant benefit to the customer in the form of steam. The syngas from the process was fired by the syngas burner to provide steam for the food processing plant and reduce the reliance on fossil fuels. The other significant feature of the project is the plants ability to recover energy from a waste that has a very low calorific value (7 MJ/KG) and high moisture content, which most other thermal conversion technologies would not be able to cope with.

Figure 14: Animal processing waste is carefully stored and tagged ready for disposal in the Entech gasification plant

11. Project 1115 Taiwan

Date Installed	1997
Customer	C G Memorial Hospital
Waste Type	Biohazardous
Country	Taiwan
Thermal Capacity	7.0MWt
Calorific Value	20MJ/kg
Waste Capacity	30tpd

Project Bibliography:

This project represented the second Entech gasifier installation for the C G Memorial Hospital Group in Taiwan. Impressed with the results of the first Entech project in 1991, the Group opted to install a larger unit to process 30 tonnes of biohazardous medical waste per day. Taiwan has one of the highest landfill diversion rates in the world and gasification of problematic waste is a vital part of the waste management solution.

Steam from the above project is used to provide heating to the adjacent hospital and for disinfection requirements in the autoclaves. The C G Memorial Hospital Group now has 9,000 hospital beds spread across nine separate campuses. The emissions from the Entech facility are regulated by the Taiwanese EPA where 83% of all waste is disposed of via energy from waste technologies.

Figure 15: waste from the C G Memorial Hospital Group is the Entech 7.0MWt gasification plant

12. Project 1106 South Korea

Date Installed	1996
Customer	LG Engineering
Waste Type	E-Waste
Country	Korea
Thermal Capacity	5.7MWt
Calorific Value	25MJ/kg
Waste Capacity	25tpd

Project Bibliography:

LG Engineering, Korea's largest manufacturer of consumer electronics identified significant waste issues at manufacturing plant. The company was concerned about the environmental impact of waste from semi-conductor manufacturing and packaging. Security of waste was also a priority in the highly competitive and secret development of new electronic products.
The diverse composition of the waste led LG to procure an Entech 5.7MWt gasification plant. The gasifier was located in the grounds of the large manufacturing plant (pictured above) so all waste could be treated on site and energy recovered from the process in the form of steam could also be utilised by the adjacent processing plant.

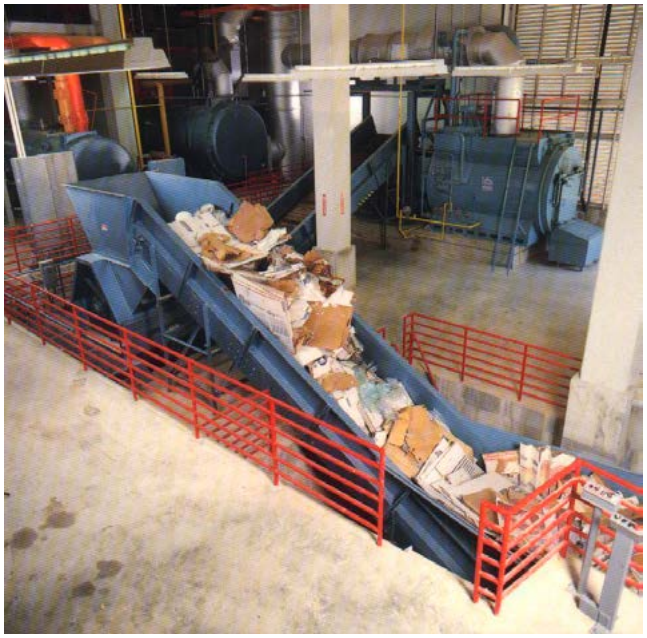


Figure 16: Waste from LG processing plant enters the gasification building and an Entech 5.7MWt gasifier can be seen in the background

13. Project 1086 Thailand

Date Installed	1994
Customer	Thai Petrochemical Ind
Waste Type	Liquid Waste
Country	Thailand
Thermal Capacity	3.5MWt
Calorific Value	30MJ/kg
Waste Capacity	10tpd

Project Bibliography:

The petrochemical industry is a major source of hazardous organic wastes, produced during the manufacture of hazardous substances such as petroleum. The transport and disposal of these liquid waste products possess a significant risk to the environment. Thai Petrochemicals sought a thermal treatment option for its waste disposal to manage this risk and also to recover the energy embodied in the waste.

Utilising Entech's "Liquifire™" liquid atomisation and injection system into a 3.5MWt gasifier, the Company achieved both objectives whilst complying to tight local emissions standards.

Figure 17: Hazardous liquid waste is safely treated by a Entech 3.5MWt gasifier after injection from the Liquifire atomiser

14. Project 1072 Thailand

Date Installed	1993
Customer	Chung Gung Municipality
Waste Type	MSW & Dried Sewage Sludge
Country	Taiwan
Thermal Capacity	4.9MWt
Calorific Value	10MJ/kg
Waste Capacity	30tpd

Project Bibliography:

This project serviced the waste management needs of a large University in Taiwan and the surrounding municipality. An Entech 4.9MWt Gasification unit was selected to treat 40 tonnes per day of municipal solids waste and dried sewage biomass. Steam from the system provides heating to the University, greatly reducing the need to consume fossil fuels. The two stage combustion process delivered excellent emissions performance. Even without a sophisticated air quality control system, this early model Entech gasifier produced a dioxin reading of 0.0307ng/mg^3 which is over three times lower than the current EU 2000/76 WID emission limit for dioxin of 0.1ng/mg^3.

Figure 18: Entech 4.9MWt gasifier, syngas burner and boiler