EQTEC™

ADVANCED GASIFICATION TECHNOLOGY

Proven, patented and proprietary: it sets the global standard

Technology Information Paper
January 2022

EXECUTIVE SUMMARY

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Accelerating the global transition to a decarbonised economy will require not just investment into large-scale, heavily centralised technologies, but also the growth of distributed, small-scale technologies that can operate to benefit local communities.

For these distributed technologies to reach their full potential, they must be commercially viable. EQTEC Advanced Gasification is one such technology. This paper is a technical overview for energy infrastructure owner-operators, developers, investors, EPCs, waste management companies and anyone looking for detailed information about how the patented, proprietary and proven process works and the benefits it offers.

You'll discover more about:

- **the history of gasification and how it was used**
- **what it is today and how EQTEC has refined the technology into a process called advanced gasification**
- **a deep dive into the technical process itself**
- **the types of waste we can convert**
- **the many profitable commercial applications available from the pure synthesis gas (syngas) we produce**
- **and our innovation, research and development work.**

INTRODUCTION

Gasification is a waste-to-energy thermochemical conversion technology that applies heat, oxygen and pressure to convert waste into a synthesis gas.

Gasification has been around in some form since the late 1700s, when it was used to produce tar. In the early 19th century, it was used to produce gas for municipal lighting and cooking. Since the 1920s, it has been used to produce synthetic chemicals.

In more recent decades, gasification has been recognised as a better way to create clean energy/fuels and reduce the world's reliance on fossil fuels. Over the last twenty years in particular,

the technology has been refined and developed into what we have innovated into 'Advanced Gasification Technology'.

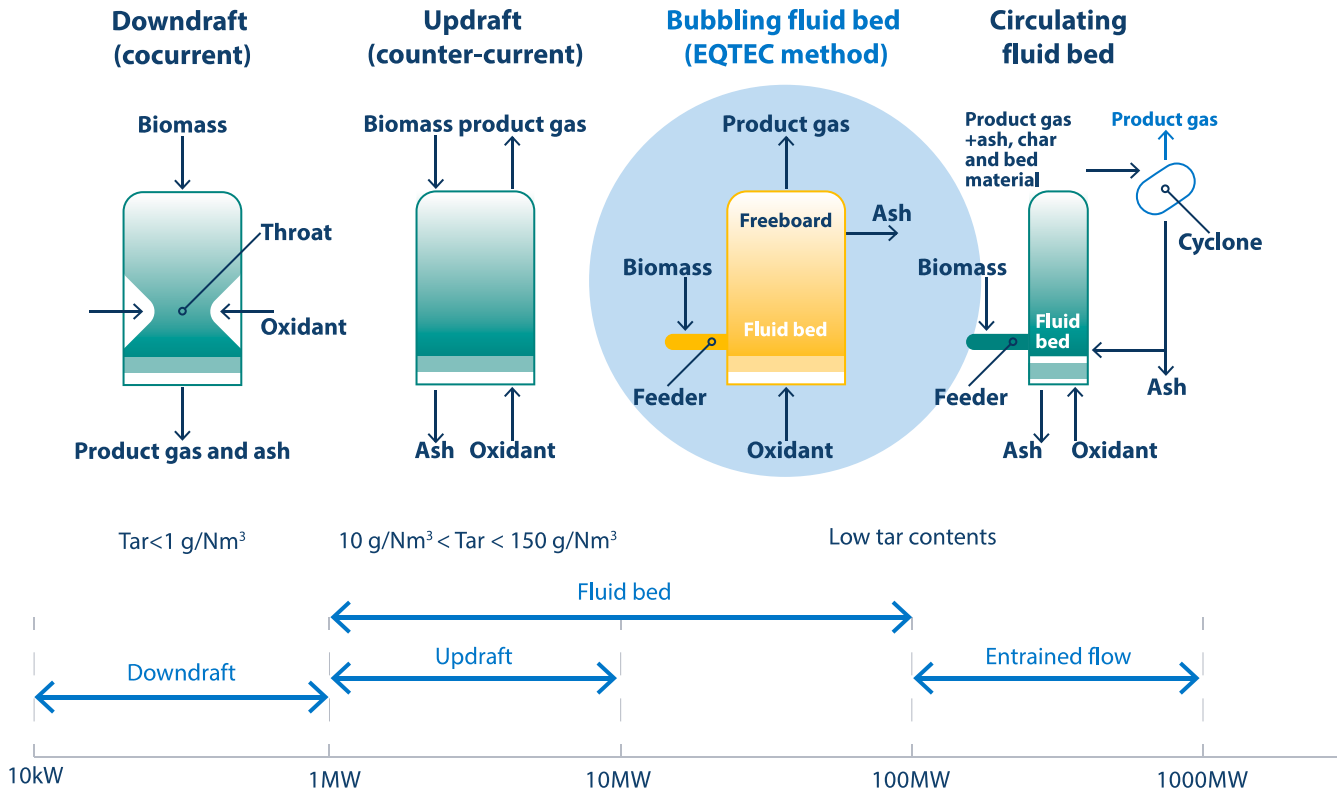
EQTEC Advanced Gasification Technology addresses two urgent global challenges:

- Rising volumes of waste
- Rapidly increasing demand for clean energy and biofuels

After reducing, reusing and recycling, converting waste into energy is the next most sustainable waste management solution. However, today most unrecycled waste goes to landfill or incineration, both of which generate large volumes of CO2 and other harmful gases.

Gasification converts waste into energy more efficiently that legacy alternatives, while having an ultra-low environmental impact. It is cleaner, more sustainable, smaller, more suited and better for local communities.

TYPES OF GASIFICATION METHODS



OUR PATENTED TECHNOLOGY

EQTEC's proven, patented and proprietary advanced gasification capabilities are second to none. They reliably and sustainably create uniquely pure, high-quality syngas from the widest range of waste products, which can then be applied to generate the widest range of applications at commercial scale.

DECADES OF EXPERTISE

Led by three PhDs in Chemical Engineering, the team in our Technical Centre includes many of the world's leading experts on gasification. Between them they have decades of experience in research and commercial operations.

Our R&D partners include several leading universities in Europe, some of whom we have been working with for over a decade. Our expert technical team and R&D partners are always looking for ways to innovate gasification and to increase the options for feedstock and offtake. Because our technology is developed in-house, we can adapt and highly customise the design to suit almost any client's needs.

UNRIVALLED OPERATING PERFORMANCE AND VERSATILITY

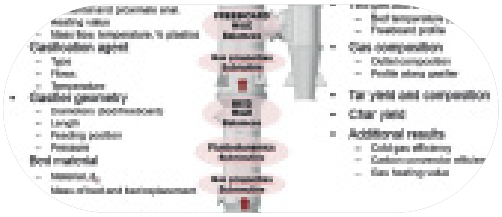
- **Highly adaptable. Proven to convert nearly 60 types of feedstock. We can design and engineer our technology to suit any feedstock and a wide range of client needs.**
- **Highest operating hours.**
- **Lowest emissions profile. CO2 emissions are far lower than alternatives, and our process does not emit harmful toxins or hazardous waste.**
- **The purest syngas we know: with a quality that addresses the most restrictive requirements.**
- **Widest range of applications.**

EQTEC Biomass-to-Energy Plant, Belišće, Croatia

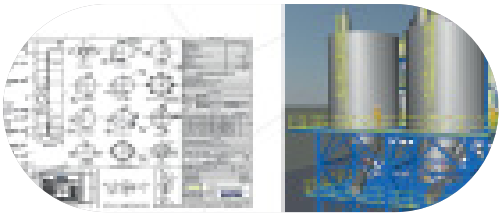
OUR PATENTS

We maintain several patents around the world for multiple elements of our proprietary technology and we continuously review opportunities for establishing new patents where we have made a unique contribution to advanced gasification.

OUR PROPRIETARY TECHNOLOGY



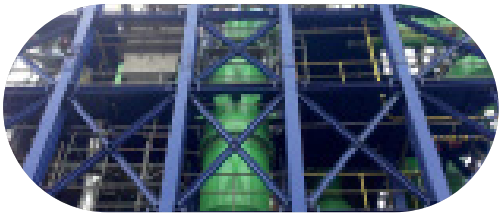
Proprietary Kinetic Simulations Software - able to simulate within a <5% margin how specific solids degrade, and the energetic requirements for efficient solid conversion.



Proprietary library - we offer different configurations to suit specific feedstocks.

Proprietary library - of nearly 60 analysed feedstocks, including Thermo Gravimetric and Differential Scanning Calorimetric analysis.

Bubbling fluidized bed gasifier - unique hardware and fluid dynamic method/process for improved performance.



Syngas conditioning - technology for thermal cracking and steam reforming reactions to maximize CO and H2 production, which ensures the high quality of the syngas produced.

In-house scrubber battery design - or soluble pollutants absorption during the syngas conditioning process.

Proprietary EQTEC Modelling Platform - for Continuous Control of plant operation.

INDEPENDENT VERIFICATION

Jenbacher gas engines

Leading gas engine company Jenbacher has commended the high quality and stability of the syngas produced and the reliability and power generating efficiency of the equipment from EQTEC's Advanced Gasification Technology process.

FEEDSTOCKS

Our commercial plants and pipeline of projects focus on producing energy from four key feedstocks:

Plant and agriculture biomass

Energy recovery capacity: 1-10 MWe per plant.

Current mission: Resolving considerable waste from agriculture and food farming and production, including the particular challenge of olive pomace.

Forestry wood biomass

Energy recovery capacity: 2-5 MWe per plant.

Current mission: Transformation of wood biomass in California, where dead trees constitute a significant fire risk, and where state policy is to use such waste to generate power for 100s of millions of homes.

Municipal solid waste (MSW)

Energy recovery capacity: 5-30 MWe per plant.

Current mission: Building the UK's first commercially successful energy-from-MSW facility. The UK exports 3.5 million tonnes of RDF annually, given insufficient processing capacity. Import taxes and legislation create opportunity for sustainable conversion of RDF and diversion from incineration and landfill.

Industrial waste

Energy recovery capacity: 1-10 MWe per plant.

Transforming challenging materials including contaminated plastics, manufacturing or industrial wood waste into syngas for use as electricity, heat and biofuels. Decarbonising industrial operations is a critical global challenge in the coming years.

Wherever possible, our plants use local feedstock sources to support a circular economy by processing local waste feedstocks into energy for local use.

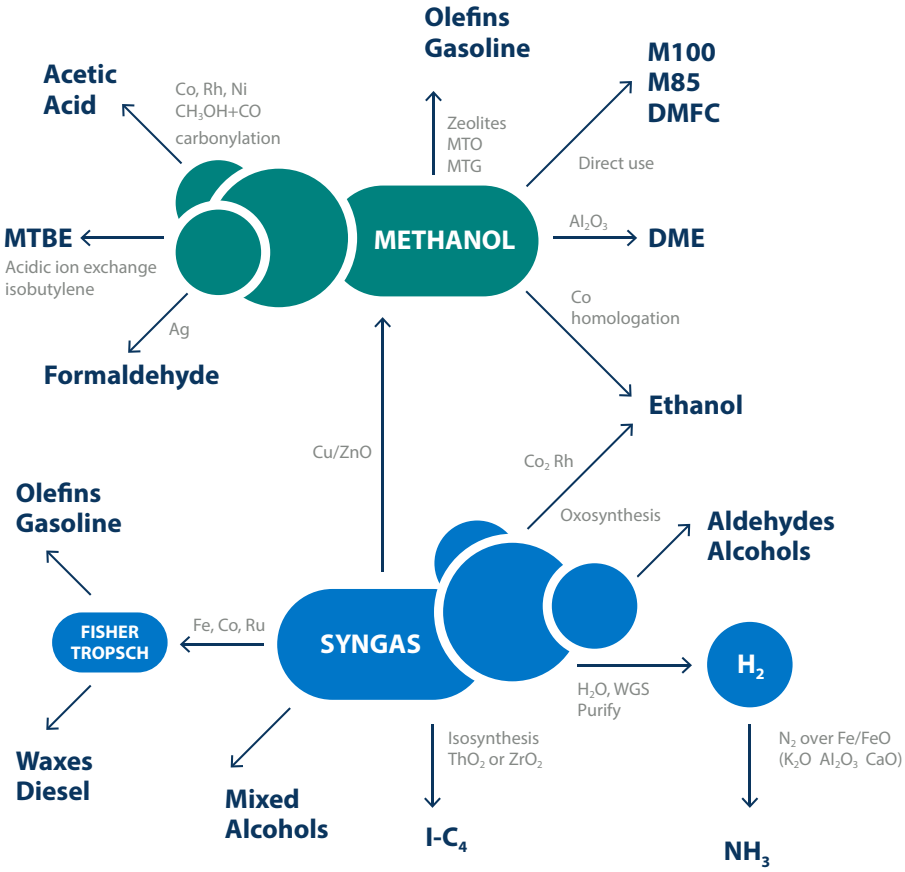
PROVEN TO TRANSFORM NEARLY 60 FEEDSTOCKS INTO VALUE

We have extensively tested our Advanced Gasification Technology on nearly 60 types of feedstocks – either in laboratory conditions, in pilot plants, or at commercial scale. As a result, we have developed our proprietary library of feedstock analyses.

This allows us to design our processes and adapt our technology to suit almost any feedstock, including:

- 12 different species of forestry wood
- Wood chips, wood pellets, demolition wood and waste from the furniture industry
- Industrial waste, including tyres, plastics, contaminated plastics, and treatment plant sludge – individually and in combination
- Further types of plant waste, including almond and coconut shells, sugar cane bagasse, grape marc and mushroom compost
- Further types of agricultural waste, including straw pellets, corn, cereals and energy crop mixes
- Varying compositions of municipal solid waste
- Animal meal
- Manure

PRODUCTS AVAILABLE FROM EQTEC SYNTHESIS GAS (SYNGAS)



IN DEPTH: THE EQTEC GASIFICATION PROCESS

Our gasification process applies our patented Advanced Gasification Technology to thermochemically transform the feedstock into a combustible gas mixture (syngas) with a low calorific value.

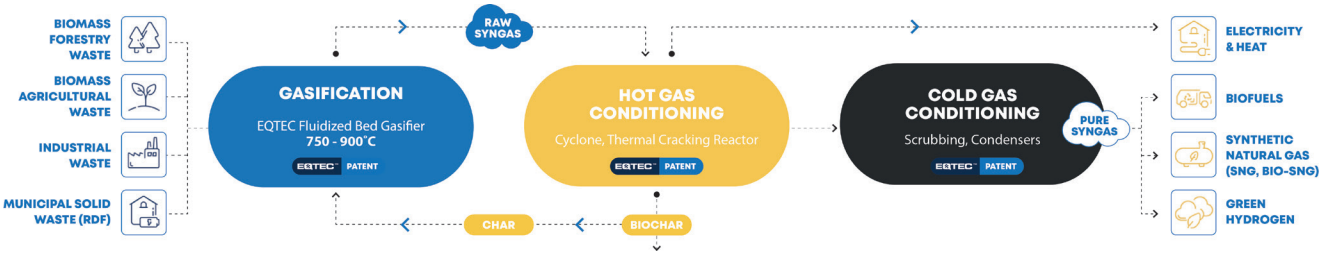
During normal operation, a Bubbling Fluidized Bed (BFB) gasifier uses air/oxygen-steam as a gasification agent to the feedstock. This produces a syngas mixture consisting mainly of hydrogen, carbon monoxide and methane, along with small amounts of nitrogen (in the case of air gasification), carbon dioxide, water vapour and other compounds in small quantities (tars and ashes).

Downstream of the gasifier, the gas undergoes a conditioning process. This includes:

- Removing solid particles
- Thermal cracking of tars
- High temperature filtration
- Cooling
- The absorption of soluble contaminants and condensable compounds that might have remained in the stream

The aim is to obtain a syngas stream with the quality requirements needed for the final application, depending on whether the plant is configured for biomass-to-energy, biomass-to-bioenergy or RDF-to-energy.

EQTEC TECHNOLOGY: THE PROCESS



GASIFICATION CHEMISTRY

Gasification is a complex process that covers a great many chemical reactions associated with material and heat transfer phenomena.

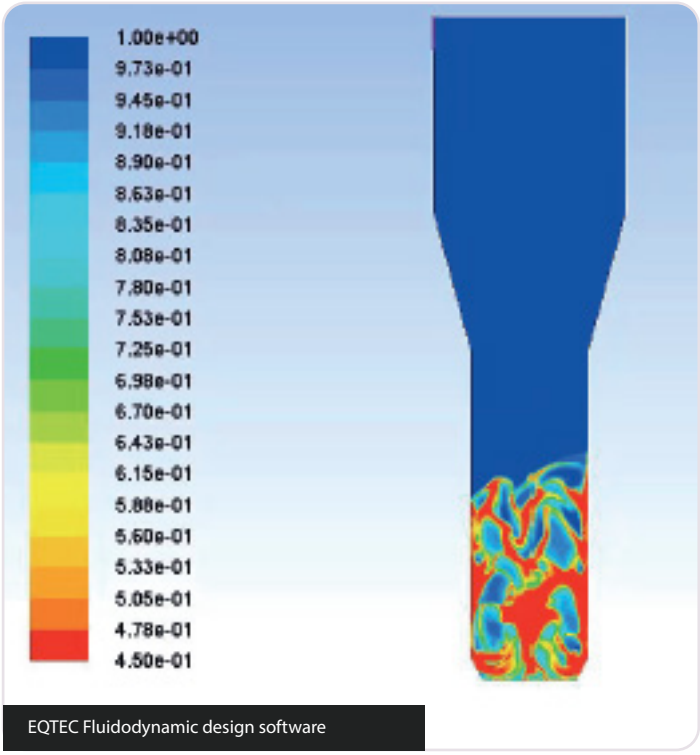
We have developed a proprietary computer-assisted kinetics model. This model simulates the main chemical reactions that occur in a gasifier with EQTEC Advanced Gasification Technology and accurately predicts the chemical composition of the gas generated.

The process conditions within our gasifiers achieve carbon-to-gas conversions of approximately 95% and a very low tar concentration of around 5 g/ m3N of gas to the gasifier output.

THE FLUIDIZED BED GASIFIER

The type of EQTEC gasification technology is the fluidized bed gasifier. This type of gasifier offers several benefits over other reactor technologies:

- Better temperature distribution in the gasifier
- Better gas solid contact
- Good scale-up potential
- Intermediate capacity range
- Versatility in terms of the wide range of feedstocks that can be treated



EQTEC Fluidodynamic design software

The fluidized bed gasifier mainly consists of an air plenum, a distribution plate with gasification agent diffusers and the refractory lined vessel reactor, with no heat transfer surfaces. The reactor can operate at atmospheric pressure or under certain pressure. The normal temperature operation range is 850-900 ºC.

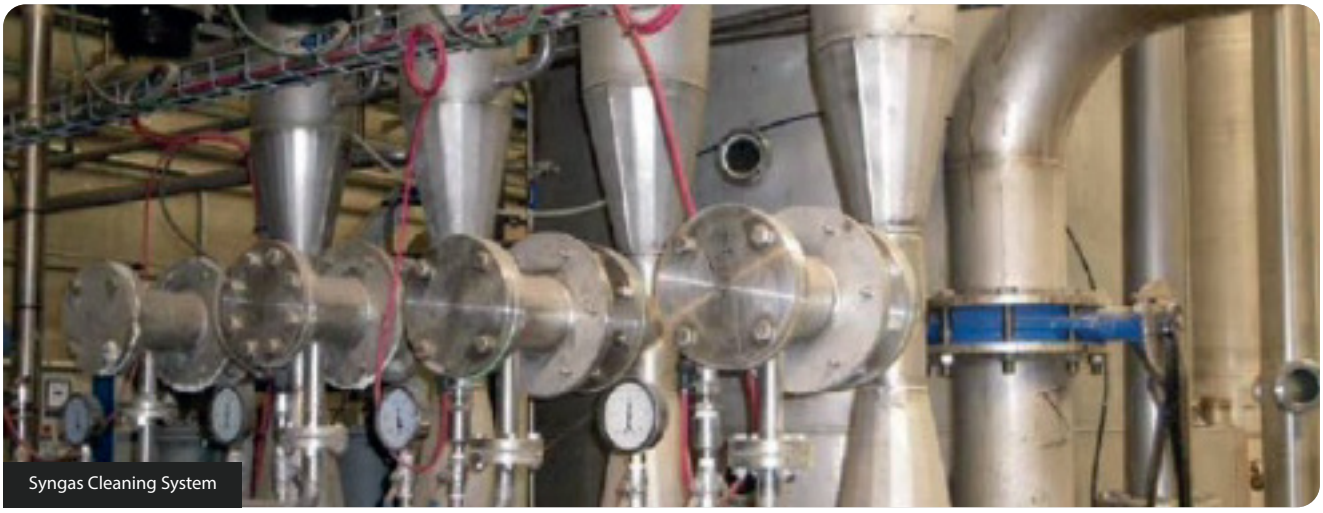
The feedstock is continuously fed to the lower section of the gasifier, as is the gasification agent. Once in the reactor, the feedstock comes into contact with the bed material. This heats the material rapidly and begins the decomposition and gasification reactions. The bed material can be inert – such as quartz sand – or catalytically active with regard to the conversion of organic contaminants in the crude gas through possible after-reactions in the gas phase.

The produced syngas travels upwards in the gasifier together with the fluidized solids comprising ash, char and bed materials. Once the chemical reactions have taken place, the synthesis gas leaves the gasifier through the cyclone, where the majority of solid particles separate from the gas stream.

To maximize the carbon conversion, the particles retained in the cyclone are directed back through a non-mechanical return leg to the lower part of the gasifier reactor. Any agglomerated or large particles of ashes and bed material are then extracted from the bottom of the reactor to avoid bed malfunctioning or sintering.

SYNGAS CONDITIONING

We tailor the design of the syngas conditioning process depending on the properties of the feedstock and the final application of the syngas. Furthermore, we design and build the cleaning units in our plants with every installation to guarantee compliance with the strictest environmental legislation.



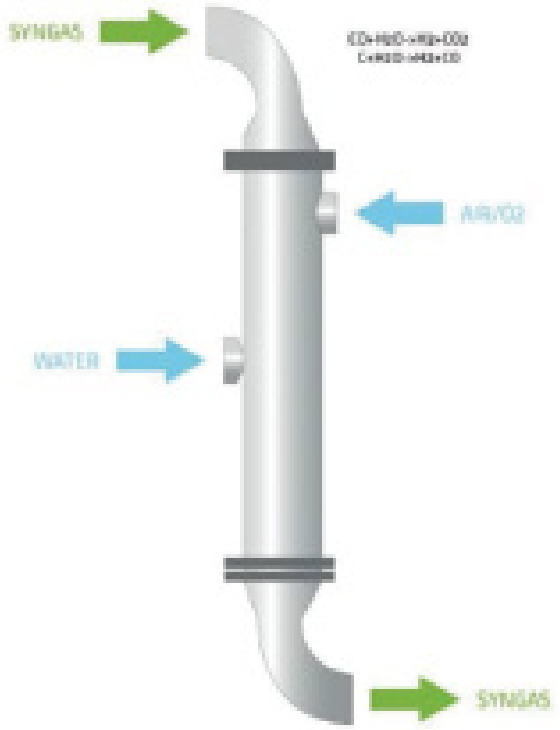
Syngas Cleaning System

Among the several conditioning steps, our thermal cracking and reforming reactor is key. It creates the conditions necessary to maximize the production of H2 and CO, which ensures the high quality of the syngas. The reactor also reduces the tars in the syngas stream, avoiding problems in the downstream equipment while also recovering part of the energy of these compounds.

Applying high-temperature filtration removes the solid particles from the gas stream, preventing condensation on the filtering elements and thus increasing the system availability.

Depending on the final use of the syngas, the technology includes a scrubber system, the design of which is proprietary and unique. This uses liquid scrubbing agents to reduce impurities and contaminants from the syngas. The contaminants adhere to these agents, which then dissolve them, thereby cleaning the syngas and making it purer.

Operational diagram of a Thermal Cracking Reactor



COMMERCIAL SYNGAS APPLICATIONS

Our gasification plants are created to maximize the commercial potential of the feedstock and required offtake applications in the following ways:

1. Converting biomass into energy
2. Converting municipal solid waste into energy
3. Converting biomass or non-recylcleable waste into energy and biofuels

The higher the quality of the syngas produced, the wider the range of energy sources – or 'offtake' – it can be applied to generate at commercial scale.

The offtake is the energy output of the conversion process that we sell to the market, whether for local or national use.

THE MOST IN-DEMAND APPLICATIONS


ELECTRICITY


HEAT


BIOCHAR


HYDROGEN

- **Clean electricity**
  Can be used on-premise or sold to the country's national grid
- **Heat**
  For district heating and decarbonising heat infrastructure
- **Combined Electricity and Heat (CHP)**
  Especially useful as an on-premise solution where the waste generated directly transforms into energy for the customer or the local community
- **Biofuels**
  For automation, as well as land and air transport
- **Synthetic Natural Gas (SNG)**
  Can be used as a more sustainable alternative to methane
- **Biochar**
  A material with many potential applications, often used to re-fertilize and increase the quality of local soil substrates as well as having carbon sequestering benefits
- **Hydrogen**
  For emerging clean energy uses including as a gas, for heat and fuel cells

The specific desired application influences how we design the technology for each plant. Different offtakes require us to condition the raw syngas output of our fluidised bed gasifier in different ways.

CONTINUOUS INNOVATION SINCE 1997

Investment in research and development has been an EQTEC priority for decades. In collaboration with long-standing R&D partners, our expert engineers are continuously innovating, testing the limits of our advanced gasification capabilities and evolving our technology roadmap in order to improve commercial performance.

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We have installed gasification equipment at the University of Lorraine in France and the University of Extremadura in Spain, where we work with their experts to operate R&D pilot plants and actively invest in the maintenance, upgrade and application of these facilities. These pilot plants have enabled us to test our Advanced Gasification Technology on an extensive variety of feedstocks, and to build a proprietary library of nearly 60 feedstock analyses – the most extensive we know of anywhere in the world.

Thanks to these and other R&D partners across Europe, we have been able to identify and test potential new applications for our technology, enabling us to expand into areas of emerging market interest.

LEADING R&D PARTNERS

Using knowledge gained from these decades of continuous innovation, we have pioneered major technological improvements to the fluidized bed gasification process, significantly increasing its efficiency, sustainability, and commercial potential:

- **Our studies into fluid-dynamics and solid materials behaviour led to our enhanced fluidized bed gasifier design, resulting in higher carbon conversion, reduced bed material agglomeration and increased efficiency.**
- **Our research on tar abatement processes was fundamental to the development of the syngas conditioning process to meet specific requirements while also reducing waste streams.**
- **Continuous R&D has resulted in our ability to use syngas in emerging applications – producing biofuels and hydrogen, for example.**

OUR PROJECTS

To date, four commercial and two R&D plants have been built and commissioned with EQTEC's Advanced Gasification Technology – in Spain, France, Croatia, Italy and Bulgaria. The oldest plant, built in 2011 for the Spanish agricultural client Movialsa, has operated for over 125,000 independently audited engine hours.

TRACK RECORD

Six plants built and commissioned, with three targeted for re-commissioning

ON-PREMISE FACILITY FOR AGRO-BUSINESS

Mostos Vinos y Alcoholes, S.A. (Movialsa)

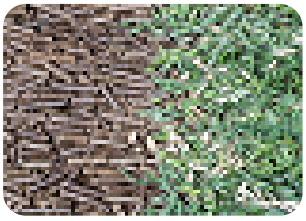
Ciudad Real, Spain

- Start-up date 2011
- 5.9 MWe
- Agricultural waste (incl. olive pomace, wine must)
- Electricity, heat

EXTERNALLY AUDITED OPERATIONAL DATA (2015 – 2020)

PARAMETER	UNIT	2015	2016	2017	2018	2019	2020
PLANT AVAILABILITY[1]	HRS/YEAR	8,600	7,300	7,060	7,800	7,314	8,157
	%	98	83	81	89	83	93
EQUIVALENT ELECTRICAL EFFICIENCY[2]	%	45	39	38	39	38	38
ELECTRICITY/FEEDSTOCK RATIO[3]	KW/KG BIOMASS	1.4	1.4	1.4	1.4	1.4	1.4

1. benchmark for gasification is 4 – 5,000 hrs/year | 2. benchmark for this particular feedstock is 30% | 3. benchmark for incineration is <1.0



R&D PILOT PLANT

Universidad de Extremadura

Badajoz, Spain

- Start-up date 2010
- Biomass trials
- Fischer-Tropsch (gas-to-liquid) trials in 2021

R&D PILOT PLANT

Université de Lorraine (LERMAB)

Nancy, France

- Start-up date 2015
- Biomass trials
- RDF trials
- Contaminated plastics trials

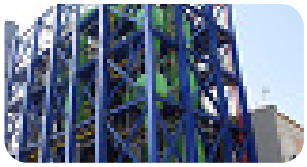
OUR CURRENT PIPELINE

EQTEC has many plants currently under construction or development:

5 UNDER CONSTRUCTION

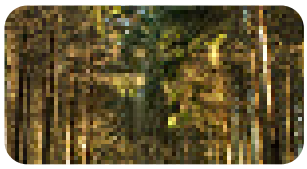
Italia MDC
Gallina, Toscana, Italy
- 1.0 MW
- Wood chips, straw pellets
- Electricity, heat

Croatia MDC
Belišće, Croatia
- 1.5 MW
- Forestry waste
- Electricity, heat, biochar



North Fork
North Fork, Caifornia, USA
- 2.0 MW
- Forestry waste
- Electricity, heat, biochar

Larissa
Thessalia, Greece
- 0.5 MW
- Agricultural waste
- Electricity, heat



Karlovaç
Karlovaç, Croatia
- 1.0 MW
- Wood chips, straw pellets
- Electricity, heat, biochar

14 IN DEVELOPMENT & GROWING

Billingham
Billingham, Teesside, UK
- 25.0 MW
- RDF (from municipal waste)
- Electricity, heat/steam, hydrogen

Deeside
Deeside, Flintshire, UK
- 9.0 MW
- RDF (from municipal waste)
- Electricity, heat, hydrogen, biogas

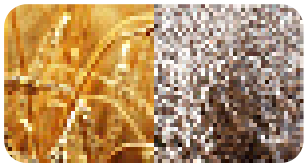
Southport
Southport, Merseyside, UK
- 9.0 MW
- RDF (from municipal waste)
- Electricity, heat, hydrogen, biogas

Sligo
Finisklin, County Sligo, Ireland
- 20.0 MW
- Forestry waste
- Synthetic natural gas, biofuels

Shannon
Shannon, County Clare, Ireland
- 20.0 MW
- Forestry waste
- Synthetic natural gas, biofuels

Livadia 1
Livadia, Boeotia, Greece
- 1.0 MW
- Forestry waste
- Electricity

Livadia 2
Livadia, Boeotia, Greece
- 1.0 MW
- Forestry waste
- Electricity



Nobilis
Almyros, Thessalia, Greece
- 1.0 MW
- Agricultural waste
- Electricity, heat

Drama
Kato Nevrokopi, Drama, Greece
- 5.0 MW
- Forestry waste
- Electricity

France
Haute-Garonne, France
- Start-up date 2024
- 4.5 MW
- Contaminated plastics
- Electricity, heat, biofuels

Exploring additional projects for gasification of biomass, industrial and contaminated waste.

GLOSSARY OF TERMS

Gasification:
the process of applying heat, oxygen and pressure to materials containing hydrocarbons under controlled conditions to convert them into synthesis gas, or 'syngas'.

Feedstock:
raw material used to fuel a chemical process; in this case waste material used in gasification to produce syngas.

Offtake:
the type of output of the conversion process that we sell to the market, whether for local or national use.

EPC:
an acronym for Engineering, Procurement and Construction used in the construction industry.

Syngas:
short for 'synthesis gas', a fuel gas mixture comprising mainly hydrogen, carbon monoxide and methane.

MWe:
short for 'megawatts electric' – the electricity output capability of a power plant.

R&D:
Research and Development

CO:
Carbon monoxide

H2:
Hydrogen

Bubbling Fluidized Bed (BFB):
a type of gasifier in which small, solid particles are suspended and pressurised to act like a liquid. This heats the feedstock material and causes it to convert into syngas.

Biomass-to-energy:
the process of using organic plant or animal material as fuel to produce electricity and/or heat. Common biomass examples include forestry waste and agricultural waste.

Biomass-to-bioenergy:
the process of using organic plant or animal material as fuel to produce a combination of electricity, heat and biofuel.

RDF-to-energy:
the process of using refuse-derived fuel (RDF) from municipal solid waste, industrial waste, or commercial waste as fuel to produce electricity or heat.

Reactor:
the part of the advanced gasification process where thermal cracking and reforming take place.

Fuel cell:
an electrochemical cell that converts the chemical energy of a fuel and an oxidizing agent into electricity. Hydrogen is often used as the fuel in a fuel cell.

Agglomeration:
when particles in the BFB gasifier clump together, at which point they are removed. Our bubbling fluidized bed gasifier is designed specifically to reduce agglomeration, which in turn increases its efficiency.

Thermal cracking:
the process by which hydrocarbons are subjected to high temperatures and high pressures to break their molecular bonds; in this case, we apply heat and high pressure to our syngas to maximise its hydrogen and carbon monoxide content.

EQTEC™

VISIT OUR INSIGHTS LIBRARY

For more information about EQTEC, industry trends, and the benefits of advanced gasification, visit:

eqtec.com/gasification-industry-news

INTERESTED IN WORKING WITH US?

Whether you're a potential partner, an investor, or you just want more information, get in touch at:

eqtec.com/contact-us