Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
ASTON	BERG	Biomass preparation and pre-treatment laboratory	ASTON1	Biomass preparation by comminution, drying, washing and impregnation with reactants and catalysts	s.banks@aston.ac.uk
ASTON	BERG	Analysis laboratory	ASTON1	Analysis and characterisation of feed materials and products. This includes conventional ultimate and proximate analysis, gas analysis, char analysis, bio-oil and upgraded bio-oil analysis by GCMS-FID, GPC, water content by Karl Fischer, viscosity and stability measurement, TGA analysis, density, heating value, corrosivity and tan numbers.	s.banks@aston.ac.uk
ASTON	BERG	Microreactor laboratory	ASTON1	Microreactor for Fischer Tropsch and similar syntheses for hydrocarbon and alcohols with in-line and off-line product analysis; analytical pyrolysis in continuous and batch modes (Pyroprobe GCMS-FID) including fast pyrolysis and catalytic fast pyrolysis	s.banks@aston.ac.uk
ASTON	BERG	Process laboratory	ASTON1	Fast pyrolysis processing in continuous fluid beds (four reactors from 100 g/h to 10 kg/h) with associated liquid, solid and gas product collection. Intermediate pyrolysis can be carried out at a nominal 20 kg/h continuous dual screw reactor. Slow pyrolysis is included with a 1 kg/h auger reactor. A drop tube reactor provides fundamental analysis for pyrolysis and combustion kinetics. There is also a batch reactor for hydrothermal processing. Catalytic reactors can be close coupled to all the reactors for multistage and sequential processing with product analysis.	s.banks@aston.ac.uk
BE2020+	Pilot Plant	Pilot scale combusion plant	BE1	The installation consists of a 34 m³ storage container (moving floor), a fuel feeding system based on screw conveyors, a biomass grate furnace (horizontally moving grate), a secondary combustion zone, a fire-tube hot water boiler and a cyclone precipitator for dust precipitation. The fuel power is approximately 180 kW. Different biomass fuels (pelletised materials, chipped or chopped woody and herbaceous fuels) can be applied. Primary combustion air, which can optionally be electrically heated up to 180°C, is supplied below the grate into two zones (separately controllable air supply). Secondary combustion air can be injected at two different sections in the secondary combustion zone. Flue gas recirculation below the grate as well as above the grate can be optionally applied to control furnace temperatures. The plant is equipped with extensive process analysis equipment allowing the measurement of all gaseous streams as well as temperatures in all different section. Furthermore, the plant is equipped with a novel model-based control system which allows the operation under well-defined conditions (e.g. the definition of a certain lambda value in the primary combustion zone).	stefan.retschitzegger@bioenergy2020.eu
BE2020+	DTF	Combustion reactor coupled with a drop-tube furnace	BE2	The installation is unique worldwide. It consists of a continuously fed grate-fired biomass furnace (fuel power: 55 kW_{NCV}), which can be operated with various chipped and pelletised biomass fuels. Due to the application of flue gas recirculation also a high flexibility concerning the moisture content of the fuels applied exists. The flue gases are led over a well isolated secondary combustion zone and a connection duct to a 2 m, 150 mm SiC electrically heated drop-tube furnace (temperatures up to 1150°C). Within dedicated test runs it is therefore possible to determine the combustion and release behaviour of various biomass fuels in a fixed-bed system as well as to evaluate particle, aerosol, and deposit formation behaviour under continuous operation conditions.	stefan.retschitzegger@bioenergy2020.eu
BE2020+	FBR	Fixed-bed lab-scale reactor	BE3	The fixed-bed lab-scale reactor is a unique device in Europe for fundamental investigations concerning the thermal decomposition, pyrolysis, gasification and combustion behaviour of various biomass fuels. It consists of a SiC cylindrical retort (height 35 cm, inner diameter 12 cm) which is heated electrically by two separated PID-controllers up to about 800°C. The fuel is put in a SiC cylindrical holder (100 mm height, 95 mm inner diameter). The mounting and vessel for the fuel bed are placed on a scale. With this setup it is possible to continuously measure the mass reduction of the 100-400 g sample during the pyrolysis/gasification/combustion process. Continuously working FT-IR, ND-IR, FID, CLD and heat conductivity analysers are applied in order to determine the concentrations of O2, CO, CO2, H2O, H2, OGC, NO, NO2, HCN, NH3, HCl, SO2 as well as of various hydrocarbon compounds during the conversion step. Moreover, discontinuous tar sampling and subsequent analyses of the tars can be applied.	stefan.retschitzegger@bioenergy2020.eu

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
BE2020+	SPR	Single particle reactor	BE4	The single particle reactor is a new lab-scale reactor with ICP-MS coupling which is especially designed to investigate the time-dependent S, Cl, K, Na, Zn and Pb release of single biomass particles. Thereby the coupling of ICP-MS represents a world-first. Hence, the reactor enables a completely new approach to investigate the time-dependent thermal decomposition of various solid biomass fuels under well-defined boundary conditions. The core element of the reactor is an Alsint tube (composed of 99.7% Al2O3) with a diameter of 50 mm which is placed in an electrically heated oven. The tube is equipped with four lateral access boards, two for optical access and two for sample handling. Through one of the latter a sample holder is introduced which is connected to a balance (Mettler Toledo XS105DU). A single biomass pellet or chip (sample mass 300 – 1200 mg) is placed on the sample holder and introduced into a protective tube mounted inside the pre-heated reactor tube (target temperatures up to 1000°C are possible). Then the system is sealed and a reaction agent (e.g. N_2, O_2 or mixtures) is injected from the bottom of the reactor tube. Extensive measurement equipment (termopcouples, FID, FTIR spectroscopy, ICP-MS) is applied to control and monitor the entire process.	stefan.retschitzegger@bioenergy2020.eu
BE2020+	TGAMS	TGA-DTG-DSC Coupled with a Mass Spectrometer	BE5	With this device samples up to 25 g can be investigated at a TG-resolution of 5 µg in a temperature range between 25 and 1450°C. Additionally, different gas phase atmospheres (oxidising, reducing, inert, Cl-, S- and/or moisture containing) can be applied. With this device biomass fuels can be investigated concerning their thermal decomposition behaviour. Furthermore, ashes, deposits and slags can be investigated concerning their behaviour at different temperatures and gas phase conditions. Additionally, due to the coupling with the mass spectrometer, the possibility is given to control the gas phase composition during a test and to identify elements and compounds released from the samples during the thermal treatment.	stefan.retschitzegger@bioenergy2020.eu
CENER	PEL	Pelleting pilot plant (PEL)	CENER1	CENER's pilot-scale pellet mill is able to working with different feedstock materials (e.g. beech, pine, poplar, wheat straw and paulownia) at different conditions. Peletting is made in a round die pellet mill with a capacity up to 500kg/h and press channels from 6x16mm to 6x39mm. Water is added at a range of 0-50 litres per hour. The combinaation of high degree of flexibility and size is rare in such a facility.	idelcampo@cener.com
CENER	TOR	Torrecfaction pilot plant (TOR)	CENER2	The Torrefaction Pilot Plant (500kg/h) consists of a rotary reactor with internal elements designed to achieve a good flow of biomass particles to improve homogenization and to assurre good heat transfer conditions inside it. The pilot plant is very flexible regarding feedstock density and particle size, being able to process difficult fuels with very low bulk density and very high fines content.	idelcampo@cener.com
CENER	GAS	Gasification unit: Atmospheric bubbling fluidized bed reactor (GAS)	CENER3	This atmospheric bubbling fluidised bed (ABFB) gasification pilot plant has a nominal power of 2MWt capable of generating a fuel gas suitable for the cleaning and syntehstic processing of 2nd generation biofuels. Two operating modes are possible: 1) use of air as a gasifying agent, or 2) use of steam/oxygen as a gasifying agent.	idelcampo@cener.com
CENER	PPB	Prototype pilot plant for biochemical conversion of biomass and new biogenic feedstocks (PPB)	CENER4	A pilot plant that can reproduce all biochemical conversion steps - from pretreatment to microbial fermentation - of the selected biogenic feedstocks. It allows the use of different feedstocks, process conditions (temperature, pressure) and catalysts (acids, alkalis) and the development and testing of new process configurations and biorefinery concepts.	idelcampo@cener.com
CENER	PBP	Pilot plant for biochemical processes development (PBP)	CENER5	Modular and flexible installation for the development, validation and optimsation of different bioprocess configurations. It can be used for the development and optimsation of enzymatic hydrolysis and/or microbial fermentation processes as well as for microorganism (yeasts, bacteria, fungus, etc.) growth and validation.	idelcampo@cener.com
CERTH	BLAB	Biomass laboratory analyses ISO certified	CERTH1	A fixed bed downdraft biomass gasification unit that operates in continuous mode coupled with electricity production (10kWe). Available fuel and residues analytical laboratory and pre-treatment methods for fuel preparation. Gas analyses and sampling available.	panopoulos@certh.gr

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
ECN part of TNO	WOB	WOB Lab-scale Reactor for Gasification, Pyrolysis and Combustion	ECN1	The WOB reactor is a multi-purpose reactor for bubbling fluidized bed (BFB) gasification, combustion and pyrolysis of approximately 0.5 kg/h fuel. It is equipped with dual fuel feeding systems to be able to make fuel mixtures or supply additives. The reactor can be electrically heated to as high as 1100°C and can be fluidized with air, steam, oxygen, nitrogen or other gases. The temperature can be controlled independently of the air supply. It is a very flexible and reliable reactor and is used for many types of research (pyrolysis, gasification and combustion using different biomass/waste feedstock and bed materials, kinetic measurements, agglomeration studies, effect of additives, calcination processes). Although it is possible to remove some bed material to keep the bed level approximately constant during a test run, users should realize that the bed composition will change by accumulation of char and ash. Hence, test runs are usually limited to a few hours, or interrupted for char burn-off. Users should be aware that regularly exchanging bed material improves data quality but reduces the amount of access time available for actual test runs. Recently, the WOB installation has been modified to allow simulation of grate firing conditions and study of deposit formation on heat exchangers as well. Given the wide applicability, the WOB installation is used very frequently in national and international mixed-funding projects and industrial contracts.	jaap.kiel@tno.nl
ECN part of TNO	WOB	MILENA/OLGA Lab-scale system for indirect gasification, tar removal (and further gas cleaning and upgrading).	ECN2	The MILENA indirect gasifier is a reactor for allothermal gasification of about 4 kg/hour biomass or waste at temperatures from about 700 to 850°C. The reactor is electrically heated, mainly to compensate heat loss. MILENA consists of two coupled sections for gasification and combustion. Heat is transported from the bubbling fluidized bed combustion section (“combustor”) to the fast fluidized gasification section (“riser”) by sand or similar bed material. Fuel is fed to the riser, where it is heated quickly by contact with hot bed material to release pyrolysis vapour which further reacts to product gas. Gas and solids (bed material + char) are separated in a settling chamber above the riser. The char residue is transported with bed material via a downcomer to the combustor, where it reacts with air to produce heat. Fast fluidization is reached by gas production from the fuel, but a limited amount (1 kg/hr) of steam with some N2 or CO2 is added to the riser to guarantee fluidization. Thanks to the decoupling between the gasification and the combustion stages, MILENA can produce a nearly N2-free gas without the need for an air separation unit. Moreover, total conversion of the biomass can be achieved. MILENA can be used to investigate gasification behaviour of fuels at different temperatures and/or with different bed materials. Tests of this kind require operator attendance and they are usually performed in test runs of up to 10 hours. MILENA can also be used to provide nearly N2-free product gas from standard wood fuel for downstream application or conversion (e.g. gas upgrading, adsorption processes, synthesis). Tests of this kind may extend over longer periods, with only day-time operator attendance, provided safety procedures can be met. OLGA tar removal will be available downstream MILENA if product gas with low tar content is required for an application or process to be tested. The amount of product gas which can be handled by OLGA is limited to about 1 mn3/hr. There is also an option (not included in the TA offer) to remove water and sulphur compounds to allow e.g. testing of sulphur-sensitive catalysts or adsorbents. Parties interested in that option need to make separate arrangements with ECN. The MILENA/OLGA system is a major “work horse” in the ECN gasification R&D activities.	jaap.kiel@tno.nl
ENEA	STEBATCH	Batch Steam Explosion reactor	ENEA1	Consists of a 10 l pressure vessel, coupled with a 125 kW boiler, which is surrounded by a steam jacket to ensure a stable temperature and minimize the steam condensation. Product is then recovered in a connected 150 l expansion tank. Temperature range of 160- 230°C with various residence times.	francesco.zimbardi@enea.it
ENEA	PARR	High pressure and temperature batch reactor	ENEA2	Comprised of a 0.5 l vessel with adjustable stirrer, with temperatures up to 300°C and pressures up to 350 bar. Typically used for pretreatment and fractionation with water and solvents; can also be used for catalytic processes (hydrotreating, oxidation) or supercritical extraction.	francesco.zimbardi@enea.it
ENEA	MERES	Membrane reactor and separator Pd/Ag based	ENEA3	A relatively new installation (2013) and consisting of hydrogen permeation section and membrane reactor. Capacity of 0.25 m^3/h gas, can be used to test WGS or other catalysts for reactions involving H_2. In particular, it is possible to tune the H_2/CO ratio in FT reactions for the synthesis of liquid biofuels.	francesco.zimbardi@enea.it
ENEA	PRAGA	Pilot scale Updraft Gasification	ENEA4	PRAGA is a full equipped gasification plant based on a 200 kWth updraft gasifier which was installed in June 2010 to test the co-gasification of biomass and sorted (plastic) MSW. The nominal input of the gasifier is 20-30 kg/h of feed with a maximum plastic content of 15%. Gas cleaning section is composed of a biodiesel scrubber and two coalescer filters in series. The facility is unique since is equipped of several solid, liquid (tar) and gas sampling probes/lines to fully characterise the process, moreover it is extensively automated and remotely controlled with in field flow-meters, pressure and temperature measurements along the gasifier and the clean-up line for on-line monitoring. Dedicated gas chromatographic analysis (off-line) have been assessed for gas quality and minor species characterisation while online devices based on FTIR have been planned and will be available for the BRISK II service time.	francesco.zimbardi@enea.it

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
ENEA	HENRI	Hydrogen enrichment module	ENEA5	HENRI is the hydrogen enrichment section connected to PRAGA, with a capacity of 20 Nm^3/h. Gas is mixed with superheated steam and is heated to 300 °; this mixture is sent to the WGS reactor where it is catalytically enriched in hydrogen. Second reactor allows CO_2 separation by absorption with MEA. The facility is equipped of flow, pressure and temperature measurements systems along the lines to allow complete on-line monitoring. Dedicated gas chromatographic analysis (off-line) have been assessed for gas quality and minor species characterisation, while online devices based on FTIR have been planned and will be available for the BRISK II service time.	francesco.zimbardi@enea.it
KIT	IKFT	Fast Pyrolysis process development unit (PYTHON)	KIT1	This installation, with maximum feed capacity of 10 kg h^{-1}, is based on a twin-screw mixing reactor (81 mm in width, 46 mm in height, 1505 mm in length) that is used to mix fresh biomass with a preheated heat carrier (spherical steel particles with a diameter of 1.5 mm) at ambient pressure. Gas residence time at 500 °C is estimated to be <4 s. Char fines are separated by two cyclones connected in series and cooled down to room temperature in an inert atmosphere (N_2). The organic condensate is rapidly cooled in a quenching system at around 90 °C. The remaining gaseous product is analysed online with a process gas chromatograph (N_2, O_2, H_2, CO, CO_2, CH_4, C_2H_4, C_2H_6, and C_3H_8). All relevant process parameters are recorded and visualized online using a process control system.	axel.funke@kit.edu
KIT	IKFT	Hydrothermal liquefaction unit (PAUL)	KIT2	The PAUL reactor at KIT-IKFT is a reactor system for HTL of biomass, originally designed to liquefy lignin. Batch mode can be used for solid and liquid feedstocks and is not limited to water as solvent. Additionally hydrogenation reactions with hydrogen or syngas are possible. HTL experiments in the continuous mode are limited to feedstocks which can be solved or emulsified with maximal 10 vol%, depending on the pump system. A complete analytical characterization of feedstocks and products is possible by different methods such as ICP, GC-MS, GC-FID, FT-IR, HPLC, GPC, elemental analysis, TGA and others.	axel.funke@kit.edu
KIT	IKFT	Continuous reactor for upgrading of biogenic intermediates (KRABI)	KIT3	The main scope of KRABI is the upgrading of pyrolysis oil by hydrodeoxygenation. Hydrogen and pyrolysis oil is preheated to 60 °C, then pressurised and mixed and in the next step heated to the operating temperature of max. 400 °C. Maximum pressure at operating temperature is 500 bar. The throughput of H2 is 60 – 720 Nl/h, the throughput of pyrolysis oil 0.3 – 3 l/h. The oil is dripping down a catalyst bed of 240 mm height with a diameter of 38 mm, then cooled, depressurized and collected in a separation vessel. One experiment is carried out during 1 operational day, 5 kg pyrolysis oil can be upgraded in 1 experiment due to the reservoirs of educt and product. Additionally chemical analysis is offered, which includes elemental analysis, Karl-Fischer titration, and can be extended to other methods like GC/MS, NMR and others.	axel.funke@kit.edu
KTH	HPT	High-pressure homo/heterogeneous, full/hybrid catalytic combustion & conversion test facility	KTH1	Unusually high, industrially representative pressure levels (35 bar) for a catalytic tubular reactor test facility that has been utilized and modified during the last 15 years. Various catalyst configurations with mono- and multicatalyst beds can be tested.	brisk2@energy.kth.se
KTH	HPT	Externally fired micro gas turbine	KTH1	A complete micro-CHP system that generates 5 kWe and 17 kWth. During 2016-2017 the rig will be integrated with the HPT Solar Simulator, thus enabling hybrid operation with biofuels and simulated concentrating solar power.	brisk2@energy.kth.se
KTH	HPT	Containerized polygeneration system	KTH1	Includes a 5 kW commercial biomass gasifier/genset integrated with 5.5 kW pV panels, 1 kW wind turbine, power router, 600 Ah battery bank and reverse osmosis water treatment unit.	brisk2@energy.kth.se
KTH	HPT	Gas quality (GasQ) meters	KTH1	Two unique instruments (fixed and portable) that enable rapid and accurate on-line calorimetry measurements (heating value, Wobbe index, methane number) of a wide variety of biogas mixtures. Ranges of operation: flow rate 600 cc/minute, temperature -20°C to +50°C, gauge pressure 50-100kPa.	brisk2@energy.kth.se
KTH	HPT	Air gap membrane distillation (AGMD) test facility	KTH1	Comprised of two single-module, semi-commercial AGMD prototypes for studying heat-driven water purification (ultrapure water quality) or alcohol/water separation. Nominal yields of 2 L/hr/module or 20 L/hr/module with water as feedstock; temperature range from 5°C to 80°C with various flowrates.	brisk2@energy.kth.se
KTH	EFT	SFP-Steam Fast Pyrolysis fluidized bed system	KTH2	Unique facility for bio oil production from biomass. The fluidized medium is high temperature steam, and it can run fast pyrolysis with or without catalyst. Capacity is 2 kg bio oil /hour production. Full instrumented with temperature and Micro-GC for gas analysis. GC-MS system is also available for bio oil characterization	weihong@kth.se
KTH	EFT	Small scale High-temperature air and Steam thermal conversion Reactor	KTH2	Unique universal facility for solid fuel thermal conversion. It can be operated both in the processes of pyrolysis (up to 900^{o}c) and gasification. Gasification agents can be O_2, CO_2 or any other medium. Gas can be detected in Micro-GC and the liquids can be analyzed in the available GC-MS system.	weihong@kth.se
KTH	EFT	High-pressure homo/heterogeneous, full/hybrid catalytic combustion & conversion test facility	KTH2	Unusually high, industrially representative pressure levels (35 bar) for a catalytic tubular reactor test facility has been utilized and modified during the last 10 years. The reactor can be readily equipped with microwave generator, used for catalyst activation/reactivation.	weihong@kth.se
KTH	EFT	Pressurized fluidized bed reactor facility	KTH2	Extremely high pressure levels (3.0 MPa) in a relatively large-scale laboratory gasification facility (fuel feed rate 15 kg/hr). Air, steam, and carbon dioxide may be employed, with operational temperatures of 900 - 950°C for the reactor and the secondary reactor, and 500°C for the Inconel filters. Auxiliary atmospheric fluidized bed gasifier equipped for drop tube or screw feeding for investigations up to 900 °C.	weihong@kth.se
KTH	KT	5 kW_{fuel} atmospheric bubbling fluidised bed gasifier*	KTH3	Consists of a biomass feeder, a pre-heater, a fluidised bed reactor, a ceramic filter and a catalytic bed reactor. The total volume of the reactor is 5.1 L. The reactor is heated with external heaters and the maximum temperature is 950 °C. Gas composition can be analysed with an on-line micro-GC after each reactor in the system. Tar samples, collected using the SPA method, may be collected at the same sample points as for the gas analysis.	kengvall@kth.se
KTH	KT	Thermogravimetric analyser (TGA)	KTH3	NETZSCH TGA-DSC/DTA instrument STA 449 F3 Jupiter system (balance resolution 0.1 µg, horizontal balance setup) consisting of thermos balance (main component), a furnace for dry conditions, a furnace for water vapour conditions and a steam generator. Maximum temperature for the furnaces is 1250 °C with heating rates of < 20K/min and <50 K/min for the dry and water vapour furnace, respectively.	kengvall@kth.se

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
LNEG	BBRI	Biomass fractionation processes development unit	LNEG1	The Biomass Fractionation Processes Development Unit contains a full range of biomass preparation equipment (comminution, drying, washing and impregnation), batch reactors for biomass deconstruction, separation/purification systems and analytical devices that can be used with different biomasses for production of energy-based products and bioproducts. This installation has several stainless steel lab-scale stirred reactors - 160 mL (max. 200 bar, 350°C), 250 mL (max. 300 bar, 500°C), 600 mL (max. 125 bar, 350°C) and 2 L (max 125 bar, 350°C) - heated by external fabric mantles/heaters; temperature and agitation controls are made by PID controllers. Both isothermal and non-isothermal operation modes have been used at different solid loadings (3-15, depending on the feedstock). Different conventional (i.e., hydrothermal, dilute acid, organosolv) or novel processes (i.e., CO_2, ionic liquids, inorganic salts, solid superacids) can be developed. A 50 L stainless steel reactor and several pilot reactors (200, 180/360 and 500 L) are also available for biomass pre-treatment in aqueous based media (direct steam injection). Chemical analyses are supported via HPLC systems (equipped with PAD-, DAD-, UV-VIS-DAD and RI-DAD detectors), capillary zone electrophoresis, FTIR and DSC equipment.	francisco.girio@lneg.pt
LNEG	BBRI	Lab scale testing in microbial-based biorefineries	LNEG2	Lab scale testing in microbial-based biorefineries consists of a range from 3-7 litres bench bioreactors and acessories (eg O_2 and CO_2 analysers) for microbial-based biofuels and bioproducts processes, provided with a powerful, intuitive measurement and control system. Four pumps have been fitted as standard together with an additional fully controllable 2 pump module providing conditions for running experiments in real fed-batch and continuous mode with exponential feeding when required. A Whitley anaerobic and an in-house designed manifold system is available. Workstation for isolation and incubation of anaerobic samples without exposure to atmospheric oxygen, and includes humidity and temperature controllers, two mini-airlocks, and an automatic sleeve gassing system accommodating 270x90mm Petri dishes. For physiological and molecular monitoring, one multiparametric flow cytometer and one real-time PCR are available. Coupled with the biochemical conversion, the lab offers different membrane separation systems for DSP which can be coupled to target bioprocesses while running, providing operation as a membrane bioreactor. Chemical analysis via HPLC (equipped with DAD- and RI detectors); different GC systems (equipped with FID and TCD detectors).	francisco.girio@lneg.pt
LNEG	BBRI	Bench scale co-pyrolysis / co-hydropyrolysis reactor for liquid and gaseous biofuels production	LNEG3	Bench scale co-pyrolysis / co-hydropyrolysis reactor for liquid and gaseous biofuels production. Features a 1 dm^3 volume with Hastelloy C276 chamber (Parr Instruments). Heating rates in the range of 5 to 6°C/min. Chemical analyses via GC (N_2, H_2, CH_4, CO and CO_2); FID for the quantification of hydrocarbons in the range C2 to C5; liquid fraction distilled according to ASTM D86 standard to obtain three liquid fractions with subsequent analysis via GC–MS and FID.	francisco.girio@lneg.pt
LNEG	BBRI	VLab and pilot scale testing in microalgae-based biorefineries	LNEG4	Lab and pilot scale testing in microalgae-based biorefineries. Available equipment for heterotrophic, mixotrophic and autotrophic microalgal cultivation modes (from bench scale to pilot scale) includes outdoor raceway bioreactors with paddle wheels from 2 to 48 m^2, flat panel alveolar closed photobioreactors (from 0.5L to 50L), column closed photobioreactors (from 1 to 60L), tubular photobioreactors and fermentors from 0.6 to 50L. Analytical support equipment includes: HPLC (equipped with DAD- and RI detectors; different GC systems, equipped with FID and TCD; multiparametric flow cytometer; microscopes; CO_2 and O_2 analysers; LI-COR photometer and pilot scale continuous clarifier/centrifuge Alfa Laval LAPX 1997, among others. A bench-scale electroflocculator device is available. Cutting-edge cell disruption equipment such as a homogenizer Heidolph Diax 600, a high energy sonicator (Bandelin UW 3400 Sonopuls) and one vibrating ball mill (Retsch Vibrating Mill MM400) are available at bench scale for fast and efficient microalgal cells disruption. Oil, sugar, pigment, antioxidants and fatty acids extraction can be performed by means of conventional techniques and protocols as well as using a modern ASE – Accelerator Solvent Extractor (Thermo ASE 150 DIONEX) yielding fast, reliable, accurate and efficient lipid extraction at low operating costs. Process design and LCA software (Superpro Designer, SimaPro, GaBi, EcoInvent database) are available for process design and life-cycle assessment studies.	francisco.girio@lneg.pt
LNEG	BBRI	Lab and pilot scale wastewater treatment biological reactors (aerobic/anaerobic)	LNEG5	Lab and pilot scale wastewater treatment biological reactors (aerobic/anaerobic). A proprietary 110 L aerobic (air-lift type) reactor JACTO.MBR, together with 10-30 L reactors alike are usually used for aerobic wastewater treatment studies, e.g., olive mill and winery wastewaters. The coupling of the reactors with several separation systems, namely based on membrane technologies, offer the opportunity to work under high-cell densities conditions. Although these systems were mainly designed for non-aseptic operation, their use under sterile conditions is also possible, especially for the smaller (up to 30 L) reactors. Besides these proprietary reactors, standard bench-top CSTR and BSTR (up to 5L) and shake-flask culture equipment are also available. Analytical facilities include support the characterization of biomass and products, chemical oxygen demand and Total and ammonia nitrogen quantification, GC for biogas, H_2 and CO_2 analysis and HPLC systems.	francisco.girio@lneg.pt
POLITO	SE	Steam explosion + enzymatic hydrolysis + fermentation (bio-H2; biogas) + final use of the gases in SOFC CHP systems	POL1	Pilot plant allowing for the study of complete lignocellulosic feedstock conversion for fuel-cell CHP, with the option to study one or more subprocesses in more detail. The first subprocess – pre-treatment and fractionation -- consists of three sections: steam explosion; acid/basic hydrolysis; and enzymatic hydrolysis. This subprocess is followed by bio-hydrogen and/or biogas production, and includes three stirred-tank digesters (5, 35, and 250 L); reactors can operate in batch or continuous modes and are equipped with pH, temperature, redox potential, and biomass flow rate monitoring system. The third subprocess includes a 1 kWe SOFC stack operating at around 750°C, integrated in a balance of plant system including biogas clean-up section, thermal recovery section, electronic load for power conditioning; and a control system.	andrea.lanzini@polito.it
POLITO	POLYG	RES-enhanced biomass-to-fuel processes	POL2	RES-enhanced biomass-to-gas (BtG) and biomass-to-liquid (BtL) processes based on Solid Oxide Cells (SOC). Facilities consist of a test-rig for the electro-chemical characterization of SOCs and a pressurized micro-reactor for the study of the catalytic upgrading of gas mixtures to fuels (gaseous and liquids). The study of the catalytic conversion of the syngas produced by co-electrolysis to synthetic natural gas (SNG) or liquid fuels (e.g. DME) can be carried out on the pressurized micro-reactor. In such a way, core-technologies of BtG and BtL chains can be investigated in the same laboratory infrastructure. Includes MS for gas analysis.	andrea.lanzini@polito.it
POLITO	BTF	Industrial scale SOFC installation fed by biogas from a Waste Water Treatment Plant (WWTP)	POL3	Financed by EU in the H2020-JTI-FCH-2014-1 Large scale fuel cell power plant demonstration in industrial/commercial market segments: the installation will be in full operation from January 2017. The site is a municipal WWTP where biogas is produced from the sludge by-product of the water treatment process. The plant will be the first industrial size SOFC installation in Europe, and the largest biogas-fed SOFC at the international level so far. The SOFC system will be the main and sole cogeneration system within the site.	andrea.lanzini@polito.it

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
SINTEF	HTS/MS	High Throughput Screening/Mass Spectometry Unit	SIN1	Characterization of bio-oils by fingerprinting methods will be investigated as an essential pre-requisite for further development of methods with respect to identification and extraction of valuable compounds from bio-oil and later catalytic upgrading to valuable chemicals for example, phenols (high value aromatics) hydrocarbons or others and/or use as co-feed in crude oil-refineries. The research groups have access to a state-of-art mass spectrometric (MS) laboratory at SINTEF Materials and Chemistry, Dept. of Biotechnology and nanomedicine, which currently holds more than 20 mass spectrometers (3 GC-MS, 1 GC-MS-ATD, 4 LC-MS (singlequadrupole), 10 LC-MS-MS-QQQ (triplequadrupole), 1 LC-MS-TOF (time-of-flight) and 1 LC-MS-MS-Q-TOF(quadrupole time-of-flight), 1 ICP-MS-MS (triplequadrupole), 1 MALDI-TOF-TOF-MS and a 1 12 Tesla FT-ICR-MS (Fourier transform ion cyclotron resonance) ultrahigh resolution MS for structure elucidation of unknown compounds in very complex matrices. The MALDI TOF-TOF-MS and the ultrahigh resolution FT-ICR-MS instruments are equipped for MSI (MS-Imaging), which makes possible to determine both the location and structure of a compound in 2D solid samples. In addition, the laboratory has ion chromatography (IC) for determination of anions (acids) and cations. The laboratory also has 2 advanced automated robotic systems for high-throughput screening (HTS), and automated sample preparation. The laboratory has invested in a RapidFire automated injection system for ultrafast screening analysis by LC-MS QQQ and LC-QTOF. This system has a capacity of analysis of more than 10 000 samples per day (6 seconds per sample).	bernd.wittgens@sintef.no
SINTEF	ThermoConv	Biorefinery Labs (SINTEF MC ThermoConv)	SIN2	Fundamental studies within thermochemical production of pyrolysis oils from biomass, including upgrading and characterization of the generated condensable fractions by catalytic de-oxygenation and hydrogenation processes, as well as preparation and characterization of necessary catalysts. Fundamental studies on the thermochemical conversion of biomass based synthesis gas to synthetic liquid fuels, like methanol, DME and diesel in microstructured reactors. Research encompasses catalyst preparation and characterization; further catalysts can be tested with syngas with respect to selectivity, yield, activity and deactivation. Modelling studies on mass balance and energy balance of thermochemical processes and the integration thereof for improved yield and reduced resource consumption. The laboratory has an array of analysis equipment tailored for the mentioned conversion processes, considerable investments into MS, FT-IR and other online-monitoring equipment has been made in recent years.	bernd.wittgens@sintef.no
SINTEF	BioChemConv	Biorefinery Labs (SINTEF MC BioChemConv)	SIN3	A fermentation unit is integrated to the following in-situ and or continuous product recovery systems, these are gas stripping, LLE-extraction, RO- and pervaporation membrane systems and membrane electro-dialysis; additionally the unit is connected to a continuous cell recycling system to facilitate a high concentration of cells in the system. Fundamental studies on the conversion of biomass derived sugar solutions with various microbes towards biofuels and high value aded chemical are possible. The integration of the fermentor with downstream processing allows for in-depth studies of production rate and product inhibition effects combined with studies on selectivity and yield of multiple products. The laboratory has an array of analysis equipment tailored for the mentioned conversion processes, considerable investments into, FT-IR and other online-monitoring equipment has been made to improve flexibility .	bernd.wittgens@sintef.no
TU DELFT	TUD	Biomass Characterization Lab	TUD1	Tu Delft offers a unique biomass characterization lab with the ability to determine reaction kinetics of pyrolysis reactions needed for modelling of thermo-chemical biomass conversion processes. Moreover, the impact of heating rate on biomass conversion can be elucidated, which is known to change conversion behaviour significantly. Furthermore, heterogeneous oxidation reactions such as partial oxidation and CO_2-gasification reactions can be characterized using the TGA-FTIR, thereby providing more information needed for determining models of such heterogeneous reactions in combustion and gasification applications. The lab also integrates (bio)chemical conversion technology with thermo-chemical conversion. A typical number of external international visits yearly to the labs is 3-4, typically for few weeks.	c.tsekos@tudelft.nl
TU DELFT	TUD	Biomass BFB gasification and gas cleaning unit	TUD2	This newly constructed integrated test rig for biomass gasification is a unique test facility as it comprises of the integration of crucial process components for Syngas cleaning and gas upgrading (reforming/water gas shift). The facility consists of a 20 kWth BFB gasifier that is steam/oxygen/air blown, and a ceramic filter unit. Herewith the whole chain from biomass to Hydrogen-rich Syngas can be demonstrated. The unit is fully instrumented with advanced PLC control, temperature measurements via arrays of thermocouples, pressure and pressure drop sensors along with an extensive set of analysis instrumentation, like a high resolution Fourier Transform InfraRed spectrophotometer, a Raman spectrophotometer for quantitative gas analysis, micro-GC's, GC for tar and Sulphur traces, on-line analysers (NDIR, paramagnetic, UV) and solids particle size distribution (cascade impactor). Moreover, the section has a SEM for particle morphology study. There is a closely integrated lab for specific wet chemical analyses, like e.g. ICP-AES (trace metals), ion-chromatography, HPLC-UV-RFI. This integrated unit allows to perform applied research, but also very closely associated with it fundamental research can be carried out making use of TUDelft's research infrastructure TUD-01.	c.tsekos@tudelft.nl
TU GRAZ	TUG	Fuel test fluidized bed gasifier	TUG1	In the testing bubbling fluidized-bed gasifier, biomass is gasified under allothermal conditions with steam as the fluidization medium. A fuel mass flow of 500 g/h is commonly fed into the reactor (fuel power approx. 2.5 kW). Temperatures are controlled by means of two 3.5 kW electrical heating elements and commonly kept at an average of 750 °C in the fluidized bed and 830 °C in the freeboard of the reactor. The following techniques are applied for gas analysis after filtering: SPA and GC-FID for tars; GC-PFPD for sulphur compounds; and on-line gas analysers for O2, CO, CO2, CH4, and H2. Downstream desulphurization of the producer gas can be conducted in a fixed-bed reactor with a volume of 1100 ml. H2S in the producer gas is adsorbed on ZnO in pelleted form at a temperature of 300°C and other adsorption material or catalysts, e.g. for hydrodesulfurization, can be employed. The flexibility of this lab-scale unit allows the characterisation of the gasification behaviour of a great variety of solid biomass feedstock, including as well innovative measures for the in-situ reduction of emissions. Specifically, the desulphurization strategies can be studied in detail, including in-situ measures in the reactor and downstream cleaning with different adsorbent materials, employing a real producer gas.	anca-couce@tugraz.at

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
TU GRAZ	TUG	Continuous fluidized bed gasifier, tar cracking and methanation unit	TUG2	In the continuous fluidized fluidized-bed gasifier, biomass in pelletized form is gasified under allothermal conditions with steam as the fluidization medium. It is possible to control the gasification temperature in a range from 700°C to 880°C. Long-term test runs of more than 10 days can run in a fully automated system. The maximum fuel power is of 5 kW and a reactor pressure up to 5 bars can be employed. Downstream, after desulphurization (described for Unit 1), catalytic tar cracking and methanation processes can be conducted in two series-connected reactors. The employed temperatures are in the range from 300 to 500°C and Ni-catalysts are commonly applied. The gas analysis methods are the ones employed as well for Unit 1. The catalytic rig of this unit can be also used for test runs with a synthetic producer gas with defined concentrations of main permanent gases, water vapour and tar compounds. The stability achieved in the gasifier allows performing stable long-term tests with conventional and novel pelletized feedstocks, in which investigations on desulphurization, tar cracking and methanation can be conducted with a real producer gas from biomass gasification. Investigations can be as well conducted with a synthetic producer gas with a defined composition (e.g. composition obtained from gasification of a novel non-pelletized feedstock in the fuel test gasifier - Unit 1).	anca-couce@tugraz.at
TU GRAZ	TUG	Fuel cell laboratory	TUG3	TU Graz's Fuel cell laboratory consists of a synthetic gas (e.g., syngas) generator, an electric heating furnace, a cell housing, high temperature solid oxide fuel cell (SOFC) and a measurement and control system. The anode side of the fuel cell can be fed with synthetically produced gas mixtures with defined concentrations of pure gases (H2, N2, CO, CO2 and CH4), condensable tar species (such as benzene and naphthalene) and water vapour. Industrial sized planar anode-, electrolyte-, and metal-supported SOFSc with a surface of 100 cm2 can be employed. Investigations concerning fuel cell efficiency, extension of the fuel cell lifetime and different degradation mechanisms, such as carbon deposition, can be conducted in the fuel cell laboratory for different syngas compositions. Electrochemical impedance spectroscopy is employed to differentiate loss mechanisms and single processes, such as gas diffusion, fuel oxidation and oxygen reduction, and it enables the detection of carbon deposition on the SOFC and cell degradation caused by operation under carbon-containing fuels. Moreover, carbon depositions are investigated with a SEM analysis of the SOFC after the experiment.	anca-couce@tugraz.at
TU GRAZ	TUG	Slurry oxy-combustion boiler	TUG4	An adaptation of a commercial oil boiler, in which the fuel is combusted with oxygen enriched air or pure oxygen. It consists of a cylindrical water cooled combustion chamber with a diameter of 710 mm. The flue gas passes the flue tubes of the heat exchanger, achieving maximum efficiencies over 90%. The boiler is designed for a maximum power of 1.4 MW and slurries with moisture content over 50% w.b. can be combusted.	anca-couce@tugraz.at
VTT Technical Research Centre of Finland	BFB	Bubbling Fluidized Bed gasification Process Development Unit (BFB)	VTT1	Atmospheric bubbling fluidized bed gasifier; Lock-hopper fuel feed 5 kg/h biomass/waste material; Bottom ash removal for continuous run; Fluidization by air, steam, O2, CO2, N2; Secondary gas feed to freeboard; Hot gas filtration unit (T 400-800 °C); Catalytic tar reformer unit with air/steam/O2 feed; Analysis of main and permanent gases, tars and N-compounds; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT Technical Research Centre of Finland	TGA	Pressurized Thermo Gravimetric Analyser (TGA)	VTT2	Fuel reactivity and ash behaviour studies; Pressure 0-30 bar; Temperature max 1000 °C; gas feeds steam, O2, N2, CO2, CO; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	AFBR	Atmospheric Fixed Bed Reactor (AFBR)	VTT3	Lab-scale catalyst studies unit; Temperature max 1000 °C; Synthetic gasification gas feed (N2, CO2, CO, H2, CH4, NH3, H2S, O2, H2O, Toluene, Naphtalene); Online analytics by GC, FT-IR, gas analyser; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	PFBR	Pressurized Fixed Bed Reactor	VTT4	Lab-scale catalyst studies unit; Pressure max 20 bar; Temperature max 950 °C; Synthetic gasification gas feed (N2, CO2, CO, H2, CH4, NH3, H2S, O2, H2O, Toluene, Naphtalene); Online analytics by GC, FT-IR, gas analyser; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	MSU	Mobile Synthesis Unit unavailable until at least summer 2020	VTT5	Synthesis unit for Fischer-Tropsch, Metanol and SNG synthesis; Continuous 24/7 operation; Pressure 10-80 bar; Temperature up to 650°C, Gas feed 7 m3n/h from bottles/gasifier product gas; Tube, HEX or stirred tank reactor; Product analytics; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	FPU	Fast Pyrolysis Unit	VTT6	Bench scale fast pyrolyser; Fuel feed 1 kg/h biomass/waste material; Product recovery by ESP, condensers; Product analysis; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	SPU	Slow Pyrolysis Unit	VTT7	Bench scale batch slow pyrolysis unit; Temperature up to 900 °C; Rawmaterial 5 kg (woody) feed per batch; Recovery of condensable products; Product analysis; Installation location Espoo, Finland	Sanna.Tuomi@vtt.fi
VTT	FBCU	Bench-scale Bubbling and Circulating Fluidized Bed Combustion Units	VTT8	Features: fuel power 0.3-1.0 kW, riser heights 1.8 m (CFB) and 0.9 m (BFB), continuous or batch feeding, electrical temperature stabilization, primary and secondary gas feeds with varying gas compositions (air and bottled gases O_2, CO_2, CO, SO_2, NO etc.).	Sanna.Tuomi@vtt.fi

Rig List

Partner	Facility	Equipment Available	Rig Code	Equipment Description	Partner Contact
WAGENINGEN	CSR	Conical Screw Reactor	WR1	The conical screw reactor (batch, 50 L) makes it possible to process raw biomass at relatively high dry matter content, resulting in concentrated product streams. The mixing screw is tapered in order to create a large mixing surface and to reduce the non-contact volume in the middle of the barrel. A conical screw has the advantage that mixing times are significantly shorter compared to a straight screw. The reactor is equipped with a ball segment valve for emptying of the reactor in a controlled manner. Heating is done by steam in the reactor wall (double walled reactor). Other specifications: volume 50 L, material Alloy 316L/RVS 316L, max processing temperature 150 °C, 5 bar. Electricity: 3x400 V, 50 Hz.	rene.vanree@wur.nl
WAGENINGEN	HSR	Horizontal Screw Reactor	WR2	Stirring of biomass is not easy to do in a vertical reactor, so a horizontal reactor was designed by Parr for biomass processing. The reactor (batch, 20 L) can function horizontally for optimal stirring of the biomass. Pneumatic controls can till the reactor upright to open the bottom drain valve for sample filtration and collection. In the vertical position the reactor can be used for (catalysed) chemical reactions and polymerization reactions. Relevant key specifications: 20 L fixed head pressure reaction apparatus; pressure 70 bar, temperature 350 °C; heavy duty magnetic stirrer; heated bottom drain valve, and material made of Hastelloy C22. It is unique in its design for the following reasons: three blade double wiper stirrer for mixing of biomass; custom stand assembly rotates 90° for horizontal operation, and reactor equipped with cartridge heaters and cooling tubing, allowing for fast heating and cooling. This makes the reactor unique in its kind and unique in Europe.	rene.vanree@wur.nl
WAGENINGEN	BFP	Belt Filter Press	WR3	The belt filter press is able to separate solids from liquids, for example after pre-treatment or microbial conversions, in a continuous mode. The belt wide of the press is 700 mm and the effective filtrate area 5.3 m^2, resulting in a capacity of 0.5-4 m^3/h of slurry input (corresponding to 50-150 kg dry/matter/h).	rene.vanree@wur.nl
WAGENINGEN	FER	100 AND 1000L Fermenters	WR4	For larger-scale fermentation, we offer a 100 L and a 1000 L fermentor, custom-made by Applicon BV. Both these fermentors are equipped with heating devices up to 120oC and pH-electrodes, allowing in-line sterilization and pH-controlled fermentations. We also offer flexible downstream-processing equipment, such as: bactofugation, and micro- and nanofiltration, to separate fermentation fluid or specific smaller metabolites/molecules from microbial biomass and protein, together with large-scale lyophilization for extended storage/shelf-life and easy shipping. Our fermentor facilities are suitable for growth of both aerobic and anaerobic fermentations and are certified for use with a large range of microorganisms, including genetically modified microorganisms.	rene.vanree@wur.nl
WAGENINGEN	DIO	Dionex-Thermo® ICS-5000 (DIO)	WR5	The ICS-5000 is able to separate the monomeric or dimeric (wood) saccharides such as: arabinose, rhamnose, galactose, glucose, xylose, mannose, sucrose and fructose. This system is equipped for the quantification of saccharides within biomass matrices. The ICS-5000 includes a CarboPac™ PA1 column which separates the saccharides in a variety of matrices by high-performance anion-exchange (HPAE) using a high-pH eluent. At high pH, carbohydrates become charged and are separated as the oxyanion. The system is ideally suited for use with pulsed amperometric detection (PAD). The ICS-5000 HPAE-PAD offers high-resolution separations without the need for derivatization, with low-picomole sensitivity.	rene.vanree@wur.nl