Application for the JP on Bioenergy

Please fill in the sections with the blue shading and submit to Bas van Bree, EERA Secretariat (vanbree@ecn.nl).

The eligibility of your institute to participate in the Joint Programme will be reviewed by the Joint Programme Management Board, consisting of the Joint Programme Coordinator and the coordinators of all subprogrammes. If you are eligible to enter the Joint Programme, the application will then be forwarded to the Joint Programme Steering Committee, in which all Participants to the Joint Programme are represented. The Steering Committee will decide on admission.

A) Contact details

Institute name	**WARE (Wallonia Alliance for Research in Energy)**
Contact person	Hervé Jeanmart
Postal address	Université catholique de Louvain iMMC, Place du Levant, 2 (L5.04.01) 1348 Louvain-la-Neuve
Country	Belgium
E-mail	herve.jeanmart@uclouvain.be
Telephone	+32 (0)10 47.22.09

B) Organisation

Please mark the appropriate columns in the table below with an X.

Type of organisation	**Yes**	**No**
Is your organisation non-profit?	**X**	
Is your organisation a public body?	**X**	
Is your organisation recognised as a research organisation by the European Commission?		**X**

There are two types of membership to the Joint Programme:

- ***EERA Participants*** *contribute to a Joint Programme with at least 5 person-years per year. Participants have a seat in the Joint Programme Steering Committee of the Programme they have committed this contribution to. Participants have a collective responsibility for the good functioning of the Joint Programme.*
- ***EERA Associate Participants*** *do not meet the threshold of 5 person-years per year. They are associated with a Participant, who represents the Associate's interest in the Joint Programme.*

Would you like to apply as a Participant or Associate Participant?
Participant

Please provide information (e.g. completed projects, publications & presentations, etc.) that substantiates that you are a recognised institute in the field of Bioenergy research.

The WARE (Wallonia Alliance for Research in Energy) is a newly created informal organisation gathering the Belgian French speaking research community active in energy. It has been created for the main purposes of increasing the regional collaborations and for the participation to the EERA at the joint programs level. All universities and major research centres are members of the WARE, thus reaching a sufficient volume of activities in the different fields put forward by the EERA. The initiative has been launched by the Wallonia regional government that provides the logistical support. Representatives of the universities and the research centres manage the activities and the effective participation to the different programs.

The members of the WARE active in bioenergy are

- University of Brussels (ULB);
- University of Louvain (UCL);
- University of Liège (ULG);
- University of Mons (UMons);
- Agricultural Research Centre of Wallonia (CRA-W).
- Institut Scientifique de Service Public (ISSEP);
- Centre des Technologies Agronomiques (CTA);

Together, they cover the different topics of the joint program on bioenergy. The following non-exhaustive lists present the diversity of the nine research teams working on bioenergy. These teams have background in agronomy, biology, chemistry, and engineering. The research topics as well as the related publications are sorted according to the subprograms definition.

Examples of research topics

Subprogram 1: Thermochemical conversion

Development through modelling and experiments of small scale fixed bed biomass gasifiers (two-stage gasifiers) for syngas production or heat and power generation. This activities includes oxy/steam gasification.

Development of physico-chemical models for biomass pyrolysis under low and high temperature conditions, i.e. for conditions prevailing in gasification or in pulverized-fuel boilers.

Application to biomass gasification of the concept of rotating fluidized bed in a static geometry.

Study of the modelling, the design and the optimisation of installations, together with the exergetic and thermodynamic analysis of processes of gasification of biomass and waste, hydrogenopyrolysis, gas valorisation, CO_2 capture.

Development of catalysts for gas phase reactions such as gas cleaning and gas conversion: hydrogenation, dehydrogenation, hydrodechlorination, oxidation, photocatalytic oxidation, …

Downstream process : syngas conversion into pure hydrogen and separated pure carbon dioxide.

Standardization process of some analytical methods such as wood particle size distribution from pellets, pellet mechanical durability, bulk density, density.

Composition of lignocellulosic feedstock, especially the amount of cellulose and hemicelluloses and the monosaccharide composition of the hemicelluloses fraction

Subprogram 2: Sugar platform

Higher alcohol production from ligno-cellulosic substrate via microbiological action. This includes fundamental studies on microorganisms.

Mastering the biogas production rate at the hour-scale by controlling the feed rate of methanogenic reactors in a 2 step anaerobic digestion process and assessment of the ability of the methanogenic step to withstand high loads under transient conditions

Investigation of the activity and efficiency of exogeneous enzymes to hydrolyse complex substrates under non axenic conditions and to improve their bioconversion efficiency to biogas combined with thermal, mechanical and/or chemical pretreatments.

Investigation of the ability of lignolytic fungi and their extracellular enzymes to make lignocellulosic substrates more digestible for further bioconversion to biogas. Mass and energy balance.

Study of the ethanolic fermentation of green herbaceous biomass under the competition of the natural endogenous microbial communities, to valorize the available soluble and hydrolysable carbohydrates into ethanol, before biogas conversion of the residual biomass.

Investigation of the efficiency of thermal, mechanical and/or chemical pretreatments and of exogeneous enzymes to hydrolyse green herbaceous biomass and lignocellulosic biomass and improve the ethanol conversion.

Investigation of the acidogenic fermentation of lignocellulosic biomass to improve the substrate bioconversion to H2 and short chain fatty acid, to be further converted to esters as new biofuels.

Second generation biofuels and bio-refinery concept including studies on the chemistry and technology of osidic structures, on integrated conversion platforms and on ethanol production from cellulosic waste with the use of phosphoric acid.

Subprogram 3: Algae

Study of microalgae production for the capture of CO_2 from industrial processes. The research includes the different steps starting from the microalgae selection, the study of the growth in external environment, flat photobioreactors optimization, the collect of the algae and their physico-chemical characterization.

Study of photo-fermentation to improve the H2 production rates by a better understanding of the microalgae hydrogen metabolism and by genetic engineering.

Improvement of dark-fermentation production rates by monitoring and optimization of bacterial diversity and activity.

Integrated program of research aimed at improving biomass yields and valorisation of biomass for two Chlorophycean photosynthetic microalgae,

Subprogram 4: Cross-cutting topics

Downstream process in relation with microalgae, the removal of VOC from gas streams, and evaluates the environmental impact of processes using life cycle analysis.

Examples of recent publications

Subprogram 1: Thermochemical conversion

Aferka, S., Viva, A., Brunazzi, E., Marchot, P., Crine, M., & Toye, D. (2011). Tomographic measurement of liquid hold up and effective interfacial area distributions in a column packed with high performance structured packings. Chemical Engineering Science, 66, 3413-3422.

Aferka, S., Viva, A., Brunazzi, E., Marchot, P., Crine, M., & Toye, D. (2011). X-ray CT study of the influence of liquid viscosityon fluid phase distribution in modular catalytic packings. Chemical Engineering Transactions, 24, 1429-1434.

Berger B., Bacq A., Jeanmart H., Bourgeois F., Experimental and Numerical Investigation of the Air Ratio on the Tar Content in the Syngas of a Two-Stage Gasifier, In: 18th European Biomass Conference and Exhibition, 5 May, 2010.

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Beuls A., Swalus C., Jacquemin M., Heyen G., Karelovic A., Ruiz P. (2011) Methanation of CO2: Further insight into the mechanism over Rh /Î³-Al2O3 catalyst, Applied Catalysis B: Environmental (In Press, Accepted Manuscript 5 March 2011)

Blondeau J., and Jeanmart H., Biomass pyrolysis in pulverized-fuel boilers: derivation of apparent kinetic parameters for inclusion in CFD codes, Proceedings of the Combustion Institute, Volume 33, Issue 2, 2011, Pages 1787-1794.

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Heinrichs B., Delhez P., Schoebrechts J.-P., Pirard, J.-P., Palladium-silver sol-gel catalysts for selective hydrodechlorination of 1,2-dichloroethane into ethylene - I. Synthesis and characterization, J. of catalysi, Volume: 172 Issue: 2 Pages: 322-335 .

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Jeanmart H., Bourgois F., Bacq A., Kuborn X., Impact of the Pyrolysis Quality on the Tar Concentration in the Syngas of a New Low-tar Gasifier, 16th European Biomass Conference, Valencia, June 2-6, 2008.

Leonard G., Heyen G., Modeling post-combustion CO2 capture with amine solvents. ESCAPE 21 (Chalkidiki-Greece, June 2011)

Rabier F., Temmerman M., Böhm T., Hartmann H., Daugbjerg Jensen P., Rathbaueur J., Carrasco J., Fernandez M., [2006], Particle density determination of pellets and briquettes, Biomass and Bioenergy, Vol 30 (2006) 954-963, Pergamon

Temmerman M. [2010], contribution to The Pellets Handbook – The production and thermal utilisation of biomass pellets, Earthscan, London, Ed Obernberger I and Thek G.

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Subprogram 2: Sugar platform

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Belboom, S., Halleux, H., Léonard, A., Renzoni, R., & Germain, A. (2010, February 01). Life cycle environmental performance of using substitution fuels in cement production. Paper presented at SETAC Europe 16th LCA Case Studies Symposium, Poznan, Poland.

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Jacquet N., Vanderghem C., Blecker C., Paquot M., la steam explosion : application en tant que prétraitement de la matière cellulosique. 2010. Biotechnologie, Agronomie, Société et Environnement, 14 (2), 561-566.

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Subprogram 3: Algae

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Huron, Y., Salmon, T., Blandin, G., Crine, M., & Léonard, A. (2010). Effect of liming on the convective drying of urban residual sludges. Asia-Pacific Journal of Chemical Engineering, 5, 909-914.

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Massart A., Hantson A.-L., Optimization of the medium composition of the microalga “Dunaliella Tertiolecta Butcher” in order to combine high cell density and accumulation of lipids for biodiesel production, 3rd International Symposium on Energy from Biomass and Waste, Venise, Italie, 2010.

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Spinosa, L., Ayol, A., Baudez, J.-C., Canziani, R., Jenicek, P., Léonard, A., Rulkens, W., Xu, G., & van Dijk, L. (2011). Sustainable and Innovative Solutions for Sewage Sludge Management. Water, 3(2), 702-717.

C) Contribution

The activities foreseen in the Joint Programme are summarised in the Description of Work (DoW). You may use this document as background information for answering the questions below. Note that it is not (at all) required that you contribute to all subprogrammes.

What activities are you planning to contribute to subprogramme 1: Thermochemical Conversion?
How does this add value to the Programme?

The research activities of the WARE match three topics of the subprogram: biofuels and hydrocarbons production via gasification, gas production via gasification and high efficiency power generation. They cover mainly the WP2 (conversion processes). Indeed, the WARE has an expertise in the following research fields:

- Biomass pyrolysis modelling (1D and 2D) using complex physical and kinetic models;
- Hydrogenopyrolysis;
- CFD (Fluent® or OpenFOAM® based) of tar cracking in the oxidation zone on two-stage gasifier with the appropriate cracking and oxidation kinetics;
- Experimental studies and modelling on biomass and waste gasification;
- Syngas cleaning by adsorption of VOC, CO_2 capture, hydrogenation, dehydrogenation, hydrodechlorination, oxidation, photocatalytic oxidation, …
- Study of the hydrodynamics in packed columns (wood particles bed).

The research teams of the WARE can contribute to the Task 2.1 (fuels, handling and feeding) on the influence of the blending of different biomass through its long experience in waste/biomass gasification and other uncommon feedstock gasification (straw, sludge, etc.). The teams are working both at the particle level and at pilot scale with an experimental gasifier of 200kWth.

The WARE can also be involved in Task 2.2 (gasification technologies) where its deep knowledge of hydrodynamics of packed bed as well as its numerical tools could be use to further improve the understanding of gasification physics and kinetics.

Even if no specific work is defined for the Task 2.2.4. (process control), the WARE has some expertise in this field that could help define the specific activities and contribute to them.

All the research based on the modelling and simulation of pyrolysis and gasification could clearly contribute to progress in Task 2.3. (gasification reactor and process modelling) with an emphasis on Task 2.3.2. (reactor modelling). This could certainly become a major contribution of the WARE to the subprogram.

Through its activities in gas cleaning, the WARE could contribute to Task 2.4. (syngas cleaning and conditioning).

Finally, the WARE could punctually contribute to the activities in WP3 (downstream process). Indeed, a research team is working on the development of catalyst for gas conversion/synthesis. It could share their experience in Task 3.1. (catalyst development and testing).

Altogether, the WARE has a recognised expertise in a selection of tasks identified as essential in the joint program. Its contribution could certainly help reaching the objectives and increasing the quality of the reports and papers foreseen in the milestones.

What activities are you planning to contribute to subprogramme 2: Sugar Platform? How does this add value to the Programme?

This topic is certainly the strongest point of the WARE even if the research activities are not necessarily oriented towards the biofuels production. The WARE can contribute to the subprogram in the three work packages defined.

The research activities that match the scope of WP1 (biomass deconstruction) are

- biomass pretreatment by chemical, mechanical methods, or using steam, microwaves, etc. in order to facilitate the conversion of cellulose and hemi-cellulose to sugars;
- enzymatic hydrolysis: investigation of the activity and efficiency of exogeneous enzymes to hydrolyse complex substrates under non axenic conditions; enzymatic hydrolysis combined with thermal, mechanical and/or chemical pretreatments;
- biomass deconstruction monitoring: characterisation of substrate bio-availability and biodigestibility with biological methods (soluble and gaseous metabolites conversion kinetics).
- biomass analysis: mono and oligosaccharide analysis, soluble and gaseous metabolite analysis.

The teams can contribute to the Task 1.1. (feedstock and pre-treatment product analysis) on the share of analysis methods. They could also participate to the Round-Robin (Task 1.1.2). Thanks to their experimental facilities. They have also some expertise in online monitoring and could share it in the frame of Task 1.1.4. (on-line monitoring).

The WARE can also participate to all the tasks defined in Task 1.3. (novel pre-treatment) and Task 1.4. (pre-treatment and hydrolysis integration). Using its experimental facilities, it could, for example, increase the scope of the comparison defined in Task 1.3.2. The WARE could contribute to Task 1.4. by bringing to the joint program activities its specific treatment methods.

The research activities of the WARE that match the WP2 (cell factories and enzymes) definition are

- ethanol conversion of green herbaceous and residual biomass, integrated with biogas production from the fermentation residues;
- H_2/acidogenic fermentation as a source of new liquid biofuels;
- anaerobic digestion processes, improvement of the biodigestibility of "resisting" substrates.

While the research activities are not necessarily oriented towards the production of molecules for a specific application, the processes could be oriented towards such a production. The WARE

could thus contribute to Tasks 2.1. (novel biofuel pathways for jet and diesel engines) based, for example, on its experience of short chain di/tri-esters production like tributirine.

Finally the WARE has some activities related to WP3 (pilot scale & modelling for nextgen biofuels),

- modelling of mass and energy balances of integrated crop-ethanol-biogas processes;
- scale up of pretreatment and modelisation (steam explosion) / opportunity to access the pilot plants by the other partners;
- design, modelling and optimisation of processes, including exergetic analysis;
- study of environmental impact of processes using LCA.

They are mainly global modelling activities that could also be, at least partly, considered as related to subprogram 4. However, these topics also match the contents of Task 3.1.1 (process conditions in pilot infrasctructures) and of Tasks 3.2.1. (database of pilot trials) and 3.3.1 (benchmarking in process control and modelling).

The accumulated knowledge of the WARE researchers could certainly increase the quality of the different deliverables defined in the description of the work. Also, the existing experimental facilities could complete those of the already involved research centres.

What activities are you planning to contribute to subprogramme 3: Algae?
How does this add value to the Programme?

The teams of the WARE are only working on microalgae. They can thus only contribute to the WP2 (microalgal biomass production) defined in the joint program. Inside this WP2, the activities of the WARE are

- flat photo-bioreactor technologies for CO_2 capture;
- microalgae collect and physic-chemical characterisation;
- genetic engineering of microalgae to improve their lipid/H2 production;
- genetic engineering of microalgae to improve their high valued molecules production;
- downstream process (settling, conditioning, filtration, drying).

The WARE teams can certainly contribute to Task 2.1. (biology) on genetic engineering on microalgae. Some researchers are also active in higher lipid productivity corresponding to Task 2.1.2. (increasing lipid productivity in *Nannochloropsis*).

The activities on photo-bioreactors as well as those on downstream process could be included in Task 2.2.2. (growth, harvesting and refining systems).

Most research activities on microalgae are already carried out inside a European frame. Joining the EERA is thus a natural step towards a better integration of the activities at the European level. Moreover, the limited but original contribution of the WARE would increase the quality of the deliverables.

What activities are you planning to contribute to subprogramme 4: Cross-cutting topics?
How does this add value to the Programme?

Please indicate in the table below how many resources you would be willing to commit to each of the subprogrammes. Note that it is not (at all) required that you contribute to all subprogrammes.

	Person-months per year
SP1: Thermochemical conversion	**24**
SP2: Sugar Platform	**36**
SP3: Algae	**12**
SP4: Cross-cutting topics	**0**

What research infrastructures would you like to bring in as part of your contribution to the Programme?

The following non-exhaustive list illustrates the diversity of the experimental facilities available within the WARE. Most of them are available to contribute to the joint program activities.

- Two-stage 200kWth fully automated pilot biomass gasifier equipped with a wet gas cleaning and and IC engine for cogeneration + analysis tools (UCL).
- Thermostatic hot rooms to host fermentation infrastructure with safety devices for toxic and inflammable gas produced by biomass fermentation (UCL).
- 1-2.5m^3 anaerobic digester (UCL).
- High sensitivity instrument to monitor at short time intervals the gaseous metabolites production kinetics in parallel bioreactors (UCL).
- Steam explosion facility (ULG).
- RMN 600MHz (liquid phase, multi nodal probe) and other structural analysis tools (ULG).
- Microwave reactors (24x100ml) (ULG).
- Photobioreactors prototypes (15 liters (flat airlift) and 70 liters) (UMons).
- Certified lab for biomass analysis (CRA-W).
- Techniques of visualization of the flows by X-ray tomography, electric tomography or by tracing technologies likely to be applied to the study of the hydrodynamic of a large variety of unit operations (ULG)
- Trickling filter, Biomethanation units for liquid and semi-liquid wastes (from 10 L to 0.25 m^3) (ULG)
- Pilot units for activated sludge process (up to 2 m^3) (ULG)
- Bubble column equipped with Electrical Resistive Tomograph (ERT) (ULG)
- Packed column equipped with X-ray Tomograph (ULG)
- Absorption column equipped with Electrical Capacitive Tomograph (ECT) (ULG)
- Perforated plate columns, Pilot scale convective dryer (ULG)
- Normalised filtration-expression cell (AFNOR T 97-001), Pressure Swing Adsorption (1-5 bar) (ULG)
- Characterization of porous materials: mercury porosimetry, gas adsorption, helium and mercury pycnometry, TGA, TG-DSC (ULG)
- A macro-pilot unit : Fixed-bed reactor of net volume = 35 Litres which can work as a semi-batch pressurized gasifier, up to 50 bars and 1100°C. (ISSEP)
- An integrated industrial co-gasification plant which a feeding rate of 200 kg/h of raw material. (ISSEP)

D) Additional Information (optional)

Please provide any other information you deem relevant for your application, if any.
The contribution to the joint program in terms of person-months is difficult to define precisely at this stage especially for universities due to the lack of a clear accounting method. The values given above are only a tentative answer that shall be refined in collaboration with EERA.