FINAL REPORT

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ABSTRACT

The REFERTIL project is an integrated applied science and industrial engineering project together for generating advanced and innovative S&T knowledge results and foregrounds, most importantly in the field of biochar and Phosphorus recovery circular bio-economical industrialization. The REFERTIL converting science into legalized industrial practice for market competitive applications for the interest and benefits of the horticultural SME farmers in the low input and organic farming, fresh fruit and vegetable Producer Organizations and gardeners sectors. The results and foregrounds of this project providing significant improvements for resource efficient recycling of agricultural and food industrial by-products by biochar specific pyrolysis technology (REFERTIL biochar "3R") and compost treatments while the use of biochar products opening new technical, economical and environmental opportunities for SME's and other wide range of stakeholders. The knowledge and capital intensive REFERTIL biochar is a leading key enabling green technology.

The objective driven, measurable and verifiable REFERTIL results that reached during the project life time 2011-2015, including development of completed and qualified biochar specific zero emission pyrolysis technology in industrial scale; production and field reference testing of 34 tons of economically interesting four different types of biochar; processing of 600 tons different types of high quality compost; biochar and compost growth field test of economically important food crops in 6 counties including vegetables (tomato, green pepper, strawberry, lettuce, cauliflower) and field crops (wheat – corn); - and most importantly development completed for comprehensive and detailed European biochar standardization, law harmonization and policy support for EC2003/2003 Fertilizer Regulation revision. Biochar EU/MS regulation based and mandatory Authority permit models accredited and validated for permitted production and application of biochar. Biochar specific laboratory EU accreditation approval certified. Biochar chemically modified substance REACH registration and Extended Producer Responsibility certificates prepared.

The REFERTIL actions are addressing food security, sustainable agriculture, climate action, environment, resource efficiency and raw materials, while proactive cooperation has been enhanced between stakeholders along with the full supply chain with cut across many industrial, agricultural and environmental sectors. The extensive biochar and compost dissemination and exploitation measures help to achieve the expected impacts of the project and address the full range of potential users and uses. New biochar application methods and good practice guide set up to support the customized and standardized biochar product symbiosis, marketing and distribution network activities.

The most important REFERTIL result and impact is that the project removed all major barriers (scientific, technical, technological, economical process scale up, environmental, safety and legal) for EU/MS regulation relevant and legalized production, economical and ecological application of the industrial biochar and recovered Phosphorus in a safe and environmentally/climate sustainable way. Based on the REFERTIL results and foregrounds, removing of biochar market barriers is targeted at post project exploitation level, whereas an 20,800 t/y throughput medium capacity and high P_2O_5 concentrated output product recovered Phosphorus (ABC Animal Bone bioChar) plant industrial replication model and best available technology reference is built and operated; according to the united and coherently integrated EU, US and Australian industrial and environmental norms and

standards to prepare global exploitation of the project. This is a prepared biochar road map from lab to industry and to market, where the REFERTIL post project time implemented industrial replication model is the “biochar research mission completed” endpoint. www.refertil.info

SUMMARY DESCRIPTION OF THE PROJECT CONTEXT AND THE MAIN OBJECTIVES.

The targeted and objective driven goal of the REFERTIL project is to improve the currently used compost and biochar treatment technologies and products for the interest and benefits of the SME farmers and resource efficient circular bio-economy in European and global dimension. In this context advanced, efficient, comprehensive and market competitive bio-waste treatment and nutrient recovery process with zero emission performance targeted. The improved output products are safe, economical, ecological and standardized compost and bio-char combined natural fertilizers and soil amendment agricultural products used by farmers. The added value and energy efficient transformation of agricultural and food industrial by-product streams made by improved pyrolysis (carbonization), biotechnological formulation and upgraded composting technologies, with particular attention to the recovery of nutrients, such as Phosphorous and Nitrogen.

The targeted high quality and safe output products aiming to reduce mineral fertilizers and intensive chemicals use in agriculture; enhancing the environmental, ecological and economical sustainability of food crop production; reducing the negative footprints and overall contributing to climate change mitigation. Low input and organic farming applications targeted, primarily in the horticultural sector. In this context the improved REFERTIL bio-waste treatment process opens new technical, economical, environmental and social improvement opportunities, while improving the use, effectiveness and safety of the resulting compost and bio-char products in agriculture. The output biochar and compost technologies and products developed in a standardized way to meet all new industrial, agricultural and environmental norms and standars beyond 2015 in European dimension.

Proactive and coherently integrated cooperation targeted between multi level stakeholder in Europe, with result oriented potential benefit to SMEs and farmers for more efficient and added value utilization of the final products by the end-users. The REFERTIL provided strong support for policy makers for the revision of relevant policies, most importantly the EC 2003/2003 Fertilizer Regulation revision biochar case. Comprehensive and detailed biochar standardization and law harmonization proposal developed for consideration by the EU Commission and MS policy makers; including science, industrial technology, economical, market competition, social, environmental and climate protection aspects with equal importance. Member State Authority biochar permit cases developed under EU regulations, for true value demonstration of the EU biochar permits; related to biochar industrial production, applications, REACH and Extended Producer Responsibility certificates above 1 t/y capacity. The REFERTIL targeting coherently integrate all mandatory EU and MS industrial and environmental regulations, REACH and biochar producer/user requirements. As a result REFERTIL biochar quality/safety standardization and law harmonization set up for year 2020 future common biochar and bio-waste recycling targets, common quality biochar standard requirements, quality and trading requirements.

The four years REFERTIL project works split up into 11 work packages, such as:

WP1: Input biowaste identification and quantification to identify and quantify main organic waste and agriculture organic residue streams. Based on the detailed analytical assessment of input organic waste streams and identification, input material criterion system set up. EU wide bio-waste characterization and positive/negative list selection criteria set up, including EU “End of Waste” and CE Ecolabel. Input material characterization and selection,

investigation of biochar/compost technology performances made which effecting the quality and safety of the resulting products.

WP2: Currently available biochar technologies and products assessed in Europe for biochar production, including environmental and health aspects. In this context detailed technology and biochar product matrix database set up, with ranking of the available biochar production technologies. Comprehensive evaluation aspects considered for the biochar producing technologies, such as environmental, technical, legislative, cost efficiently, benefit and risk (as regards mineral e.g. heavy metals and organic contaminants, PAH, PCB, dioxins, detailed SWOT analysis, aso. At the same time benefit and risk evaluation made for the different biochar products. As a results comprehensive and detailed biochar policy support and law harmonization report developed to inform the Commission for further considerations, most importantly EC2003/2003 Fertilizer Regulation revision biochar and compost cases. The objective is to establishment of common compost and biochar quality standards and trading requirements. Proactive communication and advisory with EU policymakers and national permit Authorities set up for commercial/industrial permitting of biochar/compost production and products, applications in open ecological environment and qty/risk evaluations used by the Authority accredited / independent labs. Clear technical, environmental and safety definition made for common quality standards for biochar and compost production and quality, such as for potential toxic elements, organic pollutants, PCBs, dioxins.

7 biochar processing technology evaluations made for technical, economical, environmental and output product quality efficiency point of view. Objective driven criteria system set up. The benefits and weak points of the currently available bio-waste treatment technologies identified. Technical and economical improvements worked out, and tested. Output product quality analysis made. The objective for identification of benefits, risks and development of biochar technology specific improvements made for high efficiency biochar processing from both plant and food grade animal bone meal based biochars. Biochar product quality is most importantly depending on the processing technology quality performance that is critically effecting the quality and safety of the resulting products as regards plant, environmental and human health aspects. Risk assessment carried out, in order to relate the presence of contaminants in biochar and its potential to increase bioavailability and toxicity of soil contaminants. Based on the risk assessment results, establishment of biochar quality standards and determination of safe application dose made, taking into consideration the biomass feedstock, pyrolysis conditions, as well as soil and environmental conditions.

WP3: Compost technologies and products assessed in Europe for compost production, including environmental and health aspects. In this context detailed technology and compost product matrix database set up, with ranking of the available compost production technologies. Comprehensive evaluation aspects considered for the compost producing technologies, such as environmental, technical, legislative, cost efficiently, benefit and risk. At the same time benefit

and risk evaluation made for the different compost products. As a result comprehensive and detailed compost policy support and law harmonization report developed to inform the Commission. 15 compost treatment technology evaluations made for technical, economical, environmental and output product quality efficiency point of view and objective driven criteria system set up with output product quality analysis. Identification of benefits and risks in particular linked to the potential presence of potential toxic elements and organic contaminants. Development of technology specific improvements made, including the effect

of compost and biochar blend compost qty improvement effects and on the control of plant pathogens, which effecting the quality and safety of the resulting products as regards plant, environmental and human health aspects. Constructive solutions provided for improvements at SME specific compost operations. Output product properties analysed and their potential and actual benefits and risks detailed evaluated.

WP4: Microbiological improvement of compost made. The selection of bacterial inoculants and development of inoculation technology made for improving the soil-health and disease suppression potential of the compost. The development of fungal inoculum technology aimed for compost activator and compost nutrient enrichment application, while the combined inoculum technology for compost-mycorrhiza product for arbuscular and ericoid mycorrhizal fungi.

WP5: The works on the pyrolysis technology improvement based on biochar quality engineering and improvement of different application specific biochars for pyrolysis condition improvements and 'end-of-waste' biochar production. Pyrolysis feed materials characterized, material treatability and biochar tests made in laboratory and continuous pilot scale with different raw materials. Evaluation of effects made for biochar application to soils on wide range of soil functions.

WP6: Composting technology improvement for 'end-of-waste' compost production made, also evaluating and describing the limitations of composting technologies and systems and possible areas of improvement. Good operational practices and technological improvements identified. Compost leach water/gas emission adsorption tested.

WP7: All in order to “BAT" technology demonstration for **improved and sustainable compost and biochar production** over 30 tons of different types of biochars and 600 tons of different types of compost produced for SME application field tests. Prior biochar test material production from the four prime selected biochars the REFERTIL biochar processing “3R” technology system extensively tested and improved in Hungary, and “product like” high technology readiness level to be completed and qualified.

WP8: The validation field trials for the improved technologies and products against end-of-waste criterion made both in pilot scale in Italy, Slovenia and Ireland and in larger production scale in Hungary. For large scale dose and production performance testing two different geographical areas with different conditions selected in Hungary, such as the official Authority tests require. Dose and yield tests made with the four prime selected biochars with potential economical interest, such as food grade pig/cattle bone based ABC Animal Bone bioChar (also with combination of compost, and microbiological formulation), and wood/refuse grain based plant biochars. For horticultural tests tomato, green pepper and for comparative control lettuce and cauliflower selected, while for field crops corn and wheat. Biochar and compost quality assessment, performance of field crop trials targeted under different soil and climatic condition; additionally evaluation of the environmental and economical viability of the improved technologies and products; environmental, technical, legislative, cost efficiently, benefits, risks and SWOT analysis.

WP9: Recommendation and standardisation of the improved recycling and reuse technologies and products made with setting up an input material positive list in correlation with the end-of-waste criterion and regime. Furthermore, setting up a proposal frame for common quality standard requirements, new application methods and good practice guide for the pyrolysis/compost technologies/products developed. In this context the true value modelling and demonstration of the biochar actual legal status from mandatory EU and MS

legislation point of view are critically important work elements. Therefore, extensive and official Authority consultations made and biochar mandatory Authority permit models developed and validated according to the EU/MS regulations, such as for biochar industrial production (above the 1 ton/year capacity), biochar applications in agriculture, preparation of REACH registration for this chemically modified substance and Extended Producer Responsibility certificate schemes. Biochar specific accredited laboratory investigation methods developed and official accredited biochar laboratory status targeted by REFERTIL laboratory investigation partner. In this context scientific, technical, economical, environmental, legal and market based public acceptance models coherently integrated together for legal and safe biochar market competitive industrial production and safe applications for the interest and benefits of the SME farmer end-users for production of improved yielded safe food for less cost. The REFERTIL biochar model to provide important element for the resource efficient European circular bio-economical and food safety improvement and development scheme.

WP10: Dissemination, end user promotion and development of exploitation strategies of the achieved results made. In this context EU wide dissemination and networking made with targeted SME's and farmers. Electronic media, written and person-to-person dissemination made with evaluation of the Consumer acceptance. Feasibility study and business plan made to define biochar economics under market competitive conditions, for which minimum economical throughput capacity 6500 ton/year demonstrated and the economically optimized medium scale 20,800 ton/year throughput production scenario is financially investigated.

WP11: Project scientific management and assessment of the project with the objective to fulfil all project goals made, including financial and administrative management, reporting for the Commission and monitoring the timely delivery of deliverables and milestones.

The targeted REFERTIL measurable and verifiable overall project results are:

(A) All EU available and economically important bio-waste feed materials characterized.

(B) Technical-economical-environmental evaluation of 7 biochar and 15 compost treatment technologies and products.

(C) REFERTIL biochar specific pyrolysis technology "product like" completed and qualified.

(D) 2000 tons input bio-waste treated from which 600 tons different types of high quality compost produced for field reference testing.

(E) Over 30 tons of different types of biochar produced for field reference testing.

(F) 3 economically important food crop growth field tests made from year 2 in 6 counties.

(G) Comprehensive and detailed biochar standardization, law harmonization and policy/regulatory support to be worked out with interconnection to the EC2003/2003 Fertilizer Regulation revision.

(H) Biochar EU/MS regulation based and mandatory Authority permit models to be worked out and demonstrated for biochar industrial production and applications; REACH certification prepared.

(I) Two yearly conferences held, web page operated in English and info in 10 languages, over 2000 SME organizations contacted, extensive dissemination made, exploitation of market competitive biochar results prepared, SME specific Business Plan worked out.

THE MAIN S & T RESULTS AND FOREGROUNDS.

The REFERTIL project is an applied research and industrial engineering technical development project together, that has been successfully improving the currently used compost and biochar treatment technologies and products, with particular attention to the recovery of nutrients, such as Phosphorous and Nitrogen. This resource efficiency improvement activity made for the interest and benefits of the SME farmers. Biochar is a new product and the biochar specific technology with biochar specific products needs to be newly developed; therefore the REFERTIL is significantly focused on biochar. Biochar is interconnection between life in the soil with complex functional interactions of soil's living (biotic) and non-living (abiotic) components, clean water and above ground economical agricultural productivity in a linked, coherently integrated, symbiotic and harmonized ecological system. Compost is a traditional product with many well known production opportunities, which still need improvements, most importantly for the product quality and safety.

In this context the REFERTIL project converted science into the following objective driven, measurable and verifiable S&T results that reached during the project life time 2011-2015:

(1) All EU available and economically important bio-waste feed materials characterized for the specific production of compost and biochar.

(2) Comprehensive technical-economical-environmental evaluation made for 7 biochar and 15 compost treatment technologies and products.

(3) The REFERTIL biochar specific pyrolysis technology is a result and impact oriented TRL8 Technology Readiness Level maturity demonstration and model reference according to the Commission Decision C(2013)8631 new rules to addresses the entire innovation chain for identification and definition of research status progress level. By reaching TRL8 the REFERTIL reached the end of true "biochar system development" for all major biochar technology and end-product elements. In this context the preparation is completed for post project TRL9 deployment, competitive manufacturing, industrial replication model and achievement of BAT/BREF qualification according to 2012/119/EU. This is a prepared biochar road map from lab to industry and to market, where the REFERTIL post project time implemented TRL9 is the "research mission completed" endpoint. TRL9 is the only and ultimate credible demonstration for users and market players that provides clear and transparent evidence for the past years research results and foregrounds achieved, related to REFERTIL biochar technological, economical and market viability under market competitive commercial conditions.

Over 34 tons of different types of biochar produced for field reference testing, including four different economically and technically important prime selected biochar, such as pig/cattle bone based ABC Animal Bone bioChar and wood/refuse grain plant based biochar. ABC has been formulated in different ways and also adapted with Trichoderma fungus in a solid state fermentation and formulation process at Terra Humana Ltd. All in order to supply different types and sufficient amount of biochar materials to different horticultural and field crop performance and dose trials under different soil and climatic conditions, four types of biochar in 34 tons amount has been produced for field tests, additionally to extensive productions for the pyrolysis technology and variable process condition improvements. The feed materials

tested are both variable, multi-constituent substances and mono-constituent substance as well. In this context pyrolysis technology and condition improvements made towards zero emission process conditions and emerging at industrial scale, economical and comprehensive recycling of all pyrolysis products and improvement of output biochar quality for eco-safe open ecological soil applications. Terra Humana Ltd. have been delivered high number of biochar samples to Wessling Laboratories during the project life time, such as 53 ABC Animal Bone bioChar samples, 23 plant based biochar samples and 2 manure biochars. Terra Humana Ltd. implemented the action and generated advanced and biochar specific production technology that can produce safe biochar, providing industrially validated engineering know-how, in aggregate intellectual property „IP", that is one of the most important key result of the REFERTIL applied research project. The achieved IP is the core element of the REFERTIL dissemination and post project commercial exploitation programme to demonstrate the conversion of biochar science into legalized industrial practice.

(4) 2000 tons input bio-waste treated from which 600 tons different types of high quality compost produced for field reference testing.

(5) Six economically important vegetable food crops and two field crops growth field tests made and evaluated from year 2 in 6 counties, including vegetables tomato, green pepper, strawberry, lettuce, cauliflower, and field crops wheat, corn. Performance of compost integrated biochar field crop trials made under different soil and climatic condition. Laboratory, greenhouse and field demonstration trials have been carried out in order to technically demonstrate and validate the effectiveness of compost and biochar in controlling plant pathogens, and assessing their quality and suppressiveness efficacy. Studying and developing new application methods for the use of compost and biochar to control plant pathogens were made. The performance of compost and biochar has been evaluated in field crop trials under different soil and climatic condition in the following European countries: Italy, Hungary, Slovenia, Germany, The Netherlands and Ireland.

In Italy, greenhouse and field trials have been organized by Universita degli Studi di Torino - Agroinnova for 2 years and in particular on greenhouse crops in Grugliasco (TO), on tomato and pepper at Boves (CN), on pepper and lettuce at Moretta (CN) and on leafy vegetables at Moncalieri (TO). Six composts and 2 biochars were selected to be used in the tests, and evaluation have been done on the effects for crop productivity, enhanced soil health, improved nutrients availability to plants and potential soil pathogens/diseases suppression. Universita degli Studi di Torino collaborated in the evaluation of different biochar technologies available in Italy and carried out analysis and tests on the biochars available and samples in Europe by Refertil for their use as organic fertilizers, soil improvers and growing media. Animal bone char showed a good fertilization effects on crops, while plant based biochar showed some neutral effects on crops and a limited suppressiveness to plant pathogens. Universita degli Studi di Torino provided several contributions for the biochar policy support, and in particular on the use of biochar in agriculture, including attendance together with the project coordinator to meetings in Bruxelles at DG Enterprise and Environment. Evaluation of different composting technologies available in Italy carried out including analysis and tests on the composts available and samples in Europe by Refertil for their use as organic fertilizers, soil improvers and growing media. Universita degli Studi di Torino specifically implemented the activities related to the microbiological test programme for compost safety evaluation and the technical evaluation of the selected composts, with agronomical tests. Twelve composts were used in preliminary trials to test their efficacy.

Among them, 5 were selected showing a clear fertilization and plant growth promotion effect on different crops, providing results similar to chemical fertilizers. In the best cases, some of them also showed a disease suppressiveness activity. Green waste compost generally had better results than municipal waste compost, lower E.C. and phytotoxicity effects, but in some cases not enough nutrients for crops. Regarding microbial safety and the presence of human pathogens, Listeria and Salmonellae are not a problem for compost, while E. coli are frequently presents. Further studies are necessary to better understand if compost may support or not the infestation and colonization of vegetable crops like leafy vegetables (lettuce, spinach...) by those human pathogens. Evaluating and describing the limitations of composting technologies and systems made, with particular attention to compost product improvement, and it has been developed an environmental, technical, legislative, cost efficiency, benefit and risk evaluation and detailed SWOT analysis of selected composting technologies. Different tests and analysis have been carried out, in particular potting trials on vegetable crops and plant disease suppressiveness trials comparing 6 improved compost with 3 basic compost, showing that improved composts can be used at lower dosages due to the higher amount of nutrients. Universita degli Studi di Torino lead and coordinated the overall activities, aiming to carry out field trials for validation of the improved technologies and products against end-of-waste criterion.

The performance of compost and biochar has been evaluated in field crop trials under different soil and climatic condition. Greenhouse and field trials have been organized for 2 years in Italy and in particular on greenhouse crops in Grugliasco (TO), on tomato and pepper at Boves (CN), on pepper and lettuce at Moretta (CN) and on leafy vegetables at Moncalieri (TO). Six composts and 2 biochars were selected to be used in the tests, and evaluation have been done on the effects for crop productivity, enhanced soil health, improved nutrients availability to plants and potential soil pathogens/diseases suppression. Different climatic, crop and soil types investigated when compared to possible investigation of biochar application to soils on a national or European scale. Potting trials in greenhouse have been carried out on vegetable crops to evaluate the use of compost and biochar as soil improvers, organic fertilizers or growing media. Suppressiveness trials in greenhouse have been carried out to evaluate the capacity of compost and biochar to reduce plant diseases and field trials on tomato, pepper and lettuce, to validate the use of compost and biochar in farms located in Italy. Composts deriving from animal manure and municipal biowaste reduced seeds germination and plant growth when used as growing media, and consequently they are not recommended to be applied at dosages higher than 15-20% v/v. Animal bone char showed a good fertilization effect on crops, while plant based biochar had few effects on the yields and results were variable according to soil type. The application of compost with biochar had also good effects on crop development, however it was not possible to identify a common outcome. Field trials have also been organized and discussed with other partners, supporting them in the design, data collection and reporting of the trials. Universita degli Studi di Torino collaborated in particular providing information related to biochar and compost uses and evaluations according the results about the field trials, also worked on the setting up of new application methods and good practice guide for biochar and compost products.

In Hungary four, economically interesting, different types of biochars has been used for the purpose of different horticultural (tomato, green pepper, lettuce, cauliflower) and field crop (corn, wheat) performance trials and dose evaluation in 2014-2015 under different soil and climatic conditions. The primarily selected biochar types in industrial scale are the pig bone

biochar and cattle bone biochar organic Phosphorus fertilizer with doses up to 1 t/ha and secondly plant based wood and refuse grain biochar with doses up to 20 t/ha. The yield and performance results and short term added value effects for the ABC Animal Bone bioChar have been clearly interesting and viable for the interest and benefits of the SME farmer users under market competitive conditions. True value SME user interest could be defined for the ABC. Further ABC formulations are additionally opening highly progressive markets, uses, users and environmental opportunities for the product, with special targets towards fresh fruit and vegetable Producer Organizations, under EC2200/1996.

In the plant based biochar cases (both in wood and refuse grain biochar cases), the food crop yields, quantitative performance results and short term added economical value benefits have been unclear during the monitored growing season in 2014 and 2015, therefore true value SME user interest could not be defined for the plant based biochar case, at least not for short and medium termed application targets. None of the tested high quality biochar shows any negative effects and/or risk for the plant and/or the environment, the ecology and/or human health.

In Germany, risks and advantages of a biochar-compost application for mycorrhizal formation and functioning evaluated the feasibility of combined biochar-compost-mycorrhiza inoculation technology in different economical important crops, and demonstrated nutrient transfer from the amended substrates to the roots in terms of plant growth promotion.

In The Netherlands, disease suppressiveness of biochar and compost tested in greenhouse pot trials with tomato seedlings. Disesease suppressiveness will be tested against Pythium sp. The main objective of this research task by DLO was to evaluate the potential to enhance disease suppression of potting soil substrate against soil borne pathogens by amendments of biochar and compost.

In Slovenia two years field test performed in Slovenian environment with strawberries in open field, with planting in year 2013 and picking up in 2014 and 2015.

In Ireland crop trials carried out for barley and grass. Conventional fertilizer and agri-residues biochar was used. Soil information was collected and weather analysis was performed. Plant growth and conditions were tracked. The products involved are: plant biochar, 2 standard composts, 2 improved composts and mix of compost with biochar. Biochar and compost doses are with the specification described below (10 treatments, 4 replicates). Field trials and pot trials for spring barley and grass were carried out. No significant yield advantage was observed between the two rates of plant based biochar (1t and 5t/ha) either in combination with nitrogen or when used alone.

In Denmark 3 trials made with application of increasing amounts of C (0-20 t/ha) in biochar from wood waste during 3 years. No significant yield effects are obtained any year after application – a small decrease in year 1, also no effect to nutrient concentrations and visual effect to plant diseases in samples of leafs in spring observed. A significant reduction of mineral N observed in soil in spring time with increasing application of biochar – all 3 years after. This might indicate a potential to reduce the risk of nitrate leaching. One trial with application of biochar from straw showed a small non-significant decrease in yield the first year after application.

(6) Comprehensive and detailed European biochar standardization, law harmonization and policy support worked out for EC2003/2003 Fertilizer Regulation revision and reported to the Commission for further consideration. Biochar product is a chemically modified substance used as soil improver, organic fertilizer and growing media, and as such it is the object of mandatory EU/MS permit regulations for manufacturing, application, import and placing on the market above >1 t/y capacity. As biochar is new product and most international biochar activities have been so far on low >TRL6 basic research level, therefore the REFERTIL biochar S&T results and EU high standard foregrounds at <TRL8 are important corner stones and truly demonstrated models for the fully legalized, market competitive, safe and consumer accepted biochar case. Europe is having one of the most advanced (if globally not the most advanced) and strict industrial and environmental norms with clear orientation towards resource high efficient circular economy. The REFERTIL biochar advanced results and foregrounds are high standard European specific with consideration of the global integrated US and Australian industrial norms and standards as well. In this context comprehensive, detailed and Europe specific biochar technical standardization, best practice and law harmonization frames worked out by the REFERTIL that meet the industrial and environmental norms and high standards of Europe beyond 2020 under market competitive and economically efficient commercial conditions. The REFERTIL biochar results and foregrounds based on applied science with objective driven orientation to convert science into industrial practice, containing comprehensive aspects for biochar sustainable feed material selection; advanced pyrolysis technology and manufacturing towards zero emission processing in industrial scale; product quality and safety, accredited measurements and testing; Authority permitting; legal frames; applications and use; and good practice guide for biochar all stakeholders. Maximum allowable limits have also been scientifically justified and confirmed for the EC2003/2003 Fertilizer Regulation revision considerations, where the REFERTIL biochar targeted and primary organic pollutant have overall EU standard maximum allowable limit 6 mg/kg PAH16 has been defined with MS option to define more strict limits (in some MS already 1 mg/kg PAH19 applied since 2006 for soil improvers). Potential toxic element critical content have also been defined, with special attention for Cadmium, that is accumulating in plant with no phytotoxicity symptoms thus in practice easier transfer to food chain towards consumers.

(7) Biochar EU/MS regulation based and mandatory Authority permit validated models worked out. True value Member State Authority permit models worked out, validated and documented for biochar production and applications, while REACH registration and Extended Producer Responsibility certificates prepared.

(8) Extensive dissemination made and post project exploitation of the results prepared. Two yearly conferences held, web page operated in English and info in 10 languages, several thousand SME organizations contacted, exploitation of market competitive biochar results prepared, SME specific Business Plan worked out.

In this context the most important REFERTIL result is that the project removed all major (scientific, technical, technological, economical process scale up, environmental, safety and legal) barriers for legalized production, economical and ecological application of the industrial biochar in a safe and environmentally/climate sustainable way, while the removing of market barriers are targeted post project at TRL9 exploitation level.

Based on the REFERTIL project results, the following foregrounds developed and completed, ready for post project exploitation of the results:

(A) Engineered and engineering designed zero emission performance "3R" Recycle-Reuse-Reduce biochar specific industrial pyrolysis technology (Generating beneficiary and owner: Terra Humana Ltd. (Edward Someus, biochar S&T senior engineer). IPR content: invention, specific design of biochar technology, industrial process software, specific know how, website. IPR status: confidential). The exploitable products: specifically and comprehensively designed and proven demonstrated advanced zero emission pyrolysis technology for biochar and carbon added value refinery, recycling and valorisation of agricultural, food processing and industrial by-products and waste streams, including refinery of browncoal. Sectors of applications:

a) added value recycling and recovery of resources from low moisture content by-product and waste streams;
b) recycling and waste management industry;
c) adsorbent and activated carbon;
d) high concentrated recovered Phosphorus for horticultural and adsorbent applications; (d) biochar (all types);
e) thermal and electric bio energy production;
f) Clean Coal processing (conversion of browncoal into refined carbon) and
g) recovery of organic chemicals from refined pyrolysis oil.

The foreground exploitation starts from 2016 by Terra Humana Ltd, who is the original source for the 3R invention, science and technology, comprehensive industrial engineering design, RTD -demonstration-industrialization developments; and the sole owner of the IPRs. The potential impact is the global industrialization of the REFERTIL biochar zero emission pyrolysis technology and products, including conversion of science into legalized and market competitive industrial practice.

The objective is to improve global and resource efficient industrial, agricultural, environmental and climate protection circular economical sectors using high quality biochar and refined carbon products made by 3R technology added value valorisation of agricultural, food processing and industrial by-products and waste streams.

Based on the REFERTIL results and foregrounds, in 2016 one unit of industrial Phosphorus recovery ABC biochar industrial BAT/BREF and commercial replication model set up with 20800 tons/year throughput capacity and 12500 tons/year recovered and high concentrated pure Phosphorus output production.

This BAT/BREF biochar project is specifically designed according to the EU, Australian and US industrial and environmental norms and standards, which are applied together in one TRL9 project as global reference. The ABC biochar industrial replication model and BAT/BREF will also serve as training and education on all levels. The targeted production start up is in 2017, which is also the year of international expansion towards plan to set up 5 additional units before 2020 in Europe, Australia and USA. The objective is to be the major producer and supplier for recycled Phosphorus on the global market and key technology international supplier for several pyrolysis applications. The new 3R technology opens revolutionary new technical, economical and environmental opportunities in the resource efficient circular bio-economical developments in relevant sectors.

Biochar specific technical, technological, product and application know how subpart modules to main foreground of the Terra Humana Ltd. that can be applied independently or coherently integrated to the 3R core technology:

a. ABC Animal Bone bioChar Phosphorus recovery processing and production methods.

b. Lignocelluloses based biochar processing and production methods.

c. Recovered and high concentrated Phosphorus ABC Animal Bone bioChar economical and market competitive application methods.

d. Lignocelluloses based biochar product economical and market competitive application methods.

e. Pyrolysis oil added value refinery.

Biochar specific legal know how subpart modules to main foreground of the Terra Humana Ltd., related to the EU/MS regulations and mandatory biochar permits, that can be applied independently or coherently integrated to the 3R core technology:

f. EU and MS EU28 legal Authority permit procedure for biochar industrial production and product applications, including EC 2003/2003 Fertilizer Regulation revision procedure for biochar case.

g. Quality and safety criteria for ABC Animal Bone bioChar as organic P-fertiliser.

h. Quality and safety criteria for plant based biochar as a soil improver product.

(B) Recommendation of REFERTIL standard methods for biochar analysis (Generating beneficiary: Wessling Hungary Ltd., IPR content: general advancement of knowledge, IPR status: public)

(C) Development of test methods for biochar samples, accreditation of analytical methods (Generating beneficiary: Wessling Hungary Ltd., IPR content: Exploitation of results through EU policies, IPR status: public). 72 waste samples (e.g. manure, sludge, garden wastes, forestry wastes, wastes from markets, seeds of fruits and bonemeals) and many output products (61 compost and 103 biochar samples) were analysed.

(D) Use of compost and biochar as organic improvers, growing media and organic fertilizers (Generating beneficiary: Universita degli Studi di Torino. IPR content: know how advancement of knowledge related to the use of compost and biochar. IPR status: confidential).

(E) Beneficial combinations of mycorrhizal fungi and biochars (Generating beneficiary: Gottfried Wilhelm Leibniz Universitaet Hannover, IPR content: general advancement of knowledge, IPR status: confidential)

(F) Beneficial combinations of mycorrhizal fungi and composts (Generating beneficiary: Gottfried Wilhelm Leibniz Universitaet Hannover, IPR content: general advancement of knowledge, IPR status: confidential)

(G) Shelf life of mixtures of arbuscular mycorrhizal inoculum with composts (Generating beneficiary: Gottfried Wilhelm Leibniz Universitaet Hannover, IPR content: general advancement of knowledge, IPR status: confidential)

(H) Plant health effects of mycorrhizal fungi and composts against soil-borne pathogens (Generating beneficiary: Gottfried Wilhelm Leibniz Universitaet Hannover, IPR content: general advancement of knowledge, IPR status: confidential)

(**I) Plant health effects of bacterial inoculant and composts against soil-borne pathogens** (Generating beneficiary: Dtichting Dienst Landbouwkundig Onderzoek Wageningen, IPR content: general advancement of knowledge, IPR status: confidential)

ABSTRACT OF REFERTIL MAIN S&T RESULTS AND FOREGROUNDS

In a world with finite resources there is no infinite development opportunity with sustainability, unless full cycle circular economy is not implemented for which the case example model is the REFERTIL biochar 3R zero emission biochar processing green technology that is the core exploitable result and foreground of the project. The REFERTIL biochar towards horticultural applications provides major economic opportunities, improve productivity, drive down costs and boost competitiveness and

i. ensure Phosphorus security by recovered P supply as critical raw material resource;
ii. boost economic performance of the horticultural farming while reducing resource use;
iii. provides an opportunity to keep costs under control by reducing material and energy consumption for production of recovered high P2O5 concentrated Phosphorus fertilizer and soil improver in economical interesting industrial scale; with special highlight on the interest and benefits of the SME farmers in the low input and organic farming sectors;
iv. identify and create new opportunities for economic growth and boost competitiveness; and
v. fight against climate change and limit the environmental impacts of resource use.

Biochar product is plant and/or animal biomass by-product based stabile carboniferous substance that is processed under true value reductive thermal conditions with >1 t/y capacity or more for fit for use agricultural applications; which manufacturing, product quality and safety, applications and use, import and placing on the market meet the mandatory EU/MS Authority permit and regulatory requirements.

Biochar is a specific carbonized product which import, manufacturing, placing on the market and use require mandatory EU/MS permits above >1 t/y capacity. Biochar produced up to <1 t/y capacity is research and/or test material. Biochar product is made by a specific pyrolysis process with designed quality, environmental and ecological safety, performance and character for food crop production agri applications. Plant based biochar is soil improver; and ABC Animal Bone bioChar is soil improver, organic P/Ca fertiliser and growing media. Biochar is interconnection between life in the soil with complex functional interactions of soil's living (biotic) and non-living (abiotic) components, clean water and above ground economical agricultural productivity in a linked, coherently integrated and harmonized ecological system.

High quality biochar that is legally produced under proper technological conditions from sustainable feed materials and applied correctly is always safe and successful to apply under open ecological conditions. The biochar treatment efficiency, product quality and safety are most importantly depending on the quality performance of the pyrolysis design.

Good quality and safe biochar (originating from Authority permit legalized producer for the biochar product with Extended Producer Responsibility certificate) always works, if not wrong quality and/or type product selected and/or applied in a wrong way. The key definition factor for biochar quality and thus safety, is primarily based on the quality of the biochar processing design engineering, technology design performance and secondarily the feed material characteristics. Plant base biochar is usually a multi feed strategy and ABC Animal Bone bioChar is a mono feed strategy.

Biochar is a chemically modified substance, therefore all biochar materials manufactured, imported, placed on the market, supplied and/or used in quantities of >1 t / year or more has to be registered under Article 6 of the REACH Regulation. Biochar production and application above 1 t/y capacity need to be mandatory Authority permitted under EU/MS regulations. In this context voluntarily biochar certificates does not have any legal effect and validity.

Two different types of legalized biochar types developed, such as:

A) Plant based biochar is a high (90%) carbon content plant origin micro and meso porous (1 nm – 50 nm) carboniferous product, with relatively high water holding and nutrient retention capacity and C sequestration, but almost no soil fertilization effects with economical importance. Usually 450℃ – 550℃ reductive thermal processing material core temperature used. Plant based biochar has been recognized by many researchers so far generally as energetic charcoal. The REFERTIL successfully developed and demonstrated a new generation carbon product with higher safety level, specific biochar for specific soil application, that is well justified, as biochar is irrevocably applied to soil.

B) ABC (Animal Bone bioChar) is a high calcium phosphate (92%) content animal origin macro porous (20 nm – 63,000 nm) carboniferous product, that is produced from food grade category 3 bones between 600℃ – 850℃ reductive th ermal processing negative pressure conditions with zero emission or near zero mission environmental performance. ABC is a new product, and since 2002 Terra Humana Ltd. is the only RTD and engineering organization with such specific core competence who is systematically researching and developing ABC from science into industy.

Processing of ABC and animal by-products require far higher heat transfer efficiency, far higher know how/technology level and high tech, than traditional pyrolysis process for plant based or waste materials. That is because the protein based animal bone material organic content is far more complex chemistry than same for plant materials.

Recycled ABC organic phosphorus fertilizer (also for soil improver and growing media applications) is slow release fertilizer that is advantageous from in vivo plant nutrient uptake and environmental point of view. In the mineral P fertilizer cases the P rapidly leaches out and that is a high pollution risk issue for the subsurface groundwater P contamination, while not promoting the healthy soil building up and soil microbiological life. The rapid P release intensive farming mineral phosphate versus the sequenced and controlled P release ABC organic P fertilizer having two very different mechanisms, and these are different products.

The ABC is having far many more additional beneficial effects, which mineral phosphate does not have. Such additional beneficial effects are:

a) The macroporous structure and surfaces hosting beneficial microbes and fungi, increasing colonization in root zone, diversifying soil ecosystem, and building up a sequenced release P bridge.

b) Supports nutrients increasingly bio-available.
c) Retain nutrients & water, keeping them from leaching.
d) Improving soil aeration.
e) Increase cation exchange functions in soil, boosting nutrient availability.
f) Act as a catalyst for releasing sorbed water as conditions dictate.
g) Reduce off-gassing mitigation of GHGs.
h) Increase pH & replace liming requirements of acid soils.
i) Accelerate the composting process, and help its aeration.
j) Reduce or eliminate compost odours.
k) Improve the quality and efficiency of compost.

As core result and foreground, the REFERTIL project completed and qualified the zero emission performance “3R” Recycle-Reuse-Reduce industrial pyrolysis technology at TRL8 level according to the Commission Decision C(2013)8631 and prepared TRL9 competitive manufacturing next level, that is an industrial replication model and objective driven for BAT/BREF qualification according to 2012/119/EU.

The REFERTIL biochar and “3R” carbon refinery science, technology and industrial engineering progress is based on the Terra Humana Ltd.’s TRL5 applied research pyrolysis and biochar technology validation in relevant industrial environment in years 1990-1995; TRL6 pyrolysis and biochar technology demonstrated in relevant industrial environment in years 2002-2005 under EU FP5 NNE5/3636/2001 Multi Fuel applied research project; TRL7 pyrolysis and biochar system prototype demonstration in operational environment in years 2005-2009 under EU FP6 Food-CT-2005-514082 PROTECTOR applied research project; and TRL8 pyrolysis and biochar system completed and qualified in years 2011-2015 under EU FP7 289785 REFERTIL applied research project.

Based on the REFERTIL results and foregrounds two biochar production technology schemes worked out, such as a minimum economical capacity small scale installation with 6500 t/y and a medium capacity installation with 20800 t/y throughputs, that is an interesting demonstration how to convert science into industrial practice.

The biochar specific pyrolysis process is when all the engineered design elements and the comprehensive construction is specifically designed to legally manufacture such type of specific carbon product for the purpose legally apply in functioning soil ecosystems (biochar) that unconditionally meet all the specific safety and other requirements that will be irrevocable applied in soil with no “end of the life cost” and that product is Extended Producer Responsibility certified. The “legally manufacture” and “legally apply” criteria means Authority permitted under EU/MS regulations above 1 t/y capacity. In this context biochar specific pyrolysis process is both technical and legal term together.

All in order to support the EU/MS Authority permitted, legalized and biochar specific pyrolysis technology system design developments with market competitive and economical industrial scale performance the key elements and concepts of a successful pyrolysis technology design and application recommendations and good practice guide has been worked out by the Terra Humana Ltd. In concept the high heat transfer efficiency into material core for selected feed material is critical factor, which is depending on the technology design quality performance. Plant based biochar material core processing final treatment carbonization temperature is from >450 to <550 ℃ while ABC biochar material core processing final treatment carbonization temperature is from >600 to <850 ℃. Residence time and pressure conditions are depending on the design performance.

Good practice guide for the biochar specific pyrolysis technology operators has also been worked out, including operations, training and education of the work force, prevention of occupational hazards, monitoring, maintenance and preparation for emergency case, a.s.o. Requirements for ABC organic fertilizer and plant based soil improver biochar minimum quality and safety criteria, sampling, tests and labelling defined and reported to the Commission as biochar standardization and law harmonization proposal for consideration in the Fertilizer Regulation revision process.

The REFERTIL partner Wessling Laboratories developed biochar accreditation scheme. Biochar is new product; therefore careful and material specific consideration is needed for all analytical items, also which standard to be applied. As the end result of this process, our goal was for the Environmental Testing Laboratory of WESSLING Hungary Kft. to be the first laboratory in Europe to obtain accredited status for different analyses of the biochar sample types.

The goal of accreditation is to ensure professional performance of compliance evaluations, and to eliminate multiple analyses and certifications of products and services in order to remove technical obstacles to trade. In other words, to increase trust in organizations that have obtained recognition in accreditation systems built on uniform European principles, to raise the reliability of analytical, certification and control activities, to promote mutual acceptance of analytical results and certificates, thus eliminating repeat analyses and removing technical obstacles to trade.

Animal bone chars contain very high percentage of Ca and P as their main component is calcium-phosphate; in general around 30% P2O5 and 40% CaO was recorded, so these can be considered as good fertilisers. Other nutrients (K, Mg, S) are not present in high quantities. Plant based biochars don’t show high values of nutrients, however high carbon content (70-80% total C) makes PBC suitable to be used as soil amendment.

The investigated compost samples have also fertilising effect, but first of all not with their phosphorus content (1-2% P2O5) but with their 3% K2O and 12-14% CaO amount. Furthermore these have a spectrum of micronutrients (0,8% Mg; 0.6% S, 1% Fe) as well.

Good quality input materials (with appropriate pyrolysis conditions) resulted high quality biochars. In the case of potentially toxic elements (PTEs) 3–5 times reconcentration tendency during phase separated processing was shown. This results much higher PTE concentration in solid output products than in original input average. The higher the organic matter content in feedstock, the less the yield of biochar, thus PTE high accumulation occurs especially in PBCs. The rate of enrichment is depending on the concentration of the given elements in the feedstock stream and on the yield of biochar reached with the given pyrolysis condition. In the case of pyrolysis of waste material streams with high and/or varying PTE input concentrations there is a high risk that PTEs in final biochar products may reach the recommended safety criteria, therefore the concentration of PTEs should be regularly monitored, PTEs were detected by ICP-OES. Organic waste streams generally containing high levels of light and heavy metals, which remain and concentrate in the final biochar product should be excluded from biochar production.

The analysis of PAH19 compounds is very important, because 1-, and 2-methylnaphthalenes are very common. Sometimes PAH19 concentration can be twice as much as PAH16, so it is also important point to be considered during the definition of limit values. A certain limit value for PAH 16 can be exceeded when measuring PAH19. Good quality samples were well below even a strict member state (Hungary) 1 mg/kg PAH19 criterion also in the case of

animal bone based and plant based biochars. PCBs, PCDDs and PCDFs are not present in biochars and composts, because of the low chlorine content of the feed material. Volatile organic compounds were also measured but not in remarkable quantities.

Accreditation of the analytical activities related to the REFERTIL project was an important step to be able to support the research work related to the project with analysis that have a recognized quality management background, in addition to the proper professionalism. It is also an important step to support the legal standardization and mandatory permit process of biochar industrial production, application and commercialisation. Most of the standards selected for biochar qualification were chosen from among currently valid CEN/ISO standards. As biochar is a new product, for a number of parameters it was necessary to adopt soil or waste analytical methods, which were validated to assess their analytical performance. Validation methods were developed to check the suitability of not entirely standard methods to be used in laboratory practice. The Environmental Testing Laboratory of WESSLING is the first laboratory in Europe who obtained accredited status, under Wessling-NAT-1-1398/2012 (2014.10.08) for comprehensive analyses of biochar samples. Based on the mutual recognition agreements, activities of NAT and organizations accredited by NAT are recognized internationally by all other signatories. According to Regulation EC 765/2008, authorities of the member states are obligated to accept the results of organizations accredited by NAT.

Greenhouse experiments were performed to evaluate disease suppressiveness of potting soil mixtures against soil borne pathogens. Bacterial inoculants and organic amendments were applied alone or in combination with the aim to stimulation suppressiveness of potting soil. Four taxonomically different bacterial antagonists were evaluated for their potential to control damping-off symptoms caused by the pathogen Pythium aphanidermatum in a bioassay with young tomato plants. The gram-negative bacterium Pseudomonas chlororaphis 4.4.1 was the most effective antagonist controlling this disease. This strain had no negative effect on the germination of tomato seeds. Potting soil inoculated with P. chlororaphis 4.4.1 demonstrated 41, 78, 92, and 35% less diseased plants in greenhouse experiments in successive years (2012-2015) compared to the un-inoculated potting soil. The strain was effective when inoculated as liquid formulation into the potting soil, but also when it was inoculated as a solid formulation in animal bone char (ABC). A dosage of 1 x 108 cells per g ABC was sufficient. A third effective inoculation strategy was treatment of tomato seeds, where 2.4 x 103 cells per tomato seed controlled the disease. P. chlororaphis 4.4.1 appeared to be a very good root colonizer, and was recovered from the tomato root rhizosphere independent on the method of inoculation.

One standard green waste compost from a Dutch company demonstrated significant and reproducible control of P. aphanidermatum in young tomato plants when mixed in a dosage of 10% (v/v) with potting soil. Disease reduction was 64, 74, 52, and 47% compared to the un-amended potting soil in four greenhouse experiments in successive years (2012-2015).

Also several other green waste composts were effective in controlling Pythium. However, nutrient rich compost types which are produced for fertilizer purpose, are not suitable for application in this high dosage, since seed germination was seriously reduced.

Also two types of biochar were tested for their capacity to enhance disease suppression. Plant based biochar (PBC) and animal bone char (ABC) were mixed through potting soil in a dosage of 1% (w/v). ABC did not enhance disease suppression in any of the experiments.

PBC reduced the disease to some extend in two experiments, but this reduction was not significant for the two experiments separately.

Microbial enrichment of potting soil mixtures with ABC or PBC with P. chlororaphis 4.4.1 improved disease suppression. However, addition of P. chlororaphis 4.4.1 to potting soil with compost, that already showed enhanced suppressiveness, did not further increase the suppressiveness. Thus, Pythium disease was reduced by either microbial enrichment or by addition of proper organic amendments. Measurement of plant growth and mineral uptake in two independent greenhouse experiments with young tomato plants demonstrated that recycling of minerals present in bio-waste products was most clearly for phosphorus (P) and potassium (K). P-uptake by the young tomato plants doubled in the treatments with compost and ABC amendments, whereas PBC had little or no effect. K-uptake was enhanced most strongly by the amendment of compost, followed by PBC amendment. Microbial enrichment with P. chlororaphis 4.4.1 had no significant effect on the uptake of P, although this strain has the capacity to solubilize P.

Mycorrhiza inoculants were tested in a single greenhouse experiment with strawberry plants infected with Phytophthora cactorum causing root and crown rot. The mycorrhiza Rhizophagus irregularis colonized 40% of the strawberry roots and was able to reduce infection by Phytophthora with 50% compared to the control plants without mycorrhiza. Fewer plants had brown roots and internal symptoms of crown rot. Another mycorrhiza strain, Glomus etunicatum, showed low colonization of strawberry roots and Phytophthora symptoms were not significantly reduced. Amendment of the substrate with compost, ABC, P. chlororaphis 4.4.1, and several other treatments aiming at improving suppressiveness, were not effective. Experiments were conducted using as mycorrhizal symbionts 3 arbuscular mycorrhizal fungi (2 isolates of Glomus intraradices, and one isolate of Glomus etunicatum) and 8 ericoid mycorrhizal fungi (Oidiodendron maius, Rhizoscyphus ericae, 2 Leohumicola spec., and 4 non-identified isolates) and Phytopththora cinnamomi as soil-borne pathogen. Biochars used were 3 different batches of ABC (made from animal bone material) and two different plant-based biochars. 5 different composts delivered from Spain, Hungary, and the Netherlands were used, too. Experimental plants were Tagetes erecta cv. Luna Lemon and micro-propagated Rhododendron cv. Cunningham´s White.

When different ABC and plant-based biochar materials were compared regarding their impact on the formation arbuscular mycorrhiza was investigated, there was no negative effect of a 2% biochar amendment on AMF colonization. It can be concluded that the much higher nutrient contents of ABC compared to plant-based biochars were not important in this context and all root systems could be colonized to the same extent regardless the fact that plants were up to 3 times bigger when ABC was added. The effect of ABC on Ericoid mycorrhizal fungi (ERMF) development was shown to be small. Obviously there are absolutely no problems of combination using ABC and ERMF isolates. When different compost samples were compared regarding their effect on formation of arbuscular mycorrhiza, negative effects were not visible. In contrary mycorrhizal development could in some cases even be promoted. When different compost samples were compared regarding their effect on formation of ericoid mycorrhiza, interactions of composts with ERMF were found. In the total view the effects of composts on ERM development reached from improvement of mycorrhizal formation to killing of the whole system. Having in view of the variety of possible compost qualities and the high diversity of ericoid mycorrhizal fungi it is impossible to predict whether any given compost has dramatic positive or negative effects on

ERM formation. If only plant-based composts with low salinity are concerned, the expected effects might be non-dramatic or negligible.

For ericoid mycorrhiza the functioning of the symbiosis was defined in the context of the REFERTIL project as in planta antibiotic activity against the pathogen Phytophthora cinnamomi. The experiments show bio-control of P. cinnamomi by ERMF and by composts or in combination with ERMF depending of the combination with the actual ERMF isolate; however, the results were not constant. Sterilization of COES3 and CONL1 had opposing effects: In the experiment with CONL1 there were not much significant interactions; when COES3 was sterilized, effects of non-sterile COES3 were inverted dramatically. It can be concluded that the activity of reducing the Phytophthora disease is due to nutrients in the case of CONL1 and due to organisms in the case of COES3.

For further development of inoculum methodology and to simulate a “shelf life” of a combined compost/AMF product, were stored in mixture with composts or commercial potting ground; it was expected that AMF isolates would not survive this incubation. However, this hypothesis was refuted by the results. AMF isolate 510 survived very well in commercial horticultural substrate but as well in CONL1 and COES3, less good in COHU3, inoculation success even increased after incubation. This result is very important for commercial combination of AMF and substrates made from peat or peat substitutes (compost). However, the carrier material expanded clay, which is used up to now in AMF inoculum production, probably cannot be substituted by biochars.

To substitute the normal ERMF carrier material perlite by bio-char, inoculum of two ERMF was produced in the same way as normally done but using the plant-based BCDE as carrier. A Rhizoscyphus isolate accepted the BCDE pretty well, a Leohumicola isolate not. The practical applicability of plant-based biochar as ERMF carrier material will depend on the choice of the right isolate.

The microbiological results can be summarized as follows:

1). Mycorrhizal colonization of leek was best with AMF-510 but often low when ABCHU was applied, however in all inoculated treatments colonization was high enough to expect a mycorrhizal P-bridge effect from biochars or composts to the leek plants.

2). Leek plants without P-fertilization could use ABC as P-source regardless of being mycorrhizal or not. Obviously no “P-bridge” was necessary here, this was in contrast to results in the past with other batches of ABC. Plant based had a low P-content and caused only low growth promotion.

3). The three AMF isolates used differed regarding their effects on the leek plants in combination with the soil amendments used. That underlines the conclusion that combinations of soil amendments and mycorrhizal inocula should be duly tested before application in plant production.

4). Rooted rhododendron cuttings from commercial production were mycorrhizal, in contrast to micro-propagated plantlets used in WP4. This autochthonous mycorrhizal colonization reached a high level comparable with the colonization after inoculation with selected ERMF isolates. It could not be cleared to which extent the high colonization level after inoculation with selected ERMF isolates was due to autochthonous or inoculated ERMF.

5). The rhododendron plants grew best when COES3 was mixed into the substrate, amendments with COHU114 or COHU214 in most cases reduced growth clearly. A positive effect of ERMF inoculation on plant growth was not visible in any case.

6). The selected ERMF isolates were immune to negative impacts from Trichoderma (after all, a mycoparasite). Colonization with the autochthonous ERMF was clearly reduced in combination with Trichoderma viride or COHU114 and COHU214.

7). Rooted rhododendron cuttings from commercial production were much less susceptible to Phytophthora cinnamomi compared to micro-propagated plantlets, although they belong to the same species 'Cunningham's White'. Phytophthora disease level was too low to allow reliable statements regarding the effects of compost amendments or inoculated fungi.

8). Some treatments where Trichoderma harzianum T22 was involved and the amendment of COES3 alone stayed free of the Phytophthora disease. When COHU114 was amended to the substrate the highest disease ratings were observed.

Ecotoxicity of biochars in agricultural soil was tested towards microbial bioindicators in the form of potential nitrification and specific soil enzymes (arylsulfatases). For six types of biochar derived from wood, straw, and animal bones it was found that two out of three wood-based biochars either caused no effect or even stimulated potential nitrification. For the other biochars, dose-responses initially showed 10% effect concentrations (EC10) in the range of 1.3 to 23.8% (dry wt biochar/dry wt soil), but with significant recovery potential observed for biochars causing largest inhibition of potential nitrification (i.e., EC10 increasing from 1.3 to >3.6% within 1 week). All biochars were found to increase soil pH although at varying degree (and depending on application rate); such pH effects would likely stimulate nitrification in the soil. Thus, it was concluded that the six biochars increased soil pH to varying degree, but did not cause severe inhibition of potential nitrification. For soil enzyme activity it was found that the methodological approach for the arylsulfatase assay was challenged by product sorption, but results did not suggest that biochar significantly inhibited or stimulated the enzyme activity. Thus, based on comparison of ecologically relevant doses and effects on the tested microbial bioindicators, it was suggested that the tested biochars had an ecologically acceptable profile.

Biochar sorption capacity was tested in relation organic contaminants represented by nitrophenols (NP). Studies with four types of biochar indicated a high adsorption capacity with an apparently higher capacity for plant-based than bone-based biochars. The potential ability of biochar to mitigate the ecotoxicity of organic pollutants (due to sorption) was then tested for linear alkylbenzene sulfonates (LAS). Ecotoxicity of LAS in the presence of 1.1% biochar in the soil showed diverging results for the tested biochars (two from straw and two from wood). Modelled EC10 values for potential nitrification were slightly above or below the EC10 in reference samples, where LAS ecotoxicity was tested in the absence of biochar (EC10 = 43 mg LAS kg-1). However, no clear effect of LAS sorption to biochar was observed, which could potentially have mitigated LAS ecotoxicity in the soil.

Potentially ecotoxic condensates related to biochar production may be distributed among solid (biochar) and liquid products (bio-oil). The analysis of ecotoxicological risks of biochar was therefore complemented with tests of bio-oil (produced by pyrolysis of bone residues), which has previously been suggested as repellant of weeds and pests. It was found that an application rate of 170-200 L bio-oil per ha would not be expected to significantly affect the tested bioindicators in the soil ecosystem. This application rate should be evaluated against the anticipated doses of bio-oil that would be needed for either weed control or pest insect control.

Biochar has previously been indicated to reduce soil GHG emissions although the mechanisms and the potential for climate change mitigation are not fully explored. A literature analysis qualified eight hypotheses that have been suggested as possible mechanisms to reduce soil N2O emissions after biochar amendment to soil. Further validation and mechanistic understanding of such interaction between biochar and N2O emissions could have wide-ranging implications for reducing the emission of GHG from agricultural cropping systems.

An experimental test of the effect of REFERTIL plant-based and bone-based biochar showed that both types reduced N2O emissions from soil with larger effects of plant-based biochar (i.e., reductions in the range of 24-54%, with a mean reduction of 38% for plant based biochar; for bone-based biochar the mean reduction was 7%). As an important difference between plant-based and bone-biochars is the state of porosities (micro- versus mesoporous) it was hypothesized that the porosity characteristics of biochar may generally be involved in the interaction between biochar and N2O emissions. This current effect (reductions of N2O emission) was observed in systems with different rates of biochar application (0.2 and 2%) and during interaction with added nitrogen sources in the form of inorganic N (NO3-) and organic N (pig slurry). Thus, a high relevance to agricultural practice is anticipated and should be further explored.

The thermo-chemical method, pyrolysis, can be directed to provide large amount of oil and some gas. It was recognized that using a catalytic hydroconversion technology the C-C bonds of the oil components can be preserved while the C-N and C-O bonds can be cleaved (the pyrolysis oils from bio-resources usually do not contain sulphur compounds). Processing the pyrolysis oil, obtained from animal by-products gives a hydrocarbon liquid and ammonia. The hydrocarbon liquid can be used as conventional fuel or fuel component, whereas it is possible to recycle the ammonia to the agricultural production.

During the production of different types of biochars pyrolysis gas-vapour products produced, that has been utilized for own energy supply. The main environmental objective for the biochar processing in industrial scale to achieve zero emission goal, e.g. all the elements of the feed material are converted into more useful products than energy only. In this context beyond the production of the high quality solid biochar material, the recycling and reuse of the pyrolysis gas-vapours (bio oil) is also important.

The following progressive works carried out:

a) Assessment of animal based synthetic fuel best available technology options (nitrogen heteroatom strategy), including economical scale up industrial options.

b) Assessment of plant based synthetic fuel best available technology options (oxygen heteroatom strategy), including economical scale up industrial options,

c) The minimum economical industrial scale is estimated above 950 barrels oil refinery-synfuel/day, or above 150 t/d, or >50,000 t/y.

As biochar is long termed applied irrevocably in open ecological soil environment, therefore the extended producer responsibility and having all the mandatory Authority permits are critical elements for all biochar productions, operations and use above 1 t/y capacity, including importing and placing on the market as well. Below 1 t/y production and use capacity of any biochar systems is remaining as research production category.

The REFERTIL set up for biochar product requirements with new application methods and good practice guide is based on advanced and biochar specific pyrolysis technology, safe product specification and sustainable application.

Important REFERTIL finding is that any specific carbon production with specific pyrolysis technology from specific feed materials - resulting specific end-product quality, safety and character, - can be recognized as fingerprint of each specific biochar system. For all types of pyrolysis technologies can be stated that:

1) Obsolete, low end and energetic carbon production designed pyrolysis technologies resulting toxic and variating quality carbon products from biochar product point of view that are not suitable for safe biochar applications.

2) Wrongly selected feed material selection resulting wrong carbon product with low application value, such as the straw based biochar as negative example.

3) Non-sustainable feed material selection resulting generally non-sustainable system, such as the manure and straw based biochar as negative example, where the thermal processing destruct more organic resources than new added value products created.

4) Processing of plant based biochar require lower level of technology design performance than ABC Animal Bone bioChar, that require extensive knowledge based, truly high end and comprehensive technology design.

5) There is no one fit for all biochar technology and product solution, but the biochar product safety and agronomic efficiency requirement is valid for all types of biochar.

Biochar is a specific carbonized product made by a specific pyrolysis process with designed quality, environmental and ecological safety, performance and character for food crop production agri applications. Biochar is for agricultural applications only while other types of carbons for other applications with other legal/technical requirements are not titled as biochar. In this context what is not biochar product from certain carbon processing operations:

a) the product quality is not lawful, e.g. does not meet the valid and legally EU/MS Authority permit defined minimum product quality specifically for soil application in agriculture as specific purpose (or does not fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products, including high risk for adverse environmental or human health impacts), and/or

b) energetic carbons and/or charcoal are not biochar, and/or

c) the production is not lawful, e.g. does not have valid and identified EU/MS Authority permit for production and agriculture specific purpose placing on the market in the EU or import permit according to REACH, and/or

d) the use is not lawful, e.g. does not have valid and identified EU/MS Authority permit for the agriculture specific purpose use of the substance, and/or

e) produced from non-sustainable feed material, and/or

f) there is no existing market or demand for that type of biochar product from certain carbon processing operations for the purposed use in agriculture, and/or the biochar industrial production is based on EU and/or MS community society grant supports (legal interconnection to 2008/98/EC, EoW Article 6).

Plant based biochar is a chemically modified/amended MULTI (carbon content <80%) or MONO (carbon content >80%) CONSTITUENT substance with variable composition, usually originating from MULTI FEED processing. ABC Animal Bone bioChar is a chemically amended MONO CONTITUENT substance, originating from MONO FEED processing. Raw material (feedstock) is, along with pyrolysis conditions, the most important factor controlling the properties of the resulting biochar. The chemical and structural composition of the biomass feedstock relates to the chemical and structural composition of the resulting biochar and, therefore, is reflected in its behaviour, function and fate in soils. Feedstock, along with pyrolysis conditions, is the most important factor controlling the properties of the resulting biochar. To obtain a high quality biochar product, mainly two aspects have to be considered: the input feed material and the performance of the pyrolysis technology design that provides the treatment efficiency.

Plant based biochar is having multi feed option; ABC animal bone biochar is based on mono feed, e.g. only single and well defined input option from the Authority permitted and continually controlled rendering industry.

For selecting of biomass for sustainable biochar production, the following criteria should be applied:

1. Only the listed (positive list) organic feed materials (organic waste, product, by-products) can be used for biochar production.

2. Recorded clean feedstock source. Evidence of complete feedstock documentation needed, including origin, according to the EU and Member State law.

3. Consistence feedstock quality. The quality characteristics of biomass feedstock are not to be variable and inconsistent. Production of biochar from low grade biomass brings potential environmental and human health risks and biochar quality problem.

4. Consistence feedstock quality. The quality characteristics of biomass feedstock are not to be variable and inconsistent.

5. Feedstock quality parameters and physical/chemical properties to be considered

6. Potential nutrient value and availability of the feed material. Does not compete with biological treatments (composting, anaerobic digestion) for organic fertilizer production. The potential nutrient value lost during the thermal conversion in the plant based biochar production cases versus biological conversion and producing compost. This is the case for green residuals and manure. The nutrient composition of the final biochar (the amount of carbon, nitrogen, potassium, calcium) depends on the feedstock used, the processing conditions, duration and temperature of pyrolysis.

7. The Potentially Toxic Elements (PTEs) and organic contaminats (POPs) should be minimized. Priority elements: As, Cd, Cr Total, CrVI, Cu, Pb, Hg, Ni, Zn. The PTEs concentration of input material should be regularly monitored. Requirement: If the concentration of any PTEs in the feed material are exceeding the 20 percent of the Refertil recommended limit value, those feedstock should be excluded from the biochar production for agriculture applications. The organic contaminants (PAHs, PBC) should be minimized. However PAHs are regenerated during treatments, therefore it is important to apply high end pyrolysis technology. Must be free from non-organic waste (plastics, stone, metals, glass) and hazardous waste.

8. Sustainable feed supply, only the sustainable use of biomass should be promoted (product and by-products feedstocks): Biochar feed materials does not compete with human food, animal feed and plant nutrition supply. Production biochar from low economical value by-product biomass should not create competition for land use for human and animal food production. Feedstock production: costs and inputs need to minimize for the growing and harvesting of the crop grown for biochar supply. Should be meet to the sustainable agricultural production and the environmental cross-compliance requirements in the Common Agricultural Policy (CAP). Forbid the use of biomass from land converted from forest, and other high carbon stock areas, as well as highly biodiverse areas. Increased demand for forestry or agricultural residues can lead to reduction of land carbon stock in the soil, for instance, if too few residues are left on the land. There are large quantities of carbon in soil organic matter, which can increase or decrease depending on the crops or trees planted and the management regime, such as the application of fertiliser.

9. Feedstock availability: seasonal and yearly round availability of the feedstock should be carefully evaluated. Feedstock availability can vary year to year and within years.

10. Environmentally sustainable feed material logistics. The environmental and human health impact of logistics (long way transport, dust, gaseous emissions during transport, storage and pre-treatment, safety of workers, fire hazards) should be minimized. The potential flammability of dry, stored material will require mitigation strategies to reduce the potential for fire. When biomass, especially materials with low mass density characteristics, should be transported over a long distance the transportation costs and environmental impact can be very high.

The by-product and waste stream thermal treatment options having two very different (environmental, processing, human health, product quality, aso.) risk profiles, different treatment conditions, different integrated pollution prevention and control, different safety, different production performance and different MS Authority control/reporting performances. The key definition factor which direction the permit is applied is based on the feed material classification, if the input is a by-product or waste classified. For any biochar quality/safety/user criteria determination strict specification and titled responsibility is required, as because biochar soil application is irrevocable and from that point of view the SME farmers must know for total sure what they put in into soil they own.

The composition of feed material has an effect on the nutrient and also on the potential toxic element (PTE) content of the biochar product. So feed material streams from agriculture and the food industry are not always appropriate for being feed materials of the pyrolysis process to produce biochars.

Therefore, we have to select the targeted input feed material streams strictly, we have to obtain information about their chemical and physical properties, and compile a unified system of materials suitable for the production of environmentally safe chars.

Biochar quality, safety and performance produced from waste streams having very different criteria versus biochar produced from agricultural, food and forest industrial by-products. When diverse waste streams are processed than wide range of new PTE potential toxic element inputs coming up with highly variable concentration and composition.

It is highly important to select right material core treatment temperature at specific pyrolysis technology unit with specific heat transfer efficiency, so the material is not insufficiently under heat treated or too much over heat treated; whereas both cases negatively affect biochar quality, safety and application value. However, generally the stability of biochar increases as

a function of pyrolysis material core temperature whereas the maximum allowable limits of the PAH16 and PAH19 are key process and biochar product quality/safety indicators.

The biochar specific standard pyrolysis process is characterized by the following criteria:

1) Comprehensive industrial design for treatment and management of all processed material streams in any form; including technological, mechanical and thermal engineering, electric and electronic design and instrumentation, mass and energy balances, hazard and risk evaluations, occupational health and safety design, storage and logistics, data collection and storage, auxiliary systems, a.s.o. according to the valid EU/MS industrial and environmental standards and mandatory permit conditions.

2) True reductive environment thermal processing with self sustaining thermal energy supply or electric power generation and full value surplus energy recovery as standard installation.

3) Temperature criteria: material core processing temperature is between 450℃ and 850℃. Plant based biochar material core processing final treatment carbonization temperature is from >450 to <550 ℃ at minimum 20 minutes residence time. ABC biochar material core processing final treatment carbonization temperature is from >600 to <850 ℃ at minimum 20 minutes residence time. Constant material core temperature and residence time is to be defined and followed by the producer for each mono and multi constituent feed materials, that will result targeted output biochar commecial product quality.

4) Towards zero emission performance or even zero emission performance processing to be designed, most importantly full processing of the pyrolysis-gas-vapours and energy supply units needed to fully meet relevant industrial emission standards, including the Industrial Emission Directive, with the difference that biochar – as main product - is not combusted. Full and added value recycling and reuse of pyrolysis-gas-vapours as higher value organic chemical compounds should optimally be targeted.

5) Resource efficient and sustainable biomass feed materials selected.

6) Fully monitored, recording/documentation system. Continuously 7days/24hours operated, usually 8000 h/year.

7) Authority permitted construction and operation implemented above 1 t/y capacity (usually 17 Authority permits required with specified terms and conditions)

8) REACH certification and authorization above 1 t/y biochar production capacity made.

9) Having Extended Producer Responsibility certificate for the lawful and “fit for purpose” product (full value legal and economical responsibility for the product safety and stated performance).

10) Biochar quality specification and labelling according to the expected EC2003/2003 Fertilizer Regulation revision content and format to be applied.

The three standard pyrolysis products are: carbon as main product, gas and pyrolysis oil. The relative proportion distribution carbon-gas-oil is depend very much on the pyrolysis technology design, the characteristics of the biomass and the reaction parameters. There are many different types of conventional biomass pyrolysis processes for energetic charcoal making, still few pyrolysis are suitable for biochar processing with strict requirement for the carbon product environmental and ecological quality.

In concept life-cycle cost analysis is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of

biochar or its technology, when each is equally appropriate to be implemented on technical grounds. As biochar application is an irrevocable action, there is a need to sum of all recurring and one-time (non-recurring) costs over the full life span or a specified period of the biochar. As biochar application is an irrevocable action, the “whole cost accounting” to be used, most importantly including the possible environmental costs and risks when low quality biochar is used. Therefore, it is so much important that producer and users having all the mandatory EU/MS permits and working under Authority control according to EU/MS regulations, REACH and Extended Producer Responsibility certifications.

Life-cycle cost analysis can explore trade-offs between the initial costs and long-term cost savings, identify the most cost-effective system for biochar use, and determine how long it will take for a specific system to “pay back” its incremental cost. By creating an exhaustive life cycle cost estimate for critical and major potential design elements of the biochar case features most likely to impact long-term costs identified.

It is estimated that there is no end of life cost for the biochar product applications in agriculture and that is guaranteed by the Extended Producer Responsibility certificate and insurance.

In almost all cases the SME farmer user economical calculations based on investments with payback less than 5 years time. Therefore, all in order to be market competitive – in standard case that is the majority – the biochar offers must follow this time line as well. If environmental or carbon sequestration climate protection aspects taken as prime objective and large initial finance is secured, more than 5 years payback time can also be applied. It is recommended to make life cycle cost decision matrix for biochar actions to comprehensively evaluate, truly identify, consider potential cost impacts, organize all deliverables, document all cost and scheduling implications. In this context alternative biochar product types and application method objectives established, criteria set up for alternatives, alternatives identified and such designs developed, cost information gathered and life cycle cost for each alternative developed.

Biochar processing is resulting separated streams of chemically modified substances, such as solid char (20-30% w/w yield for plant char and 50-65% w/w for ABC Animal Bone bioChar P fertilizer) and gas-vapors (70-80% w/w yield for plant char and 40-50% for ABC that maybe condensed to pyrolysis oils and gas). In this context chemically modified substance means a substance whose chemical structure is changed and does not occur in nature, and that is the biochar and pyrolysis oil. Important recognition made for the cross and re-contamination routes of the crude animal bone meal in traditional case when directly applied at high risk. Although, the usual treatment >133℃, 20 minutes, 3 bar thermal treatment, it is not enough to sterilize the category 3 bone meal, after the material is leaving the factory the cross and recontamination is a very high risk. While rendered products leave the cooker negative of the bacteria, recontamination can occur anywhere along the way. Untreated bone meal and any protein content animal rendering by-products cross and/or re-contaminated which material constitute a significant reservoir of Salmonella contamination and/ot other human and anuimal pathogens, such as anthrax, TBC, mouth and foot disease, a.s.o. Salmonella may be present in animal feeds and/or by cross / recontamination at such low levels that it is difficult to detect. Therefore, only the added value carbonization processing over 500℃ providing fully safe and for producer/user juridical fully protected solution for this issue, and also offering far better business opportunity for product

valorisation, - which is versus the risky market use of the crude bone meal for any in vivo applications.

BIOCHAR PERMITS: as of the current regulations and legal practice in the Member States the biochar production and application are subject to mandatory Authority permits according to EU/MS regulations. Biochar thermal processing/production and biochar product application are two different permit schedules.

All biochar industrial production and thermal treatment processing unit set up and operations require comprehensive and mandatory MS Government Authority permits in all the EU Member States, while the industrial system must also comply to all the EC Regulations as well. Such MS competent Authority permits titled for identified applicant, valid for identified site, specific installation and technology, identified and controlled material steams. The terms and conditions for the permit validity are specified in the permits and reference legislations.

At EU level, the basic legislation with respect to waste management is Waste Framework Directive 2008/98/EC. Article 2(1) of WFD excludes faecal matter, if not covered by paragraph 2(b), straw and other natural non-hazardous agricultural or forestry material used in farming, forestry or for the production of energy from such biomass through processes or methods which do not harm the environment or endanger human health. Article 2(2) of WFD excludes animal by-products.

By-product is a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 to WFD but as being a by-product only if the following conditions are met, such as further use of the substance or object is certain; the substance or object can be used directly without any further processing other than normal industrial practice; the substance or object is produced as an integral part of a production process; and further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

Certain specified waste shall cease to be waste when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions such as the substance or object is commonly used for specific purposes; a market or demand exists for such a substance or object; the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and the use of the substance or object will not lead to overall adverse environmental or human health impacts. Member States may decide case by case whether certain waste has ceased to be waste taking into account the applicable case law.

a) Biochar processing from by-product materials are under mandatory REACH registration for production, importing and/or placing on the market above 1 t/y capacity after mid 2018.

b) Any carbonization or thermal processing from waste materials as defined in Directive 2006/12/EC are not applied for REACH, but End-of-Waste criteria applied under Member State regulation.

In most countries the permit procedure is following the same routes for different types of thermal treatment stationary or mobile systems/technologies, such as for biochar production by pyrolysis - and - other waste/energetic processing (or using as fuel) thermal treatment units that are not suitable for biochar production, such as gasification, torrefaction, hydrothermal carbonization, plasma, incineration and co-incineration. In this context the legal meaning of 'thermal treatment' includes both incineration/combustion and other treatments as well. However, the procedure routes are different for by-product and waste classified stream treatments.

All in order to demonstrate in the REFERTIL a true value industrial biochar permit case and provide full value official reference in the demonstration of the REFERTIL project true value legal efforts, the most important elements are the Member state official Authority permit references and accredited legal models that can be applied in the EU Fertilizer Regulation revision process. This is a challenging legal and technical work part in REFERTIL, and the way to go through an real permitting procedure cannot be substituted with anything else as this is the only true value legal reference.

As the EU legal status of biochar commercial productions and applications have been confusing and unclear past years, the critically important REFERTIL legal result and foreground has been to develop, demonstrate, validate and document a true value biochar permit case model that is mandatory under the EU regulations, including sections for biochar industrial production, applications, REACH and Extended Producer Responsibility certificate. Beyond the EU/MS regulations the REFERTIL found scientific evidence for the behaviours of priority hazardous substances and biochar prime target pollutants, such as PAHs and Cadmium. Although PAH's are very low water soluble, but still soluble, and the subsurface water pollution limit EQS 2 µg/litre for PAH19 (as K1 priority hazardous substance) related to the EC 2008/105 regulation and acceptable risk correlated. The high risk of Cadmium is that the PTE is accumulated in the plant, but that is showing no visible toxicity effect and if the food chain is not controlled properly and frequently, than in some cases Cadmium easy go to consumers. In the context the 36/2006 FVM Degree, related to the placing on the market of soil improvers and yield enhancing substance, is already defining strict organic target contaminant maximum allowable limits since year 2006, such as:

- total PAH content (19 compounds) < 1,0 mg/kg organic matter
- benz(a)pyrene content < 0,1 mg/kg organic matter

The REFERTIL proposal for PAH16 in the FERTILIZER REGULATION revision is 6 mg/kg as maximum allowable limits in the EU28, for which the MS may apply for different lower value with justification in the new proposed system between 1 mg/kg up to 6 mg/kg levels, depending on the user risk assessment profile.

For manufacturing, import, placing on the market and using of all types of biochar products in the EU require mandatory Authority permits and certificates, such as:

1) Member State Authority permits for biochar production.

2) Member State Authority permit for biochar applications. Valid for issuing MS only. Mutual Recognition (EC 764/2008) procedure needs to be extended to other MS. EC 2003/2003 Fertilizer Regulation revision is under progress to include biochar, EC BIOCHAR valid for EU28.

3) REACH registration (in 2015 >10 t/y, from 2018 >1 t/y). The REACH Regulation (Regulation (EC) No 1907/2006) sets up a system for the Registration, Evaluation,

Authorisation and Restriction of Chemicals and established the European Chemicals Agency (ECHA) to implement the Regulation. The CLP Regulation (Regulation (EC) No 1272/2008) is the new European Regulation on Classification, Labelling and Packaging of chemical substances and mixtures. Biochar is also subject to REACH registration (under Article 6) for manufacturing, importing, using and/or placing on the market in quantities of 1 ton/year or more. The complex environmental/climate protection challenge and the high responsibility for biochar manufacturing, importing, supply, use and irrevocable soil applications; provides justified strict EU/MS regulations and legal/technical control on the biochar case. In this context the REACH registration is more than justified in all the biochar cases above 1 t/y capacity, that are chemically amended products with relatively large variability of composition. All biochar material manufactured or imported or supplied or used in quantities of 1 t / year or more, has to be registered under Article 6 of the REACH Regulation.

4) Extended Producer Responsibility certificate. Biochar producers having full, sole and extended responsibility for legally permitted production, product quality and safety. As biochar production is generating large amounts of potentially toxic pyro-oil/gas products and the production application is irrevocable, therefore producers full responsibility is key legal element above 1 t/y biochar import, manufacturing and placing on the market capacity.

Voluntarily biochar certifications have no any legal effects and validity in the EU. There is also a gap between the mandatory EU/MS regulations and voluntarily certifications in terms of the maximum allowable limits for PTE's potential toxic elements and organic contaminants, including the priority hazardous substance and biochar prime target pollutant PAH16, that is incorrectly defined by voluntarily biochar certifications as 12 mg/kg and 20 mg/kg, while in many MS the PAH16 limits are already between 1 mg/kg to 6 mg/kg since long time, even <1 mg/kg PAH19 since 2006. The occurrence of PAHs in biochar primarily derive from obsolete, low grade and inefficient pyrolysis condition, but in the plant based biochar cases also from contaminated and/or improper selected feed stocks as well. The plant biochar material may contribute high levels of PAHs to soil when the total PAHs concentration in the biochar product is high and/or when high application doses are applied to achieve the desired effect requirements. PAHs can be considered as the key organic pollutants and an indicator of biochar product quality.

REFERTIL BIOCHAR PERMIT MODEL RESULTS AND FOREGROUNDS:

The first European biochar national Authority permit under EU regulations has been issued in Hungary in 2009 under protocol number 02.5/67/7/2009 (applicant: Terra Humana Ltd./Edward Someus). The REFERTIL ABC BIOCHAR has been comprehensive and detailed evaluated by the Authority (National Food Chain Safety Office Directorate of Plant Protection, Soil Conservation and Agri-Environment) according to all the new and recent EU regulations after 2010, such as CLP Regulation (EC 1272/2008). The Authority consolidated and harmonized permit meet the past 5 years EU regulation changes and in line with the EU Fertilizer Regulation revision mandatory biochar standardization and law harmonization. The REFERTIL biochar 02.4/102-2/2015 permit is key technical and legal EU case, and is a real technical, legal and market break though for the biochar case in the EU. After careful and comprehensive investigations, the competent Authority upgraded the biochar permit. The REFERTIL biochar industrial production legal model – based on EU regulations - is registered under FES/01/0851-33/2015 permit for Terra Humana Ltd. in September 2015. This biochar permit model is also interlinked to EC2003/2003 Fertilizer Regulation revision; EC889/2008 and EC834/2007 for organic production and labelling of organic products; EC66/2010 Ecolabel and EC 764/2008 Mutual Recognition.

The compost group processed over 2000 tons of different types of materials to product over 600 tons of compost products treated for true value field demonstration and field testing of products in European dimension. The composts have been sent to the relevant partners in requested quantities for further testing (lab and open field trials).

The second object was the demonstration of BAT composting technologies in order to produce good quality end products under the protocols of JRC's End of Waste proposal for Compost and Digestate – Final Proposal. Outcomes and conclusions on improved compost technologies were defined in the frame of Deliverable report 8.4 and 9.4 (good practice guide for the composting technology). We have collected and laid down with together the compost group the suitable input material positive list in correlation with the end-of-waste which can go under composting regarding recommendation and standardisation of the improved recycling technologies and products. We have set out a frame for common quality standard requirements for composting treatment and for products. Furthermore detailed and comprehensive good practice guide was set up for the composting technology emphasising the occurring critical points. Finally it can be noted that we can produce safe, marketable, with high nutritive values compost products due to improved technologies which were developed and improved under the REFERTIL project.

The improved technologies were successful to perform composting process, producing hygienized compost according E-o-W microbiological requirements, with different positive results from the experimental configurations (use of static aerated technologies with positive or negative aeration, side walls of 0,75 m, membrane or semi-permeable covers, use of compost cover in thermophillic phase, different heaps sizes and configurations, etc). The improved compost technologies represent the evolution from the simpler windrow technologies, with improved process, al round year performing even in difficult weather conditions, improved control of odor and rainwater, but keeping the simplicity, the modularity and the flexibility to be adaptable to many different situations, existing or new projects. From economical point of view, these improved systems can be cost competitive with the closed or in-vessel reactor systems like tunnel, trommel or silo, that are much more costly in investment and overall operational costs.

Two laboratory experiments were set up regarding compost leach water and gas emission adsorption with bone char and plant based biochar adsorbents. The main goal of the experiments was to search for new procedures that how can different types of biochars affect the by-products of composting process. The leach water adsorption experiments showed that bone-char products (ABC) are great adsorbents to decrease many heavy metal concentrations in compost and MBH leach waters. As it was also remarkable from the results that mixing biochars (highly in the case of ABCs) with composts has a positive impact for ammonia adsorption during intensive phase of composting process. During the experiments we used special 80-litre adiabatic drum composting bioreactor which ensured satisfactory conditions for the control of the process.

POTENTIAL IMPACT

The REFERTIL project is an integrated applied science and industrial engineering project together for generating advanced S&T knowledge results and foregrounds, most importantly in the field of biochar and Phosphorus recovery. The REFERTIL converting science into legalized industrial practice for market competitive applications for the interest and benefits of the horticultural SME farmers in the low input and organic farming sectors, fresh fruit and vegetable Producer Organizations and gardeners. The most important REFERTIL result and impact is that the project removed all major barriers (scientific, technical, technological, economical process scale up, environmental, safety and legal) for EU/MS regulation relevant and legalized production, economical and ecological application of the industrial biochar and recovered Phosphorus in a safe and environmentally/climate sustainable way, while the removing of market barriers is targeted at post project exploitation level.

The project is contributing to the reduction of chemicals and mineral fertilizer use in agriculture, most importantly Phosphorus/Nitrogen and it will help to increase the amount of bio-waste diverted from landfill and recycled into the production process. The SME targeted project enhancing the proactive cooperation between applied science researchers, industry and relevant public sector stakeholders across Europe, it will also contribute to stimulating SME industrial innovation by improving the bio-waste treatment process and by improving the quality and safety of the final products (compost and bio-char).

The results and foregrounds of this project providing significant improvements for resource efficient recycling of agricultural and food industrial by-products by biochar specific pyrolysis technology and compost treatments while the use of biochar products opening new technical, economical and environmental opportunities for SME's, such as economical SME stimulance programme for long term. The project is particularly well promote a more efficient utilization of the biochar and compost final products by the end-users (farmers); studying and developing new application methods. In addition, the project will provide useful data, including economical viability information and scientific inputs, to support policy makers for the revision of relevant policies, with special focus on Fertilizer Regulation revision EC 2003/2003 and the Soil Thematic Strategy (COM(2006)231).

By REFERTIL policy support future common bio-waste recycling targets set up, the application of common quality standard requirements for bio-waste treatment, compost and bio-char quality and trading requirements, with the aim of increasing end-users and consumers confidence in their use in agriculture for food and feed production.

In this context, useful public new data provided such as economical viability and relevant EU/MS regulations relevant legal information for biochar production and applications. Clear understanding established for all stakeholders, especially for SME's and farmers, differentiated for different European climatic and economic area considerations.

The REFERTIL enhanced the proactive cooperation between stakeholders along with the full supply chain and 12 core partners, 30 associated partners and over 2000 stakeholders organized in contacting network. In this context end-users and consumers confidence increased in their use in agriculture for food production and pro active dissemination made for all stakeholders EU wide.

The main user benefits and unique selling points highlighted advanced biochar and compost products, such as:

(a) ABC Animal Bone bioChar organic phosphorus fertilizer with high concentrated Phosphorus content and porosity for target application in fruit and vegetable productions.
(b) Resource savings by substituting of Cadmium/heavy metal content phosphate fertilizers and fossil energy based Nitrogen fertilisers with natural phosphorous/nitrogen (made from food grade animal bone by-product) and different biochar with compost blends.
(c) Improve soil physical conditions increasing resistance to erosion, improving soil workability and water infiltration and water holding properties.
(d) Improve soil fertility and nutrient content.
(e) Increase soil biodiversity.
(f) Sequester carbon in the soil.

IMPROVED RESOURCE EFFICIENCY: The highest quality compost and biochar products are contributing the better use of the non-renewable resources. The production and use of compost and biochar from agri/food industrial by-products is supporting the wide up-take of the compost and biochar products by end-users and increasing the wide-European replacement of the non-renewable and energy intensive mineral fertilizers as well as maintaining the quality of EU soils. This is resulting:

(i.) Financial savings for citizen. One third of food brought by households becomes waste.

(ii.) Avoiding about 10 million tonnes CO2-equivalent emissions in Europe.

(iii.) Increased market for quality compost generating new and competitive economy.

(iv.) Improving 3%-7% of depleted agricultural soils in the EU and addressing the problem of degrading soil quality in Europe (45% of EU soil lack humus).

(v.) The most significant benefits of improved bio-waste management would be avoided emissions of greenhouse gases, which would translate into significant societal gains when compared to any additional costs.

(vi.) The management of bio-waste better with the waste hierarchy and other provisions of the WFD could result in environmental and financial benefits.

(vii.) Stronger markets for compost create a a direct financial benefits for SME’s, farmers and EU households by preventing food waste.

(viii.) The setting up quality and application criteria can pro-actively support the application of biochar and compost product and accelerate the market growth.

(ix.) The project results will contribute to the full implementation of the Landfill Directive's diversion targets and other provisions and continuing to move waste flows away from landfill.

(x.) Job creation potential: The waste management and recycling sector has a high growth rate. It is labour-intensive and provides between 1.2 and 1.5 million jobs. Preventing waste generation and promoting recycling and recovery of waste will increase the resource efficiency and creating new jobs for the European economy and reduce the negative environmental impact of use of natural resources.

The ABC innovation is recovering organic Phosphorus from renewable and pure animal biomass resulting pure and renewable organic P-fertiliser products (that are excess available in economical industrial scale). In contrary, the chemosynthetic fertilisers are extracted from non renewable rock phosphate (EU is relying on 95% import today). The natural characteristic of the P-rock is the high Cadmium and Uranium contamination with U concentrations ranges from less than 10 to more than 360 mg/kg. . During P-rock processing the radionuclide U and other radionuclide heavy metals become enriched in the P fertiliser to

about 150 % of the original concentration of the rock phosphate. The U content of P-fertilisers increases with an increasing P2O5 content of the product. Fundamental changes in global rock phosphate markets are threatening the competitiveness of the whole European food industry and the sustainability/vulnerability of the food security which is an important social and economical challenge.

Approx. 1.4 million t/y P2O5 P-fertilizer imported to Europe (from Morocco, Tunisia and Russia) - COM (2013)517, COM (2011)25, INRA 2014 P Markets- for which the ABC already in medium term and realistically having <20% substitution potential in the EU. Substitution of energy intensive P-fertilisers with recovered ABC is contributing to EU 2020 TARGETS: greenhouse gas emissions 20% lower (vs. 1990), 20% of energy from renewable, 20% increases in energy efficiency.

The ABC innovation is addressing to:

(a) Food security and sustainable agriculture: substitution of mineral fertilizers and chemicals with recovered phosphorus organic fertilisers: - The recovered ABC Phosphorus meet the world's food demand increase as food production is dependent on the efficient use of P-nutrient. The pressures on natural resources increasing, such as the rapid decline of the non-renewable phosphorus resources, which is listed on the EU critical raw materials list (COM(2014) 297 final). Reduce greenhouse gas emission targeted in the agriculture by substitution of energy intensive synthetic phosphorus fertilizers with recycled phosphorus, also the improvement of food management to reduce food waste by 50 % by 2030. ABC innovation is recovery and recycling significant quantities of phosphorus from food production (category 3 bone).

(b) Secure, clean and efficient energy: making a technological shift in the area of phosphorus fertiliser production: bringing new high-performance, low-carbon and energy efficient phosphorus recycling/recovery technology to the European markets quicker through collaboration at EU level.

(c) Climate action, environment, resource efficiency and raw materials: the phosphate rock is listed as critical raw material as of risk of supply shortage, high difficulty the substituting and impact on economy is higher than other raw material. Reducing Europe's dependency on imported rock phosphate raw material and reinforce its position by recycling of phosphorus from food industrial by-product, category 3 bone grist. ABC is recovered phosphorus and a renewable Phosphorus source that can substitute the increasingly scare mineral phosphates. Efforts will be made to develop a low-carbon, resource efficient phosphorus recovery economy. Food waste has been selected as particular priorities, on the grounds of their substantial potential for business opportunities and job creation while tackling important resource efficiency challenges.

THE MAIN DISSEMINATION ACTIVITIES

The dissemination activity of the REFERTIL project truly demonstrated advanced S&T innovation capacity and ability to convert science into legalized industrial practice in the field of biochar and compost. The new knowledge, especially on biochar, strengthened the competitiveness and growth while met the needs of European and global markets; and contributed to deliver REFERTIL innovations to the markets.

The REFERTIL biochar dissemination and exploitation measures help to achieve the expected impacts of the project and address the full range of potential users and uses including applied research, biochar technology and product commercialization under market competitive conditions, investment, social, environmental, policy making, setting standards, skills and educational training.

The REFERTIL approach to innovation is comprehensive and tailored to address the specific biochar and P recovery scientific knowledge, technical, market and organisational issues for the interest and benefits of the SME farmers.

Extended Electronic media dissemination were developed and executed. An English language REFERTIL project web site (www.refertil.info) developed (P1-TERRA) for the public presentation of the project; its concept; activities; results, recommendations and established a global networking that open many new opportunities. The website has increased visibility (picture galleries, videos) and continuously improved during the project lifetime and will be continues after the project end as well. The joint REFERTIL topic website in English project has already been interlinked with several other FP7 projects. The project website has been linked to the important online social networks (Facebook, Google+, Twitter, LinkedIn). These online social medias were used for informing the wider public community and REFERTIL stakeholders about the REFERTIL project, REFERTIL conferences, open-days and workshops. Specific sections were dedicated to SME farmers, decision makers, biochar standardisations, Refertil Surveys. In the Event calendar the most important local workshops, open days and international conferences were highlighted.

The main project web (refertil.info) site has direct links to specific established websites on all partners own web sites (12 national project websites). These national websites were in the national language designed and adapted to national conditions to efficiently inform and attract national stakeholders.

A REFERTIL multilingual SME web portal platform (refertil.info/sme) developed (P1-TERRA) specifically targeting SMEs and farmers for informing on biochar activated compost REFERTIL technology in practice. The REFERTIL SME platform operating on 8 languages (English, German, French, Italian, Spanish, Portuguese, Danish and Hungarian).

REFERTIL consortium published 9 REFERTIL newsletters presented the project activities and results. The specific "REFERTIL-designed" newsletters has been prepared, made and published by P1-TERRA. P1-TERRA also prepared the national language translated newsletters based on the translation input received from the consortium partners. The newsletter published electronic and also physically located on the REFERTIL project web site. The REFERTIL newsletter subscription facility was integrated to the REFERTIL webpage. REFERRTIL partners were circulated all REFERTIL newsletters in their local networks.

7 REFERTIL films have been uploaded on the REFERTIL website. The activities of REFERTIL project has also been disseminated in several other websites and databases,

most importantly on the website of the Cost Action Biochar, SCOPE newsletters of the European Sustainable Phosphorus Platform.

The REFERTIL consortium made intensive written dissemination activity.

In this context 3 REFERTIL pamphlets have published: intro pamphlet v1.0 (P4-VFL), revised and imrpoved intro pamphlet v2.0 (P1-TERRA) and Final pamphlet (P1-TERRA). National languages translation have been managed by the Refertil consortium, final edition made by P1-TERRA. Translation to the national languages have been managed by the REFERTIL consortium partners, final edition made by P1-TERRA.

REFERTIL Partners have been distributed the printed version of the REFERTIL pamphlet/national translated pamphlets on conferences and organized workshops/open-days.

The scientific partners have been focused on the publication of their research results through papers for periodicals, conferences and national/regional farmer magazines. Altogether 11 scientific publications prepared by P2 DLO (2), P3 AU (4), P5UNITO (3), P6 LUH (1), P7BGU(1).

The REFERTIL partners prepared 26 conference papers in proceedings of a Conference/Workshops: P1 TERRA (8), P2 DLO(2), P3 AU (2), P5 UNITO (13), P7 BGU (1).

2 specific REEFERTIL presentation abstract booklets have been published (edited by P1TERRA) presenting 22 REFERTIL presentation abstracts presented by the Consortium on the Compost and Biochar Safety, Economy and EU aw Harmonization Conference (Brussels, Belgium) and Advance Compost and Biochar Processing International Conference (Toledo, Spain).

REFERTIL partners presented their results on posters. Altogether 65 poster presentations made by P1 TERRA (17), P2 DLO (3), P3 AU(3) P4VFL(3), P5UNITO(18), P6LUH(2), P7BGU(5), P9WESSLING(4), P11 KOTO(5), P13RBL(1), P14 PROFIKOMP(4).

The REFERTIL project disseminated in 1 Euronews TV Clip on 13 different languages. 2 Interviews made in Hungarian news channel "HIR TV", 1 report on Ozone network (small Hungarian TV channel) and 1 radio report on the biggest Hungarian national radio channel.

The results of the REFERTIL project also presented in 4 innovation catalogues.

Altogether 17 articles published about the REFERTIL project in professional agri journals/magazines/websites: P1 TERRA (4), P2 DLO(6),P4VFL(3), P9 Wessling in copperation with P1TERRA (4).

The REFERTIL partners also made 19 press releases: P2DLO(2), P3AU(1), P4 VFL (2) P5UNITO(2), P7 BGU(3), P11 KOTO (2), P12 GRUGLIASCO(6), P14 PROFIKOMP(1).

In addition to the above mentioned press releases P1TERRA and P9 WESSLING made one large joint media campaigns followed the Hungarian project closing conference (25 September, 2015, Kajaszo, Hungary): 1 cover page article in Hungarian daily Newspaper,1 large national news agency publication (MTI (Hungarian News Agency) a very important governmental agency published about the project), 31 governmental and private media used the "MTI" reference article for secondary publications.

P9 WESSLING made 3 additional media campaigns.

The REFERTIL consortium made intensive person-to-person dissemination activity.

Altogether 3 REFERTIL conferences organised in Hungary (P1-TERRA, P9-WESSLING), Italy (P5-UNITO Agroinnova) and Spain (P7-BGU) towards the SMEs and public stakeholders:

In Hungary a REFERTIL project closing conference titled "Bioszen, a mezogazdaság uj csodafegyvere" has been organised (P1-TERRA) on 25 September, 2015, in Kajaszo – 3R BIOFARM, Hungary. The patronage of the Conference has been accepted by Dr. Marton Oravecz, President of the National Food Chain Safety Office (Hungarian Authority responsible for authorizing organic fertilizers and soil improver products). On the conference P1-TERRA and P9-WESSLING presented the results of the REFERTIL project to the Hungarian stakeholders and potential investors. The conference has been closed by large joint media campaigns co-organized by P1TERRA and P9 WESSLING. As results of intensive communication activities towards the stakeholders and Hungarian media a very extensive media reply was recorded: 1 article published in the header page of large Hungarian daily newspaper and 1 large national news agency (MTI (Hungarian News Agency - governmental news agency) also published a news highlighting the large potential impact of REFERTIL project for a wide European community. Altogether 31 governmental and private electronic media used the "MTI" reference article for secondary publications.

For the Italian stakeholders a REFERTIL Italy Conference and Open Day was organised by P5-UNITO on 19 September, 2014 in Torino, Italy. The REFERTIL consortium made 7 oral presentation by P1TERRA, P4VFL, P7BGU, P9WESSLING, P5UNITO, P12GRUGLIASCO. During the event the REFERTIL project has been presented, together with the policy support activities and discussed economical and environmental advantages and disadvantages related to the production and use of compost and biochar. After the event open day held, the REFERTIL experimental trials, located at the Centre Agroinnova and farms, were visited and discussed the potential use of compost and biochar as an organic fertiliser and soil improver products.

Large international conference has been co-organised by P1-TERRA and P7-BGU titled "Advanced Compost and Biochar Processing: Solution for Economical Phosphorus Recovery" on 17-18th September 2015 in Toledo, Spain. The REFERTIL consortium made 10 oral presentations (P1TERRA, P9WESSLING, P5UNITO, P4VFL, P7BGU, P14 PROFIKOMP, P6LUH, P2DLO) International speakers also presented their results on the area of recycling of nutrients. Dr. Eric Liegeois, European Commission DG Grow, made a video Conference presentation on the ongoing revision of the Fertiliser Regulation. The abstract of Conference presentations published in REFERTIL abstract booklet. The Conference was priority aimed to representatives from state, regional and local administrations, research centers and universities, recycling and fertilisers companies, and representatives from farmers SMEs and farmers unions.

One Joint REFERTIL-FERTIPLUS project conference has been co-organised by the FP7 REFERTIL and FP7 FERTIPLUS Consortium on 23 June, 2015 in Brussels, Belgium. The REFERTIL consortium made 12 presentations (P1 TERRA (4), P9 WESSLING, P5 UNITO, P3 AU, P4VFL, P11 KOTO, P2DLO, P6LUH, P7 BGU) REFERTIL presentation abstract booklet has been prepared with the abstract of oral presentation made by REFERTIL team: The morning session highlighted the results and key messages of the projects on the use of urban and agricultural and industrial organic wastes as a source of recycling valuable nutrients to agriculture. Series of 8 short and focused presentations in a plenary session

highlighted the results on both composting and biochar production and field trials and how to bring value to agriculture. The afternoon session offered parallel sessions with more detailed results and Q&A based interactions between the audience and members of the Refertil and Fertiplus consortium. This part closed with a roundtable discussion in a forum were setting with experts from EU, both projects and selected stakeholders. They discussed the projects implications for policy and practitioners and comment on innovative approaches and policy options for promoting beneficial management practices.

The REFERTIL partners organised 33 national REFERTIL open days and field trips.

In Hungary P1-TERRA organised 6 events in Polgardi for demonstrating the ABC biochar technology and 5 agri open days in Kajaszo. P9 Wessling organised 3 events, one for the National Food Chain Safety Office's soil testing laboratories. This open days had a special significance in terms of the dissemination of REFERTIL project in Hungary, as NÉBIH is the authority. P9-Wessling presented their accredited biochar analysis works. P14-Profikomp organised 4 compost related events for demonstration of the composting technology operation.

For the Danish stakeholders P4 VFL organized 2 events.

In Italy P5 UNITO organised 7 open days and field trips for demonstrating use of compost and biochar in greenhouse on potted plants. Field trip to farms involved in REFERTIL the project has been visited.

In Germany P6 LUH made 1 open day. In Slovenia P11 KOTO organised an open day and workshop for presentations of trial, test field, strawberry cultivation.

For the Spanish stakeholders P7-BGU organised 4 open days and field trips where Compost BATs demo trials have been visited.

The REFERTIL Consortium organized 30 regional workshops. P1 TERRA organized 6 regional biochar related workshop in Hungary and 1 in Poland. P2 DLO organized 4 regional workshops to Dutch stakeholder in the area of role of organic matter and microbial enrichment. In Denmark P3 AU organised 3 and P4 VFL 3 regional workshops coonected to their filed trials.

In Italy 7 workshops organised by P5 UNITO for presenting the of use of compost and biochar. P7 BGU organised 3 regional workshops in Spain, and P14 Profikomp 3 regional workshops in Hungary presenting the results of the improvements of the composting technologies. P4 VFL also presented REFERTIL results on meetings with delegations (7).

P12 Municipality of Grugliasco organised 7 REFERTIL public events.

Altogether 17 seminars and trainings has been organised by P2DLO (7), P3AU(1), P5UNITO(2), P6 LUH (5), P11 KOTO (2)

The REFERTIL Consortium made 70 oral presentations on international conferences: P1-TERRA(19), P2 DLO(8), P3AU(15), P4 VFL(3), P5 UNITO (12), P6 LUH (2), P7 BGU (2), P9 WESSLING (3), P11 KOTO (5), P14 PROFIKOMP (1)

In connection to the conferences the REFERTIL partners prepared 26 conference abstract papers: P1 TERRA (8), P2 DLO(2), P3 AU (2), P5 UNITO (13), P7 BGU (1).

2 specific REEFERTIL presentation abstract booklets have been published (edited by P1TERRA) presenting 22 REFERTIL presentation abstracts presented by the Consortium on the Compost and Biochar Safety, Economy and EU aw Harmonization Conference (Brussels,

Belgium) and Advance Compost and Biochar Processing International Conference (Toledo, Spain).

Four (4) EC fertilizer regulation revision policy support REFERTIL workshops organised in Brussels with European Commission , DG Enterprise and Industry on November 13, 2012; April 25, 2013; June 17, 2013; and on October 11, 2013. REFERTIL Consortium presented their policy supporting activities to the Commission.

Meetings with relevant bodies and develop true value legal cases has been an important part of the REFERTIL policy activity for modelling and legal demonstration of biochar permit case. P1 TERRA met and consulted with 7 Authorities and authority experts discussing the industrial production Authority permit case of REFERTIL ABC biochar in Hungary. The REFERTIL partners also organised meeting with their national Authorities, including discussion about Mutual Recognition according to EU regulations.

UK specific dissemination programme has been managed throught the EU BIOCHAR COST Action TD1107 and European Biochar Research Network eBRN dissemination programme past years.

THE EXPLOITATION OF RESULTS

The REFERTIL is a result and impact oriented TRL8 Technology Readiness Level maturity demonstration and model reference according to the Commission Decision C(2013)8631 new rules to addresses the entire innovation chain for identification and definition of research status progress level. By reaching TRL8 the REFERTIL reached the end of true “biochar system development” for all major biochar technology and end-product elements. In this context the preparation is completed for post project TRL9 deployment, competitive manufacturing, industrial replication model and achievement of BAT/BREF. This is a prepared biochar road map from lab to industry and to market, where the REFERTIL post project time implemented TRL9 is the “biochar research mission completed” endpoint.

TRL9 is the only credible and ultimate demonstration for users and market players that provides clear and transparent evidence for the past years research results and foregrounds achieved, related to REFERTIL biochar technological, economical and market viability under market competitive commercial conditions.

The REFERTIL BIOCHAR is a knowledge and capital intensive leading key enabling green technology in the fields of recovered Phosphorus materials; biochar production technology/equipment and product manufacturing; and agro biotechnology with cut across many industrial, agricultural and environmental sectors.

The REFERTIL exploitation of results efficiently made through implementation of the TRL9 industrial replication model and BAT/BREF in 2016, consisting of:

(1) BAT/BREF TECHNICAL REFERENCE: implementation, build and operation organization of an 20,800 t/y throughput capacity Phosphorus recovery plant, for production of 12.500 t/y ANV Animal Bone bioChar with 30% P2O5 from 2017. This replication model technical reference for advanced 3R pyrolysis technology is based on the integrated EU, Australian and US industrial and environmental norms and standards application together as global reference. The replication is build on modularisation and mass-customisation.

(2) BAT/BREF LEGAL REFERENCE: management and maintenance of EU/MS Authority permits and REACH registration.

(3) BIOCHAR END-PRODUCT VALIDATION COMMERCIAL REFERENCE: two years large scale field tests for formulated ABC in Italy, France, Germany, Austria, Hungary, Australia and USA for farmers “show me” demonstration. All ABC product application to evaluated and follow up as “farmers case” reference.

(4) MARKETING, SALES and INVESTORS RELATION:

(a) Customized and standardized ABC product and service marketing and distribution network build up for the production deliveries from the replication model that is generating proven sales track records that is important demonstration of the business viability for the investors.

(b) Development of industrial symbiosis and business integration, including setting up a complex system of input supplying and output using firms.

(c) Business model planning for international expansion; including development of IOI Investment Opportunity Information, IPO Investment Proposal Offer, possible interconnection to LSE, ASX or NYSE, licensing, franchising and build and operation business models,

(d) From year two preparation of global expansion, targeting set up of five replication models before 2020 in Italy, France, Germany, Australia and USA.

(5) TRAINING & EDUCATION: on-site training and education of biochar stakeholders at different knowledge and interest levels, including organization of awareness campaigns. This is an important business process replication element with combination of global marketing.

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