Algemene gegevens	
TKI-projectnummer	AF-EU-13009
Titel	BioEcoSIM
Topsector en innovatiethema	A&F
Projectleider (onderzoek)	Volkert Beekman
Werkelijke startdatum	01-10-2012 (vanaf 2013 t/m 2016 EU cofin
Werkelijke einddatum	Project was verlengd tot 31-12-2016 Project
Korte omschrijving inhoud	Wageningen Economic Research is the leader of WP7 (Integrated sustainability impact assessment) and is as such primary responsible for verification, using an approach based on ISO 14040 and 14044, of the economic, environmental and social sustainability of the BIOECOSIIM process.

Uitvoerende partijen	
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Overige partijen	• DOFCO BV (953413583) • ASB GRUNLAND HELMUT AURENZ GMBH(953432110) • YFLOW SISTEMAS Y DESARROLLOS SL(986576816) • JACEK SLIWKA GOSPODARSTWO ROLNE(953426775) • BIOCOMPOSTAJES ESPANOLES SL(953096490) • AGRO ENERGIE HOHENLOHE GMBH & CO KG(953382931) - BENEFICIARY • ATEKNEA SOLUTIONS CATALONIA, SA(999506237) GELTZ UMWELTTECHNOLOGIE GMBH(973010493) • HECKMANN MASCHINENBAU UND VERFAHRENSTECHNIK GMBH(983542462) • Initial Projects Limited (98534433) • OWS VERWERTUNGSMANAGEMENT GMBH(950904581)

Resultaten en deliverables	
1. Welke deliverables zijn opgeleverd, en is dit conform het projectplan? (geef een	**D 7.1 Environmental sustainability report** This task addressed and established the goal and scope of the study, including the definition of the functional

korte beschrijving per deliverable uit het projectplan)	units, system boundaries, product systems (reference flows) and allocation procedures. The goal is to assess impacts (environmental, economic and social), related to livestock manure and the use of fertilisers, applicable to state-of-the-art (SoA) and BIOECOSIM innovations. In other words, the goal is to compare the BIOECOSIM system with the conventional SoA system. The task will establish a benchmark of good SoA practice but will also consider variance in operational terms. It will focus on economic sustainability: capital and operating costs (e.g., energy, materials, labour), allowing for reasonable depreciation of capital, appropriate allowance for maintenance, and investment risks within operational costs (start-up, shut-down and cleaning). These boundary conditions, once established, will be kept constant for the duration of the project but will be redefined in case of unexpected developments. **D 7.2 Economic sustainability report** This task will involve the collation of data about the various aspects included within the study, ranging from energy consumption to material usage and capital investments. This will be used to generate a detailed model - using SimaPro with publicly available LCA databases and MAMBO and STARS with FADN and Eurostat data – to compare the BIOECOSIM process with published studies and ongoing assessments of different manure processing technologies. This data collection strategy recognises that the current situation on – regulation of – the manure market in European regions with high livestock densities is highly diverse. Therefore, the project partly works with calculating case studies and developing estimations on the basis of these case studies for generic impacts on a European level. The task includes the organisation of multi-stakeholder workshops to develop, social, environmental and economic benchmarks against which the BIOECOSIM process can be validated. The individual elements of the model will then go through a further intensive validation process. First, a crude and simple LCC model will be generated using Excel. This model will then be continuously fed with data from the development work, and will be reviewed by the consortium participants through a series of LCC workshops. Through a series of iterative feedback loops the model will mature as the process matures, ensuring that the consortium is aware and responsive to the full social, environmental and economic relevance of their decisions. As adjustments to the process are made in response to this feedback, corresponding adjustments will be made to the model and reported. As with all other project activities, when local resources will execute assessments and engage in discussions between project participants (e.g., LCC workshops), this activity will make use of teleconferencing facilities and other forms of electronic communication rather than formal face-to-face project meetings to minimise economic and environmental

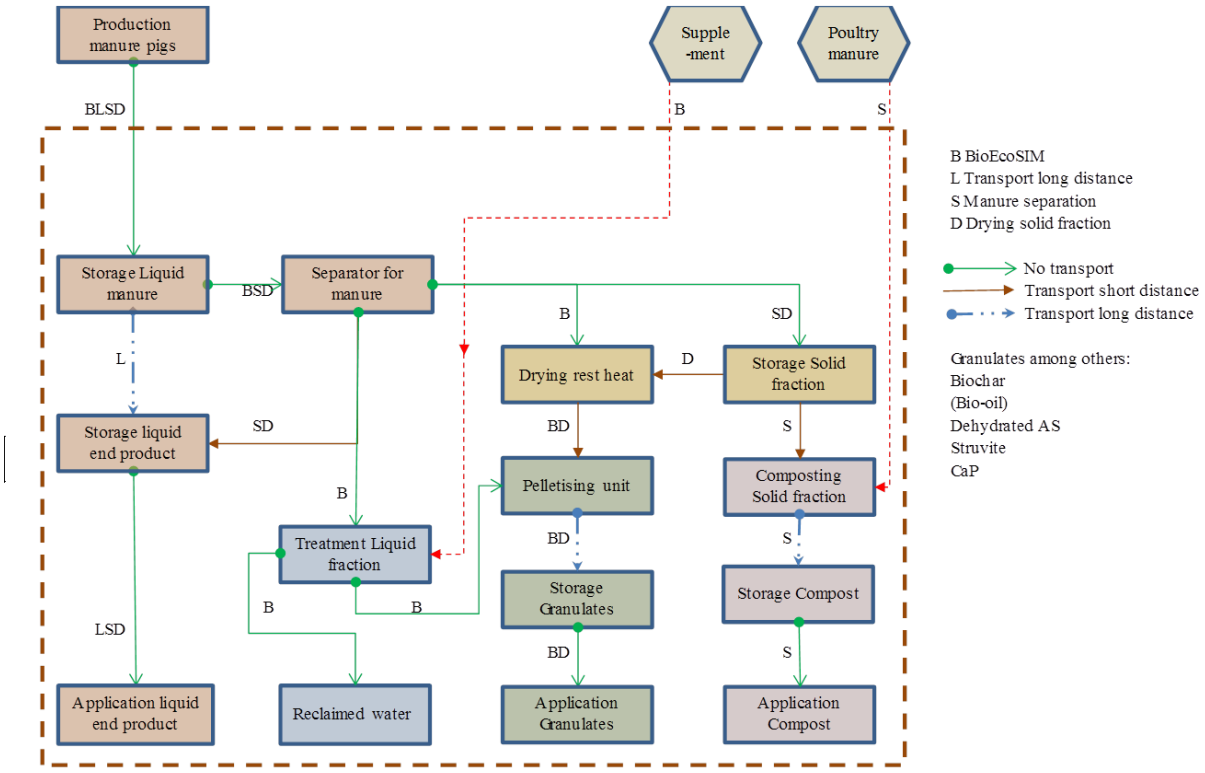
	impacts of the project. **D 7.3 Social sustainability report** In this task, the impacts on the various factors included in the social, environmental and economic system viability assessment will be compared against the benchmark with state-of-the-art as based on data scoped, collated and modelled in the previous tasks 7.1 and 7.2. In the environmental impact assessment, we will analyse energy use (including non-renewable energy use and renewable energy use) and a selection of the SimaPro's ReCiPe methodology impact categories, including: Climate change: human health and ecoystems; Particular matter formation; Terrestrial acidification and freshwater eutrophication; Terrestrial and freshwater eco-toxicity. In the economic impact assessment, we will analyse net present value (including time discounting) and a selection of cost-benefit analysis (CBA) categories, including: Production cost; Payback time; Investment risks for early adopters; Investment risks of unsuccessful innovation. In the social impact assessment, we will analyse societal acceptability (including variance among stakeholders) and selection of social return on investment (SROI) categories, including: Working conditions Health and safety Governance Socio-economic repercussions **D 7.4 Integrated impact assessment report** This task will be a thorough analysis of all major results of the separate assessments in Task 7.3. It will seek clear evidence of the reduced life cycle impacts of the proposed BIOECOSIM technology as compared to state-of-the-art and the potential of this technology for wider post-project implementation. Moreover, the task will identify environmental hotspots and recommend improvement opportunities in the early stages of product design. The challenge of this task is to combine the separate assessments in Task 7.3 into an integrated 3P (people, planet, profit) impact assessment that balances social, environmental and economic sustainability of the BIOECOSIM technology. This requires using a multi-criteria decision-making model (MCDM) that includes minimum baselines or thresholds for all three sustainability dimensions. Such an integrated sustainability impact assessment framework is under development in EST-Frame (SiS.2011.1.1.1-4). This project, in which
2. Indien bepaalde deliverables niet gehaald zijn, wat was daarvoor de reden?	-

3. Heeft het project onverwachte (neven)uitkomsten opgeleverd, die vooraf niet waren voorzien? Zo ja, benoem deze.	Nee
4. Op welke wijze is over het project en de resultaten gecommuniceerd	The dissemination of knowledge was conducted by all the BioEcoSIM partners from multiple activities. These included seminars, presentations, conferences, exhibitions and publications. BioEcoSIM video was shot at the locations of AgroEnergie and University Hohenheim. The video is located on the BioEcoSIM project website, Fraunhofer's YouTube channel and consortium partner's websites. The BioEcoSIM Demonstration Day at was held at AgroEnergie in Kupferzell, Germany on 14th June 2016. The event was attended by over 100 stakeholders from industry, agriculture, research and policy. There were participants from 7 European countries including Germany, France, Holland, UK, Spain, Belgium, and Austria. Stakeholder workshops were also held during this event to gain input from key players.
5. In hoeverre heeft het project bijgedragen aan de ontwikkeling van de betrokken kennisinstel-ling(en)? (bijv. wetenschappelijk track record, nieuwe technologie, nieuwe samenwerkingen)	**Technological development:** It targets to develop and demonstrate a resource and energy efficient pilot plant for the continuous conversion of wasted livestock manure to: (i) valorise manure into pathogen-and antibiotic-free biochar and mineral fertilisers (ammonium sulphate, calcium phosphate and struvite) supporting the production of food and other bio-based raw materials; (ii) reduce negative environmental impacts in intensive livestock regions; (iii) help to decrease ammonia (NH3) produced by the energy-intensive Haber-Bosch process for manufacturing N-fertilisers; (iv) mitigate EU's dependency on depleting mineral sources for P-fertilisers; (v) increase water efficiency in agricultural use; and (vi) generate economic benefits for farmers through the sales of electricity generated from syngas and fertiliser products. **Award** The project BioEcoSIM has been awarded with the Ivan Tolpe price from the Flemish coordination centre for manure processing (VCM) for the best innovation in manure treatment
6. Krijgt het project een vervolg in de vorm van een nieuw project of een nieuwe samenwerking? Zo ja, geef een toelichting.	Environmental, Economic and Social Impact assessment methodology will be used in following projects.

Highlights

1) Description of the main Science & Technological results/foregrounds

Impacts of an innovative manure management technology BioEcoSIM have been compared in the integrated sustainability assessment with three existing state-of-the-art manure processing systems: long distance transport; manure drying; and manure separation:



The comparative sustainability impact assessment also considered the alternative setup of BioEcoSIM without pyrolysis and with soil improver rather than biochar as product from the solid fraction processing.

The environmental impact assessment showed that BioEcoSIM with biochar production has the lowest net environmental effect. The environmental impacts of BioEcoSIM with biochar, and also of BioEcoSIM with soil improver, are substantially lower than of other state-of-the-art manure processing systems. Long distance transport of manure has the highest environmental impact, whereas manure drying and manure separation have comparable intermediate environmental effects. The environmental impacts per ton processed manure of the other manure processing systems, and of the BioEcoSIM process with production of soil improver, deteriorate with a higher dry matter content. Therefore, from an environmental perspective the BioEcoSIM process with biochar production is especially attractive when manure with a relatively high dry matter content is available. It should however be noted that both BioEcoSIM processes have a lower environmental impact compared to other state-of-the-art systems at both a 3%, 6% and 9% dry matter content. BioEcoSIM contributes especially to reducing climate change, eutrophication, acidification and particulate matter formation. However, fossil energy use of the BioEcoSIM process is higher compared to the three state-of-the-art systems due to the higher use of electricity and natural gas. Also human toxicity effects of BioEcoSIM are less positive compared to other manure processing systems, due to the use of chemicals.

The economic impact assessment showed that both BioEcoSIM systems give the lowest costs per ton raw manure. When soil improver instead of biochar is produced, the results are slightly better. No treatment of the manure, only long distance transport, gives the

highest costs per ton raw manure. The BioEcoSIM systems achieve net sales of the end products and are competitive on net costs (costs minus revenues) at disposal prices of raw manure of €15/ton or more. The costs per ton raw manure of the compared processing technologies are not that dependent on dry matter contents. The BioEcoSIM processes are slightly more expensive per ton raw manure, but not per kg phosphate, at higher dry matter contents due to costs for energy and supplements. The costs for manure drying and separation are by contrast a little lower at higher dry matter contents. The total investments for the BioEcoSIM processes are the highest, although the difference with the other systems is limited without pyrolysis and biochar production. The BioEcoSIM process needs much more energy for drying of the solid fraction into soil improver. If biochar is produced from the soil improver, the energy use will be somewhat lower because bio-oil and syngas produced during pyrolysis can be used elsewhere in the process and thus save external energy. Bigger sized BioEcoSIM plants might bring economic advantages, because of economies of scale and upscaling can thus be an interesting perspective.
The social impact assessment showed that citizens' knowledge about manure processing is fairly limited. Even within high density livestock areas in Europe few citizens are familiar with manure processing. The majority of the population in the studied regions that at least heard about manure processing has a positive predisposition towards manure processing, and this picture is rather similar across Europe. At the same time small minorities exist in all regions with a negative predisposition towards manure processing. These minorities would actively oppose manure plants, if they were built close to their houses. This even holds true for small plants and at the farm to better fit the countryside. The overall perception of the BioEcoSIM pilot plant is that it is environment-friendly and better aligned to people's associations with manure processing. Net energy recovery is regarded as positive, whereas clean process water (free from antibiotics) would add to its environment-friendly appearance. Thus, the BioEcoSIM system has good opportunities for social appreciation with farm-scale plants, limited regional transports and substantiated environment-friendliness claims but the threat of minorities mobilising protest always exists without sufficiently working on good relations with local communities.
The integrated sustainability impact assessment of BioEcoSIM in comparison to three other state-of-the-art manure processing systems resulted in a somewhat mixed message. The BioEcoSIM systems perform better in both environmental and economic terms than long distance transport, manure drying and manure separation. However, the BioEcoSIM system with pyrolysis performs modestly better in environmental terms, whereas the system without pyrolysis performs modestly better in economic terms. Other things being equal, societal appreciation tends to follow the environmental impacts in a preference for the BioEcoSIM system with pyrolysis.

2) Description of the potential impact, including the socio-economic impact and the wider societal implications of the project so far, and the main dissemination activities and the exploitation of results
The BioEcoSIM project has delivered two innovative manure processing technology prototypes, with biochar and soil improver as products from solid fraction processing respectively. Valorisation of either of these two prototypes needs follow-up on this proof-of-principle in terms of business model generation. The BioEcoSIM prototypes bring a biorefinery perspective to manure processing that aims to valorise the single components in raw manure on agricultural and non-agricultural markets and thus contributes to a sustainable circular bioeconomy in Europe.
Liquid fraction processing in both BioEcoSIM prototypes delivers products (ammonium sulphate and P-salts) with obvious agronomic value, whereas these products could also be mixed with the product from solid fraction processing without pyrolysis into a soil improver with a nutrient composition tailored to the agronomic needs of customers. Biochar as product from solid fraction processing with pyrolysis initially also promised to have agronomic value but state-of-the-art knowledge suggests that the soil-improving qualities of biochar are less convincing for (rich) soils in Europe. Since biochar

production is very relevant for climate change mitigation policies, customers might be found on non-agricultural markets to valorise the (water-)binding properties of biochar for, e.g., use in the building sector, decontamination, waste and drinking water treatment. Livestock farmers could build on existing relationships with other actors in the agricultural sector for the valorisation of (mixtures of) ammonium sulphate, P-salts and soil improver as products of the BioEcoSIM systems of manure processing. The fertiliser industry as incumbent player needs to be faced as a competitor on that agricultural market. Valorisation of biochar would require building novel relationships with customers on non-agricultural markets to identify their specific needs. The two BioEcoSIM prototypes could best be applied in small-scale plants for either an individual farm or as a cooperative of several neighbouring farms within a rural region to reduce short distance transport of the raw manure. Shrinking the volume of the solid fraction is pivotal to reduce long distance transport of the products of the BioEcoSIM systems. Further market analysis is needed to reduce remaining uncertainties about market prices of in particular biochar but also other products from BioEcoSIM manure processing. The BioEcoSIM prototypes save costs on disposal of the relatively clean process water after liquid fraction processing but this advantage comes at the price of relatively high investment costs. Uncertainty reduction about market prospects for the products of the BioEcoSIM systems is therefore also pivotal in view of investment risks.
The initial separation step in the BioEcoSIM manure processing systems could be done with either a decanter or a screw press. Since these two different separation technologies have a considerable impact on the percentage of nutrients ending up in liquid and solid fraction respectively, it is critical making a considered choice between these two technologies. A critical issue for the BioEcoSIM prototypes is energy supply for the drying step in solid fraction processing. Replacing fossil energy input with some sustainable source of energy (e.g. biogas, solar or wind energy, waste heat) would have a favourable impact on both environmental and economic sustainability of in particular the system without pyrolysis. Furthermore, it is critical to either ensure a skilled work force to operate the technologically advanced BioEcoSIM systems or to reduce the need for skilled labour through the application of remote control technologies. It could make sense to apply the technologically advanced BioEcoSIM systems in a medium-sized cooperative plant located on, e.g., a regional biopark to benefit from the economies of scale and avoid handling of chemicals in liquid fraction processing at farms in the countryside.

Aantal opgeleverde producten			
Wetenschappelijke artikelen	Rapporten	Artikelen in vakbladen	Inleidingen/ workshops/ invited lectures
	D7.1 D7.2 D7.3 D7.4		-Harry Luesink, Co Daatselaar, Edward Smeets: 'Quick scan Economic & Environmental Impact manure processing systems'; :International conference on manure management and valorization, 5-6 December, Belgium -Demonstration days -Stakeholder workshops

Bijlage: Titels van de producten of een link naar de producten op een openbare website
http://www.bioecosim.eu/

Link naar Kennisonline:
http://www.wur.nl/en/project/BioEcoSim-1.htm