Algemene gegevens	
PPS-nummer	**BBE 1610 - BTG**
Titel	Lignin2Fuels
Roadmap	Chemische conversie
Uitvoerende kennisinstelling(en)	BTG Biomass Technology Group BV RijksUniversiteit Groningen
Projectleider onderzoek (naam + emailadres)	dr ir RH Venderbosch venderbosch@btgworld.com
Penvoerder (namens private partijen)	BTG Biomass Technology Group BV
Contactpersoon overheid	
Startdatum	1-9-2017
Einddatum	31-1-2021
Korte omschrijving inhoud (max. 4 regels)	Lignin2Fuel is het omzetten van lignine-rijke stromen naar transportbrandstoffen, additieven en chemicaliën. Het is een tweetraps katalytisch proces, waarin de lignine eerst wordt gedepolymeriseerd en dan gedeoxygeneerd naar brandstof.

Goedkeuring penvoerder / consortium De jaarrapportage dient te worden besproken met de penvoerder/het consortium. De TKI's nemen graag kennis van evt. opmerkingen over de jaarrapportage.	
De penvoerder heeft namens het consortium de jaarrapportage	X goedgekeurd ☐ niet goedgekeurd
Evt. opmerkingen over de jaarrapportage:	

Planning en voortgang (indien er wijzigingen zijn t.o.v. het projectplan svp toelichten)	
Loopt de PPS volgens planning?	Diverse activiteiten binnen de PPS gaan volgens planning, echter was in de PPS voorzien in een PhD student die gedurende de looptijd van het project zijn thesis zou voltooien. Door persoonlijke omstandigheden is de beoogde PhD student gestopt met deze promotie, en is een andere invulling gekozen, te weten door een PostDoc aan te nemen, die – zoals voorzien voor de PhD student – deels van zijn tijd bij BTG werkt. Het verzoek voor wijziging PhD in PostDoc is ingediend op 30 okt 2018 en goedgekeurd 15 nov 2018. Dit heeft wel wat vertraging opgeleverd, orde grootte van zo'n 6 maanden. Een verlenging van 6 maanden is aangevraagd, ook gezien de vertraging die zijn opgelopen door Covid19. De eindtijd is nu 31-01-2021, en het ziet ernaar uit dat deze einddatum geen probleem hoeft op te leveren.
Zijn er wijzigingen in het consortium/de projectpartners?	Nee
Is er sprake van vertraging en/of uitgestelde opleverdatum?	Zie hierboven. Tgv het afhaken van een PhD student en aannemen/instrueren van een PostDoc is een vertraging van ca. 6 maanden realistisch, zeker ook de vertraging tgv Covid19. De betreffende PostDoc is van Chinese oorsprong en was gedurende de Covid19 uitbraak in (en kon derhalve 2 maanden niet reizen en werd bij terugkomst in NL wederom geconfronteerd met de Nederlandse beperkingen)
Is er sprake van inhoudelijke knelpunten, geef een korte beschrijving	Neen, anders dan hierboven aangegeven
Is er sprake van afwijkingen van het ingezette budget/de begroting?	Nee
Verwacht u een octrooi-	(Nog) niet

aanvraag vanuit deze PPS	

Highlights: geef een korte beschrijving van de belangrijkste resultaten

The project is divided into 4 main research and development tasks, one task for the technical economic evaluation and one task for coordination:
WP1. Production of lignin feedstocks and pre-treatment. Several qualities of lignin are produced; a lignin with high ash and sodium content, a lignin with low ash content, and a lignin washed to reduce the ash content. Lignin will also be produced from a selection of other lignin-rich resources such as fermentation, anaerobic digestion, composting and sludge from wastewater treatment. A lignin precipitation and separation process will be developed and lignin produced.
Main results:

a) lignin from pyrolysis liquids are produced in larger amounts and further treated in reactors to be depolymerised and deoxygenated.
b) Lignins are treated by ozone, and then further depolymerised and deoxygenated. Part of the work is published (as a part in a separate PhD project at RUG – Bernandes, Jan 2020)
c) Treated lignins from Sweden – Lignoboost – are used in the various tests.

WP2) Screening catalysts and product identification – Initial benchmarking tests are carried out on lignins derived from pyrolysis liquids. An experimental catalyst screening program will be performed in batch autoclaves to identify best catalyst, both commercial as in house made, for the depolymerisation step (step 1). A number of catalysts is tested. Process conditions are optimized using a multi-parameter study. Key performance parameter is the degree of depolymerisation of products (f.i. by GPC). Oils produced will be used as the starting feed for further LPR treatment in subsequent treatment processes to obtain the required specification as end-products.
Main results

a) Catalyst are screened in the activity in the depolymerisation of lignin; homogenous (basic and acid catalysts) and heterogeneous catalyst (Picula, NiMo) are applied. For the Picula catalyst different types and compositions are applied (and compared to effect on sugars as well). A paper is published in the journal 'Energies' regarding a Special Issue entitled "Biomass Fast Pyrolysis" (Yin, 2019).

WP3. The lignins produced are depolymerized (applying selected solvents) in a continuous trickle bed reactor by applying process conditions based on earlier performed experiments and on input provided by the screening experiments. To understand the influence of the catalysts, the process conditions and lignin quality on the oil yield, the entire product distribution is tracked.
Main results:

a) A large number of tests is done using lignins from pyrolysis liquids in continuous set-ups (Scholten 2017; Harbers 2017)
b) Test are done in a batch-wise operated autoclave system (Bassa, 2018)
c) The autoclave system has been modified to operate in (semi) continuous mode and numerous experiments have been carried out (Yin, 2019). The results from these experiments are being compiled and analysed at this moment.

WP4. Longer term demonstration of LPR using lignin. The most promising catalyst/solvent system is used in extended test runs in a continuous bench scale unit in a matrix of conditions varying the moisture content, catalyst to lignin ratio, temperature, pressure and gas feed rate. Data on conversion, yields (qualities and quantities), catalyst stability and coke formation, and results from reaction network analysis are generated, to be deployed for process design and economics
Main results

a) Tests are successfully done using lignins from pyrolysis liquids in packed bed continuous set-ups (Scholten 2017; Harbers 2017). Large amounts of pyrolysis lignins could be converted into higher valubale products.
b) The existing autoclave system has been modified to operate on a continuous basis (see also WP3). Intensive tests have been done, interrupted due to Covid19, but now restarted.

WP5. Product analysis and Techno-Economic Evaluation (TEE) (M12-M36) (BTG, RUG). Lignin oils from WP2-4 will be analysed to fit with requirements on advanced biofuels compatible with existing infrastructure. The data collected and information from WP3-4 are basis for a conceptual design of the crude lignin-oil stabilization, upgrading and refining processes. A simulation tool is used for optimization and integration this new technology in an existing environment (CoCo flowsheeting). The output will be used for a LCA-analysis and an economic assessment, with input on process layout and performance as well as estimated costs on lignin depolymerisation and

upgrading. Detailed information about process design and performance will become available in the next 6 months together with yields from the different process steps as well as estimated investment costs of equipment and operating cost. The process models developed will be finetuned, and the heat and mass balance for the overall value chain concept finalised. Costs will be estimated based on results from the comprehensive modelling software, while LCA analysis will be made. Case studies will be conducted to identify the most favourable production routes.
Main results:

a) Activities on the TEE are started but not all information is available (mass and energy balances) to finalise this phase yet. A benchmark study is selected and will be further analysed in the coming 6 months. A CoCo flowsheeting is available for the modelling purposes.

WP6 Coordination (M1-M36) (BTG, RUG). BTG is coordinator, to monitor progress towards milestones and deliverables, to properly exchange documents, follow-up of time schedules, budgets and registration of deliverables. Routines for quality control of technical work and deliverables will be implemented. The project manager will manage the communication and reporting to TKI. BTG is also responsible for setting up routines for risk management including a project risk register to be discussed and updated at project board meetings, WP-meetings and in WP project progress reports. Coordination and management of the project will also include dissemination, exploitation management and IPR management.
Main results:

a) Ongoing task

Aantal opgeleverde producten in 2018 (geef in een bijlage de titels en/of omschrijving van de producten of een link naar de producten op openbare websites)			
Wetenschappelijke artikelen	Rapporten	Artikelen in vakbladen	Inleidingen/ workshops
5); 7); 8); 9)	1); 2); 6); 8)	n/a	n/a

Bijlage: Titels van de producten of een link naar de producten op een openbare website

1) J.M.T. Harbers, 2017, Aromatics production via lignin hydrotreatment, MSc thesis, University of Twente Chemical & Process Engineering
2) W.M. Scholten, 2017, Renewable Bio-Based Chemicals: Aromatics from Lignin, MSc thesis, University of Twente Chemical & Process Engineering
3) Figueirêdo, Monique & Jotic, Z & Deuss, Peter & H Venderbosch, R & Heeres, H.J. (2019). Hydrotreatment of pyrolytic lignins to aromatics and phenolics using heterogeneous catalysts. Fuel Processing Technology. 189. 28-38. 10.1016/j.fuproc.2019.02.020.
4) Figueirêdo, Monique & Deuss, Peter & Hendrikus Venderbosch, Robertus & Jan Heeres, Hero. (2019). Valorization of Pyrolysis Liquids: Ozonation of the Pyrolytic Lignin Fraction and Model Components. ACS Sustainable Chemistry & Engineering. 7. 10.1021/acssuschemeng.8b04856.
5) Wang Yin, Maria V. Bykova, Robertus Hendrikus Venderbosch, Sofia A. Khromova, Vadim A. Yakovlev, Hero Jan Heeres, Catalytic Hydrotreatment of Pyrolytic Sugars and Pyrolytic Lignin Fractions from Fast Pyrolysis Liquids using High Loading Nickel Based Catalysts, For publication in: Energies
6) R. Bassa, 2018, Valorization of Kraft lignin via solvolysis and hydrotreatment, MSc thesis, University of Twente Chemical & Process Engineering
7) M.B. Figueirêdo, P.J. Deuss, R.H. Venderbosch and H.J. Heeres, 2020, Catalytic hydrotreatment of pyrolytic lignins from different sources to biobased chemicals: Identification of feed-product relations, Biomass and Bioenergy. 134., 105484.
8) M.B. Bernardes Figueirêdo, 2020, Valorization strategies for pyrolytic lignin, Thesis University of Groningen. 275 p.
9) Bernardes Figueiredo, M., Venderbosch, R. H., Heeres, H. & Deuss, P., 2020, In-depth structural characterization of the lignin fraction of a pine-derived pyrolysis oil, Journal of Analytical and Applied Pyrolysis. 149, 104837.