

BioMates

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Version 01



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1. Introducing BioMates

1.1. The BioMates Project

The BioMates project aspires in combining innovative 2nd generation biomass conversion technologies for the cost-effective production of *bio*-based intermediates (BioMates) that can be further upgraded in existing oil refineries as renewable and reliable co-feedstocks. The resulting approach will allow minimisation of fossil energy requirements and therefore operating expense, minimization of capital expense as it will partially rely on underlying refinery conversion capacity, and increased bio-content of final transportation fuels.

The BioMates approach encompasses innovative non-food/non-feed biomass conversion technologies, including **ablative fast pyrolysis (AFP)** and single-stage **mild catalytic hydroprocessing (mild-HDT)** as main processes. Fast pyrolysis in-line-catalysis and fine-tuning of BioMates-properties are additional innovative steps that improve the conversion efficiency and cost of BioMates technology, as well as its quality, reliability and competitiveness. Incorporating **electrochemical H₂-compression** and the state-of-the-art **renewable H₂-production** technology as well as **optimal energy integration** completes the sustainable technical approach leading to improved sustainability and decreased fossil energy dependency. The overall BioMates-Concept is illustrated in Figure 1.

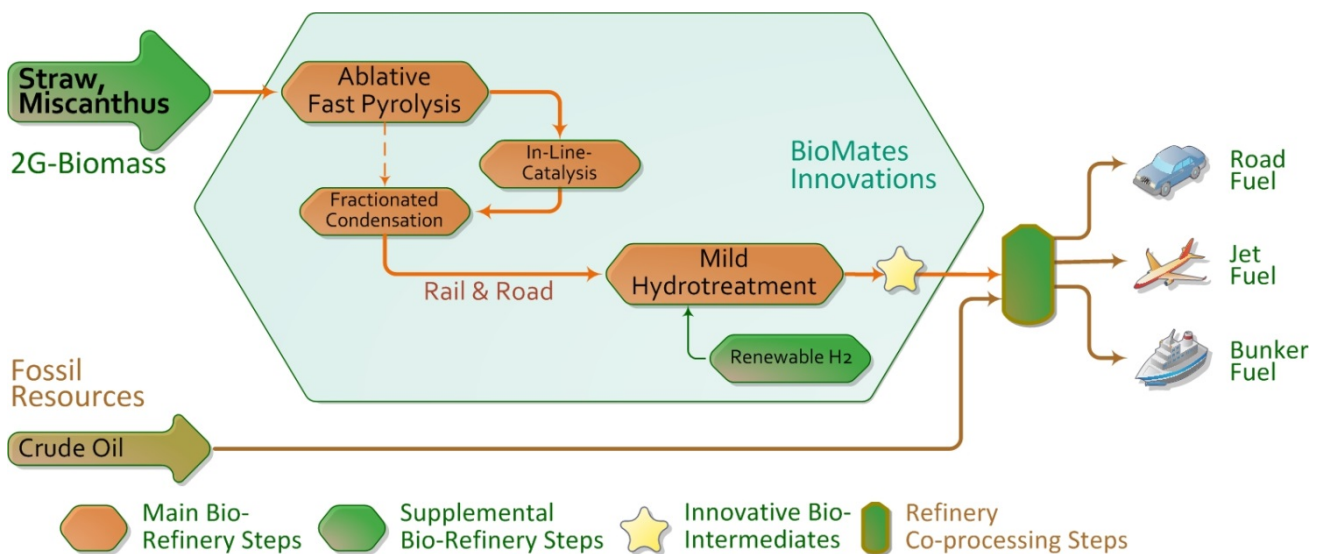


Figure 1: The BioMates-concept

The proposed technology aims to effectively convert residues and non-food/feed plants or commonly referred to as 2nd Generation (straw and short rotating coppice like miscanthus) biomass into high-quality bio-based intermediates (BioMates), of compatible characteristics with conventional refinery conversion units, allowing their direct and risk-free integration to any refinery towards the production of hybrid fuels.

1.2. European Commission support

The current framework strategy for a Resilient Energy European Union demands energy security and solidarity, a decarbonized economy and a fully-integrated and competitive pan-European energy market, intending to meet the ambitious 2020 and 2030 energy and climate targets /EC-2014a, EC-2014b/. Towards this goal, the European Commission is supporting the BioMates project for validating the proposed innovative technological pathway, in line with the objectives of the LCE-08-2016-2017 call /EC-2015/. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727463.



1.3. The BioMates team

The BioMates team comprises nine partners from industry, academia and research centres:

- Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany (Project Coordination) - www.umsicht.fraunhofer.de
- Centre for Research & Technology Hellas / CERTH - Chemical Process & Energy Resources Institute / CPERI, Greece - <http://www.cperi.certh.gr/>
- University of Chemistry and Technology Prague UCTP, Czech Republic - <http://www.vscht.cz>
- Imperial College London ICL, United Kingdom - www.imperial.ac.uk
- Institut für Energie und Umweltforschung Heidelberg GmbH / ifeu, Germany - www.ifeu.de
- HyET Hydrogen B.V. / HyET, Netherlands - www.hyet.nl
- RANIDO, s.r.o., Czech Republic - <http://www.ranido.cz/>
- BP Europa SE, Germany - www.bp.com/en/bp-europa-se.html
- RISE Research Institutes of Sweden - www.ri.se

For additional information and contact details, please visit www.biomates.eu.

2. Summary

The BioMates dissemination activities are based on three pillars:

- Conventional dissemination actions,
- Validation platform and
- Webpage

Conventional dissemination activities comprise mainly participation in scientific conferences, open days at partners with technical sites, and publication of results in peer-reviewed journals. Since delivering the 2nd Dissemination Report in September, 2018, members of the consortium participated in 13 different conferences, workshops or university courses as poster presenter or lecturer and presented a total number of 18 contributions (either poster or lecture). During the complete project lifetime until now, 28 scientific papers and proceedings' contributions were published.

In the last year of the project duration, a comprehensive video will be produced to showcase the whole process chain, which is located at several physical sites from first conversion (ablative fast pyrolysis at Fraunhofer UMSICHT and RISE) over secondary upgrading (mild hydrotreatment at UCTP and CERTH) combined with efficient hydrogen compression and purification (at HyET and CERTH) until the final co-processing in a conventional petroleum refinery (demonstrated at CERTH and BP). Guided tours to selected locations will be organised for potential customers and the interested public.

The final means of dissemination is a website which is dedicated to the project. Here the whole project is described and the participating research institutes and companies present themselves and their team members. All publicly available information on the project is gathered on the website for unrestricted access by the public. The website went online on December 23rd, 2016. Detailed description of the website is already given in deliverable report "D7.1: BioMates webpage". As of this deliverable's submission date, the website's first page is available in the four languages Czech, Dutch, English and German.



3. Conventional dissemination actions: lectures and posters

The project has been presented at several international conferences and workshops since submitting the 2nd Dissemination Report by means of posters as well as lectures. Table 1 lists all events, and Table 2 provides the respective titles and presenting authors of the contributions.

Table 1: Conferences visited to present the project

No.	Conference	Venue	Date	Type
1	7 th International Conference on chemical Technology - ICCT	Mikulov, Czech Republic	15/04/2019	Lecture
2	ISGC 2019-The world event in sustainable chemistry research & innovation	La Rochelle, France	13-15/05/2019	Lecture
3	12 th Hellenic Chemical Engineering Conference	Athens, Greece	29-31/05/2019	1 lecture, 1 poster
4	15 th International Conference on Renewable Resources and Biorefineries	Toulouse, France	03-05/06/2019	2 lectures
5	TCS 2018	Auburn, USA	08/10/2018	Lecture
6	Pyroliq 2019: pyrolysis and liquefaction of biomass and wastes	Cork, Ireland	16/06/2019	Lecture
7	27 th European Biomass Conference and Exhibition	Lisbon, Portugal	27-30/05/2019	1 lecture, 1 poster
8	5 th International Symposium on Green Chemistry	La Rochelle – FRANCE	13-17/03/2019	Lecture
9	12 th National Scientific Conference of Chemical Engineering	Athens, Greece	29-31/05/2019	Lecture
10	17 th International Conference on Chemistry and the Environment	Thessaloniki, Greece	16-20/06/2019	1 lecture, 2 posters
11	6 th Panhellenic Symposium with International Participation On Green Chemistry and Sustainable Development	Athens, Greece	18-20/10/2019	Lecture
12	28 th European Biomass Conference and Exhibition	Marseille, France	27-30/05/2020	Lecture
13	8 th international conference on sustainable solid waste management	Thessaloniki, Greece	17-20/07/2020	1 lecture, 1 poster
14	23rd International Symposium on Alcohol Fuels (ISAF)	Hangzhou, China	1-4 /11/2018	Lecture
15	13. Rostocker Bioenergieforum (13 th Rostock forum for Bioenergy)	Rostock, Germany	13-14/07/2019	Lecture
16	9 th International Conference on Life Cycle Management (LCM)	Poznan, Poland	1-4 /09/2019	Lecture

**Table 2:** Titles and presenting authors of conference contributions

No.	Title	Presenting author	Author Affiliation	Conference No. (Table 1)
1	The Influence Of Condensation Temperature On The Properties And Composition Of Miscanthus Bio-Oil (L)	Milos Auersvald	UCTP	1
2	Validating alternative technological pathways of bio-oil refinery integration: co-hydrotreatment (L)	Stella Bezergianni	CERTH	2
3	Fast Pyrolysis Bio-Oil Upgrading Via Hydrotreatment For Refinery Intermediates Production (L)	Stella Bezergianni	CERTH	3
4	Upgraded Pyrolysis Bio-Oil As Alternative Renewable Supply In Classical Petroleum Refinery Processes (P)	Stella Bezergianni	CERTH	3
5	Social dimensions of biofuel and alternative fuel production and use in Europe (L)	Yara Evans	Imperial College	4
6	Catalytic upgrading of straw-based ablative fast pyrolysis vapours in a downstream fixed bed reactor (L)	Volker Heil	Fraunhofer	4
7	Fuels from Reliable Bio-based Refinery Intermediates – BioMates (L)	Tim Schulzke	Fraunhofer	5
8	Upgrading wheat/barley straw over a sulphided catalyst (L)	Bogdan Shumeiko	UCTP	6
9	One-stage bio-oil stabilization over a sulphided NiMo/Al ₂ O ₃ catalyst (P)	Milos Auersvald	UCTP	7
10	Validating alternative technological pathways of bio-oil refinery integration: co-hydrotreatment. (L)	Stella Bezergianni	CERTH	8
11	Fast pyrolysis bio-oil upgrading via hydrotreatment for refinery intermediates production (L)	Stella Bezergianni	CERTH	9
12	Hydrotreated pyrolysis bio-oil stability study towards the logistics for its utilization as refinery intermediate (P)	Stella Bezergianni	CERTH	10
13	Mild-hydrotreated bio-oil compatibility evaluation as a renewable co-supply in conventional oil refinery (P)	Stella Bezergianni	CERTH	10
14	Bio-oil upgrading potential via mild-hydrotreatment for refinery integration (L)	Stella Bezergianni	CERTH	10
15	Green fuel production via upgraded bio-oil integration in an existing refinery stream. (L)	Stella Bezergianni	CERTH	11
16	Towards Bio-oil Integration in an Underlying Refinery (L)	Stella Bezergianni	CERTH	12
17	Straw-based bio-oil to hybrid fuels production (L)	Stella Bezergianni	CERTH	13
18	Impact of hydrogenation on miscibility of fast pyrolysis bio-oil with refinery fractions towards bio-oil refinery integration (P)	Stella Bezergianni	CERTH	13
19	Latest LCA developments in Europe: First time ever results for footprints of land use and phosphate towards more conclusive LCAs of alcohol fuels. (L)	Guido Reinhardt	IFEU	14
20	Significant extension of biofuel LCAs by introducing footprints of phosphorus and land use. (L)	Guido Reinhardt	IFEU	7



No.	Title	Presenting author	Author Affiliation	Conference No. (Table 1)
21	Phosphate and land use footprints: two indispensable extensions of previous LCAs of biofuels: methodology and results (Phosphatfußabdruck und Flächenfußabdruck: zwei notwendige Erweiterungen zu bisherigen Ökobilanzen von Biokraftstoffen: Methodik und Ergebnisse) (L)	Guido Reinhardt	IFEU	15
22	Extending LCA methodology for assessing liquid biofuels by phosphate resource depletion (L)	Heiko Keller	IFEU	16

(L): Lecture, (P): Poster

4. Conventional dissemination actions: scientific papers and proceedings' contributions

As the first two dissemination reports did not include the scientific papers and only mentioned the proceedings' contributions along with the lectures and posters, they are given in the two tables below. Table 3 lists the peer-reviewed articles, all of them being available via open access (No. 1-6 via the gold route, No. 7 via the green route). Table 4 lists the Proceedings' contributions.

Table 3: Peer-reviewed scientific papers

No.	Title	Authors' Affiliations
1	Martin Staš, Josef Chudoba, Miloš Auersvald, David Kubička, Stefan Conrad, Tim Schulzke, Milan Pospisil, Application of orbitrap mass spectrometry for analysis of model bio-oil compounds and fast pyrolysis bio-oils from different biomass sources, <i>Journal of Analytical and Applied Pyrolysis</i> 124 (2017), 230-238, DOI: 10.1016/j.jaap.2017.02.002	UCTP, Fraunhofer
2	Panagiota Manara, Stella Bezergianni, Ulrich Pfisterer, Study on phase behavior and properties of binary blends of bio-oil/fossil-based refinery intermediates: A step toward bio-oil refinery integration, <i>Energy Conversion and Management</i> 165 (2018), 304-315, DOI: 10.1016/j.enconman.2018.01.023	CERTH, BP
3	Michael Bampaou, Kyriakos D. Panopoulos, Athanasios I. Papadopoulos, Stella Bezergianni, Panos Seferlis, Spyros Voutetakis, Evaluation of a Novel Bio-oil Hydrotreating Process Integrating Electrochemical H ₂ Compression, <i>Chemical Engineering Transactions</i> 70 (2018), 2185-2190, DOI: 10.3303/CET1870365	CERTH
4	Miloš Auersvald, Bogdan Shumeiko, Dan Vrtiška, Petr Straka, Martin Staš, Pavel Šimáček, Josef Blažek, David Kubička, Hydrotreatment of straw bio-oil from ablative fast pyrolysis to produce suitable refinery intermediates, <i>Fuel</i> 238 (2019), 98-110, DOI: 10.5281/zenodo.2609174	UCTP
5	Bogdan Shumeiko, Klaus Schlackl, David Kubička, Hydrogenation of Bio-Oil Model Compounds over Raney-Ni at Ambient Pressure, <i>Catalysts</i> 9/3, DOI: 10.5281/zenodo.2608318	UCTP
6	Miloš Auersvald, Bogdan Shumeiko, Martin Staš, David Kubička, Josef Chudoba, Pavel Šimáček, Quantitative Study of Straw Bio-oil Hydrodeoxygenation over a Sulfided NiMo Catalyst, <i>ACS Sustainable Chem. Eng.</i> 7 (2019), 7080-7093, DOI: 10.1021/acssuschemeng.8b06860	UCTP
7	Tim Schulzke, Stefan Conrad, Bogdan Shumeiko, Miloš Auersvald, David Kubička, Leonard F. J. M. Raymakers, Fuels from Reliable Bio-based Refinery Intermediates: BioMates, Waste and Biomass Valorization 11 (2020), 579–598, DOI: 10.1007/s12649-019-00625-w, DOI: 10.5281/zenodo.3859789	Fraunhofer, UCTP, HyET

**Table 4:** Proceedings' contributions

No.	Title	Authors' Affiliations
1	Volker Heil, David Kubicka, Tim Schulzke, Stella Bezergianni, Fuels from Reliable Bio-based Refinery Intermediates – BioMates, Proceedings of 10 th International Colloquium Fuels, Esslingen / Germany, 2017, DOI: 10.24406/UMSICHT-N-487569	Fraunhofer, CERTH, UCTP
2	Martin Staš, Miloš Auersvald, Bogdan Shumeiko, David Kubička, Review of Pyrolysis Bio-oil Applications, Proceedings of 5 th International Conference on Chemical Technology, Prague /Czech Republic, 2017	UCTP
3	Study of catalytic hydrotreatment of pyrolysis bio-oil, Miloš Auersvald, Petr Straka, Bogdan Shumeiko, Martin Staš, Proceedings of 5 th International Conference on Chemical Technology, Prague /Czech Republic, 2017	UCTP
4	Bogdan Shumeiko, Miloš Auersvald, Martin Staš, David Kubička, Theoretical principles of pyrolysis of lignocellulosic biomass, Proceedings of 5 th International Conference on Chemical Technology, Prague /Czech Republic, 2017	UCTP
5	Tim Schulzke, Stefan Conrad, Ablative fast pyrolysis – process for valorization of residual biomass, Proceedings of 5 th International Conference on Chemical Technology, Prague /Czech Republic, 2017	Fraunhofer
6	Volker Heil, Tim Schulzke, Stella Bezergianni, David Kubička, Nils Rettenmaier, Ulrich Pfisterer, Michael Martin, Martijn Mulder, Rocio Diaz-Chavez, Miloš Auersvald, Bogdan Shumeiko, Reliable Bio-based Refinery Intermediates – BioMates, Proceedings of 25 th European Biomass Conference and Exhibition, DOI: 10.5071/25thEUBCE2017-5BV.2.5	Fraunhofer, CERTH, UCTP, IFEU, BP, Imperial College, Ranido
7	Stefan Conrad, Cristina Blajin, Tim Schulzke, Producing single phase fast pyrolysis condensates from straw by staged condensation, Proceedings of 25 th European Biomass Conference and Exhibition, DOI: 10.5071/25thEUBCE2017-3AV.3.1	Fraunhofer
8	Bogdan Shumeiko, D. Vrtiška, P. Šimáček, David Kubička, Comparison of sulphidic and non-sulphidic catalysts for pyrolysis bio-oil hydrotreating, Proceedings of 6 th International Conference on Chemical Technology, Prague, 2017	UCTP
9	Miloš Auersvald, Martin Staš, P. Šimáček, Properties and composition of bio-oil hydrodeoxygenation products, Proceedings of 6 th International Conference on Chemical Technology, Prague, 2017	UCTP
10	Martin Staš, Petroleomic Characterization of Pyrolysis Bio-Oils, Proceedings of 6 th International Conference on Chemical Technology, Prague, 2017	UCTP
11	Stefan Conrad, Tim Schulzke, Volker Heil, Producing advanced fast pyrolysis bio-oils by ex-situ catalytic vapour reforming, Proceedings of the 26 th European Biomass Conference and Exhibition, DOI: 10.5071/26thEUBCE2018-3CO.15.1	Fraunhofer
12	Miloš Auersvald, P. Straka, J. Tomášek, Martin Staš, David Kubička, Hydrodeoxygenation of Pyrolysis Bio-Oils from Ablative Flash Pyrolysis of Straw: an Analytical Study, Proceedings of 26 th European Biomass Conference and Exhibition	UCTP
13	Volker Heil, Stefan Conrad, Stella Bezergianni, David Kubička, Rocio Diaz-Chavez, Nils Rettenmaier, Martijn Mulder, Michael Martin, Ulrich Pfisterer, Intermediate aus Halmgutartiger Biomasse zur Einspeisung in konventionelle Raffinerien – BioMates (Intermediates from straw-like biomass for co-feeding into conventional refineries - BioMates), Proceedings of the 7 th status-conference of the German funding programme “Energetic Use of Biomass”	Fraunhofer, CERTH, UCTP, IFEU, BP, Imperial College, Ranido
14	Bogdan Shumeiko, Petr Straka, Pavel Šimáček, David Kubička, One-stage bio-oil stabilization over a sulphidic NiMo/Al ₂ O ₃ catalyst, Proceedings of 27 th European Biomass Conference and Exhibition, Lisbon, 2019	UCTP
15	Miloš Auersvald, Tim Schulzke, Martin Staš, The influence of condensation temperature on the properties and composition of miscanthus bio-oil, Proceedings of 7 th International Conference on Chemical Technology, Mikulov, Czech Republic, 2019	UCTP, Fraunhofer



No.	Title	Authors' Affiliations
16	Panagiota Manara, Athanasios Dimitriadis, George Meletidis, Ulrich Pfisterer, Stella Bezergianni, Upgraded Pyrolysis Bio-oil as Alternative Renewable Supply in Classical Petroleum Refinery Processes, Proceedings of the 12 th Hellenic Chemical Engineering Conference Athens, 2019, DOI: 10.5281/zenodo.3522893	CERTH, BP
17	Athanasios Dimitriadis, George Meletidis, Panagiota Manara, Stella Bezergianni, Michael Martin, Pavel Kukula, Fast Pyrolysis Bio-oil Upgrading via Hydrotreatment for Refinery Intermediates Production, Proceedings of the 12 th Hellenic Chemical Engineering Conference Athens, 2019, DOI: https://zenodo.org/record/3522891	CERTH, Ranido
18	Panagiota Manara, Athanasios Dimitriadis, Ulrich Pfisterer, Stella Bezergianni, Validating alternative technological pathways of bio-oil refinery integration: co-hydrotreatment, Proceedings of the International Conference ISGC 2019-The world event in sustainable chemistry research & innovation, La Rochelle, 2019, DOI: 10.5281/zenodo.3522917	CERTH, BP

5. Conference co-ordination participation

Supported by INEA project officers and in close co-operation with the RRB Congress Manager, Fraunhofer on behalf of BioMates organised a double-session “Bioenergy, advanced biofuels, renewable fuels and future mobility in Horizon 2020” at the conference “Renewable Resources and Biorefineries – RRB-15” in Toulouse/France 03-05/06/2019. The double-session brought together the Horizon 2020-projects BABET-REAL 5 (GA-No. 654365), To-Syn-Fuel (745749), ABC-Salt (764089), HyFlexFuel (764734) and BioMates in a joint dissemination and networking action.

A similar action had been co-ordinated by the same team for the RRB-2020 conference to be held 3-5/06/2020 in Ghent/Belgium, which has then been cancelled due to the COVID-19 pandemic.

6. Validation platform

Producing a validation-video and open days on the main technical premises are all anticipated for project year 4, which will start in October 2020.

7. Web-based dissemination

The BioMates webpage www.biomates.eu is the key dissemination tool of the project objectives, results and activities, addressed to specific target groups (potential commercial implementers, scientific community) as well as to the general public. The design of the BioMates webpage has the following goals:

- User-friendly environment for the core audience
- Improved visual design and content structuring (reduced clutter)
- Project identity leveraged to establish positive recall with the visitor
- Fast and easy navigation within the website
- Core technologies/products more visible to first-time users and easily available to repeat users

The website was built by project partner CERTH in the first 3 months of the project duration and went online on December 23rd, 2016. The overall structure of the website is fully described in the public report “D7.1: BioMates webpage” (www.biomates.eu/results/deliverables). Until 24/05/2020, the website was visited by



11,645 users in 12,178 sessions with 14,279 pageviews. On average, each user visited the website 1.05 times, opening 1.17 pages per session.

As of this deliverable's submission date, the website's first page is available in four languages: Czech, Dutch, English and German.

The main means of dissemination on the web-page is the tab "Results" with its 3 sub-categories "Publications", "Press Releases" and "Deliverables". All publications mentioned in chapter 3, either posters, lectures or contributions to conference proceedings or journal articles, are available from the "Publications" page. The page "Deliverables" provides access to all public deliverable reports as well as to the public summaries of confidential deliverable reports.

BioMates is implemented as a project on Research Gate (www.researchgate.net), having achieved 21 followers and 169 reads, and as group on LinkedIn (www.linkedin.com) with currently 25 members (all data as of 22/05/20). Furthermore, it is listed as a project in OpenAire (www.openaire.eu) with 14 publications and 2 Other Research Products, most of them being provided via Fraunhofer-ePrints (<http://publica.fraunhofer.de>) and Datacite (<https://datacite.org>) (8 research results each) as well as ZENODO (www.zenodo.org, 6 research results).

8. Education

During the period reported here, one pupil from a secondary school in Muelheim (neighbouring city of Oberhausen) performed her compulsory work experience in the BioMates group at Fraunhofer and (partially) presented her newly gained knowledge in a short presentation in her school.

9. Disclaimer

This Deliverable report reflects only the authors' view; the European Commission and its responsible executive agency INEA are not responsible for any use that may be made of the information it contains.

10. Literature

- EC-2014a European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A policy framework for climate and energy in the period from 2020 to 2030, COM(2014) 15 final, Brussels, 22.01.2014, http://www.europarl.europa.eu/meetdocs/2009_2014/documents/nest/dv/depa_20140212_06/depa_20140212_06en.pdf; <http://bit.ly/1LUcJKL>
- EC-2014b European Commission, Energy Union Package - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions and the European Investment Bank - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM(2015) 80 final, Brussels, 22.01.2014, http://eur-lex.europa.eu/resource.html?uri=cellar:1bd46c90-bdd4-11e4-bbe1-01aa75ed71a1.0001.03/DOC_1&format=PDF, <http://bit.ly/198SAUf>
- EC-2015 European Commission, LCE-08-2016-2017 "Development of next generation biofuel technologies", Publication date: 14 October 2015, <https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/lce-08-2016-2017.html>, <http://bit.ly/2ndtvPc>