NoAW project

Innovative approaches to turn agricultural waste into eco-logical and economic assets

Deliverable 7.4

Development and implementation of training courses

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1. Document Info

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3	15/12/2020	K. Kayser	Final version

1.3. Dissemination level

This deliverable is part of a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 688338	
Dissemination Level	
PU Public	**PU**
CI Classified, as referred to Commission Decision 2001/844/EC	
CO Confidential, only for members of the consortium (including the Commission Services)	

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2 Summary

Background	The project NoAW aims at contributing to a "near zero-waste" society by applying circular economy principles to residues and by-products from agriculture and vini-viti-culture in order to convert them into eco-efficient bio-based products (such as bioenergy, bio-fertilizers, bio-composites, bio-based plastics, bio-fuels). A number of technologies have been further developed to contribute to these aims. Parallel to technology development the current legislative framework has been analysed regarding its effects on NoAW-products. Additionally a territorial metabolism life cycle assessment (TM-LCA) has been combined with a techno-economic and environmental assessment to evaluate the NoAW processes and identify the most eco-efficient solutions.
Objectives	NoAW's results have to be relayed to stakeholders like farmers or representatives from industries that might be interested in using NoAW's products. One way of reaching stakeholders is to invite them to trainings and workshops regarding NoAW's products and results. According to NoAW's "Description of the Action (DOA)" one training course had to be implemented in France, Portugal, Germany, China, Italy and Hungary. Additionally webinars and a national dissemination workshop had been foreseen to reach a national audience. This deliverable summarizes the trainings and workshops that have been conducted within the project.
Methods	Training materials for the workshops have been prepared by CBHU based on the Best Practice Guide (Del. 7.3). This training material has been used and modified by the partners to suit the local context and the specific interests of the targeted stakeholders in each country. Because of the COVID-19 crisis less trainings and workshops than planned have been live events, but have been conducted online using various software platforms.
Results & implications	All six partners responsible for conducting the trainings were free to design the trainings to their focus of work and to deliver it to the stakeholders they can attract best. When looking at all the trainings that have been implemented in all countries, the partners have managed to inform all relevant stakeholder groups – farmers, research/ academia, industry, government and associations – about the project. A total number of 9 trainings has been implemented in six countries, reaching 224 participants from various backgrounds. Most partners decided to offer half-day trainings via an online platform in the second half of 2020. Feedback from the participants to the organisers of the respective training shows that more than half of the participants were satisfied to very satisfied with the trainings delivered. Especially feedback in Hungary showed that participants are interested in seeing practical examples. Taking into account that this project has been a R&D-project and the technologies that have been studied and improved during this project hint to

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	what will be possible in the future, it is clear that stakeholders have the need for more practical information – especially if capital expenditure is involved. Under Non-COVID-conditions it would have been possible in several trainings to combine them with visits to laboratories or to demonstration sites in order to give a more complete picture on NoAWs activities.

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3 Introduction

Agricultural and viticulture go along with by-products and residues which, depending on the local context, might be regarded as valuable products, environmental hazards or as under-utilized resources.

Agricultural by-products are usually defined as plant or animal residues that are not (or not further) processed into food and feed. Using them contributes to improve resource efficiency and to improve waste management in the primary food processing sector, hence reducing environmental burdens.

Within the context of the NoAW-project the focus was put on preventing and reducing environmental burdens by explicitly using manures (solid and liquid), straw, wine pomace and grape vine cuttings as yet under-utilized resources and convert them into valuable products. Those NoAW-products are designed in such a way that they contribute to a circular economy approach and also to a «near zero-waste society». Socio-economic aspects (WP2) and the generation of business models (WP6) accompanied the technology development to identify the most promising technical approaches also with regards to the regional context.

Anaerobic digestion (AD) is one technology that is capable of utilising straw, manures and wine pomace. This technology is mature and used almost all over Europe in the agricultural sector as well as in the waste management sector. As of today the main products generated with this technology are biogas as energy carrier for power, heat or as fuel – which requires further upgrading – and digestate as fertiliser. Limitations in this technology exist. The digestion of straw, just to give one example, is limited by its high content of lignocelluloses which is difficult to degrade microbially under anaerobic conditions. Pre-treatment is therefore needed to effectively convert straw in AD plants.

In NoAW anaerobic digestion is regarded as a kind of Hub that can be enhanced by adding technology modules – developed in WP3 and WP4 – to improve AD's efficiency as well as the value generation for the owner/ operator. One such technology module would be the pre-treatment of straw. The results have been published in the NoAW Best Practice Guide (Deliverable 7.3). Additionally, fact sheets have been produced to summarise the most important aspects and messages for the NoAW technologies.

To give potential users – be it farmers who could be interested in adding technology to their AD plant or industry representatives who might be interested in using the final products – and stakeholders the opportunity to learn more about NoAW's outcomes, the project offers trainings and workshops. This way NoAW shows stakeholders how to best use recommended practices and which potential business cases exist.

Due to the COVID-19 crisis the timing as well as the way to deliver trainings has been changed compared to the schedule foreseen in the contract. Originally, live events had to be hosted, but considering travel and meeting restrictions in combination with infection risks and company policies the focus for the trainings shifted to online events. If farmers are the target group, trainings can only attract participants, if they don't interfere with agricultural activities like sowing or harvesting, which usually end in October in Central Europe. Therefore some trainings have been scheduled for November, to allow more farmers to attend the event.

This deliverable summarises the trainings that have been conducted within the NoAW project. It describes the generation and use of the training materials as well as the way the trainings were implemented in the target countries of China, France, Germany, Hungary, Italy and Portugal. Last but not least the annexes will show the set of generic training materials generated by CBHU for this project.

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4 Methods

The development of the trainings followed several steps. Based on the Best Practice guide, NoAW partner CBHU has prepared a structure for the trainings in form of modules:

- Module 1: Background and the short introduction of NoAW project
- Module 2: Valuable raw materials in agricultural wastes and relevant legislation
- Module 3: Main possibilities of agro-waste valorisation, best practices and methods
- Module 4: Practical implementation
- Module 5: Group exercise – Business model Canvas

For each of these modules generic slide sets have been created and distributed to the partners, as well as flyers and instructions for trainers. They are attached as Annexes to this document.

From these modules all partners responsible for implementing and conducting trainings could choose the most relevant modules for their local context and modify them according to their needs.

Partners for conducting the trainings in China, France, Germany, Hungary, Italy and Portugal are:

- China: IAPPST
- France: INRAE, IFV
- Germany: IBBK
- Hungary: CBHU
- Italy: GCIA
- Portugal: IBET

For the duration of the trainings half day or full day trainings have been foreseen, again to allow the partners to fit the trainings to local needs. Possibly those trainings could be part of other events to reach a higher number of stakeholders.

Due to the COVID-19 crisis, live trainings have not been possible in all partner countries and online events have been held instead. Trainings that primarily target farmers need to consider agricultural work cycles. Usually the months of November to March require less of their attention of the farm compared to, for example, September or October which are times of harvesting. Therefore some trainings were held in November and December.

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5 Results

This chapter describes how the different partner have implemented the trainings in their countries. In total nine trainings have been delivered in six countries, reaching a total number of 224 participants from all stakeholder groups. As each partner has a different focus of work, there clearly are differences in stakeholder coverage per country and also the number of participants per event varies strongly. A table summarising the results from all countries is shown in Annex 9.1. It gives a good overview about the trainings per country.

5.1 Training conducted in China

IAPPST conducted the training in China in form of a half-day online event on 16 July 2020 within the frame of “The Enlarged Council Meeting of Sweet Potato Starch-Specialized Committee, China Starch Industry Association”.

With this training IAPPST aimed at increasing the understanding of more enterprises, researchers and government officials about the importance and necessity of comprehensive utilization of agricultural waste. The target groups for this training were stakeholders from industry, research institutes and government who are dealing with starch processing.

In total the training reached 55 persons (excluding trainers) which all belonged to the targeted stakeholder group.

IAPPST chose Modules 1, 2 and 3, because the stakeholders need to know the information mentioned in these 3 modules. With this selection the focus of the training was put setting the basis for a better understanding of the implications agricultural wastes have in terms of environmental burden and to show by which means NoAW contributes to finding solutions.

The training started by introducing the background and feasibility of high value utilization of agricultural wastes to the audience. Afterwards, the research progress IAPPST has made under the support of NoAW project was shown and finally the next R&D plan was presented to the participants.

The training was very successful, and most participants thought that the comprehensive utilization of agricultural waste is of great significance.

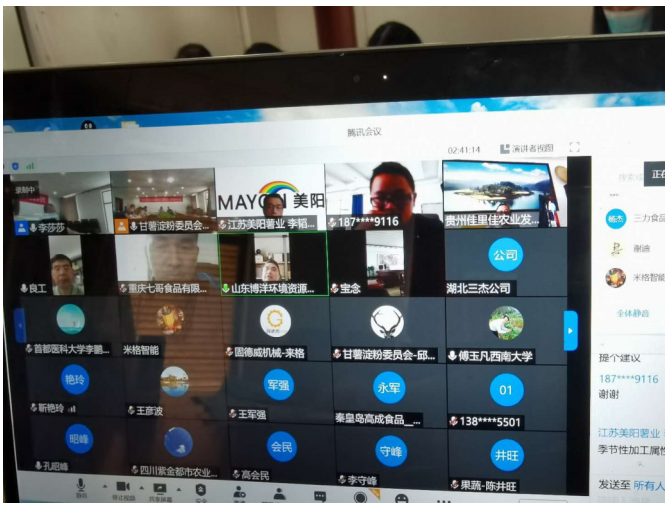

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Figure 1: Pictures from IAPPST training course (picture credit: IAPPST)

The following figures show the invitation and agenda of the training.

中国淀粉工业协会甘薯淀粉专业委员会

中国淀粉工业协会甘薯淀粉专业委员会二届四次理事会
线上会议通知

中淀协甘淀委
[2020]02 号

为提升我国薯类加工与副产物综合利用技术水平，增进中国淀粉工业协会甘薯淀粉专业委员会各理事单位之间的交流合作，总结委员会近一年来开展的各项工作及取得的成绩，中国淀粉工业协会甘薯淀粉专业委员会拟于 2020 年 7 月 16 日召开二届四次理事会。受新冠肺炎疫情影响，中国淀粉工业协会甘薯淀粉专业委员会二届四次理事会将采取线上会议形式进行，请各理事单位代表参会。特此通知！

一、会议名称、时间、形式

会议名称：中国淀粉工业协会甘薯淀粉专业委员会二届四次理事会
会议时间：2020 年 7 月 16 日上午 09:00-11:30
会议形式：腾讯会议线上会议

二、参会人员

中国淀粉工业协会甘薯淀粉专业委员会所有理事会成员

三、会议日程

中国淀粉工业协会甘薯淀粉专业委员会二届四次理事会会议日程

时间	会议内容	主持人
09:00-9:10	致欢迎词及参会人员介绍	中国农业科学院农产品加工研究所、中国淀粉工业协会甘薯淀粉专业委员会 木泰华 研究员/会长
09:10-9:40	报告题目：农业废弃物高值化利用的可行性、研发进展及实际应用（Training of best practices for farms and business on agro-waste management） 报告人：孙红男 博士/副研究员 中国农业科学院农产品加工研究所	
9:40-9:50	报告题目：甘薯淀粉专业委员会 2019 年工作总结、2020 年工作进展与计划 报告人：陈井旺 秘书长 中国淀粉工业协会甘薯淀粉专业委员会秘书处	
9:50-10:00	企业交流 1： 江苏美阳薯业发展有限公司 李韬韬 总经理	
10：00-10:10	企业交流 2： 贵州佳里佳农业发展有限公司 张诚 董事长	
10:10-10:20	交流 3： 西南大学重庆市甘薯工程技术研究中心 傅玉凡 教授	
10:20-10:30	交流 4： 贵州绿薯青山农业发展有限公司 欧兴华 董事长	
10:30-10:40	交流 5： 重庆七哥食品有限公司 陈彰国 总经理	
10:40-10:50	交流 6： 秦皇岛三力食品有限责任公司 杨杰 总经理	
10:50-11:00	交流 7： 重庆市武隆苕粉集团有限公司 王晓路 总经理	
11:00-11:10	交流 8： 乳山华美淀粉制品有限公司 孙秀虎 董事长	
11:10-10：20	新增理事成员、降级理事成员表决及结果公布	
11：20-11：30	企业自由交流	

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四、注意事项

1. 发言形式为现场 PPT 演讲或视频播放，请所有发言人员于 7 月 13 日前将 PPT 或录制好的视频发送至 ganshudianfen@163.com 邮箱，视频格式推荐为“mp4”。
2. 请参会人员详细填写参会回执并务必于 2020 年 7 月 13 日前将参会回执附件发送至 ganshudianfen@163.com 邮箱，参会回执详见附件 1。
3. 请各参会人员提前下载腾讯会议 APP 熟悉该程序的使用，请于会议召开前 10 分钟进入腾讯会议室并将话筒调为静音，会议室 ID 为 684826739。

五、会务组联系方式：

李莎莎：13051460647

陈井旺：13581748021

中国淀粉工业协会[illegible]淀粉专业委员会

二〇二〇年七月七日

Figure 2: Invitation and agenda of IAPPSTs training in China

5.2 Training conducted in France

In France INRAE and IFV were responsible for conducting the training on NoAWs results. In total three trainings have been implemented by both partners in France.

Figure 3: Training session in Liergues, Beaujolais (France). January 2020. IFV

IFV conducted a training session on 8 January 2020. The target group was adults undergoing professional retraining in the wine sector in Beaujolais and Burgundy wine region. The training session (from 9 a.m. to 12 a.m.) focussed on module 2, 3 and 4. The NoAW project was presented. 25 participants were registered. IFV organized this training session at *Chateau de l'éclair* (Liergues, Beaujolais) in order to demonstrate and show some biowastes valorisation actions implemented by a classical wine cellar.

This event was organized in the framework of a partnership with University of Burgundy. Students were very interested, so this event will become an annual one. Another training session is scheduled in February 2021 with the same university. Between 25 and 30 students will participate.

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INRAE conducted a professional training session on the 18th of November, by web, to 15 professionals of the agro-food and packaging industry sector (BSc level). The half-day training session (14:00-18:00) was carried out by N. Gontard, and focused on module 3 "developing circular economy from agricultural residues to reduce food and packaging waste and losses".

The content focused on: the benefits and the risks related to the use of petrochemical polymers for food packaging; the definitions, strengths and weaknesses of existing bioplastics; the availability and potentialities of agricultural residues as raw materials to substitute oil; and a clear focus on the NoAW technology for processing bioplastics to be used as food packaging that are both biodegradable and bio-based but non-food based; the safety regulation related to food contact materials; the environmental long-term impacts assessment.

INRAE has also conducted another training session on the *"Transition towards a bio-based society"*, which was integrated in a wider training course on strategy development with the ambition to become young professionals in the bioeconomy. The training has been given to students in their last year of their Master 2 program. At the end of their Masters, they will receive the grade of national engineer 'agronomy or chemistry', as well as the grade Master of Science. The half-day training (13:30-17:00) was conducted by Hugo de Vries in Montpellier and was related to module 4 *"Practical implementation: Business models for use of agro-wastes".* The content of the training focused on transitions towards sustainable bioeconomy systems, what are these, which scenarios are relevant and which examples contribute to such transitions.

5.3 Training conducted in Germany

IBBK is the partner responsible for trainings in Germany. They conducted an online training on 25 November 2020 for farmers/ biogas plant operators as the main target group. The training was scheduled as a half day event running from 10:00–13:00 hrs. It was based on the modules 1, 2 and 3 and put a main focus on the legislation (especially the fertiliser ordinance) and results regarding digestate and fertilisers, because this is still *the* hot topic amongst German farmers due to new legal regulations regarding fertilising as well as soil and water protection from over-fertilising. NoAW provides solutions for this topic and those were presented in the training.

The training started with a general introduction to the NoAW project and gave an overview over the products and value streams that have been developed (Module 1).

From possible contents of Module 2 IBBK introduced the relevant agricultural residues for most operators of biogas plants, which are straw and manures. Regarding the legislation the training focused on the latest information regarding the fertiliser ordinance, because new rules have been implemented for this autumn.

From Module 3 IBBK selected technology for the pre- or post-treatment of recalcitrant feedstock, because and despite already existing technologies there is still the need for efficient (technical) solutions. Furthermore the training showed what options for digestate processing and for precision fertilising have been assessed in NoAW. Bio-based plastics played a minor role, because of the needed economies of scale compared to the size of AD plants existing in Germany and the yet difficult business case.

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For advertising the event IBBK primarily used its own website, network and database of biogas plant operators as well as its social media channels, namely LinkedIN and facebook. Additionally, the workshop has been sent to various event calendars in agricultural and renewable energy media.

IBBK Website	https://www.ibbk-biogas.de/termine/noaw-webinar-2020/
Facebook	https://www.facebook.com/IBBK.BiogasDE https://www.facebook.com/FnBB.eV
LinkedIN	https://www.linkedin.com/in/ibbkbiogas/
Event calendars	https://www.carmen-ev.de/infothek/veranstaltungskalender/icalrepeat.detail/2020/11/25/3525/-/landwirtschaftliche-reststoffe-gewinnbringend-und-duev-konform-nutzen

The following figure shows the flyer that IBBK used for advertising this event.

Figure 4: Flyer for advertising the webinar

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Figure 5: Programme of Online-training in Germany

The online-training was implemented using the German platform edudip. In total 38 persons participated in the online training. A survey at the beginning of the training regarding participant structure showed that approximately 60% were operators of biogas plants. It should be noted, that not all participants had logged in when the survey was running.

The feedback on this training was generally good. Of those filling in the feedback questionnaire, 75% were very satisfied and 25% were satisfied with the training.

Additionally, C.A.R.M.E.N. e.V. – a Bavarian association working in biogas and bioeconomy – has asked IBBK to present NoAW results in two of their events in 2021.

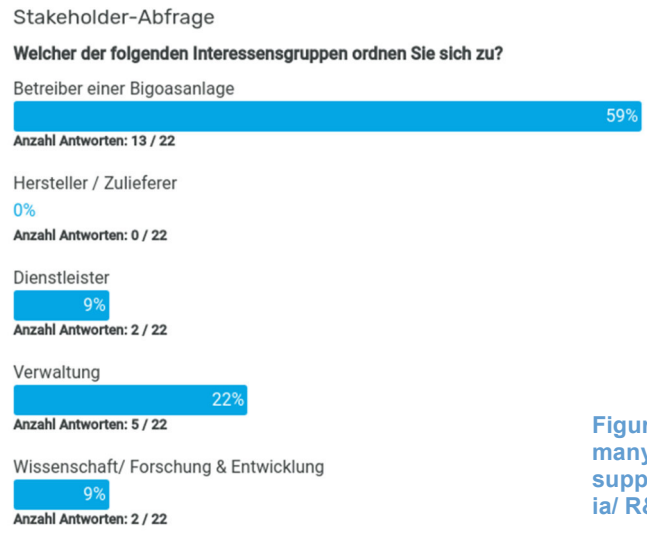

Figure 6: Stakeholders present in the NoAW-training in Germany. From top to bottom: AD plant operators, technology suppliers, consultants, administration/ government, academia/ R&D

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5.4 Training conducted in Hungary

CBHU conducted the training online on 13 November 2020 as a half day event and targeted mainly farmers and agricultural enterprises. In the training, all modules were used. CBHU used Zoom as a platform to deliver the training.

The training aimed to show new sustainable strategies, eco-friendly technologies for the valorisation of manure, straw and winery waste and business models. The training also offered participants a "space of exchanges" in this field with CBHU as local NoAW partner.

CBHU used different tools to reach potential attendees, such as using our industry contact list, dedicated governmental organisation and web-based tools, social network. The invitation was shared with Federation of Hungarian Food Industries (FÉSZ) who sent it to their members and displayed in their newsletter. The Hungarian Chamber of Agriculture also shared the information about the training through their channels.

The event displayed on:

CBHU homepage: https://campdenbri.hu/hirek/hirek.php#noaw2020_09

CBHU's Linkedin page: https://www.linkedin.com/company/campden-bri-hungary/

NoAW Linkedin page: https://www.linkedin.com/feed/update/urn:li:activity:6720230614160736256/

The following picture shows the invitation for the online training.

Figure 7: Invitation for the online training in Hungary

In the training CBHU introduced the background of the NoAW project in order to have a better understanding of the focus of the training.

The Modul on “Types of agricultural wastes that can be valorized” provided an overview of the valuable raw materials in agriculture waste. The actual potentials were emphasized through examples to raise attention and potential for producing valuable products from these agricultural residues

The Modul on “Main possibilities of agro-waste valorisation, best practices and methods” aimed to show new eco-efficient products and technologies such as bioplastics & their production, biogas production and bioenergy, organic fertilizer production and composting. In this session, the main learnings from NoAW’s development were presented.

The Session on “Practical implementation” introduced main triggers, success and failures factors, that are important aspects when implementing a new process. Additionally, it gave an overview of business model development. This is a useful procedure, as it can assist a practical user to identify a combination of values represented by an intended new product, new process, and service (even for those which were developed by using agricultural residues) for targeted customers and consumers.

The event aimed to combine lectures and exercises to have more interaction with participants. In the exercise session the Business Model Canvas was be used. The participants were asked to develop the value proposition for a product together. The results were discussed amongst the group and with the trainers.

Figure 8: Programme of the online training in Hungary

15 participants registered for the event. On 13th of November 9 participants took part on the online training.

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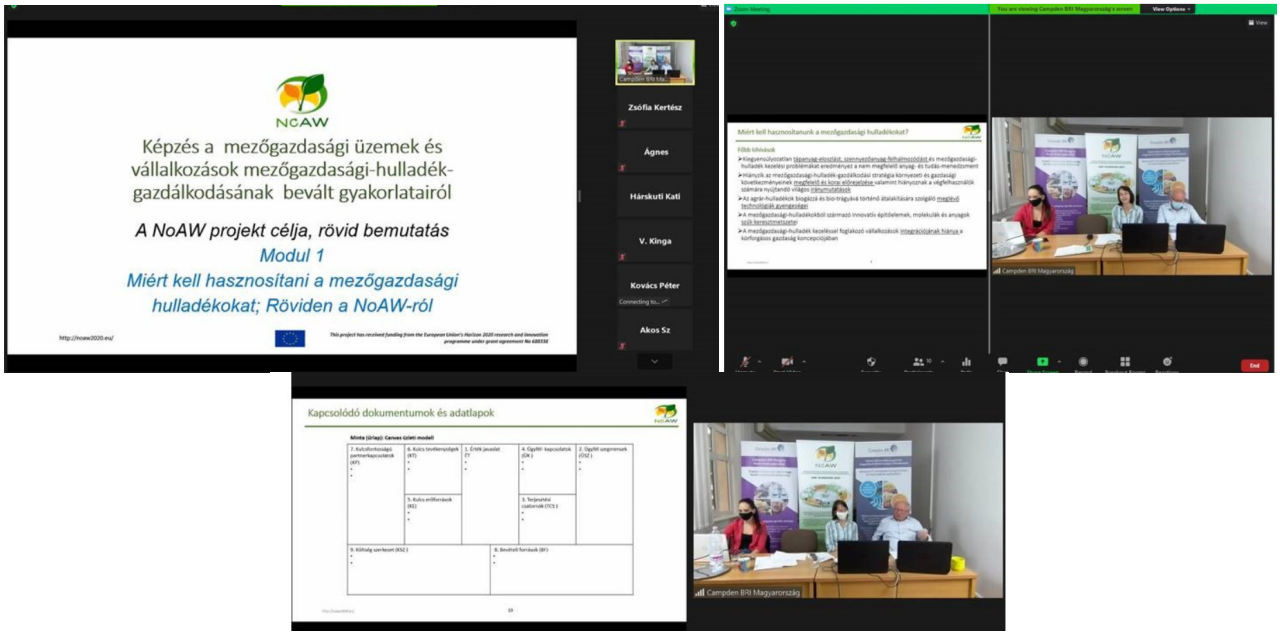

Overall the above program is focused on the importance of to turn agricultural waste into ecological and economic assets. This training does not claim to be a definitive collection of all available solutions, but introduces best practices in the light of the NoAW project, with a special focus on bioplastics and solutions centred around biogas facilities.

The participants completed a short questionnaire after the training. Half of the participants indicated that the training completely met their expectation, others were moderately satisfied with the training. Most of the participants indicated that they liked the practical examples shown. They could select the most useful topics, which were the followings: Overview of the valuable raw materials in agriculture waste (100%), Bioplastics (100%), Biofertilizers (75%), Biogas / Bioenergy (50%).

5.5 Training conducted in Italy

In Italy GCIA organised a one day training on NoAW best practices for farms and businesses on agro-waste management during their Erasmus + PLANET project training pilot activities, in particular the day after the testing and following up of the biomasses and biogas modules, starting from the 15 October 2020 and ending on 22 October 2020.

The training was structured in three sections:

- Section 1: Biomass (2 hrs)
- Section 2: Biogas (2 hrs)
- Section 3: Best Practices and Business Model. (1 hr)

Section 1 on Biomass covered the topics:

- types of agro wastes to be valorised
- best practices and methods
- biomaterials and bioplastics
- legislative review,

while Section 2 was used to give and overview on or discuss about

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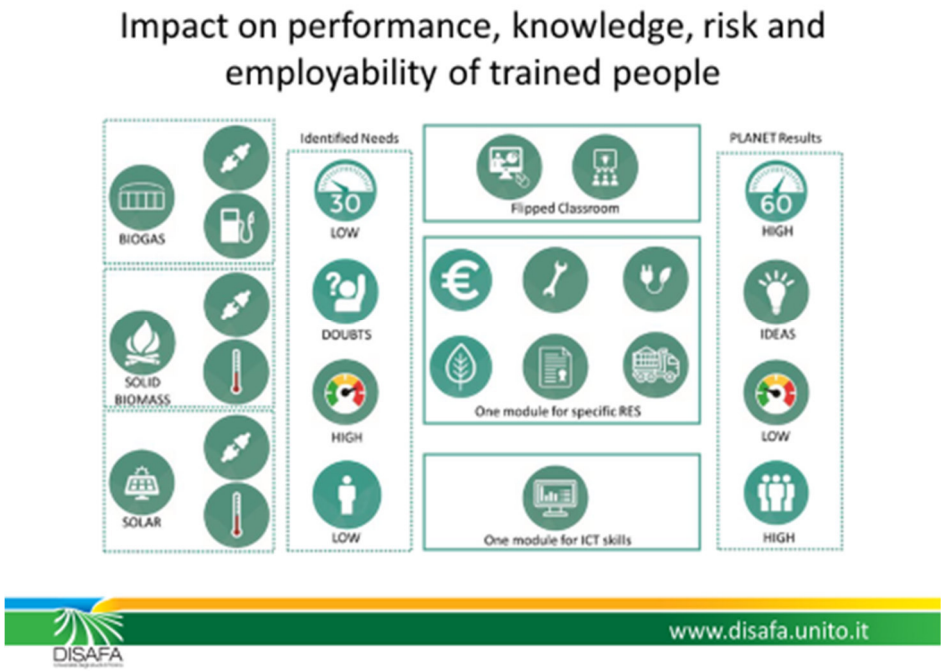
- renewable energies
- biogas in a circular bio economy
- Biogas production /plant management
- Bio-fertilizers/ biomaterials/ digestate

and Section 3 finally dealt with showing successful cases and discussing business model generation or supporting participants in making business models, respectively.

In total 25 learners joined this dedicated NoAW training, 20 of them were young entrepreneurs (ANGA – Young Farmers' Association in Italy, belonging to CEFA in Europe – Brussels), 4 of them PhD researchers in AgriFood matters, 1 coming from the regional government of Piedmont.

The training was very successful and the evaluation was positive. Sometimes the topics were too technical (e.g. Biogas production/plant management module) or too generic/ simplistic (canvas business model module), but in general the learners were satisfied.

See below post planet – impact on performances (module renewable energies)



5.6 Training conducted in Portugal

In Portugal iBET is the partner responsible for the training courses. The training was scheduled the 10th of December 2020 as an online event targeting an audience professionally linked with the wine sector, in particularly, from the Portuguese wine region of Bombarral, with the participation of wine producers from different wine companies (e.g. Companhia Agrícola Sanginhal www.vinhos-sanguinhal.pt). In addition, since the event was online, iBET also opened the training to doctoral students conducting their studies in the area of wastes valorisation.

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iBET promoted the event through its dissemination channels and also by contacting agricultural companies in the surrounding regions of Lisbon that could be linked with the NoAW technologies of valorisation of agricultural wastes, like the vine shoots (Figure 9).

The workshop was attended by 9 participants comprising 3 wine producers, 2 wine farmers and 4 PhD students.

The training was programmed as a half-day event and focused on Module 1, 2 and 3 (Figure 10):

Module 1: Introduction of the NoAW project and the need to valorise agora wastes;

Module 2: Type of agro wastes (focus on winery wastes) and legislation (focus on fertilizers regulation)

Module 3: Anaerobic Digestion, Biogas production, Organic fertilizers.

The final session provided the opportunity for asking questions and sharing ideas. In this last session the possibility of future research collaborations between the iBET and the wine sector participants, regarding the valorisation of their locally produced wastes has been discussed

Figure 9; Flyer for advertising the online training in Portugal

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Figure 10: Training Agenda for online training in Portugal

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6 Conclusions

All partners responsible for implementing trainings have offered them to their main stakeholder groups. Due to the COVID-19 crisis most of the trainings have been organised or will be organised as online trainings.

In total nine trainings have been implemented in six countries. A minimum number of 224 persons have been trained. For some partners it has been difficult to attract participants for their trainings. According to our – IBBK's – experience the attractiveness of trainings directly relates to how relevant the topic is for a company's or farmer's day-to-day work or strategic business development, respectively. Especially with regards to R&D-projects that are future oriented it is thus crucial to link project results to today's challenges of the target stakeholder groups.

Overall, the trainings were very diverse regarding content and audience. Each partner informed the stakeholders they usually work with on the results relevant for their sector. Whilst, for example, the training in China focused on new options for valorizing sweet potato wastes, the training in Germany focused on results relevant for the operators of (agricultural) AD plants and in France the trainings addressed residues from viticulture, bioplastics and business model development.

CBHU has prepared template training materials covering all topics that were studied during the NoAW-project and the partners implementing the trainings could select from them according to their needs. Looking at the topics covered in all trainings of all partners, all prepared topics have been covered. Thus the training materials have been flexible enough to meet the partner's needs for their relevant stakeholders. Especially in a project with a consortium as large as in NoAW this is the only reasonable way to approach trainings.

Compared to trainings implemented in previous projects the shift to online seminars did not necessarily have a negative impact on the numbers of participants. Especially in Germany a wider range in terms of the location of the participants has been reached. With regards to the duration, half day trainings fit well to online events and reduce the hurdle of joining, especially when farmers belong to the stakeholder group. Nevertheless, live events have the advantage of small talk and stronger interaction and networking between the participants and were often enriched with demonstrations / visits in relation with the training subject. This should be considered in future projects. When the main task is in relaying information, then half day online seminars are a good way to attract participants from all over the country. If networking and the opportunity to visit demonstration or best practice plants is in the focus as well as exchanging experiences live events are much more promising and better to implement.

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7 Partners involved in the work

Organisations:

CBHU: Campden BRI Magyarország Nonprofit Korlátolt Felelősségű Társaság, Hungary

GCIA: Confederazione Generale dell'Agricoltura Italiana, Italy

IAPPST: Institute of Agro-Products Processing Science and technology, Chinese Academy of Agricultural Sciences, China

IBBK: IBBK Fachgruppe Biogas GmbH, Germany

IBET: Instituto de Biologia Experimental e Tecnologica, Portugal

IFV: Institut Français de la Vigne et du Vin, France

INRAE: Institut National de Recherche en Agriculture, Alimentation et Environnement, France

Edited by: IBBK Fachgruppe Biogas GmbH, 2020

Commented by:

Acknowledgements:

We gratefully thank all authors and partner contributing to this deliverable.

The No-Agricultural Waste (NoAW) project has received funding from the European Union's Horizon2020 research and innovation program under grant agreement No 688338. We express our gratitude for founding our work.

8 FAIR Data management

Not applicable, because no data sets were used in this deliverable. All literature that has been used for creating this deliverable has been clearly indicated. The generic presentations are an Annex to this deliverable.

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9 Annexes

9.1 Summary of NoAW-trainings by partners

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Trainings conducted within NoAW

Country	Partner	Date	Time	Title	Location		No. of Participants	Type of Stakeholder			
					Live (pls. name city)	Online	excl. Speakers	Farmer	Industry	Research	Gov./Assoc.
China	IAPPST	16.07.2020	9:00-12:00	Feasibility, research progress and prospect of high value utilization of agricultural wastes		x	55		x	x	x
France	IFV	08.01.2020	9:00-12:00	Economie circulaire : valorisation des biodéchets de la vigne et du vin	Liergues, Beaujolais (France)		25	x			
France	IFV	02.02.2020	9:00-12:00	Economie circulaire : valorisation des biodéchets de la vigne et du vin	Liergues, Beaujolais (France)		25-30	x			
France	INRAE	16.10.2020	13:30 - 17:00	Transition towards a bio-based society; Training course on strategy development	Montpellier		15			x	
France	INRAE	18.11.2020	14:00-18:00	Developping circular economy from agricultural residues to reduce food and packaging waste and losses		Zoom	15		x	x	
Germany	IBBK	25.11.2020	10:00–13:00	Landwirtschaftliche Reststoffe gewinnbringend und DüV-konform nutzen		x	38	x	x	x	x
Hungary	CBHU	13.11.2020	9:00 - 13:00	Képzés a mezőgazdasági üzemek és vállalkozások részére a mezőgazdasági hulladékok hasznosításának jó gyakrolatáról		Zoom	12 (till 16/10/2020)	6	3	1	2
Italy	GCIA	15.10.2020	10 - 13;14 - 16	Biomasses - types of agro wastes to be valorised, best practices and methods, biomaterials and bioplastics, legislative review.	remote - Rome Turin	Zoom	25	19	2	3	1
Portugal	IBET	10.12.2020	14:00-17:00	Workshop de disseminação do projeto NoAW		Zoom	9	2	3	4	
							224				

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9.2 Templates for training materials developed by CBHU

9.2.1 Module 1: Reasons for agro-waste valorisation

9.2.2 Module 2.1: Types of agro-wastes for valorisation

9.2.3 Module 2.2: Review of relevant legislation

9.2.4 Module 3.1: Short summary of bioplastics

9.2.5 Module 3.2: Biogas production and bioenergy

9.2.6 Module 3.3: Organic fertiliser production

9.2.7 Module 4.1: Triggers, success and failure factors

9.2.8 Module 4.2: Business model development

9.2.9 Module 4.3: Success stories & best practice examples

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Training of best practices for farms and business on agro-waste management

Aims and short introduction of the project

Module 1

Why we need to valorise agricultural wastes;

Modules of the training;

About NoAW

http://noaw2020.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Why we need to valorise agricultural wastes

The problem

- Food production and supply chains consume app. 30% of total the global energy production
- Projected 9 billion people world population by 2050 will lead to a demand for increased food production, inevitable yielding a proportionally increase in primary agricultural residues
- 50% of the fresh weight of harvested crops and represent a potential of 90 Million Tons Oil Equivalent (MTOE), far more than any other waste streams
- Undesirable economic and environmental burdens (e.g. odours, pollution, greenhouse gas (GHG) emissions, nutrients imbalance) from agricultural primary residues are correlating with both the crop and animal production

Why we need to valorise agricultural wastes

- In order to further improve resource efficiency, reducing waste and improving waste management in primary production is considered of paramount importance to promote circular economy.
- Agricultural wastes
  - are unavoidable and continuously generated
  - are a huge pool of untapped biomass resources
  - should be rather considered and called agricultural by-products.

Turn agro-wastes into ecological and economic assets!

Why we need to valorise agricultural wastes

Major challenges

- Inappropriate materials and knowledge flows management resulting in unbalanced nutrients distributions, contaminants accumulation and agro-waste conversion issues
- Lack of adequate and early prediction of environmental and economic consequences of agro-waste management strategy and clear guidance to end-users
- Weaknesses of existing technologies for converting agro-wastes into biogas and bio-fertilizer
- Bottlenecks for innovative building blocks, molecules and materials issued from agro-waste
- Lack of integration of agro-waste business in a circular economy concept

Why we need to valorise agricultural wastes

The treasure chest

- Agro-wastes / residues can be converted into a portfolio of eco-efficient and valuable products:
  - bio-energy,
  - bio-fertilizers,
  - bio-packaging and bio-molecules

Why we need to valorise agricultural wastes

The residues conversion is crucial for

- economic growth and human well-being
- preventing putting pressure on land
- causing adverse effects on biodiversity

Turning waste into resources is one of the key elements of a circular economy and "near-zero-waste-society!

The sustainable agro-waste bio-refinery concept

- shifting from an a-posteriori environmental assessment to **an early eco-design approach**

About NoAW

NoAW (**No** **A**gricultural **W**aste)

- an European-Chinese project
- European Horizon 2020 research and development project, running from 2016 to 2020

Website: http://noaw2020.eu/

Twitter: https://twitter.com/noaw2020

Linkedlin: https://www.linkedlin.com/groups/13507644

About NoAW

NoAW is about developing a circular economy approach applicable to agricultural wastes on a territorial and seasonal basis

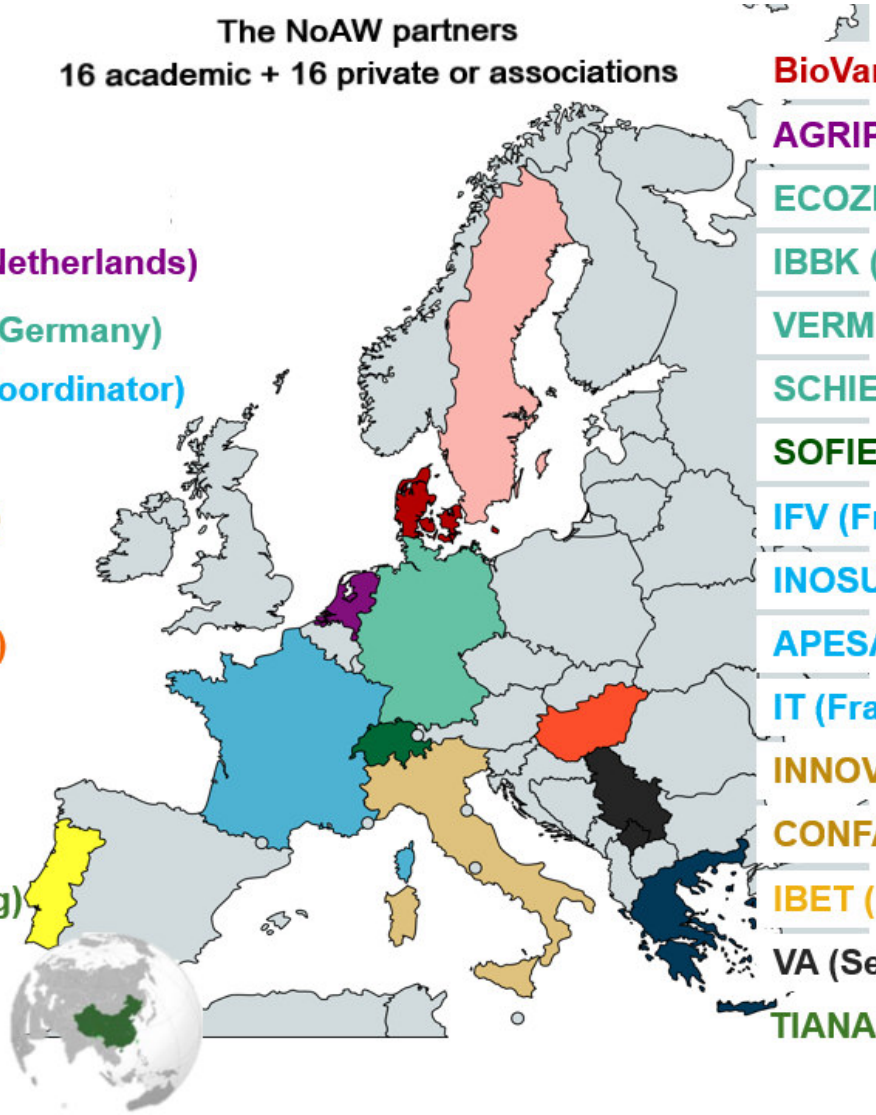
Concept of NoAW

- **Developing innovative eco-design and assessment tools of circular agro-waste management** strategies and address related gap of dialogue, knowledge and data;

- **Improve agro-waste resources use efficiency** by upgrading the most widespread mature technology and by eco-designing innovative **bio-processes and products;**

- Ensure and accelerate the **development of new business concepts and stakeholders platform for cross-chain valorisation of agro-waste** on a territorial and seasonal basis.

List of Beneficiaries



Modules of the training

1. **Aims and the short introduction of NoAW project**
   - ➢Why we need to valorise agricultural wastes
   - ➢About NoAW

2. **Valuable raw materials in agricultural wastes and relevant legislation**
   - 2.1 Types of agricultural wastes that can be valorized
   - 2.2 Review of relevant legislation

3. **Main possibilities of agro-waste valorisation, best practices and methods**
   - 3.1 Summary of bioplastics & their production
   - 3.2 Biogas production and bioenergy
   - 3.3 Organic fertilizer production and composting

Modules of the training

4. Practical implementation

4.1 Main triggers; Success and failure factors;

4.2 Business model development using business model canvas

4.3 Success stories and best practice examples

5. Group exercise

Developing business models for agro-waste valorisation using business model canvas in groups

Modules of the training

- The most appropriate modules (specific for the country) can be chosen by the trainers

- Organizing training courses
  - France-INRA, IFV,
  - Portugal FCT-UNL,
  - Germany-IBBK,
  - China-IAPPST,
  - Italy- GCIA,
  - Hungary-CBHU

- A group exercise/ practical activity (Module 5) should be included

Thank you for your kind attention!

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Training of best practices for farms and business on agro-waste management

Valuable raw materials in agriculture wastes and relevant legislation

Module 2.1

Types of agricultural wastes that can be valorized

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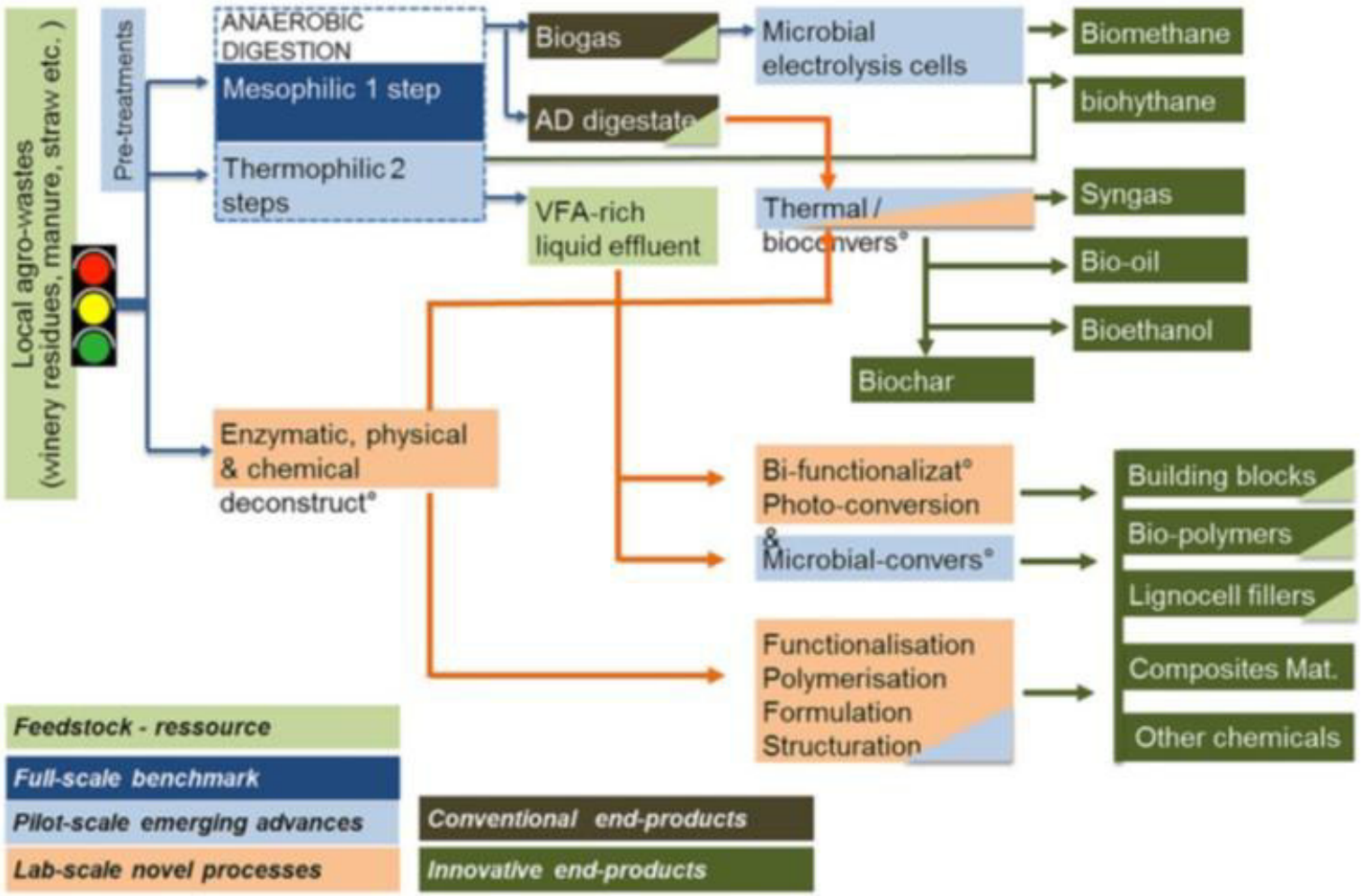
5 Valuable raw materials in agricultural wastes

- Losses during primary production
  - harvesting of crop,
  - milking
  - and farmed animal production
- Crop by products / examples
  - Cereal straw,
  - Beet leaves,
  - Potato tops,
  - Corn cobs,
  - Hay grass, etc.
- Vine production by products, Winery residues
  - Vine shoots
  - Grape pomace
- Livestock farming
  - Manure
  - Bone residues, etc.

Transformation of agricultural wastes and by-products

- Agricultural products, lignocellulosic material and waste biomass could be converted to
  - platform chemicals and then to
  - secondary chemicals,
  - intermediates and
  - final products
- By product transformation into biofuels and value added molecules is becoming increasingly popular to mitigate
  - global warming
  - and diversify energy sources
- Anaerobic digestion (AD)
  - is a biological process by which organic matter (for e.g manure) is transformed in absence of oxygen into biogas (a mixture of carbon dioxide and methane)
  - Biogas: can be valorised as transport biofuel or injected in the national gas grid (biomethane after a purification step) or further converted into heat and electricity
- Bioplastics derived from renewable resources
  - could replace, at least partially, the traditional oil-based plastics

Conventional and innovative end-products of agro-waste valorisation

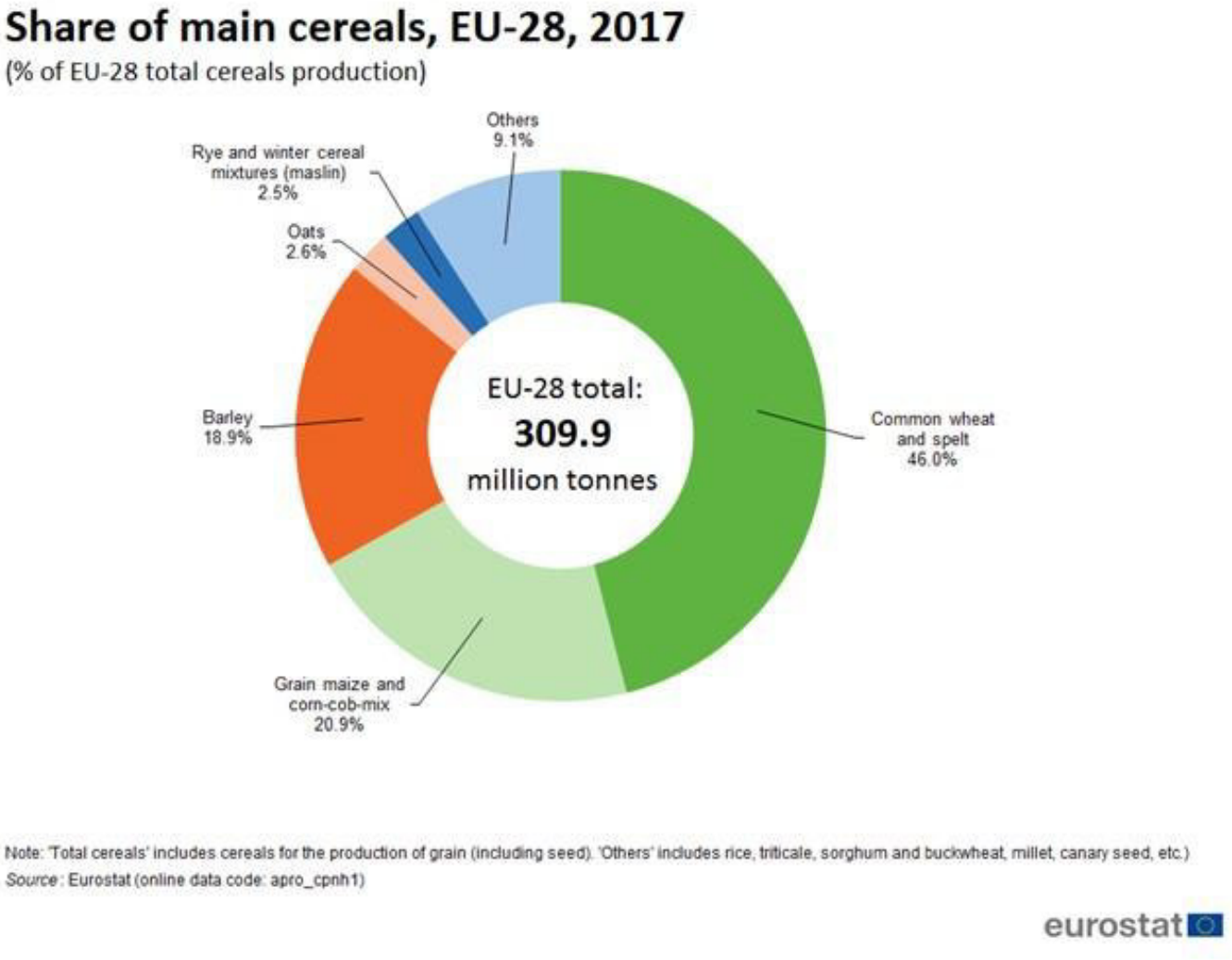


Source: Gontard et al. 2018: A research challenge vision regarding management of agricultural waste in a circular bio-based economy . Critical Reviews in Environmental Science and Technology

Straw and stalk

- Huge amount of straw and stalk as agriculture by-products from the cultivated crops
  - Straw: from wheat, spelt, rye, rice, barley, oat, and triticale
  - Stalk: for example from maize

Share of main cereals, Eu-28, 2017



Source: EUROSTAT

Straw

Straw (wheat and/or rice) as lignocellulosic biomass

- Current biofuel situation: biofuels mainly produced from „first-generation substrates" (sugar cane, wheat grain, vegetable oils), whch compete food production
- Potential to contribute to the future production of biofuels (straw as „second-generation biomass")
- Straw left after harvest in many cases under-valorised even though it can be used as one of the inputs for renewable energy and materials
- 1 kg of wheat grain generate of 1.1 kg of straw
- However, are limiting factors which reduce the collectable straw
  - after seeds harvest the bottom part of the stems released on the soil
  - cereal breeding to prevent lodging of grain is directed towards the production of short stems varieties
  - modern combines cut the stems higher

Corn residues

- Corn is one of the main agricultural crops In EU countries and worldwide
- Valuable corn residues
  - Corn stover (consists the different part of the plant like stalk, leaves, husks, cobs, tassels) belongs to the „second-generation ethanol crops”
  - However, there are challenges in harvesting, handling, storing and transporting the biomass
  - Cobs (US examples):
    - Milled cobs used for various industries (feed filler-additive, oil-drilling adsorbent, desiccant, or bio-abrasive)
    - Corn cobs as as feedstock for gasification projects, co-firing, and cellulosic ethanol
  - Cobs residues can be used as valuable raw material to produce bio packaging compounds
  - Relative yield of maize cobs are about 18.7%

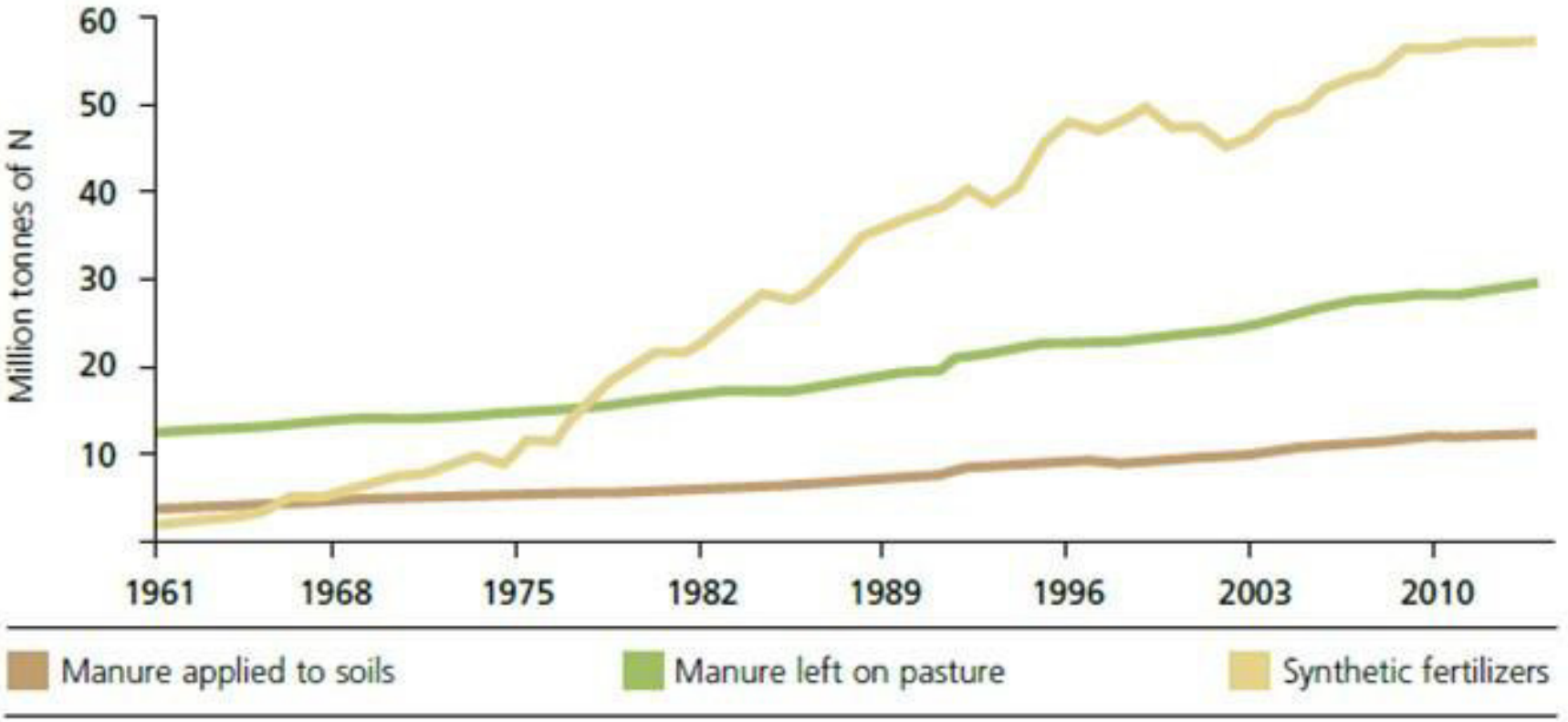
Animal manure

- Varieties of animal manures from the farming stage
  - e.g. livestock dung,
  - liquid manure from livestock holding facilities

- As fertiliser, the animal manure is one of the most used by-products in agriculture

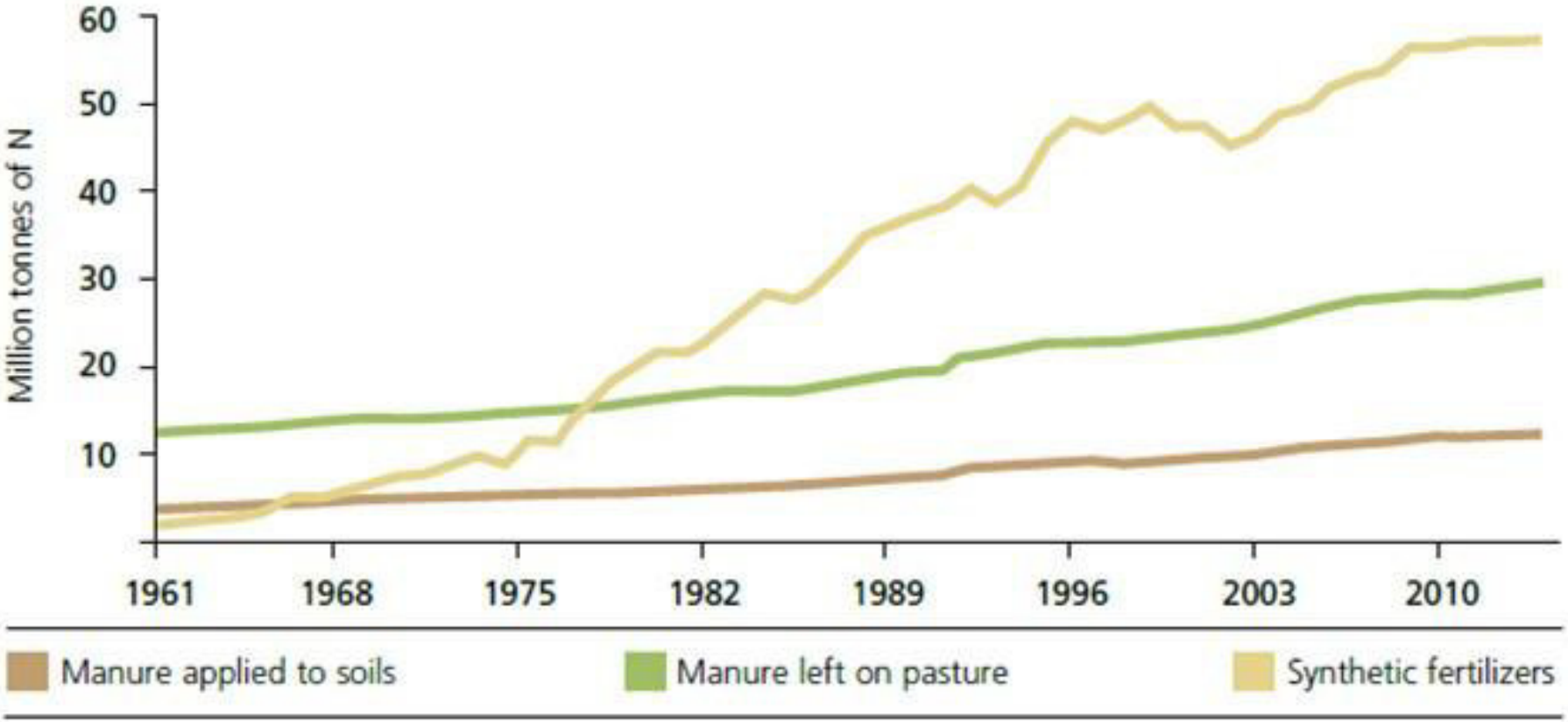
- Challenges in handling and storage of manure:
  - odours,
  - ammonia evaporation,
  - pathogens, nutrient run-off and infiltration into water bodies caused by nutrient leaching, and
  - greenhouse gas emissions

Global N input from livestock manure and synthetic (chemical) fertiliser during the period 1961 – 2014



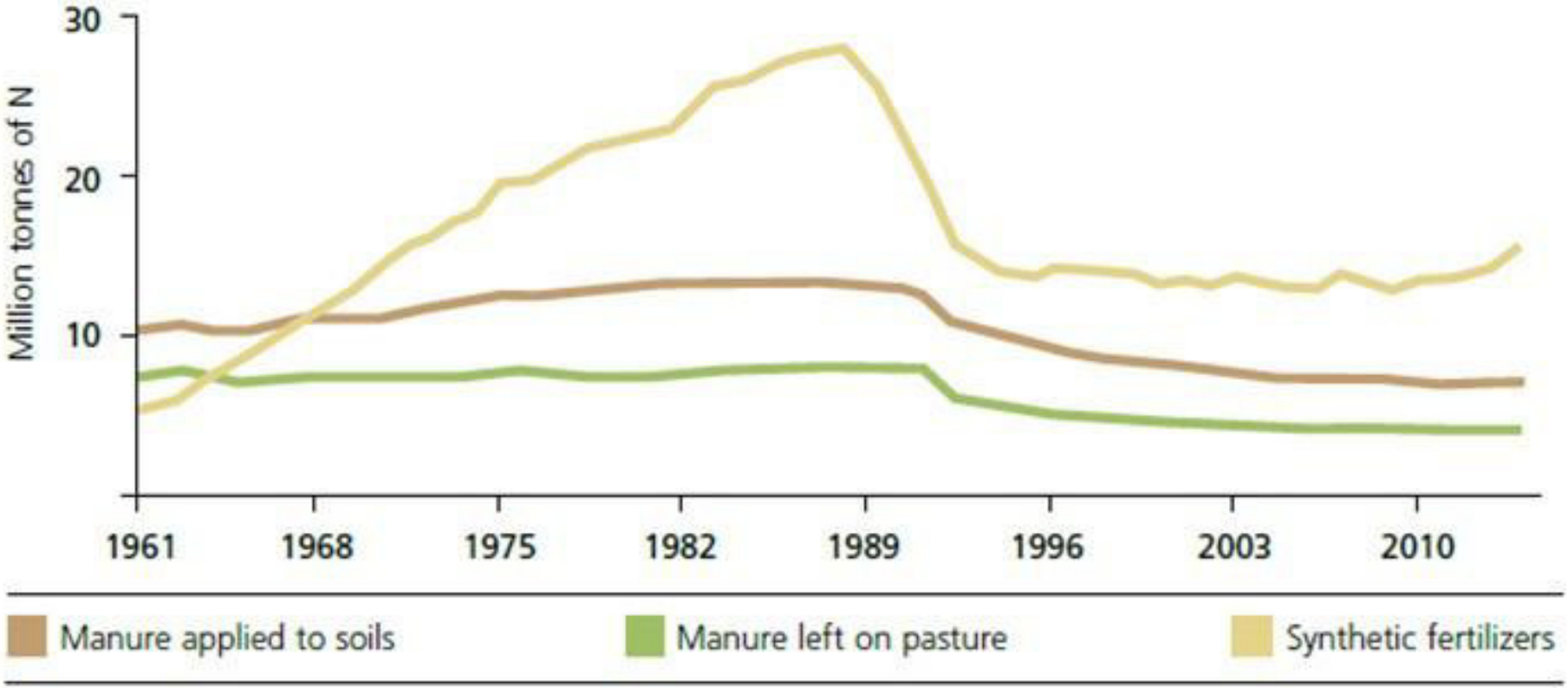
Source: FAO New Statistics, 2018

Asia, N inputs from livestock manure and synthetic (chemical) fertiliser during the period 1961 – 2014



Source: FAO New Statistics, 2018

Europe, N inputs from livestock manure and synthetic (chemical) fertiliser during the period 1961 – 2014



Source: FAO New Statistics, 2018

Winery wastes in context of production grapes and wines

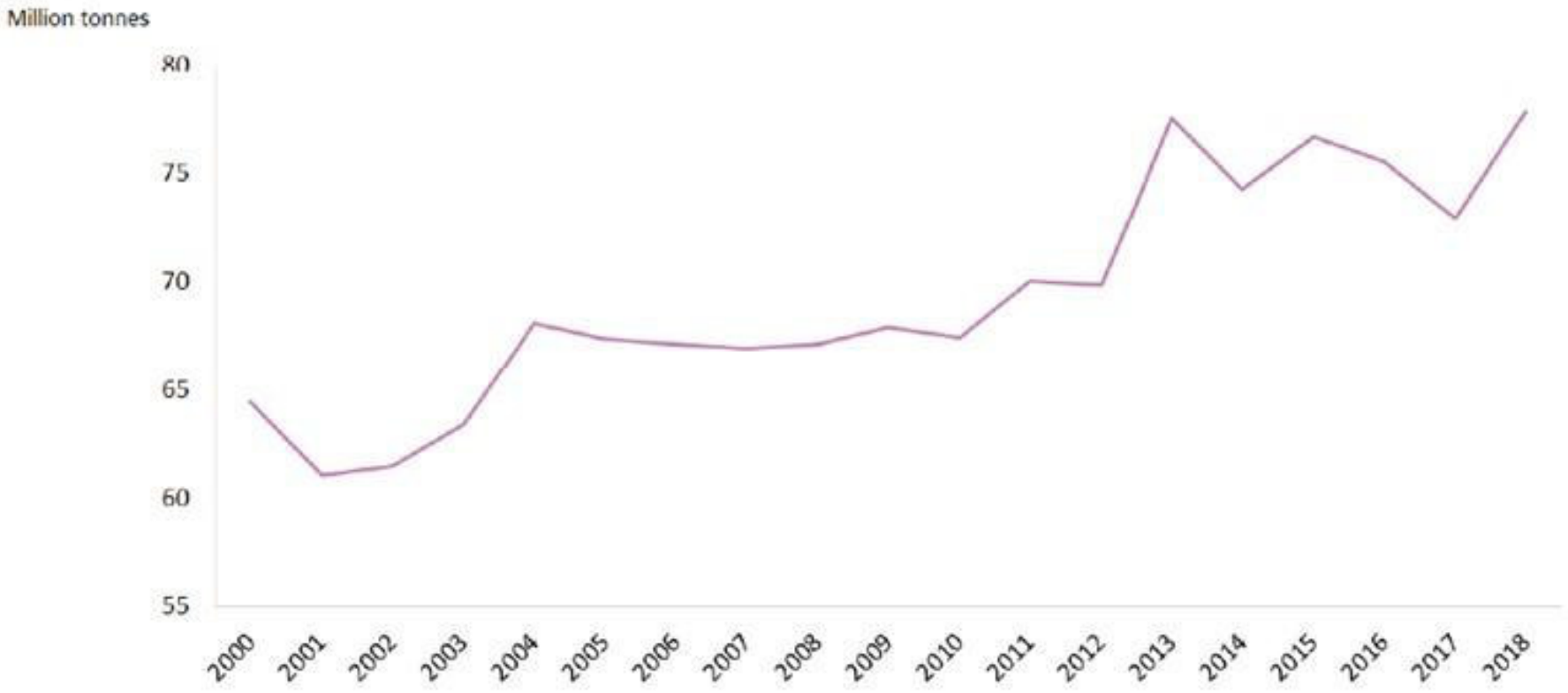
- Grape crops are one of the main extended agro-economic activities in the world

- 77.8 million tons grapes were produced global in 2018

- Grape production shows an increasing trend between 2000 – 2018
  - wine grape (57%)
  - table grape (36%)
  - dried grape (7%)

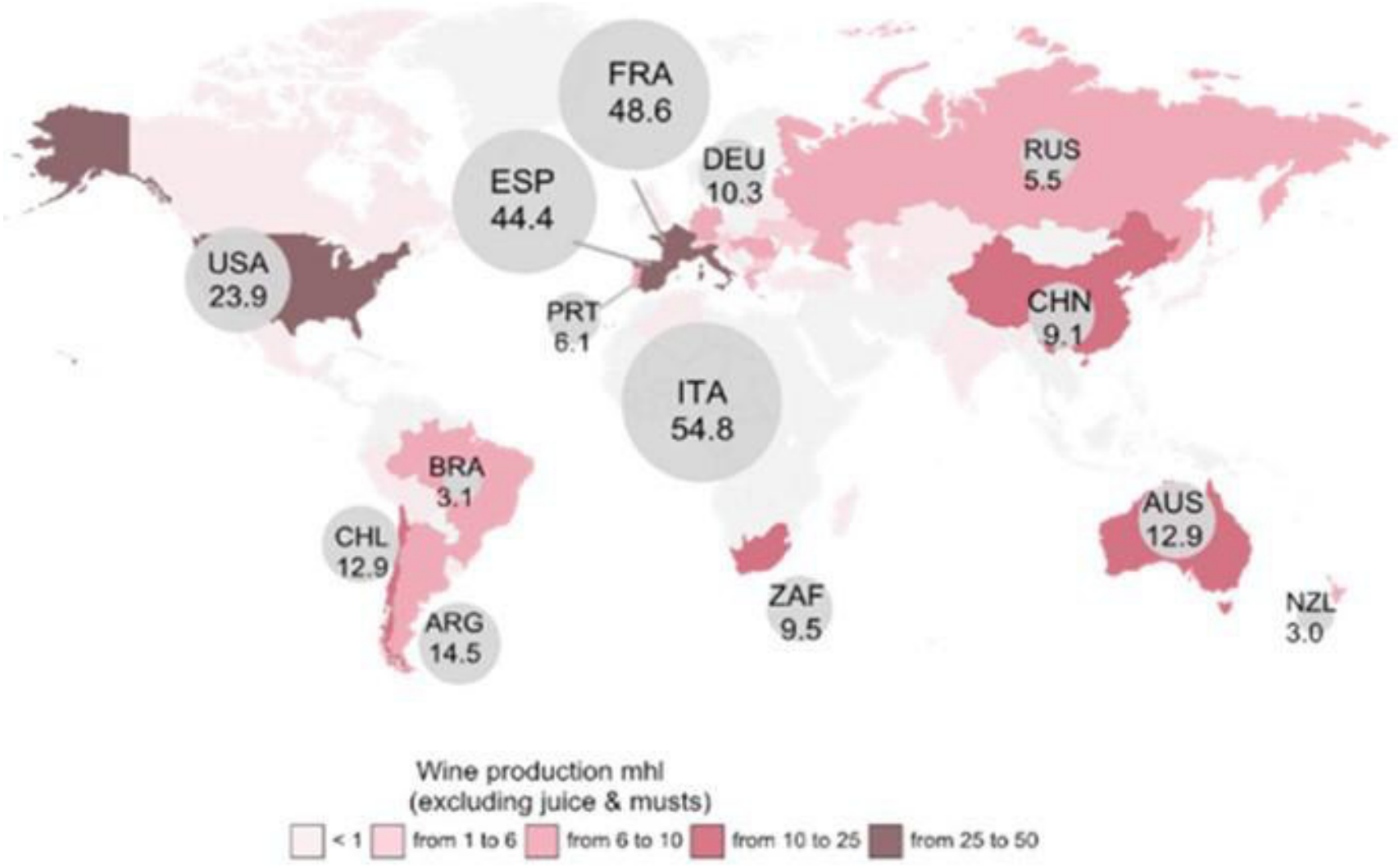
Source: 2019 Report on World Vitiviniculture of the International Organization of Vine and Wine

Evolution of the global grapes production, 2000-2018



Source: 2019 Report on World Vitiviniculture of the International Organization of Vine and Wine

Wine production by countries (million of hectolitres), 2018



Source: 2019 Report on World Vitiviniculture of the International Organization of Vine and Wine

Winery sector as high waste producer

Main winery wastes

- grape stalks, grape pomace and grape seeds and wine less (liquid)

Large amount of grape pomace disposed

- Italy, France and Spain the estimated annual grape pomace is nearly 1200 tonnes per year

- Main components of pomace
  - seeds, stems, residual pulp and skin
  - all contains a significant amount of bioactive compounds, such as phenols, and fibres

Thank you for your kind attention!

http://noaw2020.eu/

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Training of best practices for farms and business on agro-waste management

Valuable raw materials in agriculture wastes and relevant legislation

Module 2.2

Review of relevant legislation

http://noaw2020.eu/

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Review of legislation – from NoAW point of view (1)

NoAWs concept

- Is to valorise agricultural residues and by-products in order to substitute fossil-based energy, plastics, chemicals and fertiliser

NoAW looks at

- the feedstock,
- digestion process itself
- and the output streams, which partly cover already existing outputs
  - like biogas and digestate,
  - but also innovative outputs like biopolymers as a basis for biobased and possibly biodegradable plastics

NoAW focuses in particular on EU Directives

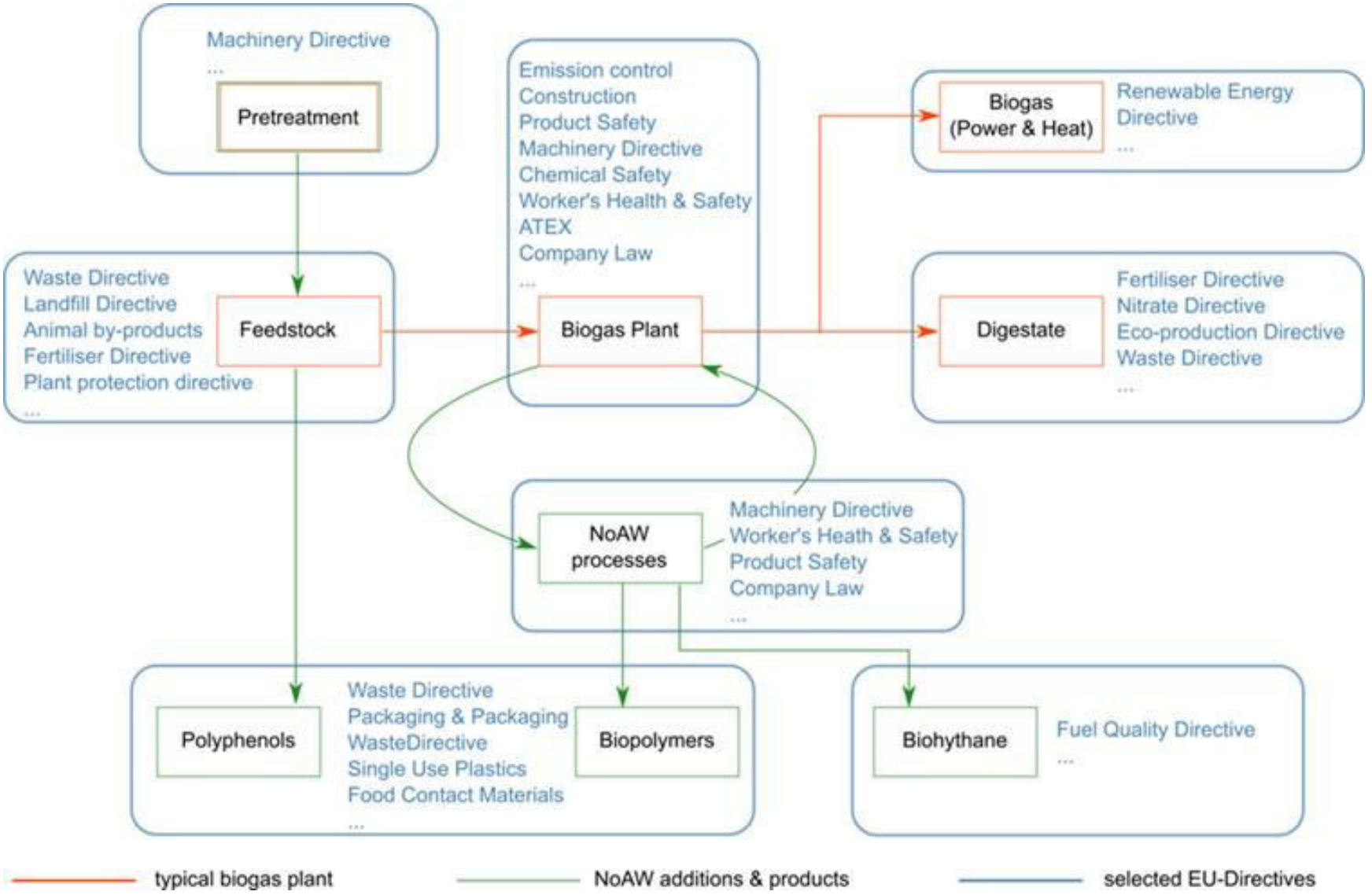
- have already been or soon need to be implemented into national legislation

EU Waste Legislation & Circular Economy Package -EU Directives-

Waste Framework Directive (WFD) – Directive 2008/98/EC

- sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery
- explains when a waste ceases to be a waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products
- lays down some basic waste management principles:
  - it requires waste to be managed without endangering human health and harming the environment,
  - and in particular without risk to water, air, soil, plants or animals,
  - without causing a nuisance through noise or odours,
  - and without adversely affecting the countryside or places of special interest
  - introduces a hierarchy of how to manage waste with the top priority of preventing waste via preparing for reuse, recycling, recovery and finally disposal

EU Directives and how it relates to the NoAW



Packaging and Packaging Waste Directive (Directive 94/62/EC)

- *In its original version* it defines “organic recycling” as one means to reduce negative impacts of packaging on the environment

- *In the latest amendment* (regarding lightweight plastic carrier bags (Directive (EU) 2015/720) a clearer distinction between oxo-degradable, biodegradable and compostable is discussed, at least in regards to specifications and labelling

Single-Use Plastics Directive

In recent years the Circular Economy Package of the European Commission revised and complemented the legislative framework on waste

Directive (EU) 2019/904 on the reduction of impacts of certain plastic products on the environment

- opens the field for the introduction of biobased and truly biodegradable plastics as one option to solve the issue of increasing accumulation of plastics and micro-plastics in the (marine) environment

- highlights the need of new, innovative solutions

EU Agricultural & Fertiliser Regulation (1)

Nitrate Directive (Council Directive 91/676/EEC)

To protect (ground)water bodies against pollution caused by nitrates from agricultural sources

- Promotes good farming practices, for example
  - by limiting the periods and amount of applying nitrogen from organic fertilisers like livestock manure,
  - by reducing nitrogen run-off or leachate through better fertiliser management on farm level,
  - by planting intercrops that « catch » nutrients outside the main crops vegetation period or before the main crop fully covers the soil
  - or by storing manures over a longer period of time.

EU Agricultural & Fertiliser Regulation (2)

Fertiliser Directive (Regulation (EC) No 2003/2003)

- *Focuses only on mineral fertilisers*: aims at removing trade barriers between member states
- However, *does not cover fertilising products made from organic materials* (e.g. livestock manures, organic wastes, agricultural by-products)
- Contrary to most other product harmonisation measures in Union law, does not prevent non-harmonised fertilisers from being made available on the internal market

EU-Eco-Directive (Council Regulation (EEC) No. 834/2007)

- on organic production and labelling of organic products defines how agricultural products and food labelled as organic products
- In general is very open towards the use of digestate as fertiliser
- only limitation it makes is that *livestock manure from conventional farms may only be used, if it comes from non-industrial and area* bound animal husbandry

EU Critical Raw Materials (COM (2017) 490 final)

- Disrupted nutrient recycling is a problem for Europe (and all over the world)
- Phosphorus and nitrogen are lost across environmental media during food production or are wasted instead of being used for plant nutrition
- Reserves of the phosphate rock are finite
- One of the main fertiliser constituents is chemically processed phosphate rock, which has been identified by the Commission as a critical raw material
- EU is currently highly dependent on import of phosphate rock mined outside of the EU
- Mined mineral rock phosphate contains dangerously high levels of Cadmium/Uranium toxic metals

New EU Fertilising Products Regulation (EU 1009/2019) (1)

- Provides harmonised conditions for making fertilisers made from recycled or organic material
- Includes EU-wide end-of-waste criteria for compost and digestate, which can be used in organic fertilisers, soil improvers and growing media
- Encourages a move toward more environmentally-friendly agriculture
- Shall apply from 16 July 2022
- Regulation (EC) No 2003/2003 will be replaced by the new Regulation by July 16, 2022

The aim is

- to *reduce the EU dependency* on nutrients from third countries
- to *replace the Cadmium and Uranium contaminated* mineral phosphate fertilisers

The key elements of the new and bioeconomy driven agri fertilizer product rules

- Opening the market for new and innovative organic fertilisers by defining the conditions under which these can access
- Providing strict rules on safety, quality and labelling requirements for all fertilisers
- EU fertilising products divided into different product function categories (PFC): should each be subject to specific safety and quality requirements (adapted to their intended use)
- Component materials for EU fertilising products divided into different component material categories: should each be subject to specific process requirements and control mechanisms
- Introducing new limit values for contaminants in fertilisers

NUTRIMAN Nitrogen and Phosphorus recovery thematic network

- The content of the new EU regulation 009/2019 was demonstrated in practice by this network (**https://nutriman.net/farmer-platform**)

Type of fertiliser and the maximum limit of Cadmium

Type of fertiliser	Maximum Cadmium limit
Organic fertilisers, inorganic soil improver and other bio-fertilisers	1.5 mg/kg dry matter
Organic soil improver and liming materials	2 mg/kg dry matter
Inorganic macronutrient and organo-mineral fertilisers less than <5% P_2O_5 content by mass	3 mg/kg dry matter
Inorganic macronutrient and organo-mineral fertilisers above >5% P_2O_5 content by mass ('phosphate fertiliser').	60 mg/kg phosphorus pentoxide (P_2O_5)
Low cadmium content organo-mineral fertilisers	20 mg/kg phosphorus pentoxide (P_2O_5)
Inorganic micronutrient fertilisers	200 mg/ kg total micronutrient content

EU legislation on Food Contact Materials (FCMs)

- Biobased plastics and polyphenols extracted from agricultural by-products might come into contact with food

Regulation (EC) No 1935/2004: gives framework

Regulation (EU) No 10/2011(Plastics Implementation Measure): rules for plastic materials and articles with food contact

- Describes rules on the composition of plastic FCMs
- Establishes a Union list of materials that are permitted for use in the manufacturing of plastic FCMs
- Uses „migration limits" to ensure the safety of plastic FCMs
  - *Specific Migration Limits (SML):* based on the toxicity of each specific substance
  - *Overall Migration Limit (OML):* overall migration to a food from all substances together (max. 60 mg/kg food, or 10 mg/dm² of food contact area)

Thank you for your kind attention!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Training of best practices for farms and business on agro-waste management

Main possibilities of agro-waste valorisation, best practices and methods

Module 3.1

Summary of bioplastics & their production

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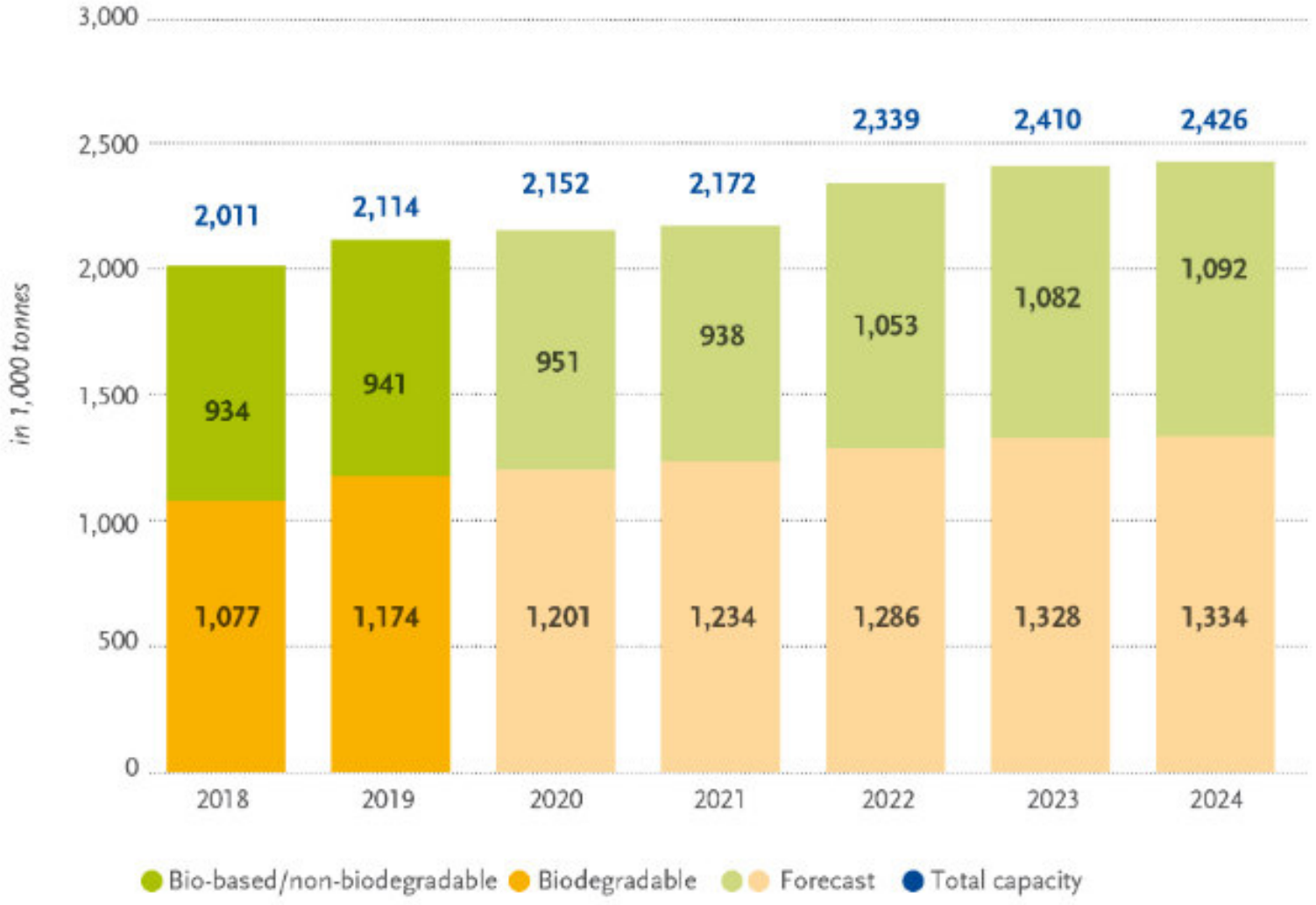
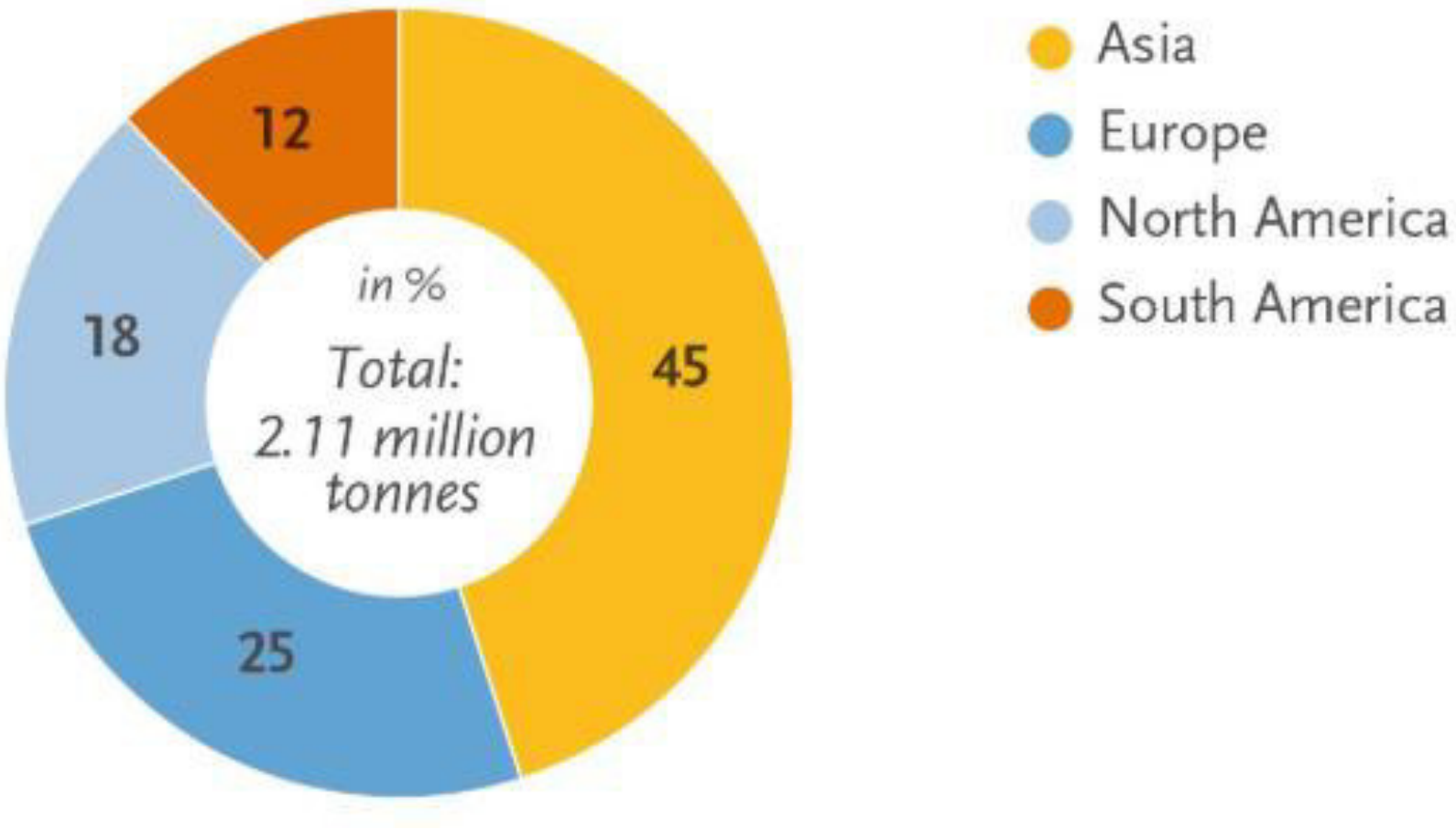
Global production capacity of bioplastics (2019)



Source: European Bioplastics, nova-Institute (2019)

Global production capacity of bioplastics by region in 2019



Source: European Bioplastics, nova-Institute (2019)

Terms: Biobased, Biodegradable

Biobased

- means that plastics are derived from renewable resources

Biodegradable

- Indicates the property of a material to be degraded into natural substances (such as water, carbon dioxide, methane and compost) by means of microorganisms
- Biodegradation depends on the surrounding environmental conditions (e.g. temperature, humidity), on process conditions (aerobic / anaerobic conditions), on time-frame
  - *biodegradability' is only unambiguous, if environmental conditions and time are specified*
  - Standards are different
    - for industrial compostable packaging
    - for home compostable packaging

Standards

Standard for industrial composting, examples

- European standard EN 13432: plastic packaging is certified industrially compostable (for treatment in industrial composting facilities and anaerobic digestion)

Standard for home composting, examples

- Currently no international standard specifying the conditions for the home composting of biodegradable plastics
- Existing national standards:
  - Belgian certifier Vinçotte had developed the OK compost home certification scheme
  - French standard NF T 51-800 “Plastics – Specifications for plastics suitable for home composting”
  - Australian norm AS 5810

Classification of bioplastics (1)

Three main groups

1. bio-based or partly bio-based, non-biodegradable plastics such as bio-based PE, PP, or PET (so-called drop-ins) and bio-based technical performance polymers such as PTT or TPC-ET;

2. plastics that are both bio-based and biodegradable, such as PLA and PHA or PBS;

3. plastics that are based on fossil resources and are biodegradable, such as PBAT.

Source: FACT SHEET, European Bioplastics

Classification of bioplastics (2)

Fossil based / biodegradable

- For e.g. copolymer polybutylene adipate terephthalate (PBAT) or polycaprolactone (PCL), that is a polyester
- These bioplastics are typically used in combination with other bioplastics in order to increase their biodegradability

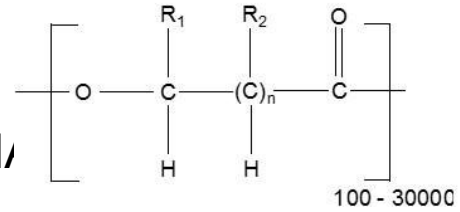
Biobased / Non biodegradable

- Biobased polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyamides (PA), polytrimethylene terephthalate (PTT)
- For the production of these bioplastics the most commonly used feedstock is bioethanol („first generation" bioethanol obtained from sugarcane, sugar beets, corn grains or from other crops, such as potatoes and wheat)
- Because the „first generation" bioethanol competes with food production, nowadays intensive R+D of the "second-generation" ethanol, produced from lignocellulosic biomass (agricultural wastes, wood, and grasses)

Classification of bioplastics (3)

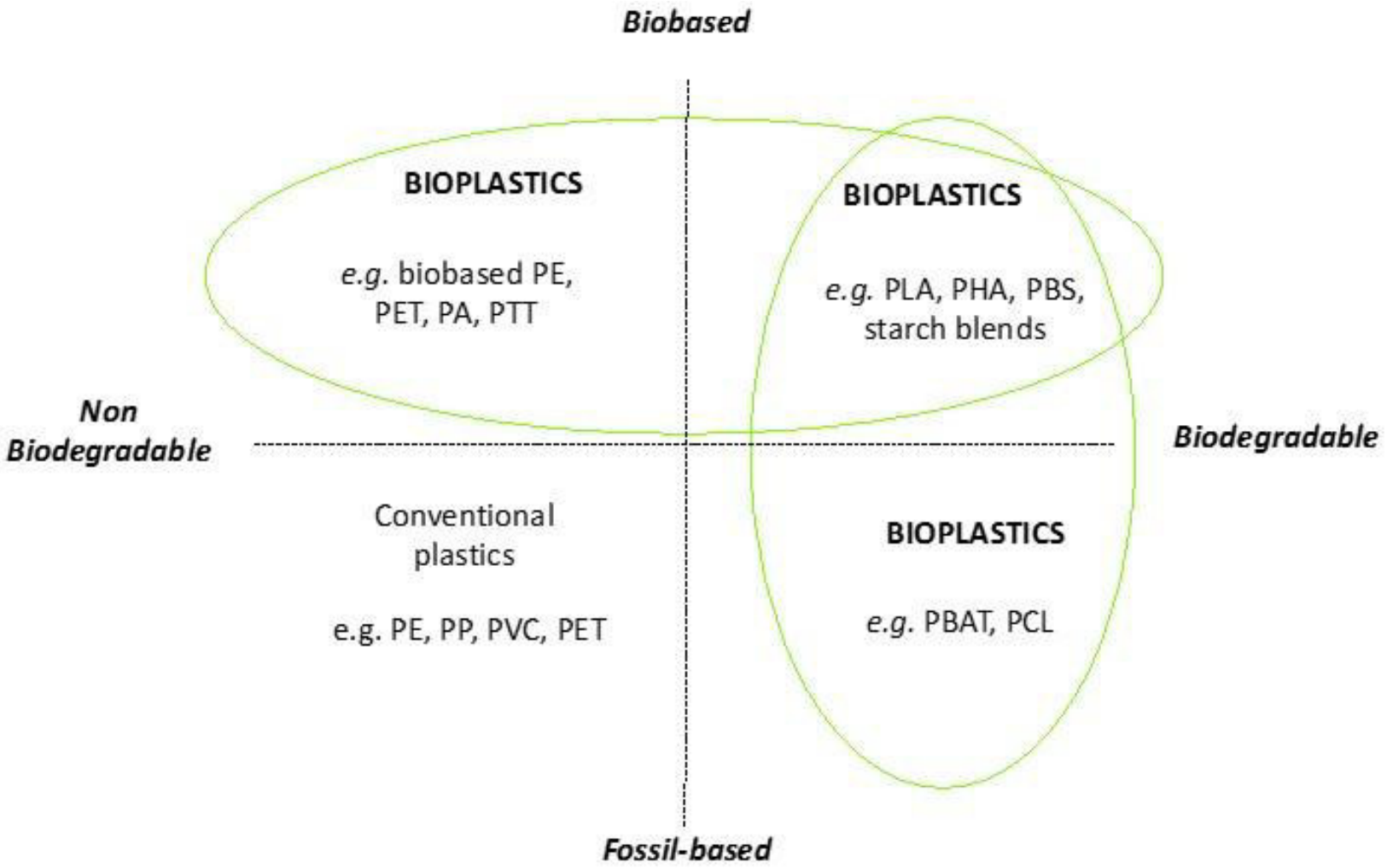
Biobased / biodegradable

- mainly include starch blends made of thermo-plastically modified starch or polyesters like polybutylene succinate (PBS), polylactic acid (PLA) and polyhydroxyalkanoates (PHA)



- PHAs
  - are among the main drivers of the growth of bioplastics (PHA not a single polymer, but a family of copolymers)
  - are synthesized biologically by over 300 different species of microorganisms
  - obtained from a large range of available organic feedstock (industrial and agricultural wastes, food waste, animal waste, and molasses)
  - recently the large commercialization of PHA yet is limited by their high production cost
  - can be used for a broad portfolio of market applications, including packaging, heat sensitive adhesives, disposable utensils, bulk commodity plastics, agricultural films, etc.
  - properties of PHAs offer specific advantages for their use in agriculture and horticulture as mulching films: can be incorporated into the soil at the end of the crop season, undergoing biodegradation by soil microorganisms (presently the most commercially available biodegradable mulching films are based on polysaccharides such as cellulose and starch blends)
  - Other applications in agriculture and horticulture: films for banana bushes, or

Classification of bioplastics (4)

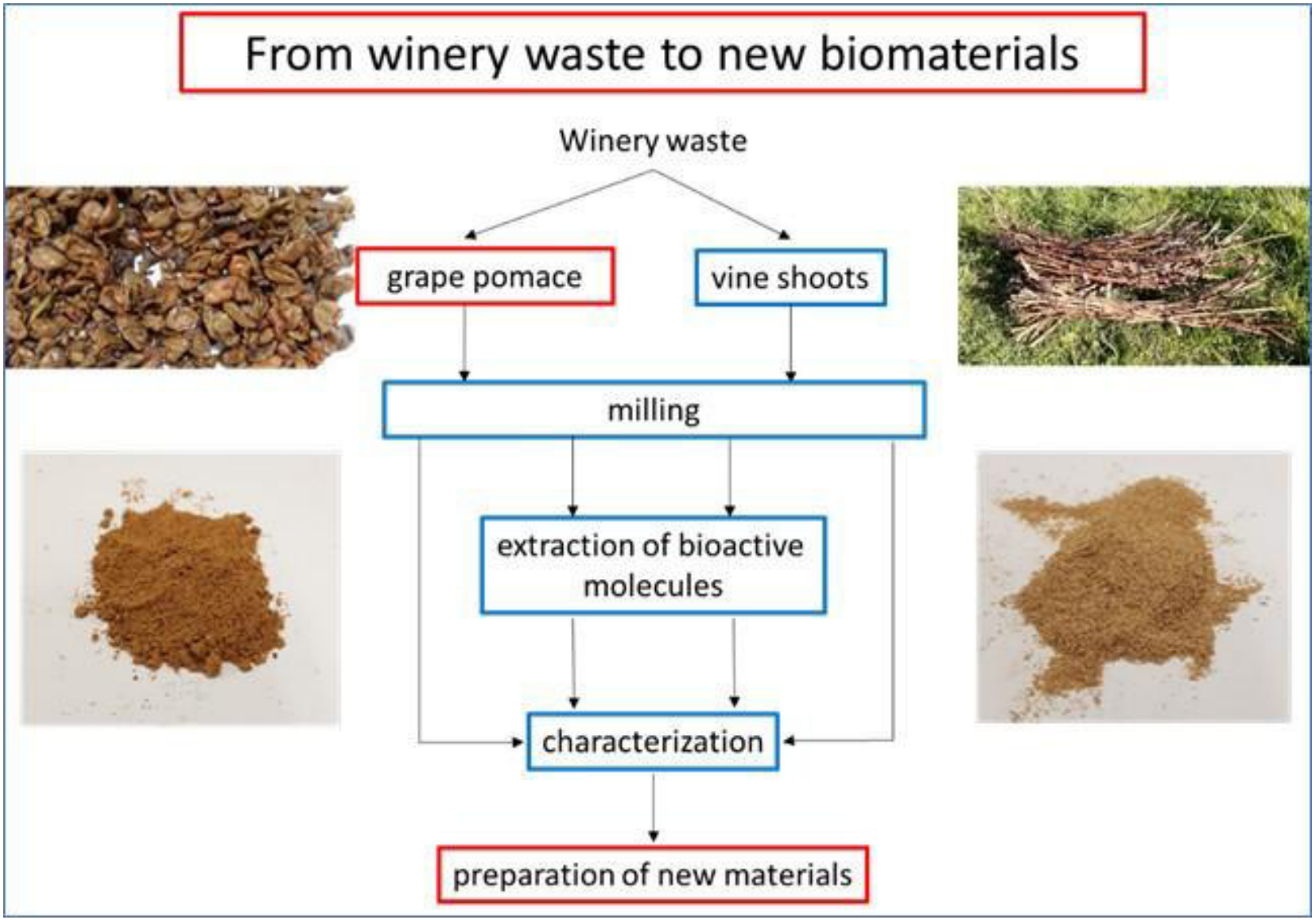


Source: FACT SHEET, European Bioplastics

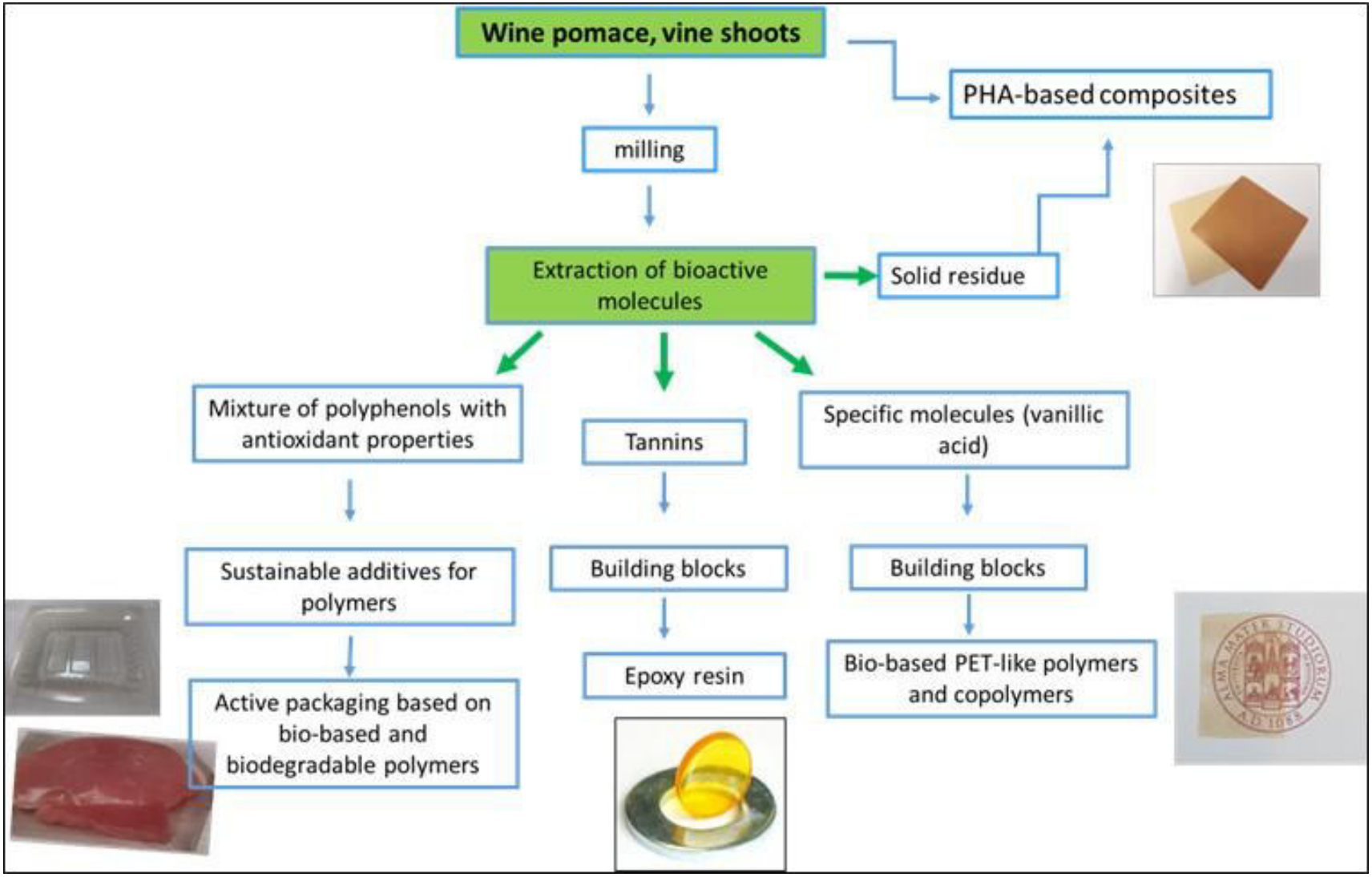
NoAW progresses

- In NoAW the production of PHAs is developed by starting from Volatile Fatty Acids (VFA), produced by two step anaerobic fermentation
- NoAW contributes to develop new strategical routes towards the valorisation of winery waste for the production of a series of materials
  - Vine shoots and grape pomaces can be processed to produce bioactive molecules can be extracted from winery waste: a mixture of polyphenols, tannins, some specific molecules, for example vanillic acid, if present in a sufficient amount can be obtained
- The mixture of polyphenols can be used as antioxidant additives for polymers. In this way an active packaging, with intrinsic antioxidant properties, by exploiting natural polyphenols extracted from grape pomace can be produced
- Tannins can be used as building blocks to obtain new bio-based polymeric resins. Vanillic acid (or similar difunctional molecules) can be used to prepare new bio-based polymers and copolymers, such as PET-like (co)-polyesters.
- Finally, the residues of extraction are added to a polymeric matrix to

Activities developed in NoAW to valorize winery waste



Activities developed in NoAW correlated to the extraction of bioactive molecules from winery



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Training of best practices for farms and business on agro-waste management

Main possibilities of agro-waste valorisation, best practices and methods

Module 3.2

Biogas production and bioenergy

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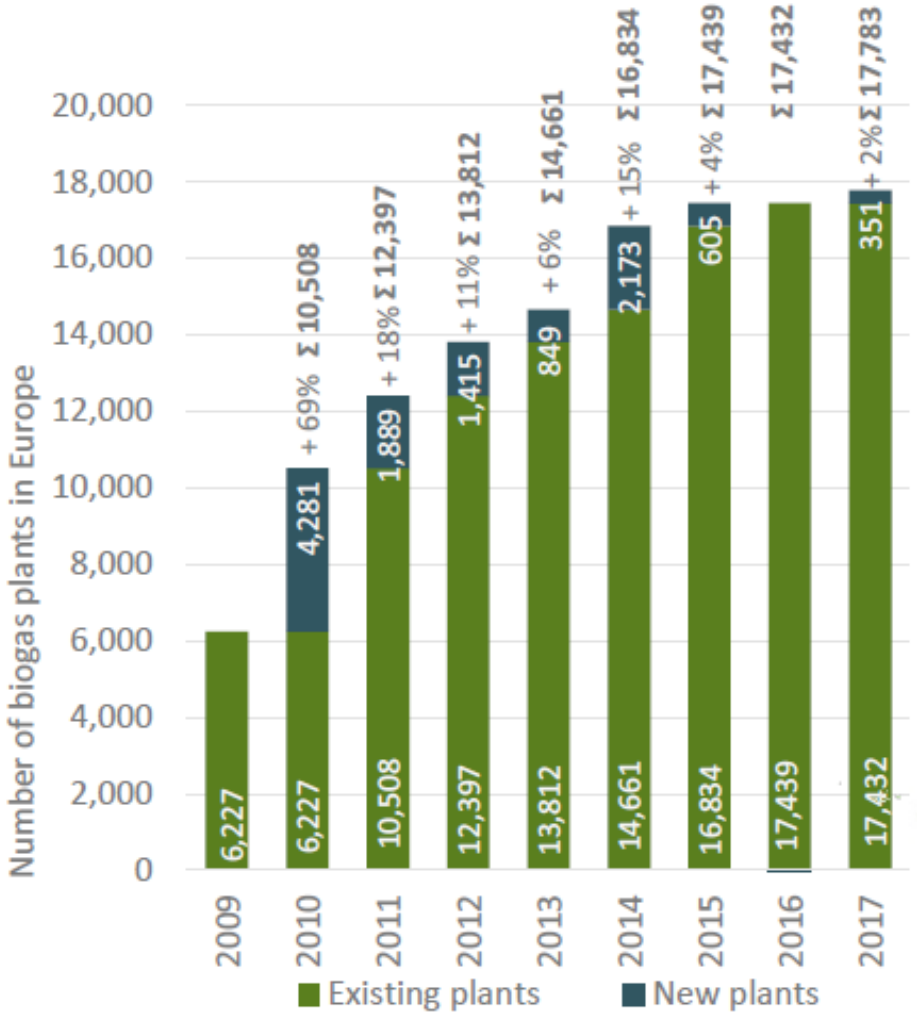
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

European Biogas Market, 2017

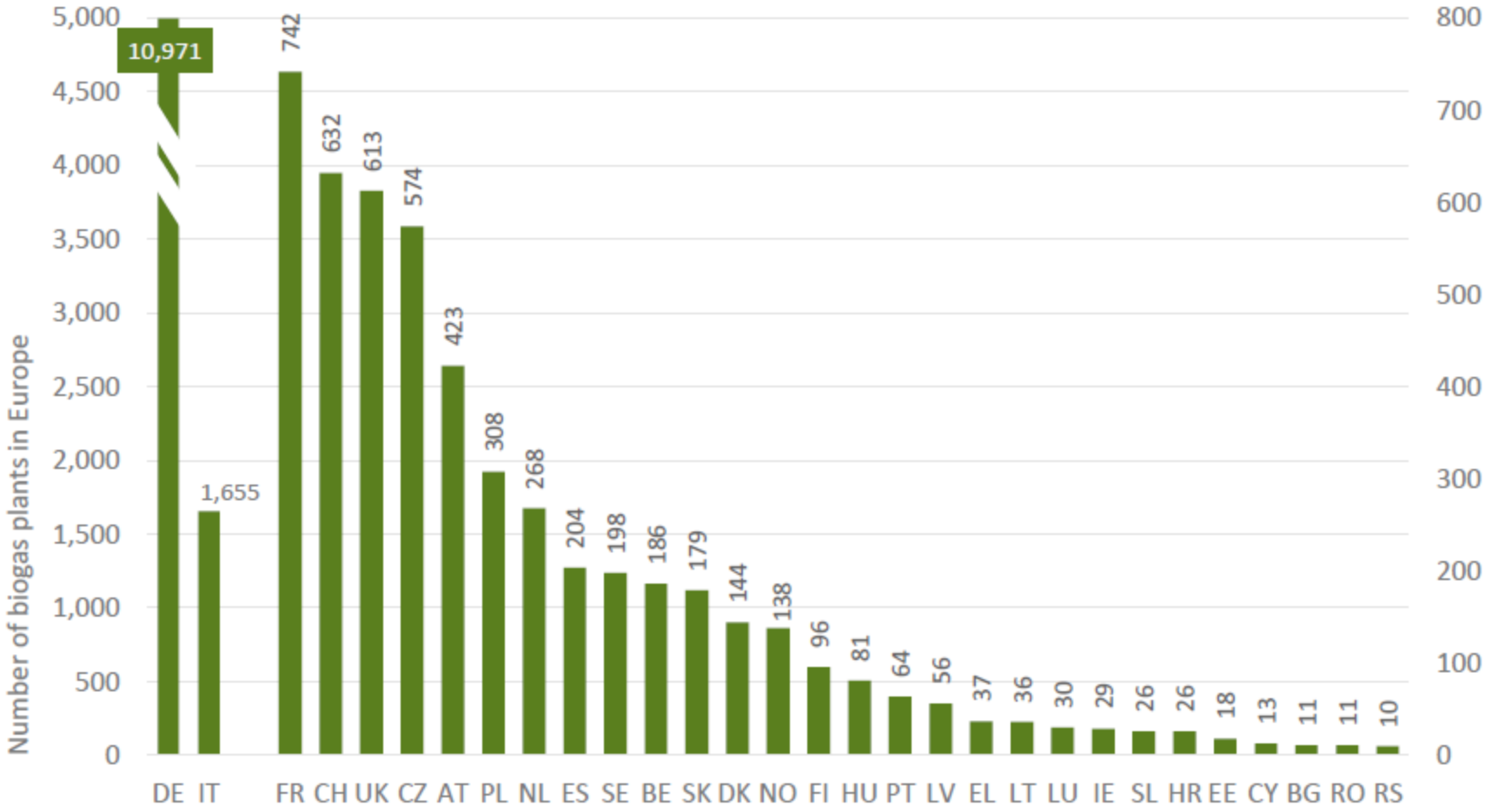


Steady growth in European Biogas Market

- 2017: 17,783 biogas plants
- Within the past five years:
  - 3,122 new plants
  - 18% increasing

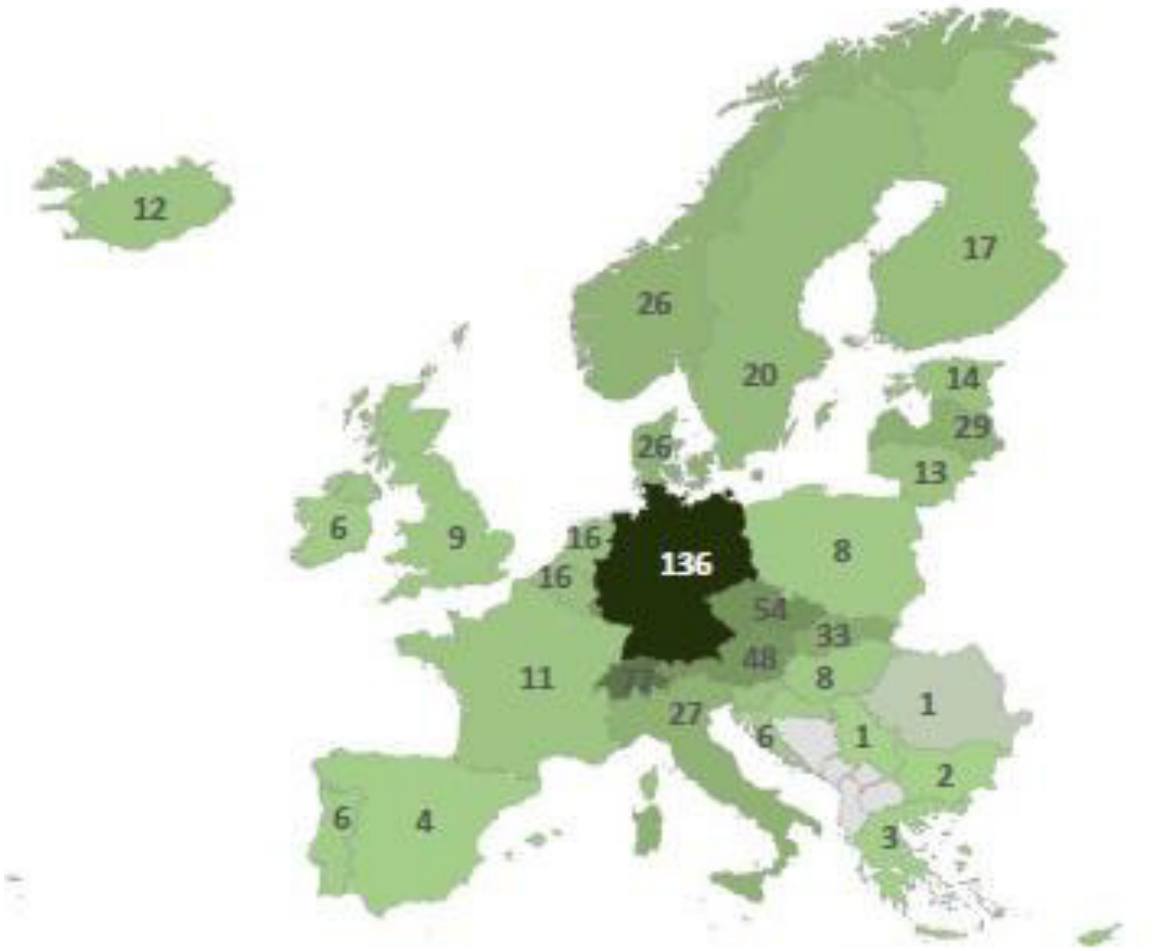
Source: EBA 2018. "Statistical Report of the European Biogas Association 2018." Brussels, Belgium, December 2018.

Number of biogas plants in European countries, 2017



Source: EBA 2018. "Statistical Report of the European Biogas Association 2018." Brussels, Belgium, December 2018.

Number of biogas plants in Europe per 1 Mio capita, 2017



Source: EBA 2018. "Statistical Report of the European Biogas Association 2018." Brussels, Belgium, December 2018.

Bioenergy, Biogas production, Anaerobic digestion

Bioenergy

- is a form of renewable energy that derives from organic material
- Organic matter: biomass as feedstock, e.g. wood, straw, manure, agricultural products and by-products as well as the organic fraction of municipal solid waste, catering waste and residues from the food processing industry

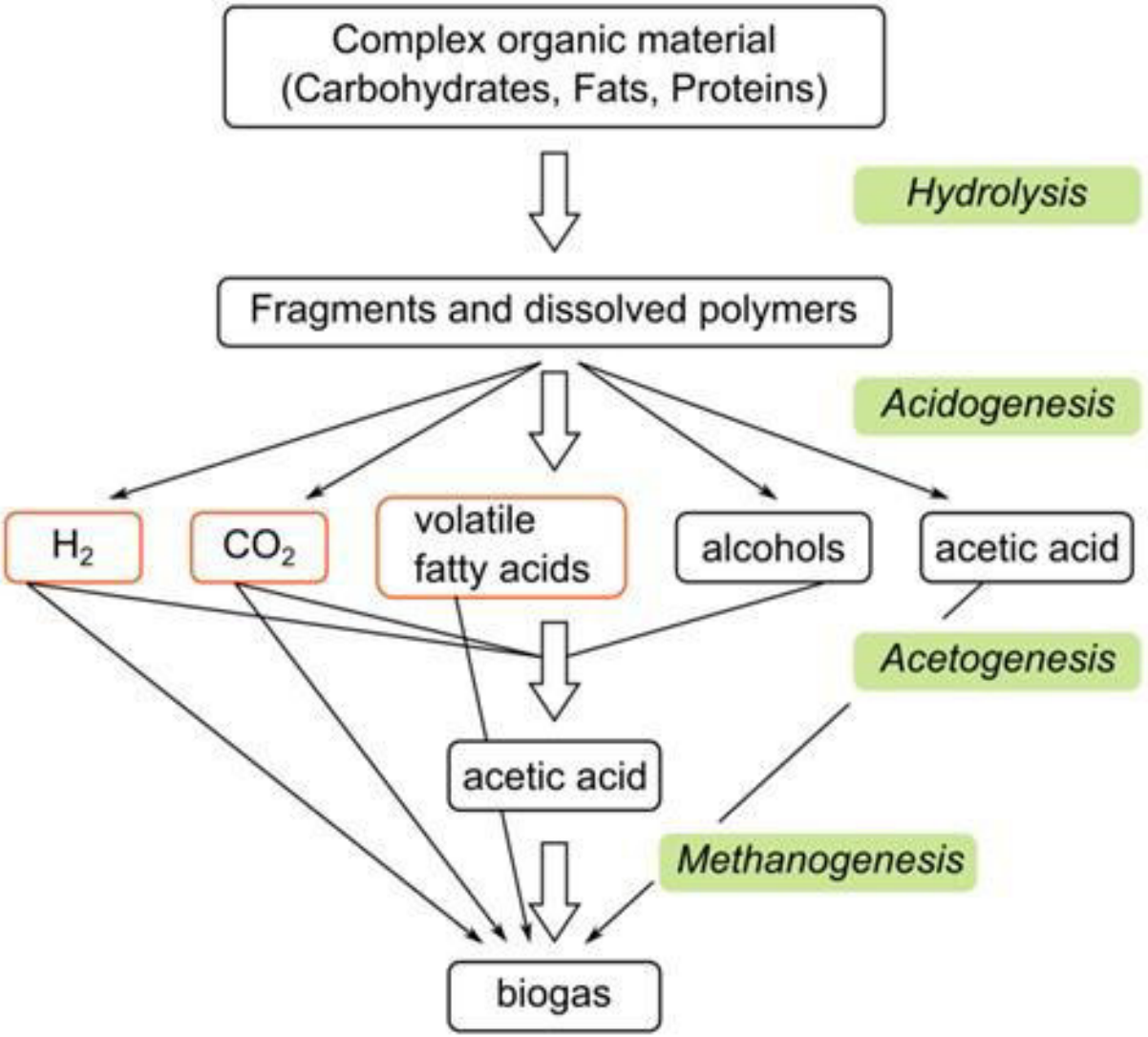
Biogas production

- Processes to convert organic matter into energy can be physical, chemical, thermal, biological or a combination of those
- By using organic residues, biogas production is part of the circular economy in agriculture

Anaerobic digestion (AD) a biological process

- in which consortia of microorganisms convert organic matter into biogas and fertiliser
- by which organic matter is transformed in absence of oxygen into biogas (a mixture of carbon dioxide and methane).
- However, interesting intermediates (e.g. longer chain fatty acids such as butyric acid) for the bioeconomy sector can be also produced by modified AD processes
- Traditional biogas process relies on the complete degradation of volatile fatty acids (VFA) to acetic acid, hydrogen and carbon dioxide

Degradation steps in anaerobic digestion



Biogas production via Anaerobic Digestion (AD)

Suitable feedstocks for AD

- Any type of "soft" biomass: meaning that it is poor in lignin and celluloses
- Cellulosic feedstock like straw: needs special pre-treatment before it can be added to the digester

Anaerobic digestion

- Takes place in digesters which aim at providing ideal conditions for the microorganisms

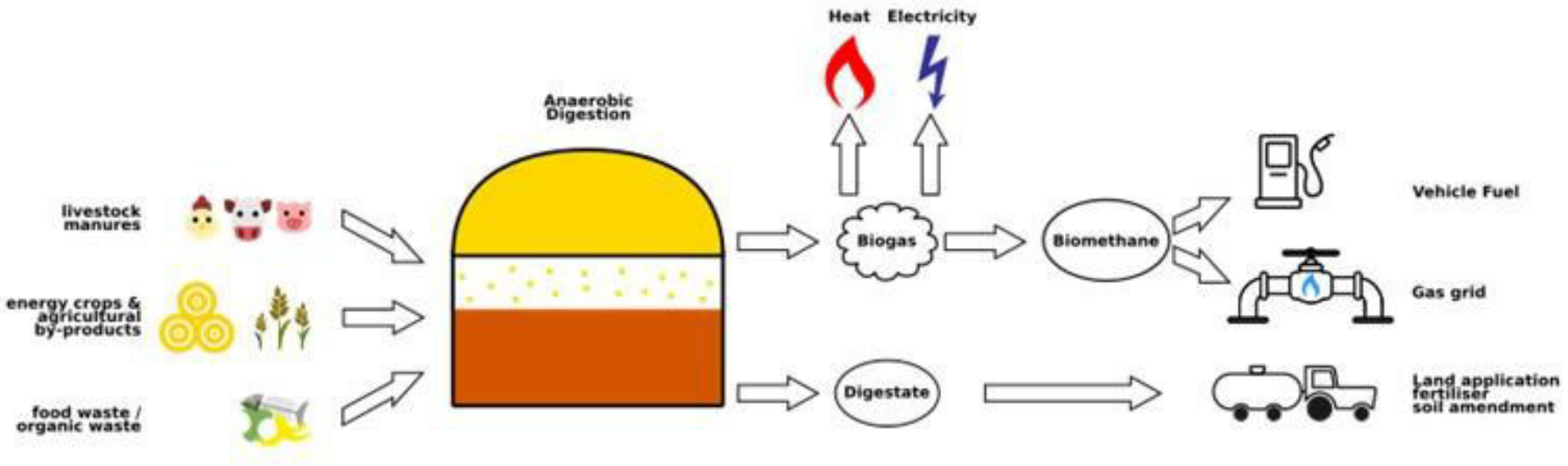
Biogas produced

- Mix of methane, carbon dioxide with traces of hydrogen sulfide and ammonia

Traditional Flow streams on biogas plants

Usage of biogas

- *Usually burned* in a combined heat and power unit (CHP), also called cogeneration unit, the generated electricity is fed into the public grid
- *Alternatively, the biogas can be upgraded to biomethane* by separating the CO2 and thus be used as a natural gas substitute

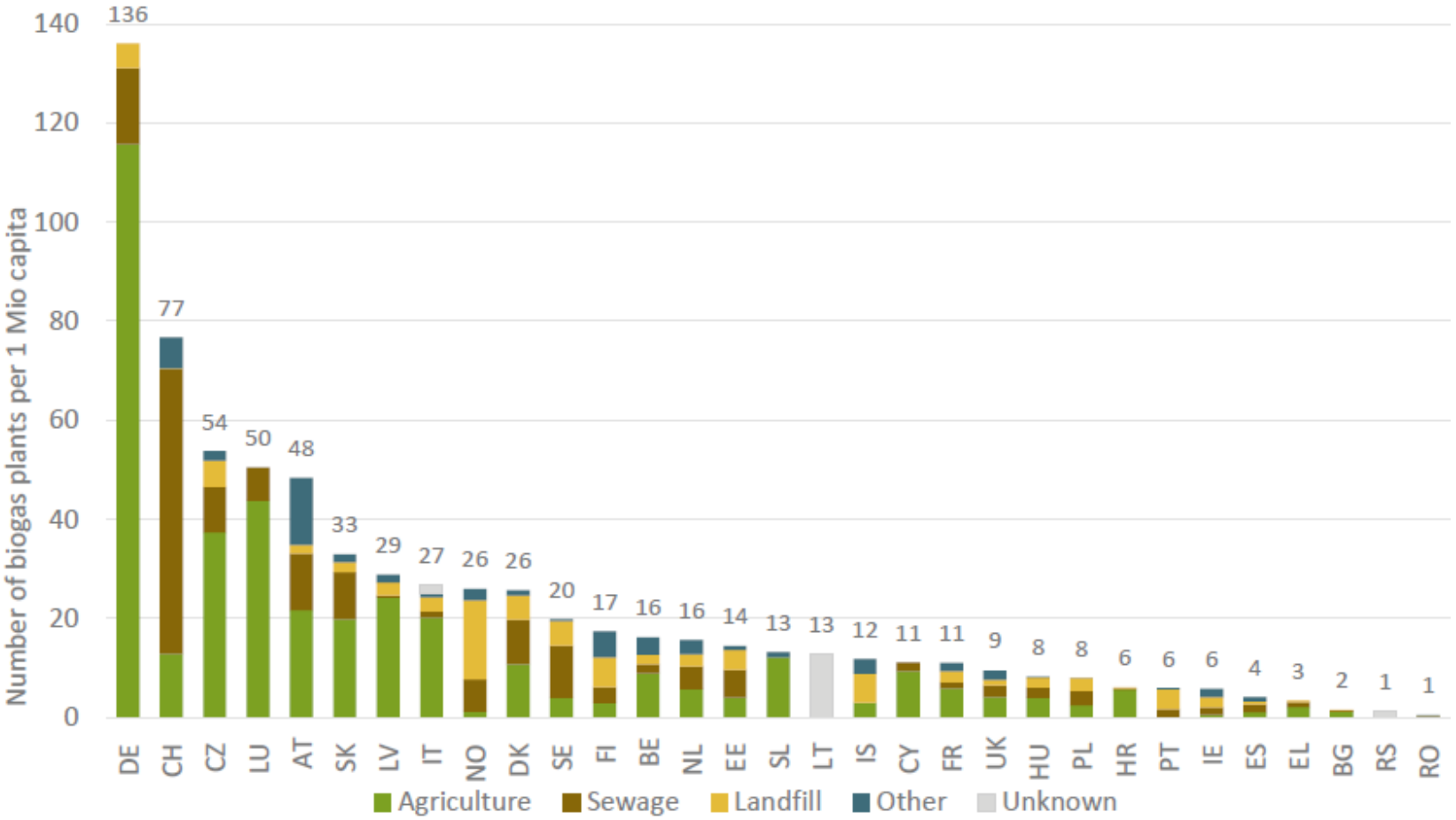


Typical electric and thermal efficiencies of CHPs

- The amount of power and heat produced by one CHP depends on its electrical and thermal efficiency
- Rule of thumb: the electric efficiency increases with size, while the thermal efficiency decreases with size

	50 kW	75 kW	160 kW	250 kW	550 kW	1 MW	2,2 MW
El. efficiency	35 %	38 %	41 %	42 %	42 %	41 %	43 %
Therm. efficiency	50 %	43 %	40 %	42 %	43 %	45 %	41 %
Total	85 %	81 %	81 %	84 %	85 %	86 %	85 %

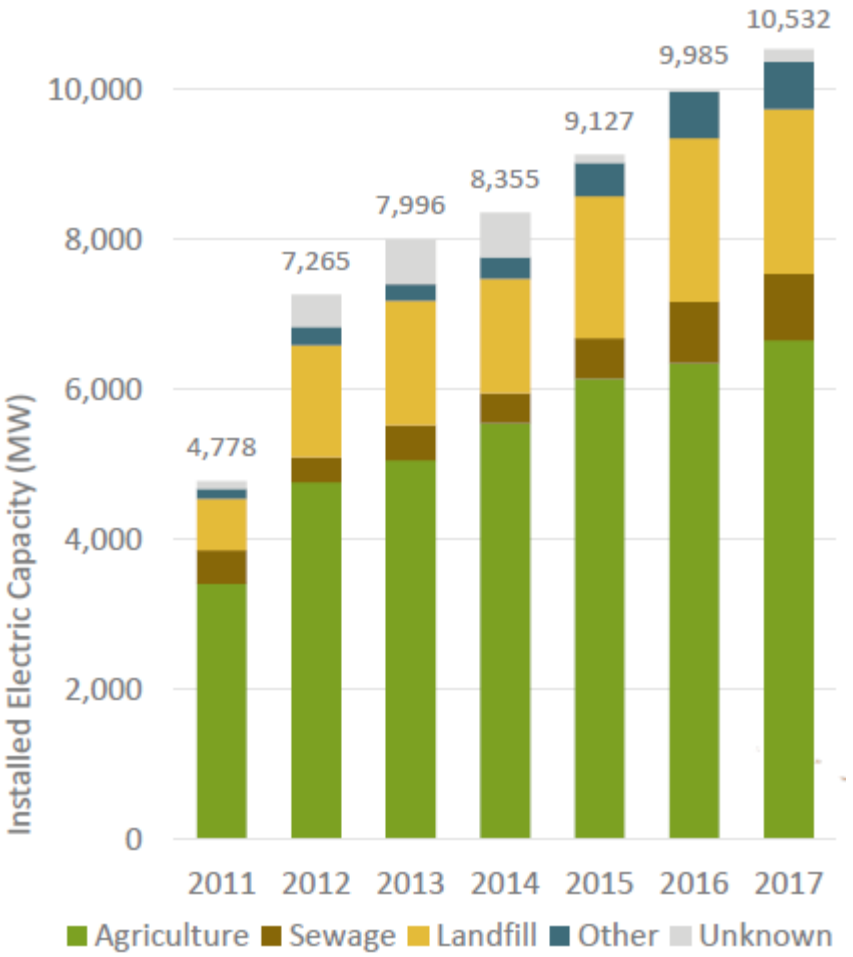
Biogas plants in European countries by feedstock type per 1 Mio capita



Majority of the feedstock of biogas plants given by Agriculture

Source: EBA 2018. "Statistical Report of the European Biogas Association 2018." Brussels, Belgium, December 2018.

Development of total Installed Electric Capacity (IEC) of biogas plants in European countries by feedstock



IEC of biogas plants (MW)

- 2017: 10532 MW
- Within the past five years:
  - Newly installed 2.536 MW
  - 24% increasing
- Trend: installation with higher capacities
- Biogas IEC
  - primarily from agriculture (plant matter & animal manure)
  - from landfill also significant

Source: EBA 2018. "Statistical Report of the European Biogas Association 2018." Brussels, Belgium, December 2018.

Application of Digestate (1)

Digestate leaving the process , contains

- useful organic matter for humus production (depends on the feedstock composition, their nutrient content and the fermentation conditions),
- Plant available: phosphate, potassium as well as sulphur
- but also heavy metals as well as organic pollutant

Nitrogen present in digestate: organically bound and dissolved form

- *Dissolved form* (during AD up to 80% of the nitrogen is converted into ammonium (NH_4 -N) which is the dissolved form)
  - readily plant available
  - has the same fertilising properties as mineral nitrogen fertiliser
- Organically bound nitrogen
  - remains in the soil, needs time to mineralise in order to

Application of Digestate (2)

- Because of the utrients and the organic matter, digestate serves as fertilizer and also as soil conditioner, *however*
- Digestate usually has a pH-value of around 8 or even slightly higher.
- In combination with the ammonium this bears the risk of loosing nitrogen in form of ammonia

Important :

Apply digestate close to the plants' demand as possible!

Work immediately the digestate into the soil when land-spreading it – e.g. by using trail hose or trail shoe technology!

(see in Module 3.3 Organic fertilizer production and composting)

Application of Digestate (3)

Consideration of the maximum allowed nitrogen placement (170 kg/ ha)

- Where biogas plants meet a high number of animal heads, the totally needed area might not be available, thus creating local nutrient surpluses

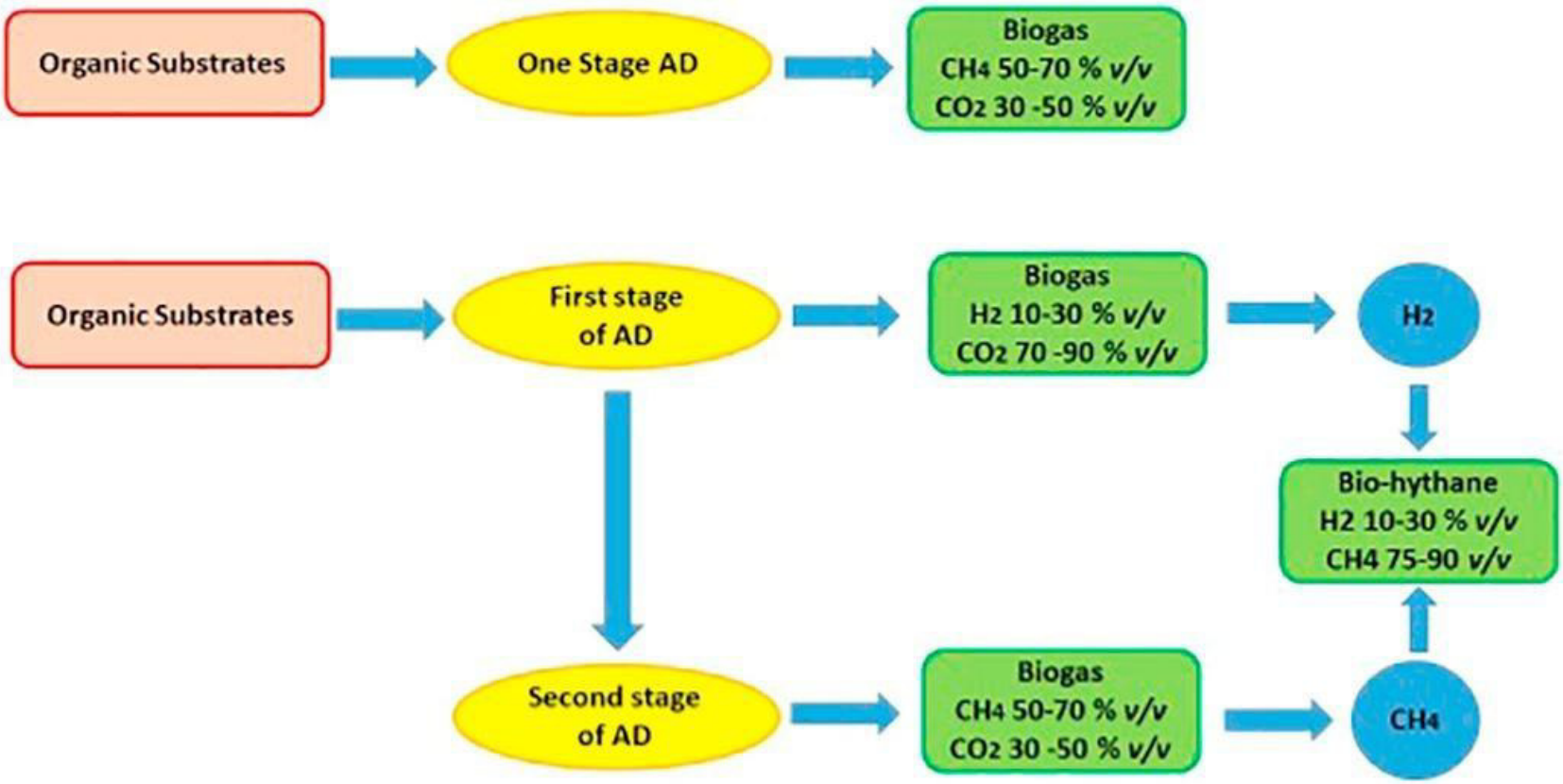
- In that case
  - Digestate needs to be transported – often over long distances – to other sectors or regions;
  - Alternatively digestate processing allows to recover nutrients in a very concentrated form that can also be marketed.
    - After recovering nutrients from the digestate, the remainder is a liquid that can also be used for irrigation purposes.

Biogas upgrading into bio-hythane – Fuel for the Future

Bio-hythane

- Is hydrogen-methane blend (H_2+CH_4) with hydrogen concentration between 10 and 30% v/v
- Bio-hythane has better combustion performances and lower emissions than other fuels
- The major potential of bio-hythane application in automotive sector
- Bio-hythane can be produced from different organic substrates (from manure, crops residues, winery waste …..) by two sequential anaerobic stages:
  - a dark fermentation step followed by a second an anaerobic digestion step, for hydrogen and methane production

Comparison the traditional & two stageS AD

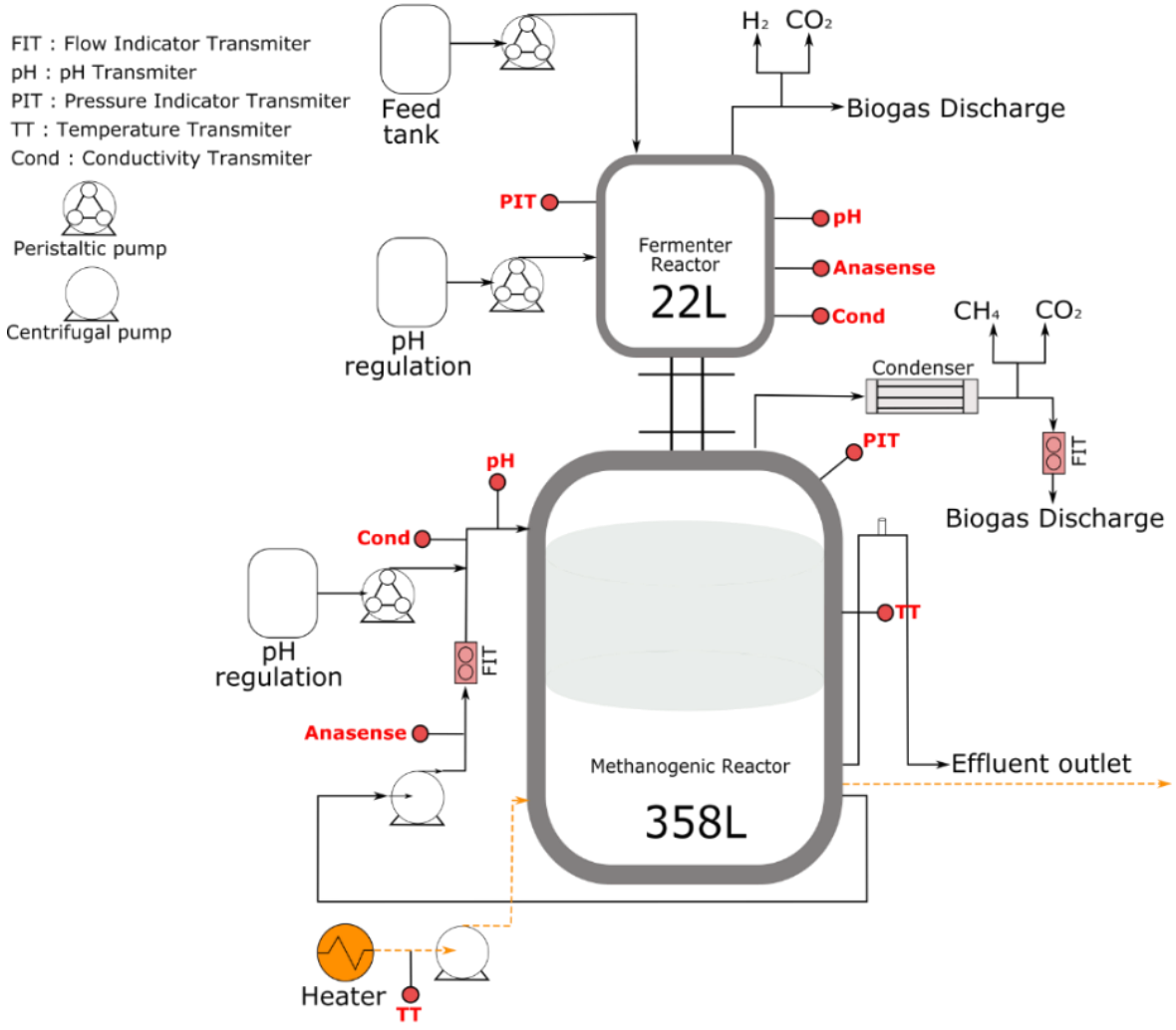


Source: Bolzonella D., Battista F., Cavinato C., Gottardo M., Micolucci F., Lyberatos G., Pavan P., Recent developments in biohythane production from household food wastes: A review. Biosource Technology, Vol 257, June 2018, Pages 311-319

Biogas upgrading into bio-hythane at pilot scale (1)

Description of the pilot plant dedicated to bio-hythane (H_2+CH_4) production

- ***First reactor*** (22L) is dedicated to hydrogen production (acidogenic step).
- ***Second reactor*** (358L) is dedicated to methane production



Biogas upgrading into bio-hythane at pilot scale (2)

Preparation of the Inlet

- The substrate (here wine distillery effluents and waste) should be used immediately or stored in a tank of 1 m^3 cooled at 5°C prior feeding
- mixture composed of vinasses and microbial inoculum (5% vol) must be preliminarily prepared and the pH adjusted to 6, than can be injected into the acidogenic reactor for hydrogen production

Biogas upgrading into bio-hythane at pilot scale (3)

Special recommendations for running a two-step reactor system

- From the mixture of vinasses (concentrated and tartrate-poor vinasses) can produce biohythane whatever the ratio of vinasses.
- In order to reach a ***stable and robust biohythane production*** we recommend to using a temperature of 37°C, initial pH of 5.5, and regulated pressure at 550 mBar in the dark fermenter (energy recovery 3686±205 kJ with a ratio of H2/CH4 of 23.3±4.7 % per feeding).
- If the objective is ***to produce a maximum of energy***, the best performance was observed using 55°C and pH 7.0 in the dark fermenter reactor (energy recovery of 4906±926 kJ with a ratio H2/CH4 of 8.9±2.1 %).
  - However, these conditions provoke a higher instability on hydrogen production (thus maintenance of the process needs to be performed more frequently)
- The optimization of the acidogenic step enables the reduction of some pollutants, in particular nitrates.

Thank you for your kind attention!

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Training of best practices for farms and business on agro-waste management

Main possibilities of agro-waste valorisation, best practices and methods

Module 3.3

Organic fertilizer production and composting.

http://noaw2020.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688338

Applications of organic matter

Today organic matter is mainly being converted into organic fertilizer by applying either composting or anaerobic digestion possibly with post-treatment of the digestate.

- Anaerobic digestion is mainly suitable for treating organic matter with a high water content
- Composting is used for treating organic matter with a lower water content and higher shares of substances that are difficult to degrade, such as lignin

Main points distinguishing composting from anaerobic digestion are:

- the energy balance
- oxygen demand
- emissions
- odours
- technical complexity.

Composting an aerobic process

- Needs a constant supply of air for optimal degradation of the organic matter
  - It is important to provide a porous structure for the air to enter the composting heap
  - Coarse material (green waste or branches) help to create the needed pore volume
  - Composting depends on active ventilation during the main composting stage
  - If ventilation is not sufficient, parts of the process become anaerobic which results in greenhouse gas and other emissions.
  - Application of best practices is crucial to maximise the benefits of composting

- The temperature inside the composting heap rises up to 70 °C, thus pasteurizing the material

Main advantages of composting

Composting

- Mainly contributes to increasing the soils nitrogen reserve,
- composting activates the soil organisms,
- improves soil structure,
- improves the soils air and water balance,
- and improves the soils aggregate stability.

Anaerob digestion

- Anaerob digestion does not rely on air, but provides an environment free of air (anaerobic) for the processing of organic matter
- Anaerobic digestion produces more energy than is needed to maintain the process
- Digestate arises mainly in liquid form

Main differences between composting and anaerobic digestion

	Composting	Anaerobic Digestion
Substrate properties	Rich in structure, rich in lignin	Poor in structure, Lignin poor
Water content	25-65%	45-90%
Microorganisms	facultative anaerobic, aerobic, bacteria, fungi, molds, yeasts, protozoa, rotifers, earthworms	fermentative, facultative anaerobic bacteria, strictly anaerobic archaea
Temperature	thermophilic (50-70 °C)	mesophilic (30-40 °C) thermophilic (50-55°C)
pH-Value	neutral to low alkaline	acidic to low alkaline
Process duration	8-19 Weeks	2-8 Weeks
Degradation products	Carbon dioxide, Heat	Methane, Carbon dioxide
Technical input	low to big Danger of corrosion	big to very big
Specific Land Use	0,7-1 m²/Mg Input	0,2-0,3 m³/Mg Input 0,2-0,5 m²/Mg Input (aerob)

Fertiliser products from digestate

- Digestate from anaerobic digestion plants contains considerable amounts of ammonium nitrogen (NH4-N)

- Organically bound nitrogen needs time to mineralise in order to become plant available, this part contributes to the soils' nitrogen reserve

- Ammonium is in a balance with ammonia (NH_3, a gas molecule)
  - Ammonia (gas) can be released from the digestate at high temperatures and/or high pH-levels,
  - Ammonia volatilisation leads to nitrogen losses into the air and causes air pollution

To minimise nitrogen losses and reduce air pollution special care has to be taken when applying digestate to the land!

Minimize nitrogen losses & reduce air pollution when applying digestate to the land

- Apply digestate in land during good grooving conditions (when nutrients can be absorbed efficiently)
- Use flow meters and smart near infrared sensors (NIRs) make slurry application more accurate

- Use low emission spreading techniques (band applicators , like trailing hose or trailing shoe or injection system) to spread liquid manure directly under existing crops

Comparison different type of band applicators

		Low emission spreading equipment			
	Surface broadcast	**Trailing hose**	**Trailing shoe**	**Shallow injector**	**Deep injector**
Typical range of dry matter	Up to 12%	Up to 9%	Up to 6%	Up to 6%	Up to 6%
Requires separation or chopping	No	Yes	Yes	Yes	Yes
Relative work rate	→ → → →	→ → →	→ → →	→ →	→
Uniformity across spread width	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Ease of bout matching	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Crop damage	Moderate	Low	Low	Moderate	High
Relative odour	High	Moderate	Low	Low	Very low
Relative ammonia reduction	0%	30-35%	30-60%	70-80%	90%
Capital cost	£	££	£££	£££	££££

Source: Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions; Department for Environment, Food and Rural Affairs, UK, 2018

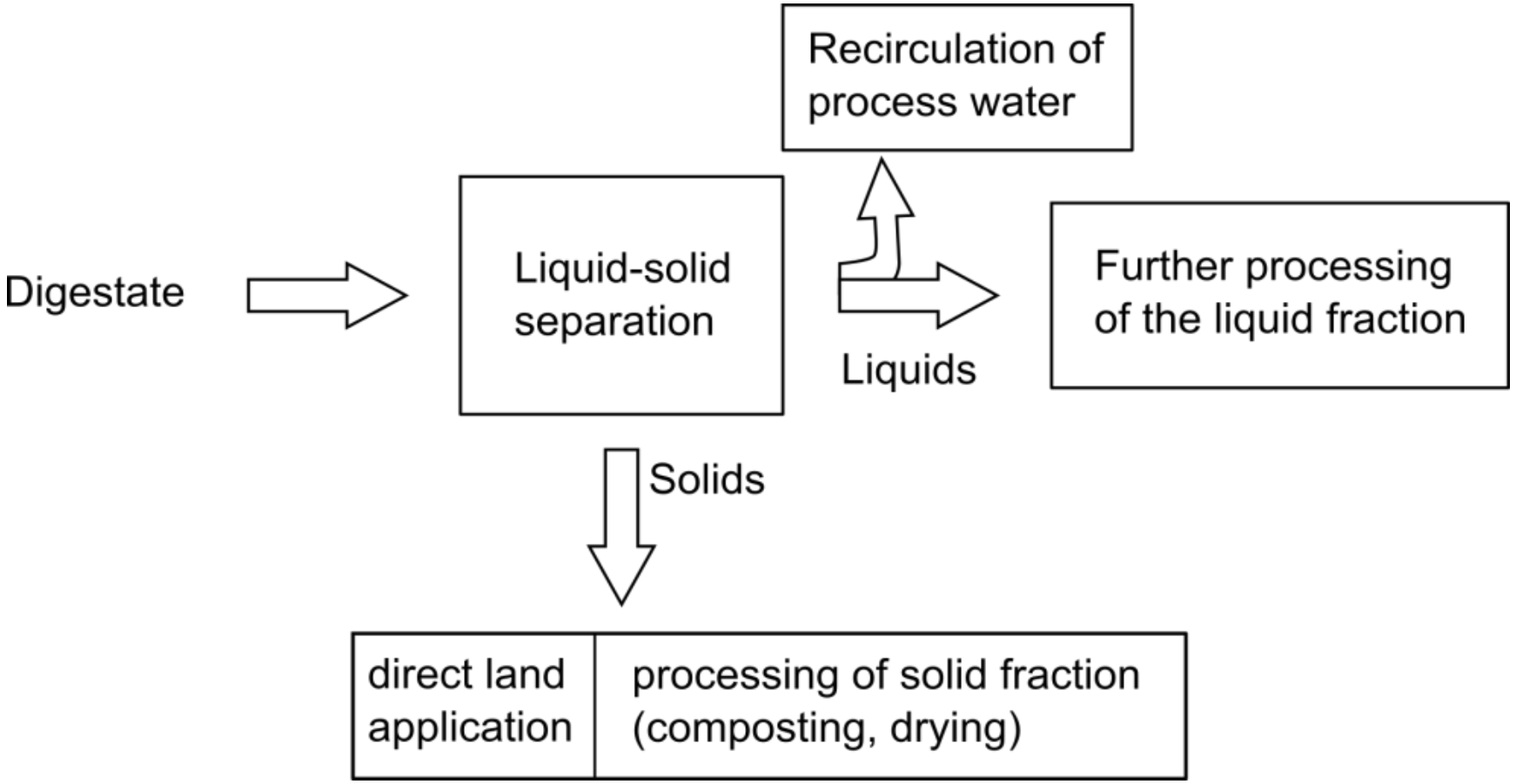
Digestate treatment as an alternative to conventional land application

Digestate treatment is carried out to:

- Save application costs
- Facilitate transportation and nutrient export away from regions with a high nutrient concentration
- Produce marketable fertilizer
- Produce compost
- Reduce the amount of nutrients in the liquid phase
- Avoid the escape of gaseous pollutants into the atmosphere
- Decompose odour intense components
- Deactivate pathogens and weed seeds
- Improve transportability and reduce storage space through liquid removal

Source: Lokale Energie Agentur Oststeiermark, 2007; Weiland, 1997

Basic processes of digestate upgrading



Source: Fuchs, W., & Drosg, B. (2010). Technologiebewertung von Gärrestbehandlungs- und Verwertungskonzepten. Tulln: Universität für Bodenkultur Wien

Physical treatment methods

- Screw press separators and decanter centrifuges
- Belt filters
- Drying through evaporation
- Filtration and reverse-osmosis
- Ammonia-stripping

Physical treatment methods

- Physical treatment usually starts with separating solid matter from the liquid
  - reduces the storage volume for the liquid phase,
  - allows a better fertilizer management
  - and also facilitates further treatment of the solid matter.
- Further treatment of the solid matter
  - drying or composting and sometimes pelletizing of the solid phase
- Liquid phase, most popular application is agricultural biogas plants
  - However, for in regions with a high nutrient concentration it might be necessary to further treat the liquid phase, because the maximum amount of nitrogen in the soil would otherwise be exceeded
    - Mass reduction, mostly through vaporization or membrane separation techniques
    - Extraction of nutrients or other components which allow the remaining liquid phase to be brought into surface waters

Physical treatment: Screw press separators and decanter centrifuges

- It is not possible to separate or extract nutrients from the digestate with these applications, meaning that the nitrogen will remain in both phases (predominantly in the liquid phase)

Screw press separators

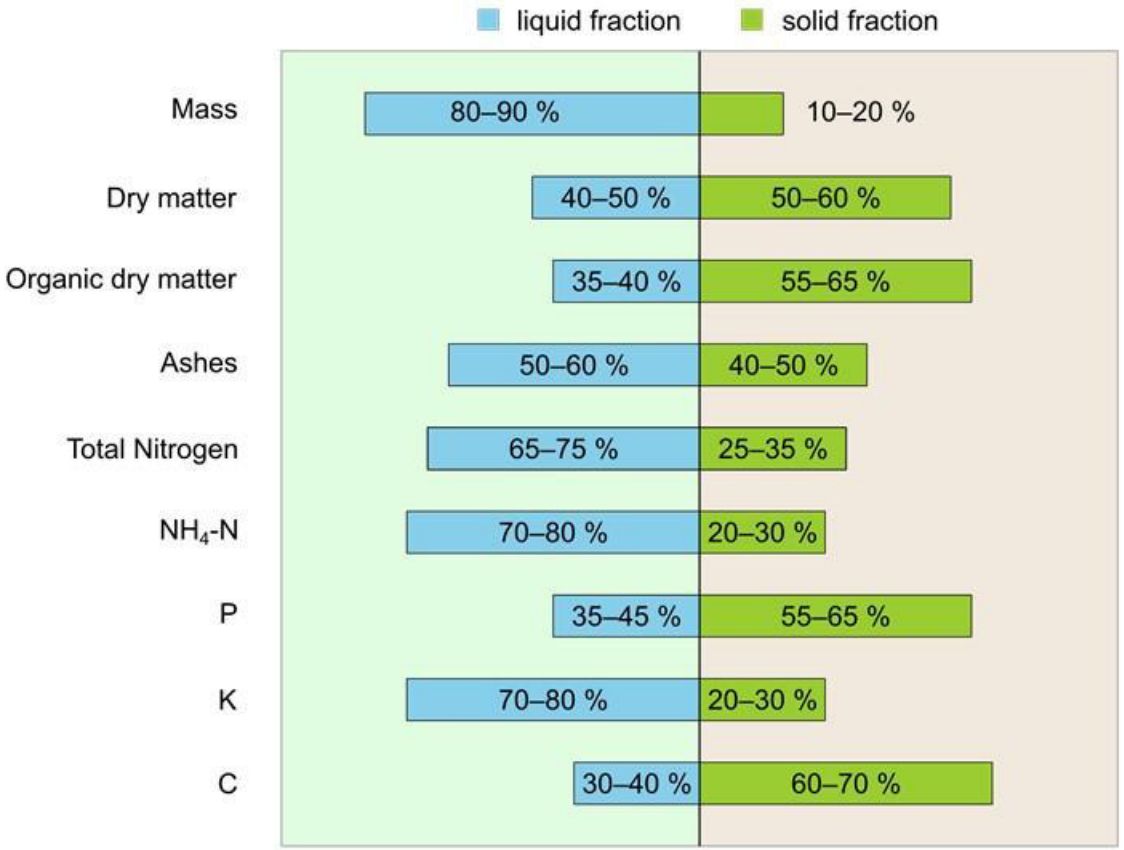
- are used for fibrous digestate, as the fibres build a press cake that contributes to the result; energy consumption around 0.4-0.5 kWh/m³

Decanter centrifuges

- For separating liquids from solids; e.consumption around 3-5 kWh/m³
- Are used for non-fibrous slurries, e.g. from anaerobic sludge stabilization or from catering waste digestion
- Often flocculants are needed to achieve an acceptable separation result

*Both the screw press separators and centrifuges represent **"state of the art"-technology** which means that they are relatively easy to handle and cost efficient in both investment and maintenance.*

Nutrient distribution in digestate (after separation)



Source: Fuchs, W., & Drosg, B. (2010). Technologiebewertung von Gärrestbehandlungs- und Verwertungskonzepten. Tulln: Universität für Bodenkultur Wien

Other physical treatments (1)

Belt filters

- Produce a solid phase with very high dry matter content compared to the screw press separator
- Consume less energy (1.5–2 kWh/m³), however, the major downside is demand of flocculation products (chemical treatment)

Drying through evaporation

- As a *thermal drying* is very energy intensive, this method is only used after a mechanical separation of the solid and liquid phases
- Also possible using *vacuum evaporation*: to reduce the water and concentrate the nutrient.
  - The concentrate often mixed with the separated solids before they are either dried further or spread on the land
  - water vapor also still contains nutrients and can only be released into surface waters after yet further treatment

In any of the two cases a cheap heat source is needed, which is typically the recovered heat from the CHP-unit burning the biogas!

Other physical treatments (2)

Filtration and reverse-osmosis

- If fine separation of organic / inorganic components is desired, before reverse osmosis ***micro- and ultrafiltration*** can be applied ***as pre-treatment***
  - size of removable particles 10 µm to 0.01 µm

- ***Reverse osmosis***
  - applied to remove suspended solids, organic compounds, colorants, viruses and bacteria from the water
  - around 95-99 % of all suspended solids and 99 % of the bacteria can be removed through this method

Other physical treatments (3)

Ammonia stripping

- For removing ammonia from the liquid phase or to extract it for fertiliser production
- ***Volatile compounds*** inside the liquid are ***pushed out via stripping gas***
  - Usually the stripping gas passes an acid washer to remove the ammonia from the gas before it is released
  - Alternatively the gas can be passed through gypsum
- In both cases the final product is ammonium-sulphate-solution, a commercial fertilizer product
- Depending on the stripping method CO_2 might also be released from digestate
  - This CO_2 would also react with gypsum producing lime, which is also used on agriculture as soil amendment

Chemical treatment methods

Digestate is treated chemically for the purpose of

- extracting nutrients
- Prepare the digestate or slurry for liquid-solid-separation
- Multiple processing steps: if complete removal of all nutrients is necessary

Flocculation and precipitation

- are the most common chemical treatments
- Expensive, not relevant for nitrogen removal: not commonly used in agricultural biogas plants
- Iron- and aluminium-salts added to the digestate to cause flocculation
- Removal flocculants from the liquid: via sedimentation, filtration or flotation

Newer approaches

- Combination of lowering the pH-value by adding acid to raw manure or digestate and thus dissolve phosphorous into the liquid phase
- After separating the solids, a caustic base (sodium hydroxide) will cause the precipitation of phosphorous salts that can then be separated from the liquid

Biological treatment – composting as aerobic degradation

Composting of the solid phase of the digestate after the first mechanical separation is a widely exerted method

- Since the digestate already underwent anaerobic digestion
  - the composting will be shorter
  - process temperature is lower
  - however, it takes more time for the digestate to be sanitized
- Condition of the composting process
  - Regulation on the recovery of biowaste agricultural, forestry and horticultural use soils
- Composting is especially popular in dry digestion biogas plants since the digestate does not need to be separated into a liquid and solid phase

Comparison of specific costs for digestate treatment methods

	Direct digestate application	Screw press separation and application	Screw press separation and drying on a belt dryer	Centrifugal separation, ultrafiltration and reverse-osmosis	Centrifugal separation and evaporation	Centrifugal separation, stripping and flocculation
	[€/m³ Digestate]					
Fixed costs	1.62	2.15	4.01	5.19	3.03	5.07
Energy and operation materials costs	0.29	0.30	3.74	2.77	7.03	3.42
Transportation and application costs	4.42	4.77	4.53	3.17	2.82	2.21
Gross costs	6.33	7.23	12.28	11.13	12.88	10.70
Nutrients (saved fertiliser costs)	-4.40	-4.40	-4.26	-4.40	-4.40	-4.38
Bonus for own heat usage	-	-	-1.23	-	-2.15	-0.88
Net costs	**1.94**	**2.82**	**6.80**	**6.72**	**6.32**	**5.43**

Source: Fuchs, W., & Drosg, B. (2010). Technologiebewertung von Gärrestbehandlungs- und Verwertungskonzepten. Tulln: Universität für Bodenkultur Wien

Comparison of specific costs for digestate treatment methods

Most economical solution to treat digestate

- direct application onto the fields
- followed closely by the solid-liquid separation using screw presses in combination with land application

Digestate upgrading can only be economically attractive

- if there is a market for recovered and easily transportable nutrients
- or if the nutrient pressure on soil is very high

Combination of methods more and more relevant in future

- Combination of treatment methods aiming at removing and concentrating nitrogen and phosphorous from digestate (the recovered nitrogen and phosphorous products can be used in dedicated fertiliser products)
- Remaining water rich in potassium and can be applied to the land

Thank you for your kind attention!

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Training of best practices for farms and business on agro-waste management

Practical implementation: Business models for use of agro-wastes

Module 4.1

Main triggers; Success and failure factors

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Main triggers of eco-innovatinos for use of agro resources

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Analysis of successful initiatives

- Participant researchers in NoAW project by the leading of SOFIES and DLO-FBR have collected and listed existing international business concepts designed for an efficient use of agro-resources.

- More than 60 successful initiatives have been analysed.

- Success and failure factors, as well as key triggers of initiatives were analysed and concluded in case of clustered and non-clustered agricultural waste utilization initiatives at different levels

Key triggers

List of key triggers and objectives of the analysed initiatives according to occurrences:

1. Market need
2. Technical development
3. Valorization of agricultural by-products, recycling wastes
4. Avoiding or reducing pollution
5. Environmental awareness and need for sustainable development
6. Legislation and incentives
7. Need to cooperate to increase effectiveness
8. Additional income generation
9. To be energetically independent
10. Green marketing

Market needs for use of agro resources

Examples

- Increasing demand for bio sourced aromatic and other valuable molecules

- Demand to replace a significant share of conventional fossil-based plastics with 100% bio-based and biodegradable plastics

- Growing needs for
  - ✓Proteins based on agricultural by-products to feed animals
  - ✓Producing cellulosic ethanol from biomass as an alternative to petroleum from agricultural residues
  - ✓Promoting the development of a bioeconomy model based on the efficient use of renewable resources and on the regeneration of local areas

Technical development as trigger for use of agro resources

Technical development is an important trigger when industrial technology goes forward, and companies intend to keep their competitiveness

Examples of Technical development as trigger

- Increase theresource efficiency and better process control with an environmentally friendly alternative to fossil-based heater

- District heating can also be developed by using agro-waste or biogas from agro-waste

Valorization of agricultural by-products as trigger of eco-innovations

Valorization of by-products, recycling wastes can trigger eco-initiatives, because agricultural by-products are valuable resources of raw materials.

Examples as triggers of eco-innovations

- Corn husk and rice husk at the same time in a region may led actors to cooperate
- Recycling vegetable remnants from food industry can be used for eco-friendly colours in textile industry
- Valorizing manure on farms in energy production can lead to being self-sufficient and energy independent

Avoiding / reducing pollution as trigger of eco-innovations

Avoiding pollution or reducing pollution is a strong trigger for companies because of the environmental and health effects and consequences of pollution, and environmental challenges.

Examples as triggers of eco-innovations

- Producing biodegradable product alternative or producing renewable energy on the territory
- Recycling of agricultural residues to reduce air and noise pollution from burned agricultural wastes

Success and failure factors of existing eco-innovative case studies

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Practical implementation - Success factors (1)

Examples

- Huge quantity of feedstock, available local
  - Agro by products (plants (straw, rice, vegetable, fruits, etc.), livestock (manure, bones, etc.))
  - Possibility to use by-product as substrate for biogas production
    - Can cover a large part of electricity and heat demand
    - Can reduce disposal cost
  - Use of local biomass resources based on long-term contracts for high security of supply
- Combining a variety of energy and supply tasks in a unified system concept to optimize synergies between individual elements by making efficient use of the energy flows between the individual plants
- Feed-in tariff for electricity coming from anaerobic digestion

Practical implementation - Success factors (2)

Examples

- Geographical proximity of actors: agriculture, R&D organizations, academia (Universities)
- Strong and long-lasting Public-Private partnership at regional level (in particular with a clustered competitiveness approach)
- Going from R&D innovation to markets: having a network of strategic partners ready to invest in the next phases. i.e. industrialization
- Protect innovative products with a patent makes them more stable and interesting for investors
- Optimization of logistic costs (in and out)
- Co-investment in R&D and demonstration plants; EU financial support
- Economic promotion of local areas through the creation of new industries, products and jobs
- Communities are always more interested in ecological products
- Keeping process cost-effectiveness: reach the highest technical

Practical implementation - Risk or failure factors (1)

Examples

- High dependency to large investment
- Need to organize the value chains and de-risk investments
- Sufficient space (at least one hectare) is needed to set up a small biogas plant
- Odour emission needs to be considered (depended on the local context and the baseline)
- Seasonality alters the availability of by-products; thus, stocks must be carefully planned
- Working with fresh by-products requires an efficient logistic; but scaling-up might result into not enough (fresh) by-products available in nearby surroundings

Practical implementation - Risk or failure factors (2)

Examples

- The biogas branch relies on subsidies to be profitable
- Entering an existing market with a new product is challenging
- To produce Bio-based structural elements are much more expensive compared to those that are mass-produced
- There is competition between different sectors for the same agricultural by-products
- Difficult to open a market for pellets from digestate as single plant operator
- Getting food security/safety approvals is time consuming
- Future remuneration of electricity (power) coming from anaerobic digestion
- Public financial support is difficult to get
- Change in legislation is a risk

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Practical implementation: Business models for use of agro-wastes

Module 4.2

Business model development using business model canvas

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Definitions (1)

Business model (BM)

- Is a tool for identification of the distinguishable, potentially unique value, what an organisation delivers to its clients and the society and also the method how the organisation makes this available for the targeted clients and beneficiaries
- Business models include further aspects of the business strategy development such as the identification how this value is produced and how the organisation offering this value will achieve its profit

"The way for the company to create value for ensuring its sustainability"

Business model (BM) & business plan (BP) are very often confused!

The BP include the BM: when a business is created, the **BM is building first**, and then the business plan

Objective of the business model

The main objective of building up a specific business model **to develop an attractive offer** to the customers/ consumers based on the bundle of

- Products or
- Services and
- Related value adding services

which can be delivered in a profitable way.

Scope of application

- Innovative products, processes, services and systems, and market concepts,
  - which are based on the commercialisation of the results of research, development and innovation activities.

Tool: the business model CANVAS

- The CANVAS model is a graphical tool with 9 boxes. It is an easy to use tool, which helps to handle substantive issues.
- The model CANVAS, created by the Switzerland Alexander Osterwalder, is divided into two parts:

"Organisation" part:

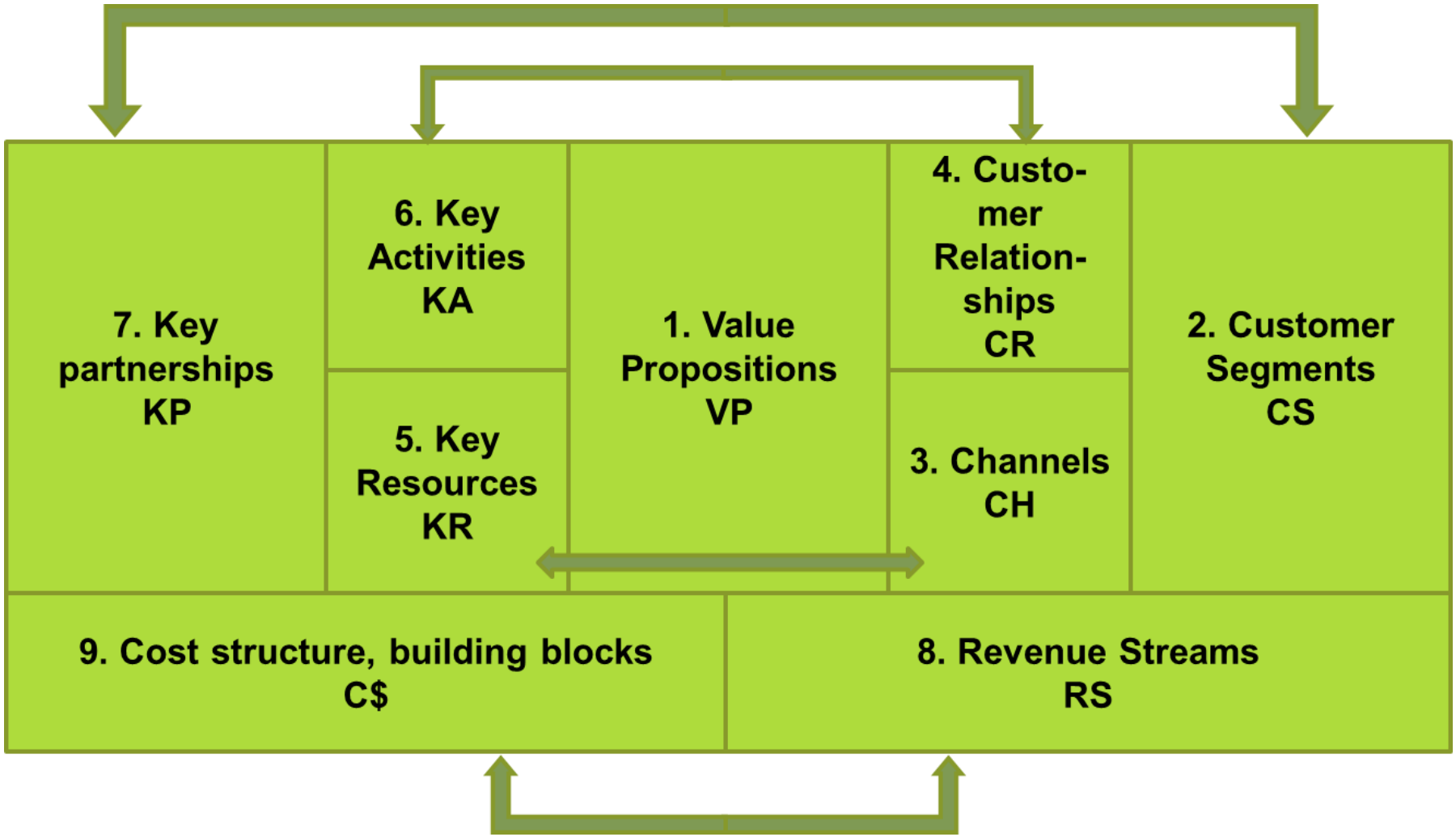
How the company should organize itself to generate value?
What partners?
What cost structure?

"Market" part:

Who is selling? How?
What?
How to monetize?
How to achieve the objectives?
How the business generates value?

The difference between the 2 parts ensures the sustainability of the company

Steps of developing a business model following the concept of Business Model Canvas



Source: Business Model Canvas (Osterwalder, Pigneur 2010.)

Step 1: Define the core value propositions

Main aggregated benefits offered to a specific customer/consumer segment through

- a bundle of products and/or related services
- What we offer for them what they see as a valuable solution for one of their problems
- What is the problem for what is the new need, which has not been serves?
- Are they ready to pay for it?
- Why they should choose our offer compared to other competitive offers?

Define value propositions individually for each customer/consumer segment what your organisation intends to serve

Typical elements, for creating values to a specific customer/consumer segment

- Newness, novelty
- Better performance
- Customisation of products and services to specific needs of customers/consumers or their segment
- Provision of related services
- Attractive design
- Brand and the status represented by it
- Price
- Enabling cost reduction
- Risk reduction
- Accessibility
- Convenience/Usability

Step 2: Identify customer segments

Customer/consumer segment: a distinct group

- having common needs, expectations, behaviour or other attributes

  whom we want to reach – who are most likely to be attracted by our value proposition

Consider similarities and differences in

- needs
- product and service attributes seen as a value
- preferred distribution channels
- expectations and requirements for relationships with the product/service provider
- buying power
- willingness to pay for different elements of the offer, etc.
- other potential grouping criteria

Typical examples of customer segments

- Mass market
- Niche market
- Slightly segmented, slightly differing
- Diversified
- Multi-sided platform (or multi-sided markets representing a situation where two or more interdependent customer segments are served

Step 3: Establish distribution channels

How we communicate – with our customers and consumers?

- Define, which channels cover the following functions:
  - Raising awareness among customers/consumers about your products and services
  - Helping customers/consumers to evaluate your value proposition(s)
  - Allowing your customers/consumers to purchase your specific products and services
  - Making your value proposition based on your products and services and their combination available to your customers/consumers
  - Providing post-purchase support
- Mix several channels may be necessary

Potential distribution channels

Owned channels (direct such as own web-site, in-house sales force, etc. and indirect as own retail shops and outlets)

- cannels may enable higher profit margins, but at higher risks, usually higher costs
- access is limited to own customer/consumer population

Partners channels & networks

- retail stores of partners, wholesale distribution, partner owned websites
- channels may allow lower profit margins, but at lower costs and lower risks
- access to a broader customer/consumer population

Consider

- number of contacts
- profit margin
- cost efficiency
- financial risks

Step 4: Determine customer relationships (1)

- How customers/consumers will be attracted and retained

- Define your aim in the segment
  - Acquire new customers/ consumers (usually through marketing)
  - Retain existing customers/ consumers (usually through services)
  - Add-on selling (increase the purchase of the existing customers/consumers), (usually through sales)

Step 4: Determine customer relationships (2)

- Define, what your customers/consumers expect in relationships
- What you provide now and what has to be added?
- Consider typical types of customer relationships:
  - Personal assistance
  - Dedicated personal assistance
  - Self- service
  - Automated service
  - User communities (including online ones)
  - Co-creation by involving customers into the development process
  - Adjustment to personal needs
  - Etc.

Step 5: Specify key resources, capabilities and core competences (1)

- Which resources, capabilities and competencies are necessary to
  - create and offer value proposition
  - reach markets
  - main customer relationships
  - earn revenues in your customer/consumer segment?

- Describe your main
  - resources,
  - capabilities
  - competences

- Define your core competence
- Define, which resources, capabilities and competences can you access from your chain partners (customers/consumers)

Definitions (2)

Competencies

- are substantial capabilities for enabling the organisation to deliver a fundamental customer benefit based usually on the combined, integrated and harmonised, use of resources and/or (several) capabilities

Core competencies

- are such competencies which enable an organisation to exceed its rivals. These competencies should be:
  - distinctive, applied better than the competitors;
  - ypical (collective) for the company across-functions, products, business units;
  - unique, rare, difficult to imitate;
  - flexible for continuous upgrading, reorganizing the routines, resources and capabilities.

Step 6: Define key activities to create and offer value propositions (1)

- Which key activities are required to
  - create and offer our value propositions
  - reach markets
  - maintain relationships with our customer/consumer segment
  - earn segments

- Analyse and evaluate
  - Inbound logistics (purchasing, receiving, warehousing, inventory control of input – raw material, ingredients, additives, packaging material, other resources- materials

Step 6: Define key activities to create and offer value propositions (2)

- Analyse and evaluate
  - Production (designing, preparation, manufacturing, delivering a product in required quantity and quality by the required deadline)
  - Problem solving (developing new solutions for individual customer problems, knowledge management, regular training)
  - Outbound logistics (warehousing, order fulfilment, transport, etc.)
  - Platform/network (establishing and maintaining matchmaking platforms or network- related activities)
  - Marketing and sale (channel selection, advertising, pricing, etc.)
  - After-sale (customer support, repair services, etc.)

Step 7: Identify key partnerships

- With whom is necessary to collaborate systematically?
  - Who are our strategic partners, alliances with
  - with non-competitors
  - with competitors
  - joint ventures
  - buyer-supplier relationships for providing our value proposition

- What are the motivators of these partnerships?
  - optimisation economy of scales
  - reduction of risks and uncertainty
  - acquisition of complementary/additional resources, capabilities, competences from your chain partners – what? from whom?

- Who are your suppliers?

Step 8: Establish revenue streams (1)

- Define how we will generate revenue?
  - For which value are our customers/consumers in the targeted segment really willing to pay?
- Describe the answers for each segment
- Evaluate several options for getting revenue
- For which value are paying your customers/consumers now?
- How they prefer to pay?

- Consider
  - One time payments
  - Revenues from on-going repeated payments
  - Post purchase customer support

Step 8: Establish revenue streams (2)

- Consider typical ways to generate revenue:
  - Asset sale
  - Usage fee
  - Subscription fee
  - Lending/Renting/Leasing
  - Licensing
  - Maintenance and updating fee for softwares, books and other knowledge based products
  - Maintenance service fee for machinery
  - Refilling

Step 9: Define cost structure (1)

- How our costs are calculated, allocated and covered?
  - creating, marketing and offering value reaching markets
  - using resources, assets, carrying out activities
  - maintaining customer/consumer relationships and partner network relationship
  - earing revenues
- Which costs structure is most appropriate for our approach?
  - cost driven, which focuses on minimising costs
    - typically related to price value propositions, high level of automation and extensive outsourcing
  - value driven, which focuses on value creation
    - typically related to premium value propositions and high degree of personalised services

Step 9: Define cost structure (2)

- During describing your costs analyse
  - fixed costs
  - variable costs
  - cost advantages through economies of scale and economies of scope

Design and use business model

- Think over the findings of the analysis of the building blocks of your business model, revise and harmonise them and organise them into a coherent, realistic model

- Integrate your business model into your business strategy. Develop an action plan for implementation

- The elements of the business model should be developed by the management of the business with the assistance of the expert of the intermediary

Associated documents and record sheets

Template 1. Business Model Canvas

<table>
<tr>
<td rowspan="2">7. Key partnership (KP)
• ..
•</td>
<td>6. Key Activities (KA)
• ..
•</td>
<td rowspan="2">1. Value Propositions (VP)
• ..
•</td>
<td>4. Customer Relationships (CR)
• ..
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<td rowspan="2">2. Customer Segments (CS)
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<td>5. Key Resources (KR)
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<td>3. Channels (CH)
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<tr>
<td colspan="3">9. Cost Structure (C$)
• ..
•</td>
<td colspan="2">8. Revenue Streams (RS)
• ..</td>
</tr>
</table>

Summary of business models developed (1)

Six types of circular business models have been identified by NoAW project leader INRA, which differ in their way of value creation strategy (from lower to higher value) and/or in their organisational structure:

1. biogas plant,
2. upcycling entrepreneurship,
3. environmental biorefinery,
4. agricultural cooperative,
5. agropark and
6. support structure (figure).

Summary of business models developed (2)

- Identifying the organisational forms and types of valorisation pathways **highlights the potential of using biomass firstly** for higher-added-value products, before exploiting finally unused products as an energy source

- Cascading biomass use becomes to play a key role in the development of a circular economy, especially at territorial levels where clusters of SMEs and start-ups seek competitive advantages

Thank you for your kind attention!

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Module 4.3

Success stories, Best practice examples

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Succesfull story: Agroenergie Hohenlohe GmbH (1)

Original business was pig fattening

⇩

2001: started to operate a relatively small biogas plant

(simple technology, digester volume 600 m^3, co-generation unit (CHP) with small (55 kW) electric power)

⇩

2004: new plant started

(increased size, bigger CHP unit (300KW), increased amount of digested energy crops, addition leftovers from fruit and vegetable processing)

⇩

2007: biogas plant was upgraded

(micro gas-turbine and green-house type system was installed to for drying the digestate; synergy effect of greenhouse and micro gas-turbine: exhaust gas from the gas turbine served as hot air for the drying; after drying: letised fertiliser sold)

Pelletised fertiliser

Pellets for private Ga

⇩

picture credits: IBBK Fachgruppe Bigoas Gm

Succesfull story: Agroenergie Hohenlohe GmbH (2)

2009/2010: a district heating grid to supply the village of Füßbach

(another part of the heat is used for grain drying by an external company)

2012: micro gas-turbines were taken out, second CHP-unit was installed

(because of technical issues with the gas cleaning)

Since 2013:

(CHPs are operated flexibly, when electricity is expensive;)

Next step was: foundation of “eFüßle”, car-sharing initiative for the village

(***at the moment*** the electricity for this initiative is taken from the grid into which the biogas plant also feeds the produced power)

(***in future:*** after the period of fixed feed-in tariffs, electricity for charging the cars might directly come from the biogas plant

Succesfull story: Agroenergie Hohenlohe GmbH (3)

Currently:

(pilot plant for recovering nitrogen and phosphorous from digestate is taken to the next step by implementing a full-scale demonstration plant)

Biogas Plant Karle / Agro Energie Hohenlohe GmbH & Co. KG; blue containers in from: pilot plant fro nutrient recovery (picture credit: IBBK Fachgruppe Bigoas GmbH)

After a careful solids separation the liquid phase is processed further

- Nitrogen is recovered by firstly stripping it from the liquid and then washing it out of the stripped air in an acid washer producing ammonium sulphate solution
- Phosphate is recovered by precipitating phosphorous salts.
- With those recovered nutrient streams it will be possible to produce tailor-

High nutrient dense „ABC”-BioPhosphate recovery from food grade animal bones (1)

EU actual Phosphate demand

- Almost fully imported (over>88%)
- Mined mineral rock phosphate contains dangerously high levels of Cadmium/Uranium toxic metals, & low Cd/U resources depleted
- European Commission defined phosphorus as critical raw material

European Fertilising Product Regulation (EU) 2019/1009

- includes EU-wide end-of-waste criteria for compost and digestate, which can be used in organic fertilisers, soil improvers and growing media
- encourages a move toward more environmentally-friendly agriculture

High nutrient dense ABC-BioPhosphate recovery from food grade animal bones (2)

Terra Humana Ltd.

- **„3R"** technology (**R**ecycle-**R**educe-**R**euse)
  - BioPhosphate recovery from food grade animal bones
  - Zero emission refinery pyrolysis technology
    - reductive thermal process at 850°C material core temperature, in the absence of oxygen

3R development & scaling up

<2010: pilot concept (500 t/y)

⇩

>2010-2019: EU co-financed field demo (1.000 t/y)

⇩

Next step 2022: full scale large unit (20.800 t/y)

https://www.3Ragrocarbon.com

High nutrient dense ABC-BioPhosphate recovery from food grade animal bones (3)

„ABC" Animal Bone Char BioPhosphate Key Characteristics

BIO P HOSPHATE

- >30%-36% phosphorus pentoxide (P_2O_5) and 37% calcium content
- Made from food grade category 3 cattle bones
- BIO-NPK-C formulated as of Users need
- Other important recovered trace elements, and other nutrients, such as K and Mg
- Recommended dose: 0.2 t/ha - 1.5 t/ha

BioPhosphate product, main advantag

100% ORGANIC

- Organic recovered Phosphorus fertiliser
- Soil improver, growing media and special adsorbent
- Safe (no Cd /U),
- Agronomic efficiency: P utilisation >90%
- Macroporous structure
- Controlled P nutrient release

Thank you for your kind attention!

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