COASTAL BIOGAS

Cluster On Anaerobic digestion environmental Services and nuTrients removAL

Report on instruments for feasibility analysis

December 2021

Deliverable 5.1

Preface

The project receives funding by the Interreg South Baltic Programme under the project “Cluster On Anaerobic digestion, environmental Services and nuTrients removAL (COASTAL Biogas)“, STHB.02.02.00-DE-0129/17.

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2. Gdansk University of Technology (GUT), Poland – project partner
3. Baltic Energy Innovation Centre (BEIC), Sweden – project partner
4. Roskilde University (RUC), Denmark – project partner
5. University of Rostock (UROS), Germany – project partner
6. Lithuanian Energy Institute (LEI), Lithuania – project partner

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1. Introduction

The tool described within this report is intended to give an overview on the estimation whether at specific conditions it is feasible to use cast seaweed for nutrients recycling and biogas production.

The aim of developing this tool was to unlock the potential of seaweed in south Baltic countries. This calculation tool covers several aspects such as location and applicable legal frameworks, infrastructure availability, biomass collection, pretreatment and processing as well as biomass characteristics. The tool is divided into modules according to the aspects that have impact on feasibility. Each includes several questions to answer. The tool is designed mainly for municipalities, local authorities and biogas plants owners and operators.

The tool is available online at http://technologia.gda.pl/coastal. The website is intended for any beneficiary interested in the use of marine algae for biogas production and was created within the COASTAL Biogas project.

This evaluation tool has been prepared with the most diligence, but is not a substitute for the traditional decision-making model and cannot be used for economic evaluation of the investment. Although calculations and data on seaweed use are included in the tool, they are based on current legislation and the case of the Solrød biogas plant. The results obtained in this tool cannot be considered as a commercial offer. Neither the developers of the tool, nor the project partners, INTERREG or the European Commission can be held responsible for the results obtained from the tool.

2. Data base

The database contains initial data for all the aspects covered by the tool within the project partner countries Denmark, Germany, Poland, Lithuania and Sweden. The parameters such as location, infrastructure, biomass collection methods and processing, characteristics of the biomass used in the biogas plant and its processing have been included. Data was gathered from the project partners based on the project activities. The data was categorized into two modules: biogas plant or municipality. Some of the data in the database overlap with both categories. The data were translated by each partner into their national language.

3. Algorithm

The algorithm is divided into four separate parts and five with the final evaluation. Each part includes several questions. The answer is weighted with the number assigned in the circle. The numbers were set based on the data obtained within Work Packages 3, 4 and 5 of the COASTAL Biogas project.

Location

When using seaweed as a resource for anaerobic digestion, location of investment is important for several reasons. The first one is the number of residents in the municipality where the plant is located as in most cases it indirectly relates to the amount of the feedstock for digestion and to the prosperity of the region, therefore the highest weight of +5 was assigned to the >100k number. Another aspect is the distance of the biogas plant from the coast. The closer it is, the lower is the financial cost of biomass transportation and the environmental impact of the transportation process. Moreover, if the distance is short, the frequency of collection can be higher and the biomass can be collected as fresh as possible to ensure high biogas yield and low sand content. Therefore, for distance closer than 15 km the weight was set for +5 and for distance over 60 km for -5. In addition, the type of the road connection is important, mostly from the economic point of view concerning the machines wear (asphalt roads +2, dirt roads -2). The last issue in the location part includes the fate of digestate resulting from the digestion process. If it has to be landfilled, the weight is -4, because the volume of the material is large. Using as a fertilizer or selling is more profitable, so the weights are set for +2 and +3, respectively. Further benefits are dependent on the distance to the end recipient, if closer than 15 km, than the weight is +1, if further than 60 km, the weight is -1.

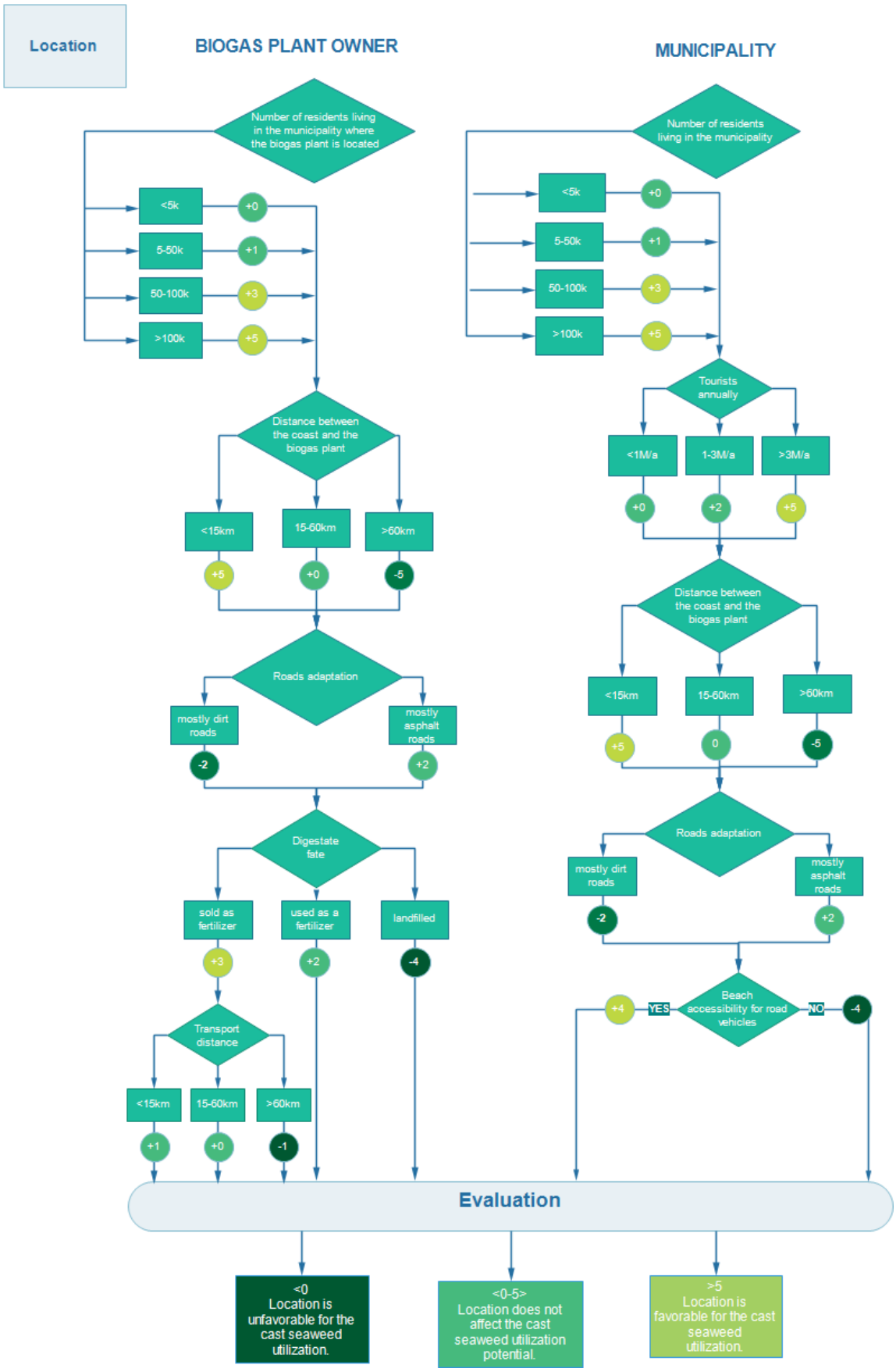

Figure 1 Algorithm of the 'location' module

Biomass characteristics

Concerning the process efficiency and products quality, the biomass parameters are essential factors. From the point of view of biogas plant owners, biogas potential of the feedstock is a key parameter. Therefore, in the module designated for biogas plant owners and operators, the algorithm takes into account the types of the feedstocks and the amounts. The most commonly used types of the biomass are initially coded in the database. Based on the biogas potential of specific feedstock, the system calculates the weight and evaluates the results for the feedstock parameters not favourable for anaerobic digestion, neutral or beneficial for the process.

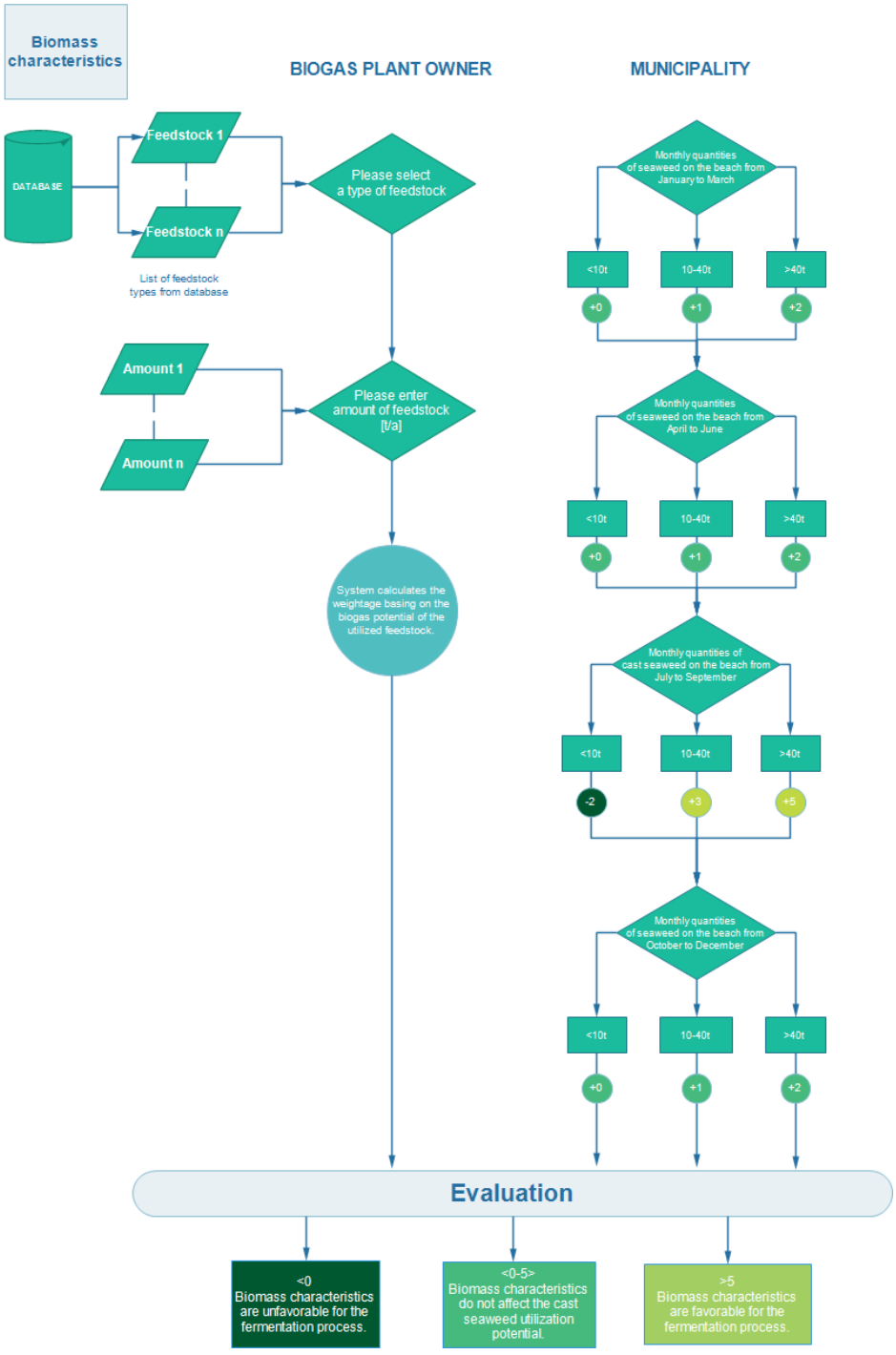

Figure 2 Algorithm of the 'biomass characteristics' module

In the module intended for the local authorities in municipalities, the algorithm takes into account first the amount of seaweed that is being washed to the beach during summer season. If it is below 10 tons per season it might be the case when the environmental and economic costs of using seaweed for the anaerobic digestion exceed the benefits, therefore the weight is -3, and for the monthly amount it is 0. More than 40 tons would give many environmental, economic and aesthetic benefits for the region, so the weights are correspondingly higher.

Biomass collection and processing

From the point of view of biogas plant owners or operators, the pre-treatment step is crucial to increase the bioavailability of substrates and thus increase biogas yield, not only when using cast seaweed but for many other substrates as well. Therefore, the algorithm is strongly oriented towards a pre-treatment step, namely substrates grinding, chemical hydrolysis, thermolysis, if available, each has a weight 3, if not -3.

The type of the digestion process also can lead to different results. In general, the thermophilic process and the potential to degrade organic matter is larger and produces more methane compared to the thermophilic process and thus is preferred by the algorithm with weight 2, mesophilic is 1. Several advantages of multistage anaerobic digestion are also know, therefore, the more stages, the higher is the weight set to the answer.

In terms of the quality of the products, the algorithm includes treatment of both biogas and digestate. The weights are set to prefer biogas upgrading to methane and digestate processing by liquid/solid phase separation and drying.

Based on the stakeholders and authorities consultations, municipalities are mainly involved in seaweed collection. If the biomass is already collected, the set weight is 5. Moreover, the more frequent the collection is, the higher weight is set. The quality of the collected material and the cost of its pre-treatment are affected by the amount of impurities that are collected together with seaweed. The biggest problem is rubbish and sand so that the separation is considered as beneficial.

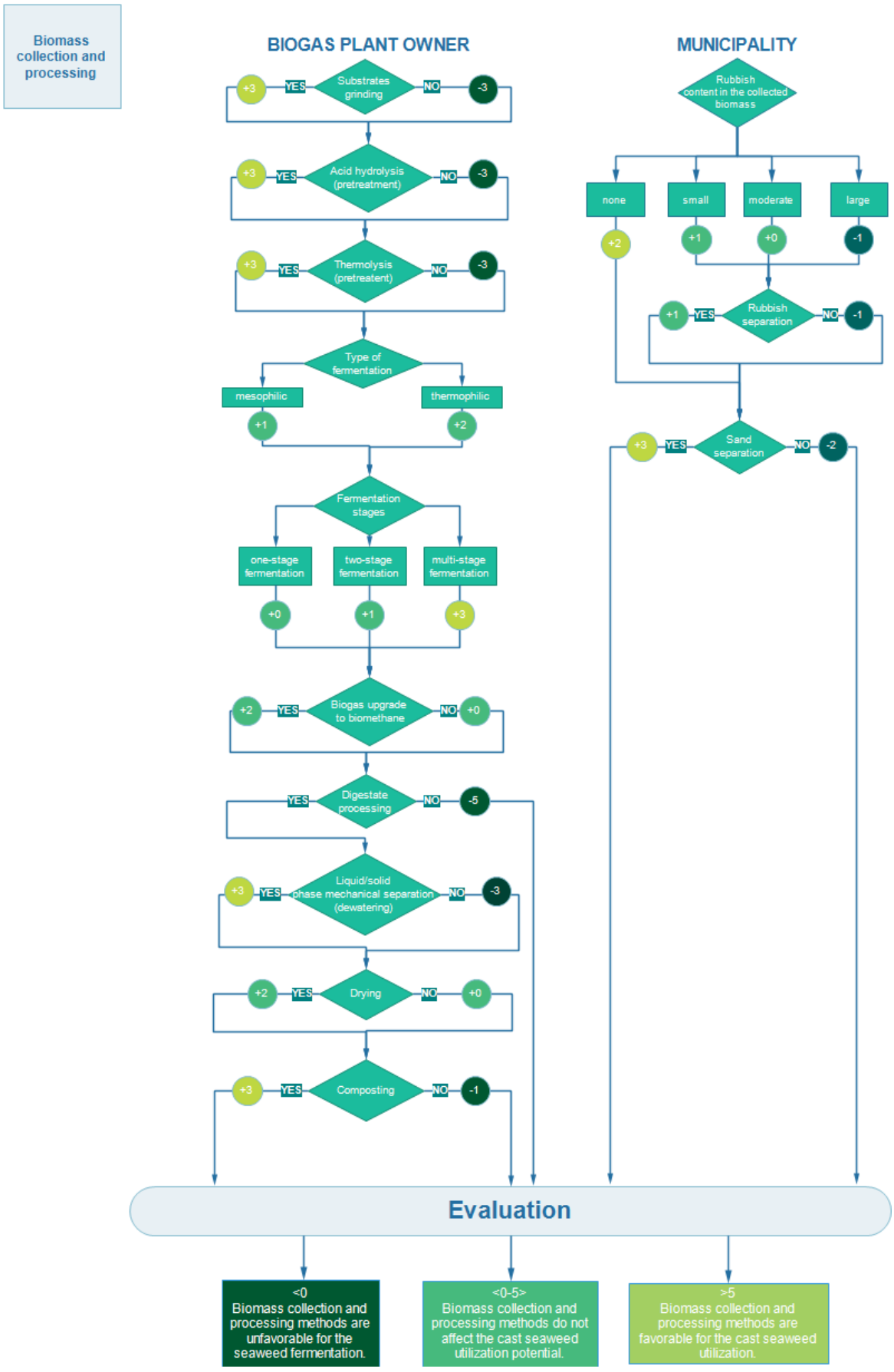

Figure 3 Algorithm of the 'biomass collection and processing' module

Infrastructure and availability

For the biogas plant owner module, the algorithm is focused on the storage space. If it already available or possible to build, the weight is positive.

For the municipality module, the infrastructure that is taken into account is mainly collection equipment. The algorithm is set to give a preference to the beach cleaning infrastructure that is designed specifically for the cleaning of sandy beaches.

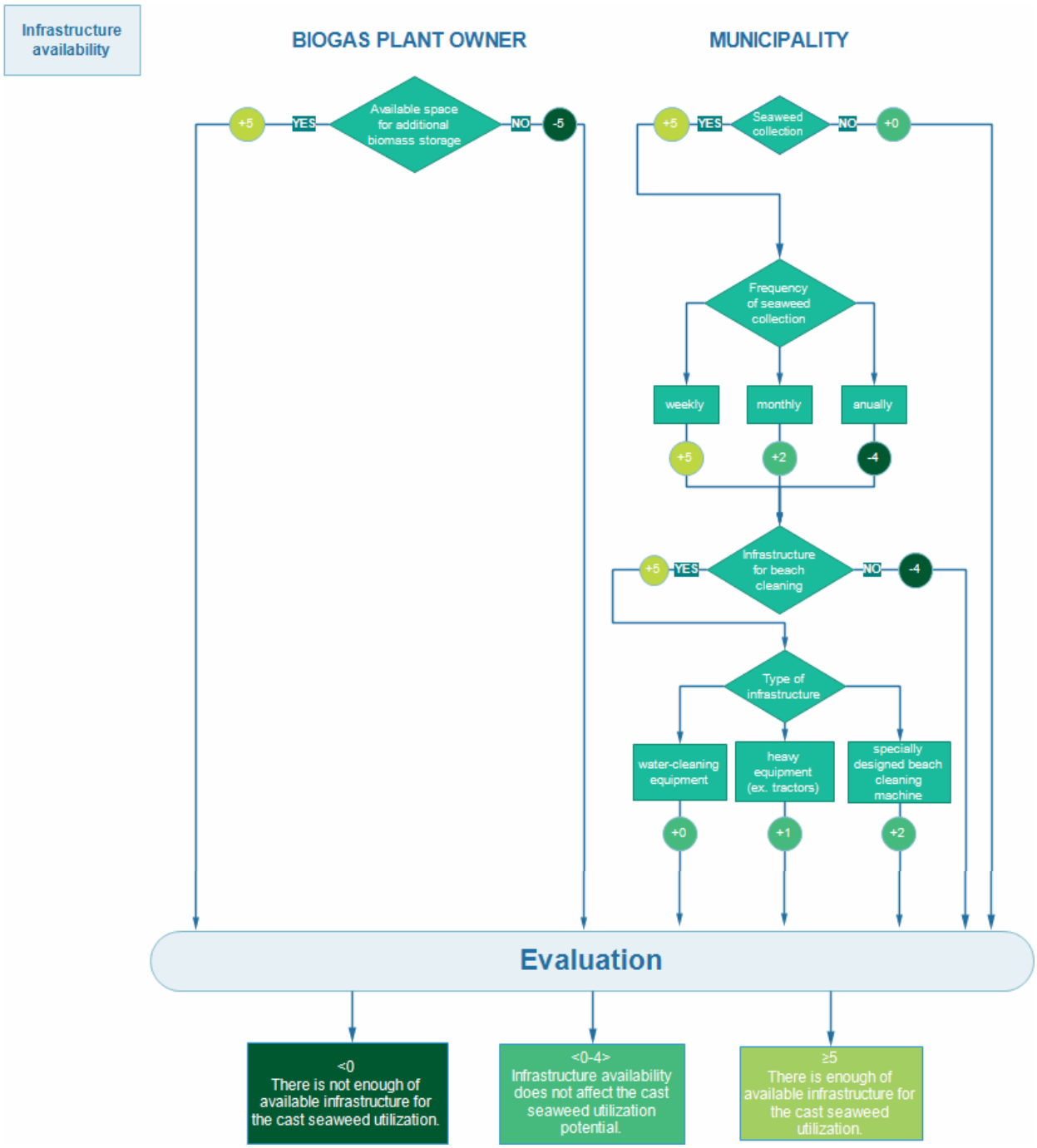

Figure 4 Algorithm of the 'Infrastructure availability' module

After evaluation of each part is performed, the algorithm gives a recommendation whether cast seaweed utilization is profitable, unprofitable, does not affect the process or it can be profitable but some factors must be carefully considered.

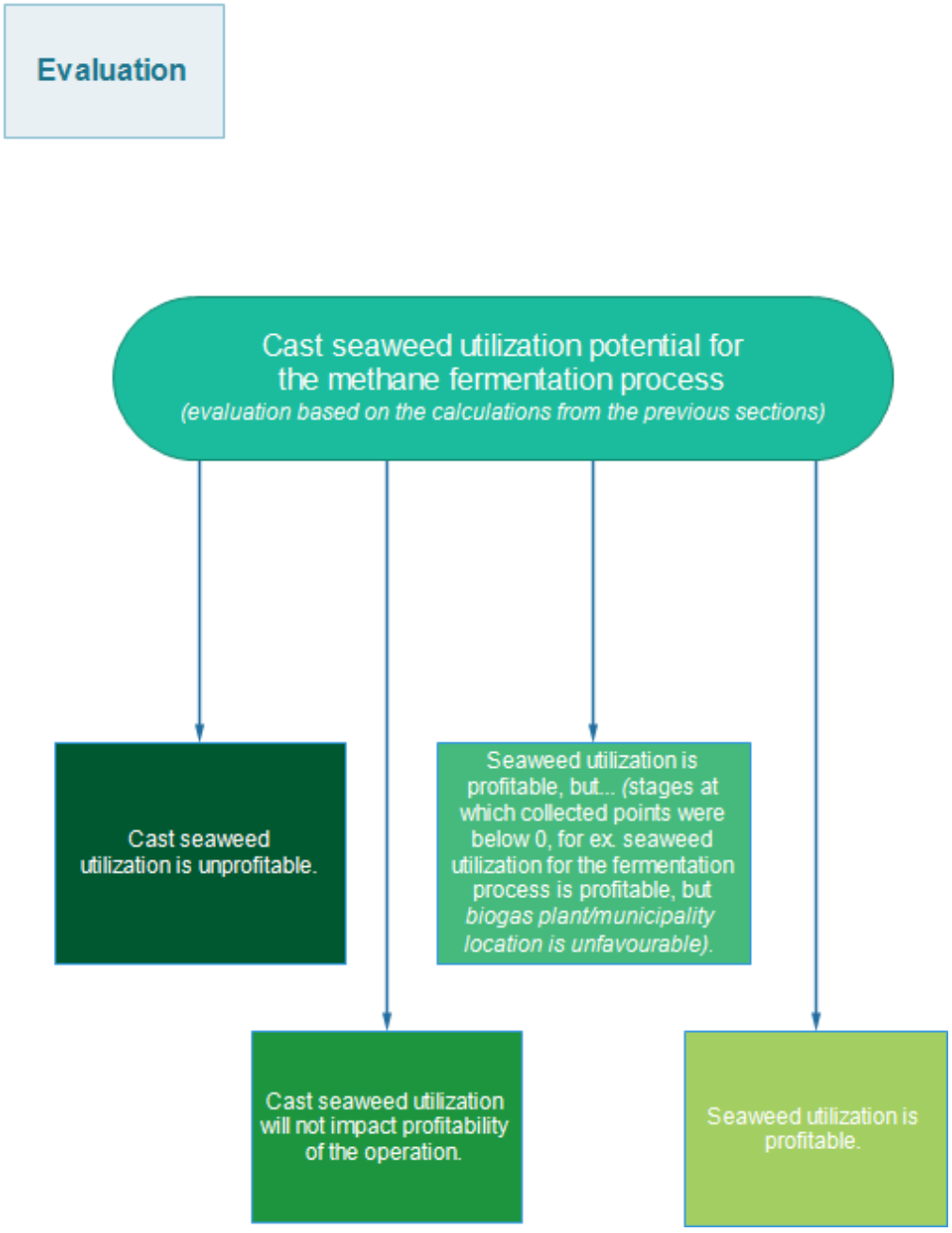

Figure 5 Algorithm of the evaluation step

4. Tool manual

4.1. In this chapter, the decision tool is described. The web application is available in six languages: English, Danish, German, Polish, Lithuanian and Swedish.

4.2. To use the decision-making tool, the user is required to visit the application page at: http://technologia.gda.pl/coastal. The website opens with a welcome message that should automatically display in the user's native language. If this is not the case, the user can change the language to the preferred one in the menu line.

Figure 6 Welcome screen

4.3. In order to perform an evaluation, the user should click the "Evaluations" button located on the menu bar or make a registration under the "Sign In/ Sign Up" button. Registration allows the user to view and save a list of evaluations that have been performed. One can always return to them later.

Figure 7 Registration screen

4.4. Once reached the "Evaluations" page, the user should click the button: "Start Evaluation".

Figure 8 Evaluation start screen

4.5. The next step is for the user to choose whether to carry out the evaluation for the biogas plant or for the municipality.

Figure 9 User type choice screen

4.6. After the user chooses one of the two options, a list of five available aspects for which the evaluation can be done will appear. In order to unlock the four aspects, the user first needs to perform an evaluation for the aspect "Legal".

Figure 10 Module choice screen

Municipality Module

4.7. When the user enters the legal aspect sub-page, at first the country for which the potential of marine biomass will be analyzed is to be selected. After selecting one of the five options, a question about the region will be asked, and after answering this question, a question about the area where the biogas plant is to be located will appear.

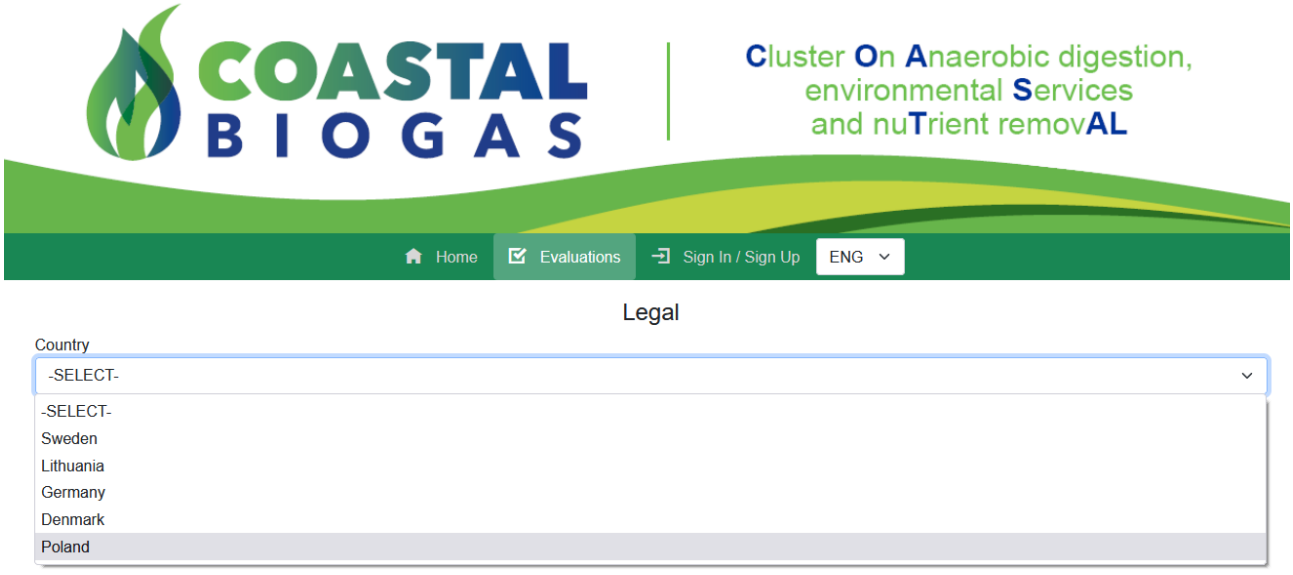

Figure 11 Country selection screen

4.8. After answering all the questions for the aspect "Legal", a preliminary evaluation result for this aspect will appear at the bottom of the user's page. If the result of the evaluation indicates that marine biomass is not feasible, a thank you message will appear. If the result of the evaluation shows that marine biomass can be used, after clicking “Go back” button, the user is redirected to the page with other aspects: location, infrastructure availability, biomass collection and processing, biomass characteristics.

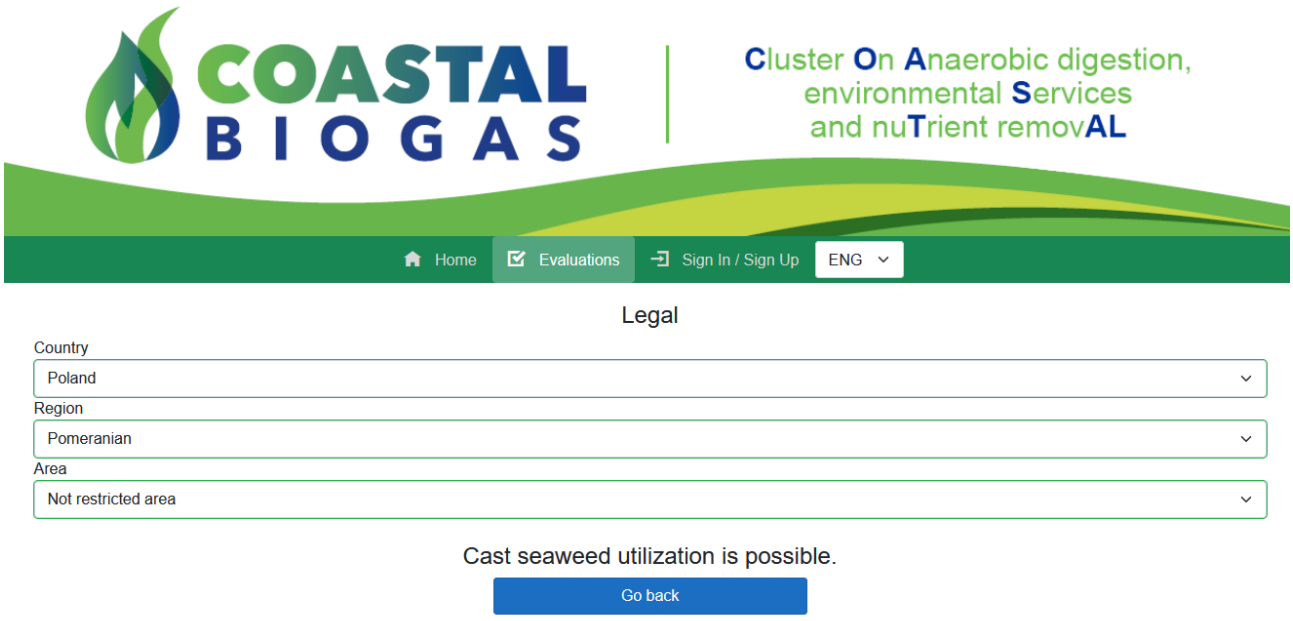

Figure 12 'Legal' module questionnaire screen

4.9. The user can navigate to the unlocked sub-page of the aspect. In the aspect "location", the user is asked to provide data on the number of inhabitants in the municipality, the annual tourism, the distance between the coast and the biogas plant, the road adaptation and the accessibility of the beach for road vehicles. After the user has answered the questions, the evaluation result for the "Location" aspect will be displayed on the page and a "Proceed" button will appear, which the user can click to return to the page with all aspects.

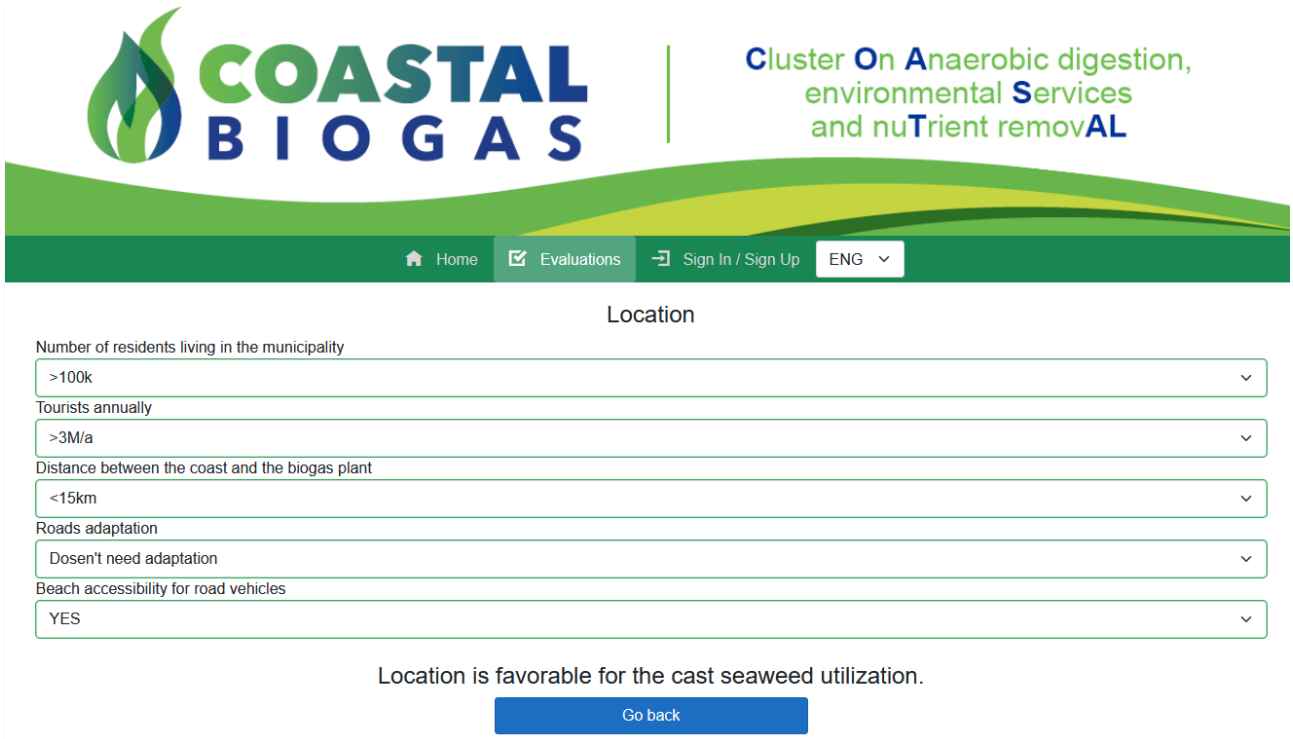

Figure 13 'Location' module questionnaire screen

4.10. When the user clicks on the "Infrastructure availability" aspect, he will be asked to answer the questions about seaweed collection, frequency of collection, beach cleaning infrastructure and its type. After the user has answered the questions, the evaluation result for "Infrastructure availability" will be displayed and the "Proceed" button can be clicked to return to the page for all aspects.

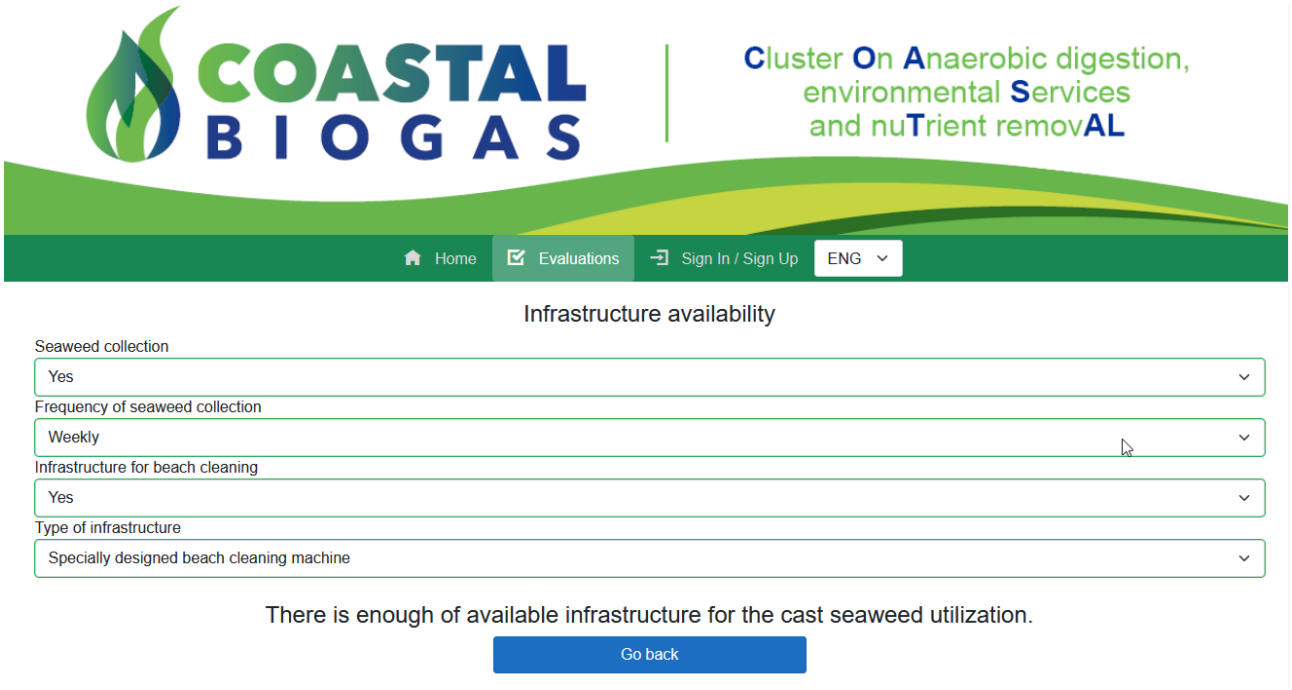

Figure 14 'Infrastructure availability' module questionnaire screen

4.11. When the user clicks on the "Biomass characteristics" aspect, he will be asked to answer questions on the monthly amount of seaweed on the beach from January to March, the monthly amount of seaweed on the beach from April to June, the monthly amount of seaweed on the beach from July to September and the monthly amount of seaweed on the beach from October to December. After all answers are provided, the page with evaluation result for the aspect "Biomass characteristics" will be displayed and there will be a button "Proceed" which the user can click to return to the page for all aspects.

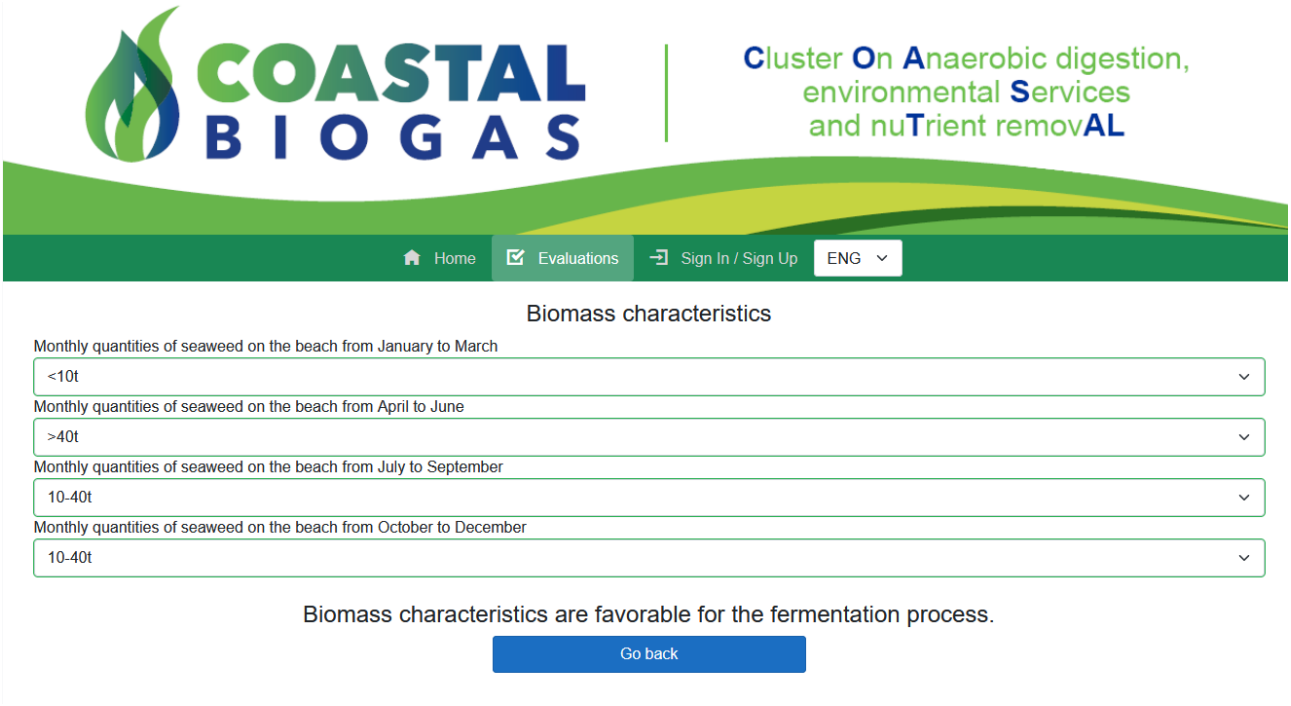

Figure 15 'Biomass characteristics' module questionnaire screen

4.12. When the user clicks on "Biomass collection and processing", he is asked to answer questions about the amount of litter in the collected marine biomass, about the separation of litter from marine biomass and about the separation of sand from marine biomass. After the user has answered the questions, the page displays an evaluation result for the aspect "Biomass characteristics" and a button, which can be clicked to return to the page of all aspects.

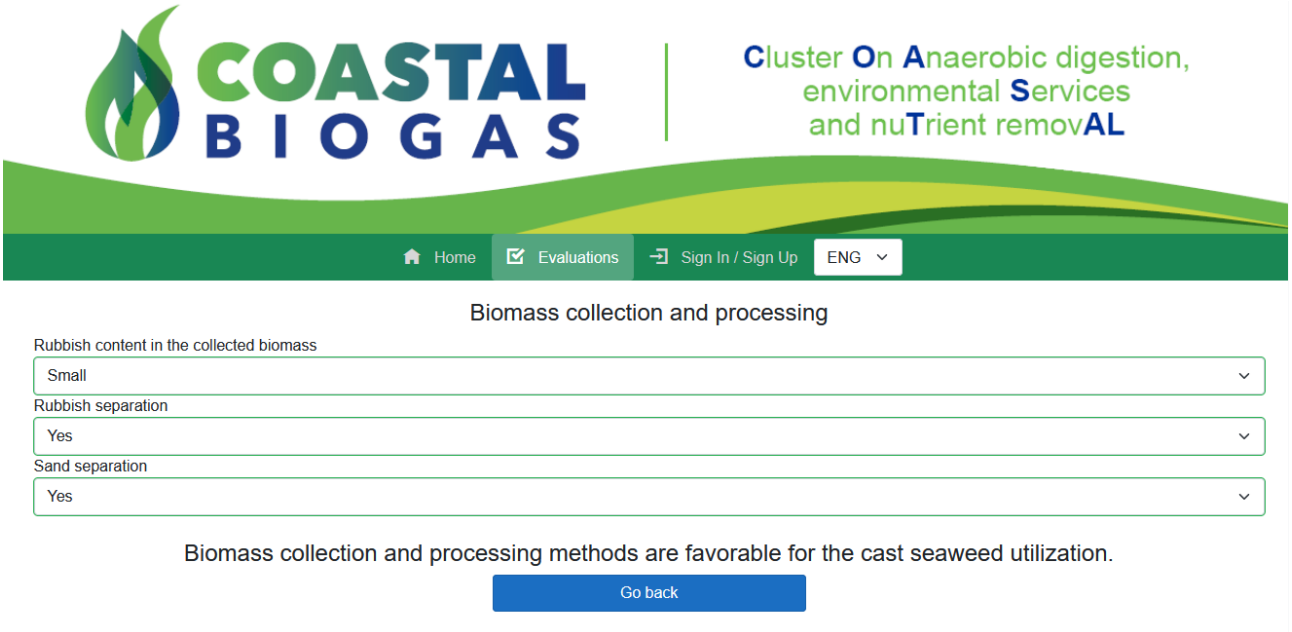

Figure 16 'Biomass collection and processing' module questionnaire screen

4.13. After answering the questions for all aspects and clicking on the "Go back" button, the user will be redirected to the page with the five available aspects. On this page, at the bottom, there will be a main evaluation, which will be generated based on the intermediate evaluations.

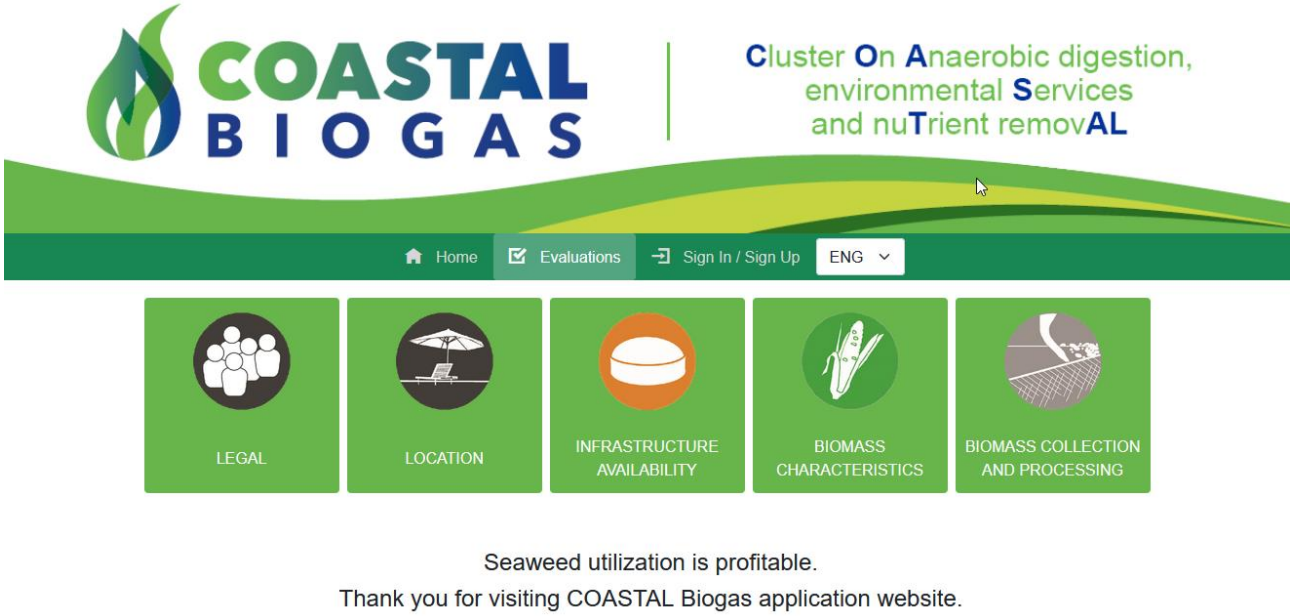

Figure 17 Evaluation result screen

Biogas Owner Module

4.14. When the user enters the legal aspect sub-page, he first selects the country for which the potential of marine biomass will be analyzed. After selecting one of the five options, a question about the region will be asked, and after answering this question, a question about the area where the biogas plant is to be located will appear.

4.15. After answering all questions for the aspect “Legal”, a preliminary evaluation result for this aspect will appear at the bottom of the user’s page. If the result of the evaluation indicates that it is not possible to use marine biomass, a message will appear thanking the user for the using the page. In case the result of the evaluation shows that marine biomass can be used, the user is redirected (“Proceed” button) to the page with other aspects: location, infrastructure availability, biomass collection and processing, biomass characteristics.

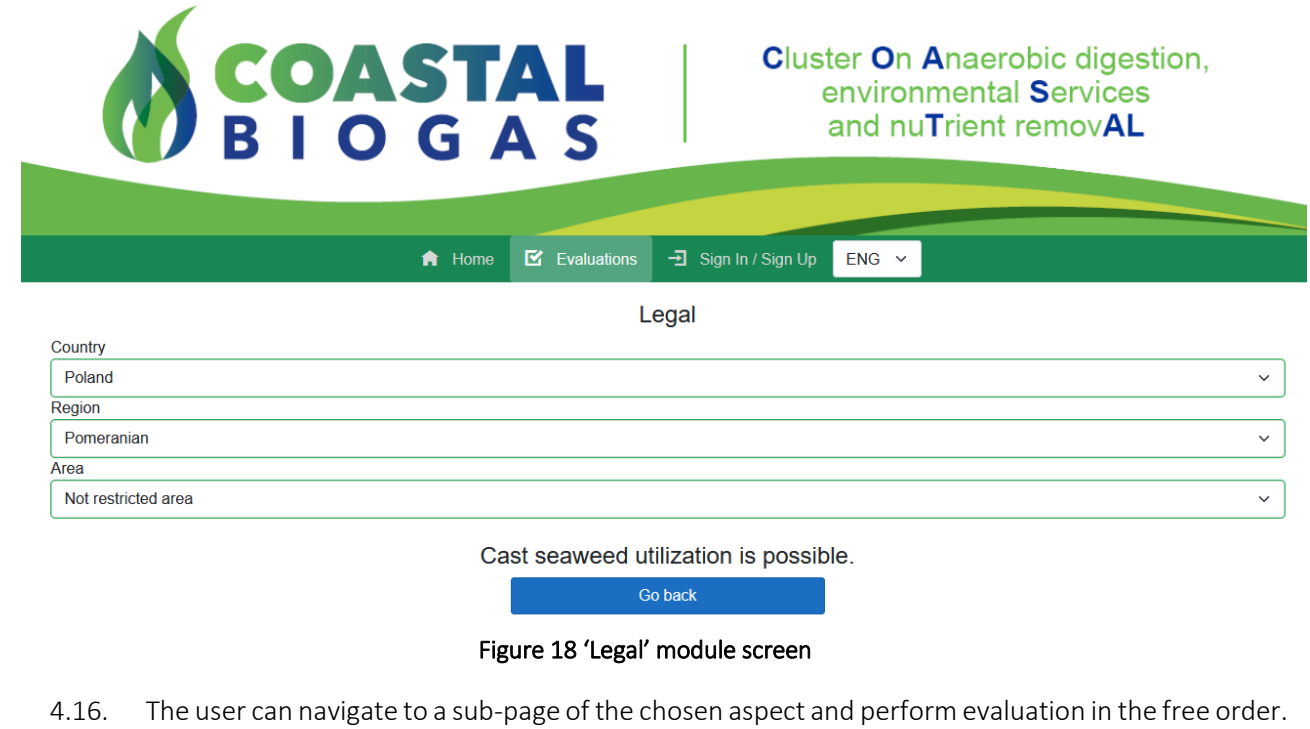

Figure 18 'Legal' module screen

4.16. The user can navigate to a sub-page of the chosen aspect and perform evaluation in the free order.

4.17. In the aspect "location", the user has to provide data about the number of inhabitants in the municipality, the distance of the biogas plant from the coast, the type of road between the biogas plant and the coast and the destination of the digestate. After the user has answered the questions, the evaluation result for the "Location" aspect will be displayed on the page and a "Proceed" button will appear which can be clicked to return to the page for all aspects.

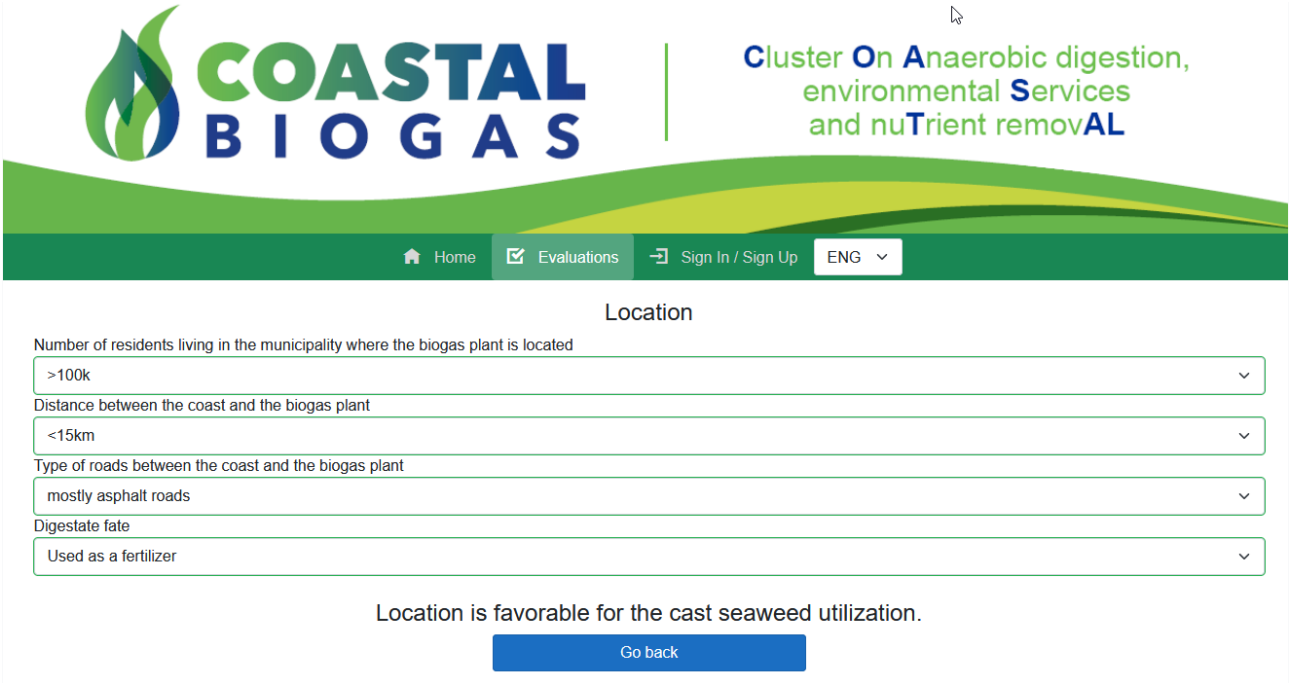

Figure 19 'Location' module screen

4.18. When the user clicks on the "Infrastructure availability" aspect, he is asked to answer questions about the available infrastructure for marine biomass storage and about the possibility of renting infrastructure for marine biomass storage. After the user answers the questions, the evaluation result for the "Infrastructure availability" aspect will be shown and the "Proceed" button will be displayed and the user will have to click on it to return to the page of all aspects.

Figure 20 'Infrastructure availability' module screen

4.19. When the user clicks on the "Biomass characteristics" aspect, he will be asked to answer questions about the substrate and the substrate amount. When you click on "Biomass characteristics" you will be asked to answer questions about the substrate characteristics and the amount of substrate.

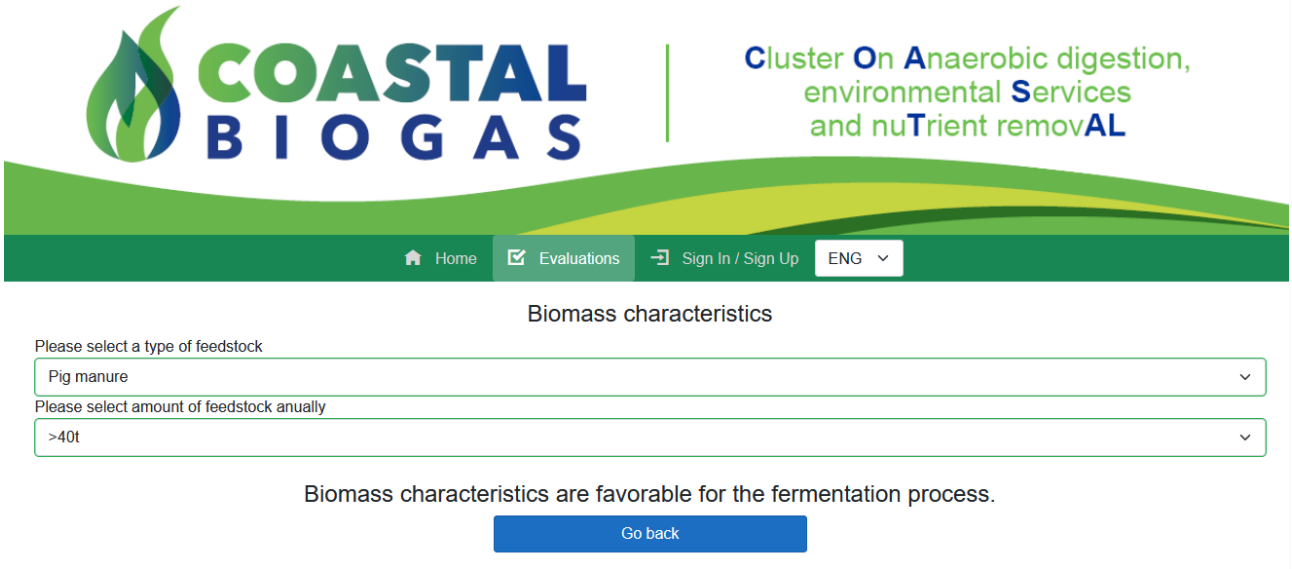

Figure 21 'Biomass characteristics' module screen

4.20. When the user clicks on the aspect "Biomass collection and processing", the user has to answer questions about the substrate treatment and the type of process, the type of fermentation and the type of fermentation, the number of fermentation steps, the upgrading of the biogas to biomethane, the digestate treatment and the method. After the user has answered the question, the evaluation result for the aspect "Biomass characteristics" will be displayed and there will be a button, which can be clicked to return to the page for all aspects.

Figure 22 'Biomass and collection' module screen

4.21. After answering the questions for all aspects and clicking on the "Proceed" button, the user will be redirected to the page with the five available aspects. On this page, at the very bottom, there will be a main evaluation result, which will be generated based on the intermediate evaluations obtained.

Figure 23 Evaluation result screen

5. Tool testing

The tool was tested for several different scenarios. To the best knowledge and experience of the testers, the results obtained were reasonable and the feasibility results was adequate to the given scenario. The example of the simulation is presented below:

By selecting the legal aspect, the user provides answers to the following questions:

1. In which country is the seaweed to be harvested?
Denmark

2. In which region is the collection area located?
Zealand

3. In which area is the collection site located?
not restricted

The result of the intermediate evaluation: Cast seaweed is possible.

The next aspect is location. By selecting this aspect, the user gives answers to the following questions:

1. Number of residents living in municipality?
50-100k

2. Tourists annually?
>3M/a

3. Distance between the coast and the biogas plant?
<15km

4. Roads adaptation
Doesn't need adaptation

5. Beach accessibility for roads vehicles?
Yes

Result of intermediate evaluation: Location is favorable for the cast seaweed utilization.

The next aspect is Infrastructure availability. By selecting this aspect, the user answers the following questions:

1. Seaweed collection
Yes

2. Frequency of seaweed collection?
Weekly

3. Infrastructure for beach clearing?
Yes

4. Type of infrastructure?
Specially designed beach clearing machine

Result of intermediate evaluation: There is enough of available infrastructure for the cast seaweed utilization.

The next aspect is Biomass characteristics. By selecting this aspect, the user answers the following questions:

1. Monthly quantities of seaweed on the beach from January to March?
10-40t

2. Monthly quantities of seaweed on the beach from April to June?
>40t

3. Monthly quantities of seaweed on the beach from July to September?
>40t

4. Monthly quantities of seaweed on the beach from October to December?
10-40t

Intermediate evaluation result: Biomass characteristics are favorable for the fermentation process.

The next aspect is Biomass collection and processing. By selecting this aspect, you provide answers to the following questions:

1. Rubbish content in the collected biomass?
Moderate

2. Rubbish separation?
Yes

3. Sand separation?
Yes

Intermediate evaluation result: Biomass collection and processing methods are favorable for the cast seaweed utilization.

Final evaluation: Seaweed utilization is profitable.

6. Conclusions

The tool developed within the project is a simple solution for the first stage evaluation of the investment feasibility and can be successfully applied to estimate the feasibility of using cast seaweed in the biogas plant as a feedstock. A number of parameters taken into account are sufficient to give the valuable result and to provide the basis and the initial point for biogas operators or local authorities for further evaluation of the investment. To perform an analysis, the user needs to collect several data, which can be used in data-driven decision process.

The simplicity of the tool enables non-experts in biogas industry or IT to evaluate the idea and gives an overview of the parameters that are crucial in making the decision.