D.T.2.3.1 FIRST PART OF THE FEASIBILITY STUDY (STEP 1 + 2) FOR THE PILOT PROPOSED – ITALY

Project Title: REEF 2W—Increased renewable energy and energy efficiency by integrating, combining and empowering urban wastewater and organic waste management systems

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1. Introduction

1.1. The REEF 2W Project

In the wake of the “Energiewende”, an increased focus is concentrating on the yet unexploited energy-saving potential of the wastewater sector. Wastewater treatment plants are large consumers of energy and often have key shares in the carbon footprint of municipalities and urban governments. Their energy consumption usually accounts for the bulk of operational costs of wastewater utilities, sometimes up to 60 per cent. However, despite being a large source of electricity and heat, sewage is generally overlooked. In fact, the amount of energy it contains can be 10 times bigger than that is required to treat it. Lately an increasing number of wastewater operators have deployed energy-efficiency measures and novel technologies to better harness the energy of sewage. Evaluations of pioneering projects show that utilities are not only capable of becoming energy self-sufficient, but also suppliers of energy thereby diversifying the local mix.

The project Reef 2W recognizes that wastewater is an integral part of the water-energy nexus. The project is funded by the European Development Bank’s Interreg Central Europe Programme and is carried out through 11 research institutes and wastewater utilities from Italy, Czech Republic, Germany, Croatia, and Austria. The projects main objective is to drive up energy efficiency and renewable energy production of wastewater treatment plants. It provides an innovative approach in integrating organic waste and wastewater streams and infrastructures. Where beneficial, bio-waste will be used to enrich sewage sludge, helping to elevate outputs of heat and electricity in a process called co-fermentation. To prove that the new technologies can be technically feasible and economic viable, project partners will develop a comprehensive assessment tool in close collaboration with utility operators in a series of workshops. Another key task of Reef 2W is to investigate the legal and policy framework conditions and to advocate for policy alternatives that spur the large-scale use of wastewater-to-energy solutions.

1.2. Scope of the deliverable

The purpose of this deliverable is to analyse the energy efficiency and the potential to produce renewable energy in the project’s five pilots. This will be done using the REEF 2W tool, which is based on the Integrated Sustainability Assessment (ISA). The methodology and its five steps are described in deliverable 3.1.1 of the project. Implementing the first part of the feasibility study will allow to understand how much energy the wastewater treatment plants (WTTPs) currently use, and at what level of efficiency. Furthermore it will provide a quantitative understanding about the potential to increase energy outputs. In the (fictitious) technological upgrades defined for each pilot, these include measures to optimise existing processes and to install new technologies that produce renewable energy.

How is it relating to previous deliverables?

The REEF 2W tool has been continuously improved and tested, also by external actors during the training courses. While the feedback gathered from the participants is integrated, the first part of the feasibility study is the first organized attempt to test the tool for all pilots and document the results. The results from the application of the tool will provide the data required to conduct the second part of the Feasibility Study (in Work Package 3). The results will also be important for other communicational purposes. For example, they provide evidence of the potential of wastewater-to-energy solutions, which is demonstrated in the Regional Strategies (DT2.5.1) and the MOUs (DT.2.5.2).

Structure & Approach

There will be five reports using the following approach. First, the background chapter introduces the ISA-methodology and its five steps, as well as the benefits that can be generally expected of the REEF 2W solutions. The second part, mostly building on previous deliverables, describes technological characteristics of the WTTP, used as pilot site for this study, and the envisioned (fictitious) upgrade investigated during REEF 2W. Based on that, chapter 4 analyses the energy performance of the WTTP and evaluates the current level of energy efficiency. Chapter 5 analyses the energetic yields that result from deploying the renewable energy solutions. Lastly, the final part will distil key results, shortcomings of the methodology, and further improvements to be made.

2. Description of pilot site (status quo)

2.1. Characteristics of the Waste treatment plant

The High Valmarecchia is located between the regions of Tuscany and Marche, the Republic of San Marino and Emilia-Romagna, to which it belongs.

The High Valmarecchia is relatively large and hilly with a low population density.

Montefeltro Servizi is a multi-utility that provides environmental services in the area for all the seven municipalities in the valley with a total population of about 17.000 inhabitants.

Due to a recent change in the regional reorganisation of waste and wastewater management, the company is no longer involved in wastewater treatment. This new situation that arose after the start of the project, determined a modification of the possible scenarios applicable at the pilot site. For this reason, the model presented in the project application form is no more valid.

At present, the company only manages the waste produced in the area and sorts and delivers it to specialised centres for the final disposal. This work is done in an area owned by all the seven municipalities.

The collected waste contains a large proportion of dry organic waste that cannot be used for anaerobic digestion and must be stabilized in the composting process. Composting is a well-known and energy-intensive process that in the specific case of Montefeltro Servizi is conducted in another plant several kilometres away from the collection point. To reduce the number of transports from one end of the valley to the other, and to valorise the energy content of the organic waste, the company has decided to investigate the possibility of using a gasification process to recover thermal and electric energy from the organic waste.

To increase the energy production potential, not only the collected dry organic material was considered, but also the availability of other lignocellulosic materials collected from agricultural or industrial activities.

For this reason, the new model that the company wishes to evaluate is the possibility to gassifying the lignocellulosic material with the aim to produce the electricity and thermal energy necessary to cover the needs of the treatment platform.

2.2. Technology upgrade of the pilot

At this moment, any environmental technology is applied to reduce the energetic impact of the treatment technologies at the treatment site.

In the meantime, there is a plan by the company to reallocate different working sites and offices in one place to optimise space and working time. For this reason, there is a strong interest in the evaluation of the possibility to identify technologies capable of recovering energy from collected wastes. Gasification technology represents one of the most probable options, as it can be used with locally available material, offers the possibility of combining electricity and heat recovery, and can be switched on and off as required.

The other interesting aspect of the gasification process is that the end products are ash and biochar. The advantage of this treatment technology is the reduction of volume and weight of the input material during the treatment. The ashes could provide inorganic elements that can be reused in agriculture. If this is not possible, the ash could also be disposed as a stable material in landfills or used as an inert material in building or road construction.

Biochar, on the other hand, is a carbon concentrate that can be used in agriculture to return the carbon to neighbouring lands.

The Electricity produced could be used for the different appliances in the treatment platform. The heat could be used for heating the offices during winter time and all year round to warm up the water in the worker’s sanitary facilities.

At this stage, it isnot yet decided which specific gasification technology will be applied. This will strongly depend on the current evaluation. But it is clear that gasification is the only possible technology that can be applied at the pilot site at this moment under the conditions under consideration.

The organic material available for gasification at that moment will consist of the organic fraction of the municipal solid waste, the excess sludge of the WWTPs, and brushwood. The available amount of these materials is not very large and for this reason the company has carried out a survey of the territory to evaluate alternative available substrates.

2.3. Data availability and quality

Since Montefeltro Servizi is in charge of waste collection at local level, the company have an historical data collection of the available quantities of different types of waste collected. For the organic waste some data are summarized in the following table.

Type of waste	Tons per year
MFOSW	405,98
Prunings	261,51
Exhaust vegetal oil	1,58

The company has already conducted a survey of the energy consumption (electricity and heat) of the different production facilities and offices. The result of the survey highlighted the following average values per year: 17247 kWh of electricity and 2117 SCM of methane, equivalent to about 80400MJ or 22.400 kWh.

As already mentioned, due to the limited amount of available waste and the level of investment costs, the company conducts a survey on the availability of other sources for organic waste in the territory. One of the best options offered by a farm that produces cultivated mushrooms. This farm generates every week about 16 tons of exhaust litter that must be disposed. At the moment, these 16 tons are distributed directly to the surrounding cultivated fields. But, as the costs for transport, spreading, and burial of the litter are relatively high, the farm is looking for alternative solutions. As the litter consists mainly of lignocellulosic materials, the opportunity to use the litter in a gasification process seems interesting.

3. Energy performance of pilot

The tool was not designed for the energy assessment of waste plants. Consequently, the current data availability does not allow a detailed description for a correct identification of the energetic performances of such a pilot site. Moreover, Montefeltro Servizi does not have detailed data on its energy consumption, which makes an evaluation impossible.

4. Application of renewable energies and associated energy output improvements

4.1. On-site renewable energy generation through traditional technologies

Among the variety of traditional renewable energetic technologies, such as photovoltaic, biogas production, wind energy, hydropower, hybrid collectors, and solar thermal available on the market, iat this moment at the OFMSW in Novafeltria only photovoltaic and gasification technologies are applicable. Photovoltaic is a technology that can be considered because the probable available roof space in the new building will be sufficient to install this technology. The feasibility of using the gasification process has already been discussed on the previous chapters, and is directly related to the new situation the company is facing in these years. On the other hand, this new situation determines the need to evaluate the possibilities to reduce costs and environmental impacts, where the REEF 2W Tool can help.

Photovoltaic: At this moment, there aren’t possibilities to install photovoltaic panels as well as to do an assessment of their installation, because it doesn’t exist a draw of the new space availability for the new productive site of the company. One can only assume that photovoltaic technology will be installed on the roof of the new headquarters, as required by law in Italy. The area available for installation should be about 100 m^2.

Biogas production: due to the amount and quality of the waste collected this is not a technology that can be considered for the near future.

Wind energy: local legislation doesn’t allow the installation of wind turbines in the valley according to the environmental evaluation. Furthermore, the valley doesn’t have a very interesting wind profile. Due to these considerations, this technology will not be applied.

Hydropower: there is no more the availability for the company of the sewage wastewater, furthermore in any case the limited amount of water collected doesn't allow to consider this kind of investment advantageous.

Solar hybrid collector: It is feasible to equip the roof surfaces that were intended for the installation of photovoltaic panels with hybrid collectors. Hybrid collectors have the advantage that they produce heat at the same time as electricity. However, this is in competition with the recoverable heat from the gasification process. Since only a limited amount of heat is required on the WWTP, the authors recommend limiting the technology upgrade to photovoltaic panels to keep investment costs low.

Solar thermal energy: For the same reasons as for solar hybrid collectors, this technology is not considered.

Gasification: The gasification process is the only evaluable process with the data available. The general consideration done on the applicability of this process at the pilot site are related to the quality of biomass available and the possibility to switch it on and off in a very short time. Compared to other technologies, this provides the possibility to produce energy when it is requested, without having to store it or feed it into the public grid.

4.2. Evaluation of renewable energy generation.

This section will provided a brief analysis on the advantages of renewable energy use in the treatment platform of Montefeltro Servizi according to the results obtained using the REEF 2W Tool.

As already mentioned, the results are based on the actual energy consumption provided by the company and take into account the possibility of installing photovoltaic panels on the roof area of 100m^2 and a gasification system that can be used with the available organic waste. Three different scenarios are considered:

- In the first scenario, only the biomass already available on the treatment platform without the organic fraction of municipal waste (OFMSW) has been considered.
- In the second scenario, available biomasses has been integrated with exhaust mushroom litter.
- In the third scenario, all available biomasses including OFMSW were considered.

At the moment energy consumption of the pilot is limited by the public supplier due to the limited availability of gas and electricity. The following graph shows the total energy consumption in kWh and in standard cubic meters (SCM). For a simpler comparison of the two values, SCM is given in kWh equivalent.

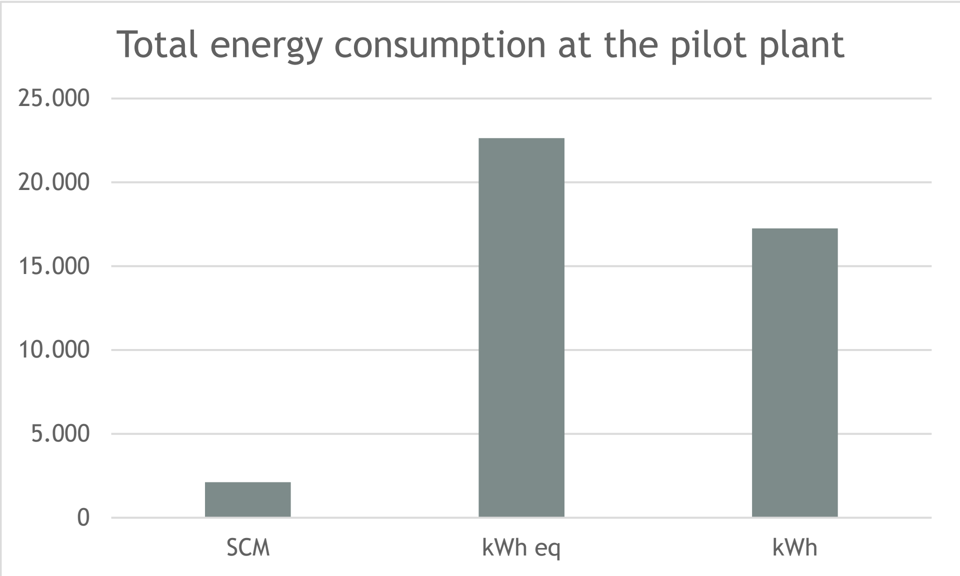

Fig. 1: Actual energy consumption at Pilot plant

Applying the tool to the Italian pilot site, taking into account the already available biomass and the energy production from the possibility to install photovoltaic panels, the following result is obtained:

The changes in energy generation are shown in the following figures according to the tool results:

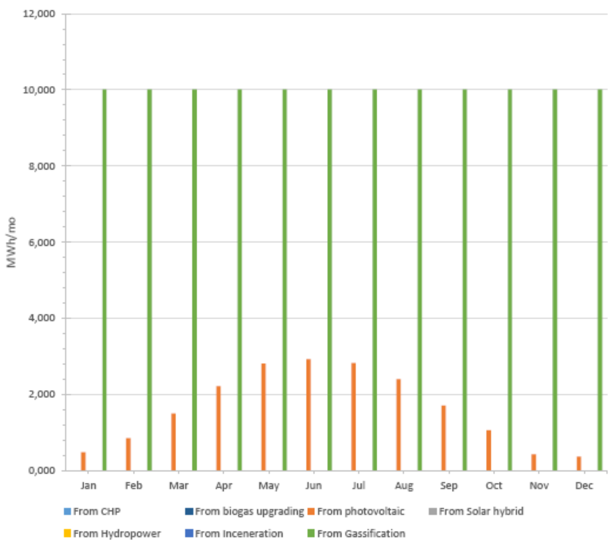

Fig. 2: Results of the energy production from available biomasses without OFMSW

The potential energy produced by photovoltaic panels could reach the value of 19.52 MWh per year. This amount would be sufficient to cover almost four fifths of the company’s total energy consumption.

Furthermore, the energy recoverable from biomass gasification is 10.08 MWh per month in form of electricity and 19.80 MWh month in form of thermal energy.

Considering all values, the total energy producible in the pilot site could be 127 MWh per year in form of electricity and 119 MWh year in form of thermal energy.

In the second scenario, an integration of the already mentioned biomasses with the mushroom litter was considered.

In the second hypothesis, with the integration of mushroom litter, the results are the following:

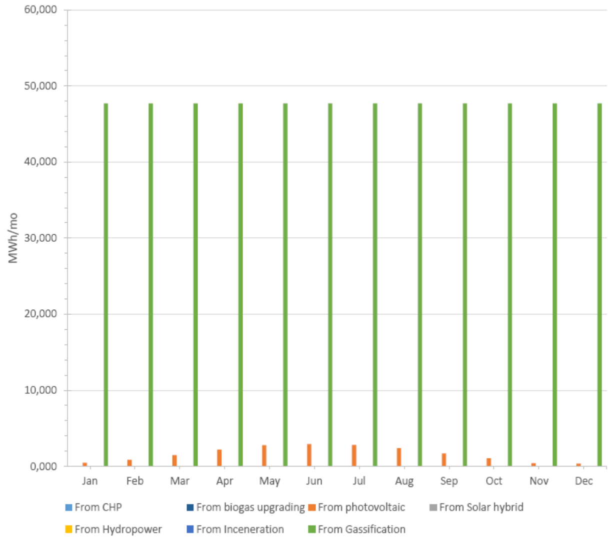

Fig. 3: Results of the energy production from available biomasses plus the litter

The total available energy could be about 515 MWh per year in form of electricity and about 570 MWh per year in form of thermal energy.

For the third scenario, which also includes OFMSW in the process, the results are presented in the following graphic:

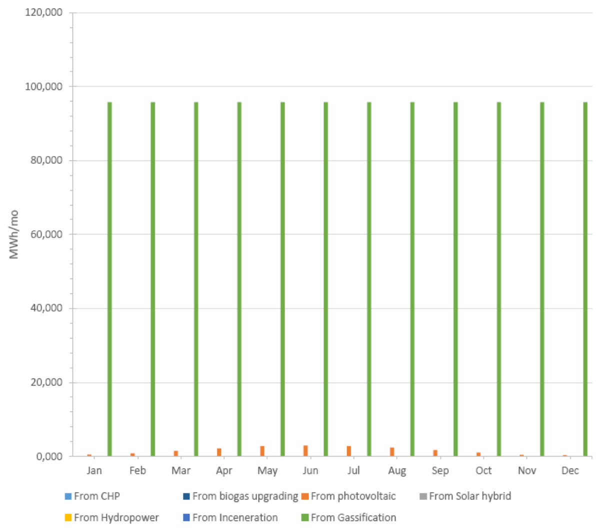

Fig. 4 Results of the energy production from available biomasses

From the latter scenario it can be seen that a potential energy production of about 1025 MWh per year in form of electricity and 1136 MWh per year in form of thermal energy would be possible.

4.3. Evaluation of further assessment

4.3.1. Spatial Assessment

If the possibility to sale the electric energy at the grid it is possible and it could provide an economic advantage. The possibility of selling the generated thermal energy to third parties is much more complicated due to the orographic situation of the valley and the long distances that must be overcome. From the different evaluation done, the maximum connection density obtained is 1.5 MWh/m. This value requires further and more detailed analysis.

No data are available for the industrial areas nearest to the plant, so a specific heat release value of 1200 MWh/y was assumed for the two identified areas.

The total length of the pipeline is about 3.5 km serving two different industrial areas of 5 and 20 ha.

These scenarios result in a connection density of about 0.31MWh/(m y), which is significantly lower than the suggested values necessary for a more deep evaluation of the application.

As can be seen, the reason for this difficulty is directly related to the length of the connection necessary to connect the treatment area with the nearest industrial area. Unfortunately, at the moment there is any other possibility to use the produced heat.

4.4. Environmental assessment

The environmental assessment of the considered solutions shows a strong advantage in terms of reduction of carbon emissions. In the assessment, only the electric energy produced and eventually introduced in the grid has been considered. The reason for this choice is directly related to the spatial assessment done that reports a strong disadvantage for the use of heat. Consequently, considering only this aspect, more than 19.000 tons of CO_2eq could be removed, if the gasification of the biomasses can be applied.

4.5. Economic assessment

The economic assessment of the solutions is quite difficult to do especially in terms of investment costs.

From the analysis done in the first scenario the installed power of the gasification system should be around 40 kW increasing to 178 kW for the second scenario, and to 356 kWh in the third.

The rough cost estimation of such kind of appliances require from 1 to 5 M€.

The payback period of these costs depends very much on the subsidies and the opportunity to find a convenient solution for the heat use, which could produce a further interesting income.

Looking at this scenario, the payback period of the range from 5 to 10 years.

4.6. Discussion & Conclusion

From the analysis with the REEF 2W tool it can be seen that applicable technologies are able to provide much more energy than is required by the pilot. By using the already available biomass, they can provide much more energy than needed, if used locally in a gasification system.

Unfortunately, the analysis of the heat use provides a negative feedback and this reduces considerably the economic advantage of the application.

From the suggestions provided by the tool, considering the actual energetic consumption of the platform and the related cost due to the transport costs and environmental effects related to this activity, it seems that the most convenient solution could be the second scenario, that provide a large quantity of energy sufficient to cover the necessities of the treatment platform and, for the part sold at the grid, a sufficient income to cover the investment costs in an acceptable period of time.

An interesting aspect allowed by the Italian legislation for the use of the energy produced by public bodies is the possibility to produce electricity in any place of the Italian territory and use it in any other place of the Italian territory where the same public body has a utilization point. This is call “scambio sul posto altrove” (exchange on the site elsewhere). In the case of the Italian pilot this could be particularly interesting because the land of the treatment platform is owned by the seven municipalities and the excess of electricity produced could be used by the municipalities for all the necessities of the municipality (public lighting, provide energy at schools, and social centres, etc.)

This is an evaluation that is still ongoing because the large number of utilization points and the possibility to exactly identify if a building is property of the municipality or by another public body is not easy, and it could change largely the evaluations.