DELIVERABLE ICE T4.4.3

CASE STUDY OUESSANT - TOOL FOR ENERGY RECOVERY FROM WASTE

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About ICE

Supported by the Interreg VA France (Channel) England program, the Intelligent Community Energy (ICE) project aims to design and apply innovative intelligent energy solutions for isolated areas of the Channel. Islands and peripheral territories face specific energy challenges. Many islands are not connected to European electricity grids and are dependent on imported fossil fuels, especially oil-fired thermal generators. The energy systems on which they depend tend to be less reliable, more expensive and emit more greenhouse gases than on the European continental grid.

In response to these issues, the ICE project considers the entire energy cycle, from production to consumption, and integrates mature or new technologies to develop innovative energy solutions. These solutions will be tested and tested at two pilot demonstration sites (Ushant Island and the University of East Anglia campus), to prove their feasibility and develop a general reproducible method for other isolated smart energy systems. elsewhere. To transfer this methodology to other isolated territories, ICE will offer a global low-carbon transition commercial offer. This will include a comprehensive assessment of local energy resources and conditions, a tailor-made model proposal for the energy transition, and a set of low-carbon skills and technologies available in a consortium of selected companies. This ICE-certified consortium will promote this offer to other isolated territories in and outside the Channel area (5 territories initially). The ICE partnership brings together researchers and support organizations for SMEs and benefits from France – UK complementarity in terms of knowledge and technological and commercial development.

The involvement of local and European SMEs will help to strengthen competitiveness and transnational cooperation.

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1. Introduction

Valorising Waste to energy is the last step, according to the European Union's "Waste Hierarchy", where a valorisation of waste is possible. Landfilling waste (in controlled landfill or not controlled dump) is the main waste treatment in the world, however, waste-to-energy valorisation is almost only performed by "high income" countries (Gross National Income > 11 k$/cap)1.

In the particular context of isolated territories, fossil fuel is imported to produce electricity, while in the majority of the cases, waste are exported to be properly treated on the continent. These two aspects conduct to high cost for energy production and waste treatment.

The idea is to identify on isolated territory what is the share of waste that could be valorise on site, in order to evaluate the production of renewable electricity and heat, and to design the gasification unit and cogeneration.

In order to provide a solution suitable for big as well as for small territories, the technology selected is the downdraft fixed bed gasification reactor, which known a worldwide development during World War II, and is able to cover electricity production from few kWe up to 1MWe using 1 reactor. A set up in parallel of several reactors allows to reach any power desired.

The idea of the creation of the tool succeeded a study on the Ushant Island to assess the potential of waste wood collected locally and exported, which could be rather valorized on the island, in order to produce renewable energy (electricity and heat).

2. Description of the tool

The tool consists of an excel file, with the aim to provide a quick estimation of a waste-to-energy unit in terms of:

- Quantities of fuel
- Size of the unit
- Energy available: electricity and heat
- Needs in terms of preparation, residues
- Economical estimation (CAPEX, OPEX)

The tool is composed of 3 sheets:

- "Input Waste-biomass": it regroups the input data of the different waste or biomasses stocks available, with their properties.
- "Calculation": it regroups all the calculation of the tool. The user as to fill some cells with input data.

[1] D. Hoornweg, P. Bhada-Tata, and A. Joshi-Ghani, "What a waste: A global review of solid waste management," Washington, DC 20433 USA, 2012

- “Summary”: this sheet is a summary of the results of the calculation. It aims to regroups principal data regarding technical and economical design of the chosen solution based on the amount of waste

A color code has been used to ease the understanding of the user:

- Blue cells are input data from the user
- Yellow Cells are specific input data regarding the gasification technology. Standard values have been implemented but a user with knowledges in Gasification is able to change these values.
- White cells / non colored cells are data that are used for the calculation but are not usefull as results.
- Green cells are results data, that are intended as output data of the tool.

The user needs to enter as input data in blue cells:

- amounts of wastes, and quality: moisture, ash content, inert content
- Needs in terms of energy availability required: all year long or a defined period (e.g. only in winter)
- The characteristics of the territory: cost of importation, current cost of electricity, cost of waste treatment, cost of Full-Time Employee… These data are mainly economic data.

3. Results of the Ushant Case Study

The results presented in this report are extracted from the "Summary" sheet with the input data of Ushant Case Study.

Context							
Total mass of identified waste/biomass - t	**Total mass of fuel, inert free (with effiency) - t**	**Total energy potential - MWh th**	**Total Electricity Potential - MWhe**	**Total Heat potential - MWh th (in case of cogeneration)**			
100	63	313	69	203			

The context of Ushant is a rather low amount of waste, reaching 100 t/y of waste wood from pallets, wood remnants from construction… The raw amount of waste needs to be crushed, dried and sieved to produce a suitable fuel for air downdraft gasification (in form of chips), which results in a total amount of fuel of 63 t/y. This amount of fuel leads to a potential of 313 MWh-thermal, which could be converted into 69 MWh of electricity and 203 MWh of heat, and energy losses.

Based on this amount, the technical design of the unit is given below:

Design of the valorization unit					
Energy valorization		Minimal Power output of the unit recommended based on the chosen			
Electric power output (user's choice) - kWe	10	8,18			
Thermal power output - kWth	30				
Total electricity produced - MWh/y	69				
Total heat produced - MWh/y	203				
		in grey : fixed parameter, in red : variable to ensure the scenario			
Hours of operation per day - h/d	24	**Scenario**	**Non-stop Operation (24/24, 7/7) - 1 annual stop**	**Operation spread over 1 year + condition : 5 d/week**	**Operation spread over 1 year + condition : 16 h/d**
Number of operating day per week - d/week	7	**h/d**	24	26,44	16
Nombre operating week per year - week-year	50	**d/week**	7	5	8,26
		week/year	40,92	52	52
Number of working hours - h/y	8400				
Preparation and Storage of the fuel					
Surface occupied by fuel (as received) in the storage 1 - m2	34				
Surface occupied by shredded fuel in the storage 2 - m2	52				
Inert et residues					
Inert removed during preparation phase (status as Waste) - t/y	6,84				
Residues of gasification - t/y	5,00				
Quantities of fly ash (from cyclone or filters) - t /y	0,63				

The minimal size of the unit to be able to valorise the fuel over 1 year is 8,18 kW-e (kW-e for kW electric). The choice made is a 10 kW-e – 30 kW-th unit (kW-th for kW thermal).

This design allows to valorise all the fuel, and then produce 69 MWh of electricity and 203 MWh of heat.

The chosen working conditions are : 24 h/d, 7 d/week and 50 w/y, which gives 2 weeks per year for the maintenance.

Based on the amount of fuel and the chosen storage capacity (input data in the “Calculation” sheet), the surface of the storage are : 34 m² for raw waste and 52 m² for prepared fuel.

Regarding waste management, the amount of residues that should be treated after the energy valorisation are :

- 6,84 t/y of inert removed from the raw waste during preparation of fuel (rock, stone, metals)
- 5 t/y of residues as “bottom ash” of the unit. Practically, this appears like small pieces of charcoal with a high share of ash.
- 0,63 t/y of fly ashes from the filtration part of the unit. This appears like fine charcoal dust.

The economic design of the unit is given below:

Economical analysis

Sensibility of incomes vs Elec Price vs Heat Price - in green, when incomes exceeds operational costs

Price of heat - €/MWhth	Price of electricity - €/MWhe						
	100	150	200	250	300	350	400
10	28 000	31 000	35 000	38 000	42 000	45 000	49 000
50	36 000	39 000	43 000	46 000	50 000	53 000	57 000
100	46 000	49 000	53 000	56 000	60 000	63 000	67 000
150	56 000	59 000	63 000	66 000	70 000	73 000	77 000
200	67 000	70 000	74 000	77 000	81 000	84 000	88 000
250	77 000	80 000	84 000	87 000	91 000	94 000	98 000
300	87 000	90 000	94 000	97 000	101 000	104 000	108 000

Capital Cost	275 000	€
Fuel management	97 000	€
Process (energy production)	135 000	€
Engineering, Construction, Transport	43 000	€

Incomes	61 000	€/y
Electricity - €/y	15 000	€/y
Heat - €/y	27 000	€/y
Revenues as waste treament - €/y	19 000	€/y
* depending on hypothesis of electricity, heat, and waste treatmen		

Price of electricity - €/MWh	225
Price of heaty - €/MWh	135

Operational Cost	74 000	€/y
Fixed Charge	58 000	€/y
Maintenance	6 000	€/y
Salary	50 000	€/y
Other	2 000	€/y
Variable Charge	16 000	€/y
Fuel	0,00	€/y
Self consumption	3 000,00	€/y
Evacuation of Residues	2 000,00	€/y
Loan	11 000,00	€/y

For the chosen unit, the capital cost reaches 275 000€, decomposed into :

- 97 000€ for the fuel management (grinder, storage)
- 135 000€ for the gasification process (reactor, filters, engine, generator)
- 43 000€ for the engineering, construction, transportation…

The operational cost reaches 74 000€/y, decomposed into :

- fixed charge: 58 000€/y, which is mainly for the salary (50 000€/y for 1,3 FTE – Full-Time Equivalent)
- variable charge: 16 000€/y, which is mainly for the loan reimbursement (11 000€/y, with 20% of contribution to the loan).

With a price of electricity of 225 €/MWh-e and a price of heat of 135 €/MWh, the incomes reach 61 000€/y. The unit also get incomes from waste treatment (19 000€/y), with a cost of 300 €/t treated.

In this case, the project is not profitable, since incomes are lower than operational cost.

The summary sheet provides a sensibility analysis of incomes when varying prices of electricity and heat. This gives in green colored cells the conditions for price of electricity and heat which results in a positive economical balance of the unit. For example, with electricity price of 250 €/MWh-e and heat price of 200 €/MWh-th, the incomes reaches 77 000€/y.

4. Conclusion

This tool aims to quickly design a waste-to-energy air downdraft gasification unit, on technical and economical aspects. However, it requires data from the user of the tool which could be sometimes difficult to obtain.

The anticipated benefits of this tool are:

- Increase knowledges for isolated territories of such technology to both valorise waste, and produce renewable electricity and heat.
- Provoke the emergence of local, small-scale unit in isolated territories
- Increase, in the end, the self-reliance of territories

The anticipated challenges of this tool are:

- Territories must have the will to take in charge this project
- On the renewable energy point of view : Valorising waste to energy is not as easy as installing photovoltaic plant or windmill, although it can produce energy regardless of the external conditions : night/day, winter/summer… as long as there are waste/biomass available.
- On the waste treatment point of view : Valorising waste to energy is sometimes considered as incineration, which requires high level of pollutants controls, which are expensive for a small unit, and for an isolated territories.