David Tomás Sánchez Martínez
Lourdes García Rodríguez
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Proceedings of the 7th International Seminar on ORC Power Systems

Editorial Universidad de Sevilla

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(ORC2023)

4th to 6th
SEPTEMBER
SEVILLE 2023

EDITORIAL UNIVERSIDAD DE SEVILLA

Sevilla, 2024

Colección Actas
Núm.: 91

Review chairs of the 7th International Seminar on ORC Power Systems

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ISBN 978-84-472-2745-7
DOI: https://dx.doi.org/10.12795/9788447227457

Diseño de cubierta y maquetación: los autores

INDEX OF CONTRIBUTIONS

SEVILLE 2023
7th International Seminar on O.R.C. Power Systems

DOI: https://dx.doi.org/10.12795/9788447227457_77

VALORISING THERMAL RECYCLING PROCESSES OF FIBRE-REINFORCED COMPOSITES USING ORGANIC RANKINE CYCLES FOR COMBINED HEAT AND POWER APPLICATIONS

Ramin Moradi*, Liu Yang

Department of Mechanical and Aerospace Engineering, University of Strathclyde, Glasgow, UK.

*Corresponding Author: ramin.moradi@strath.ac.uk

ABSTRACT

Recycling is one of the most challenging issues in many different sectors, which can bring both significant economic and environmental benefits. Hence, recycling is one of the few domains in that economic interests are in line with diminishing environmental concerns. Among the feasible and profitable recyclable materials, fibre-reinforced polymers (FRPs) are at the early stages of technology readiness with end-of-life FRP material projected to increase significantly in the coming years. Therefore, the economic and environmental impacts of FRP recycling plants should be investigated to develop a reliable business case to support the development of a circular economy for these materials. To this end, the recycling process should be robustly designed, optimised, and integrated with energy systems to maximise economic and energy-saving benefits. In this work, an FRP thermal recycling plant coupled with a 30 kW_{el}/175 kW_{th} organic Rankine cycle (ORC) system for combined heat and power (CHP) is studied. The environmental benefits of this integrated recycling-energy system are presented in terms of net CO_2 and operational costs. Results show that the integration with at least 50 residential apartments can significantly improve the economic and environmental indicators compared to the separate recycling plant and buildings being supplied by the electricity and natural gas (NG) grids. These indicators are identified by comparing the direct and indirect CO_2 emission and operational costs of the recycling plant coupled with the ORC-CHP system with those generated by stand-alone systems producing virgin fibres, supplying domestic electric demand using the electric grid, and domestic space heating using the NG grid.

1 INTRODUCTION

Wind energy is one of the most promising and fast-developing renewable energy sources that can replace a significant share of fossil fuels in producing electricity leading to the mitigation of the global warming issue (Liu et al., 2022). Wind turbine (WT) blades are made of glass fibre-reinforced polymers (GFRPs) mainly constituted of thermosetting resins and glass fibres (GFs). Therefore, manufacturing WTs require large energy consumption and CO_2 emissions, which should be considered in the blades' life cycle to correctly calculate the environmental impacts of wind energy power systems. The strong structure of the blade and the properties of the thermosets that they cannot turn to the liquid phase by heating, make their recycling difficult (Krauklis et al., 2021). On the other hand, the volume, and the growth rate of the WT blades to be decommissioned in coming years are huge: an estimated 789000 tonnes in 2021 and a total of 43 million tonnes by 2050 (Liu & Barlow, 2017). Therefore, a thermal recycling process of GFRPs having WT end-of-life (WT EoL) scraps as the main material is proposed within the project (*PRoGrESS, 2022*, n.d.) to build the first pilot-scale plant of this process in the UK.
Since the recycling process (*PRoGrESS, 2022*, n.d.) requires electric and thermal energy, its carbon emissions and operational costs are included in the overall evaluation of the recycling of the GFs. To assess the potential for valorizing this system, a waste heat recovery (WHR) system using organic Rankine cycle (ORC) systems is investigated in this work. The ORC system is coupled with residential

buildings to supply their electric and thermal demands for a year in Aberdeen, Scotland, which makes a combined heat and power (CHP) system.
Indeed, WHR has great potential to improve the efficiency of industrial plants thus reducing their fossil fuel consumption and related carbon emissions (Moradi, Habib, et al., 2021). Organic Rankine cycle (ORC) systems have attracted particular attention in recent years due to their reliability, flexibility, safety, and applicability for low-temperature power generation (Li et al., 2018). ORC systems are one of the most promising technologies to valorize low-grade heat into electricity (Mahmoudi et al., 2018). In addition, the building sector is considered as the application since it is accounted for approximately 40% of the EU energy consumption and 36% of the greenhouse gas emissions (*European Commission-Energy-Energy Performance of Buildings Directive*, 2021). In particular, 27% of final energy consumption accounted for households in 2020 (*Eurostat, 2022*, n.d.), out of which 62.8% for space heating, 15.1% for water heating, and 0.4% for space cooling. Therefore, the annual performance of an innovative GFRP recycling unit coupled with an ORC-CHP system is investigated in this work for the first time to assess the benefits of such integration for similar thermal FRP recycling processes.

2 Modelling of the integrated CHP plant

The integrated CHP system consists of five main units: I) the GFRP recycling unit; II) the ORC system; III) the water heating/cooling unit, IV) the electricity grid, and V) the residential buildings. The waste heat from the GFRP recycling plant is exploited by a small-scale ORC unit to generate electricity and heat. The generated electricity supplies the users' electric demand, and the excess electricity is sent to the grid, while users may use the grid if the on-site production is not adequate. The produced heat at the condenser of the ORC system is sent to the water tank and passes through an internal spiral tube heat exchanger (HE) unless the tank temperature has reached its pre-set maximum resulting in the cooling water being redirected to the dry cooler (DC). The hot water (HW) and service water for space heating (SH) are modelled using thermal energy taken from the water mass in the tank at each time step without modelling the heat transfer process. If the tank temperature is below the pre-set threshold, the required thermal energy is supplied by the boiler and the tank is charged by the hot water from the condenser. 467
Therefore, the tank temperature is calculated at each timestep using the energy balance constituted of the output thermal energies of HW, SH, the thermal losses, and the input thermal energy coming from the ORC unit. The latter is modelled using a fixed overall heat transfer coefficient (OHTC) of the HE. The schematic of the integrated system is shown in **Figure 1**. The models of the main units and their components are presented in the following sub-sections in detail.

2.1 The GFRP recycling unit

The GFRP recycling unit is considered with the capacity, thermal process, and configuration as in the developing pilot-scale plant within the (*PRoGrESS, 2022*, n.d.). The considered GFRP is the WT blade scraps downsized to the suitable range for the recycling process. Nonetheless, the recycling plant can handle other types of GFRP materials manufactured with thermoset plastics. In addition, the designed process can be used to recycle carbon FRP (CFRP) materials with some considerations in the component design and adjustments in the process and operating conditions. Hence, the product will be recycled carbon fibre (rCF), which replaces virgin CFs (vCFs) having significantly higher manufacturing cost and carbon footprint compared to vGFs. However, only WT EoL materials are considered in this work based on the scopes of (*PRoGrESS, 2022*, n.d.).
The design adopted in this work is the most conservative one presented in (*PRoGrESS, 2022*, n.d.) for being a scaling-up mission from a lab-scale rig to a pilot-scale plant. In addition, the capacity of the pilot-scale plant is the first intermediate step on the commercialisation route. Hence, it is more energy intensive with higher operational costs and carbon emissions than the prospective commercial plant. Furthermore, additional economic benefits from charging the FRP scrap owners for carrying the recycling task and avoiding landfilling are not considered in the model which can be a game-changing factor in real commercial cases. Yet, the results of the pilot plant can be used to have an overview of the economic and environmental impacts of the integration with a CHP unit.

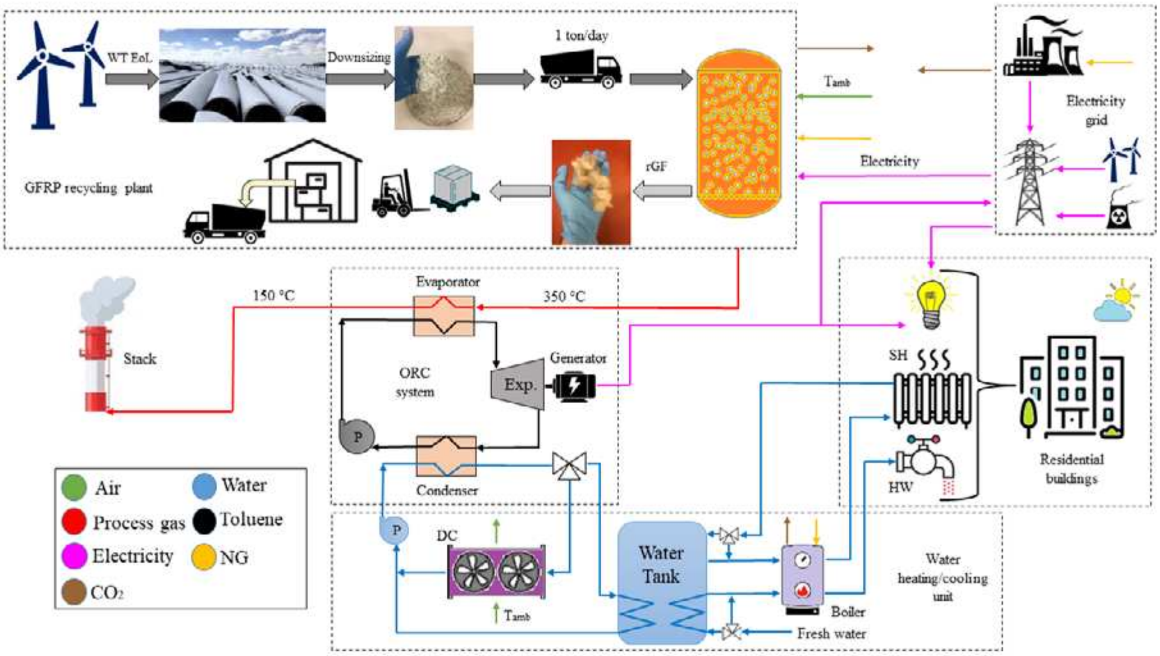

Figure 1: The scheme of the integrated GFRP recycling-ORC-CHP plant.

The recycling process and its models and parameters are not presented in this paper due to the non-disclosure agreements within the project. Nevertheless, the main energy, economic, and environmental parameters of the plant model used in the net calculations of the integrated system are presented in **Table 1**.

The CO_2 production of the plant is based on the direct emissions due to the decomposition of the WT blades in the recycling process and NG consumption on site, and the indirect emissions due to the electricity consumption at the site calculated using the Scottish grid performance in 2020 (*Scottish Energy Statistics Hub*, n.d.). It is noteworthy that 57% of the Scottish grid is supplied by renewable sources (mostly wind energy) and 29.8% by nuclear energy in 2021 (*Scottish Energy Statistics Hub*, n.d.). Hence, its equivalent emission is significantly lower compared to typical values like the English grid with 152.1 g CO_2/kWh_{el} in 2020 (*Scottish Energy Statistics Hub*, n.d.). Furthermore, the considered rates for buying and selling energy vary by time and the energy company; hence, typical values in the UK market are considered without any incentives. 468

Table 1: The economic and environmental parameters and results of the pilot-scale WT blade recycling plant and the energy and cost parameters adopted in the model.

Model inputs				Model outputs	
p/kWh_{th}	10.3	MJ_{th}/kg vGF	48.33	rGF [t/y]	243.7
p/day_{th}	28.0	kg CO_2/kg vGF	2.04	MJ_{th}/kg rGF	16.38
p/kWh_{el}	34.0	£/kg vGF	1.77	MJ_{el}/kg rGF	20.14
p/day_{el}	46.0	GF landfill [p/kg]	5.0	kg CO_2/kg rGF	2.45
$p/kWh_{el,ex}$[1]	7.5	g CO_2/kWh_{el}[2]	33.6	£/kg rGF	2.37

[1]Selling electricity to the grid.
[2]For the Scottish grid

2.2 The ORC system

The ORC system is a non-regenerative, small-scale unit producing electrical and thermal power. The working fluid is toluene based on the recommendations for the design temperature of the waste stream (Moradi, 2021; Rahbar et al., 2017) and its good environmental indexes. The ORC system is modelled using the characteristics and assumptions presented in **Table 2**. Box models are adopted for the heat exchangers using the fixed temperature difference and maintaining a minimum temperature pinch, which gives the high and low pressures of the system. The other two assumptions for the system boundary identification are fixed superheating and subcooling degrees in the evaporator and condenser respectively.

In particular, the high and low pressures of the ORC system are identified using the temperature difference between the inlet of the hot fluid and the saturation temperature of the working fluid in the evaporator, and the inlet temperature of the cold fluid and the condensation temperature of the working fluid in the condenser. Considering the scope of this work, a reasonable temperature difference of 60 K is taken for the evaporator corresponding to the evaporation temperature of 290°C for toluene, which has a critical temperature of about 319°C. Hence, 60 K is a reasonable value for having gas in the hot stream and keeping toluene in a subcritical state. The high and low pressures of the system are 28.84 and 0.39 bar respectively using the design temperature differences reported in **Table 2**. The temperature pinch in the HEs is maintained by adjusting the design values of the temperature differences reported in **Table 2**. In addition, the mass flow rate of the hot fluid is calculated from the GFRP recycling plant model. The mass flow rate of the cooling water in the condenser is calculated assuming the net electric efficiency of the ORC system of 10% and cooling water temperature equal to the initial temperature of the tank (60°C) and 20 K temperature increment at the condenser outlet. The design values of the hot and cold fluid mass flow rates are 0.83 kg/s and 1.85 kg/s respectively. The mass flow rate of the working fluid is calculated to maintain the design superheating degree in the evaporator.

The pump and turbine are presented using single-coefficient models. The combination of the single-coefficient models for the machines and the box models for the heat exchangers with the fixed temperature differences for system pressures are suitable for such analysis when the monthly and annual performances of the system are of interest (Moradi et al., 2021). It is a good compromise between the computational time and modelling efforts and the accuracy of the calculated monthly or annual electric and thermal powers.

The varying heating demand affects the water tank temperature and may bring the boiler and the dry cooler to the service. This affects the low pressure of the ORC system resulting in changes in the expander pressure ratio and the mass flow rate of the working fluid. Hence, the ORC system mostly operates in off-design conditions, and it is considered in the model by the changes in the expander's pressure ratio and the mass flow rate of the working fluid. These affect the produced electric and thermal power of the system.

Table 2: The characteristics of the ORC main components and the model assumptions.

Turbine isentropic efficiency	0.80	Superheating degree	10 K
Pump isentropic efficiency	0.60	Subcooling degree	5 K
Pump & turbine mechanical efficiency	0.95	$dT_{ev,des}$	60 K
Generator efficiency	0.95	$dT_{cd,des}$	20 K
Working fluid	toluene	Temperature pinch	5 K

2.3 The residential users

A five-floor building having a 100 m^2 floor area with walls directed toward the four cardinal directions is modelled using TRNBuild® considering the indoor comfort temperature of 20-24°C. Since the model is performed for weather conditions of Aberdeen in Scotland, the cooling demand is found negligible and disregarded. The demand for HW is calculated in a separate TRNSYS simulation according to the European standard UNI EN15316-3 (Technical Committee CEN/TC 228, 2006). Both SH and HW demands have been considered with a unitary contemporaneity factor.

The hourly electrical demand is taken from the results for the working days in a survey study on seasonal variations of the electrical demand of dwellings in the UK based on electrical appliances only (Fazeli & Gillott, 2013). The different seasonal demands are attributed to the active occupancy that is higher in winter compared to summer and the difference between seasonal daytime, which grows in higher latitudes. For the sake of the present analysis, the same pattern of hourly electrical demand is considered for each season. The data were reported for 1000 two-person dwellings; hence, a coincidence factor is introduced to estimate the electric demand of one dwelling. The coincidence factor considers the asynchronous effect in the total demand from all the users in a network. For *n* apartments, it is defined as the following:

$$c = \frac{W(n)}{n \cdot W_i} \tag{1}$$

where c is the coincidence factor, $W(n)$ is the power demand of the network of n users, and W_i is the power demand of each user. The coincidence factor is estimated using a model based on empirical studies (Nickel & Braunstein, 1981):

$$c = 0.5\left(1 + \frac{5}{2n+3}\right) \tag{2}$$

The coincidence factor is then applied to the calculations of the electrical demand of any arbitrary number of dwellings considered for the simulation.
The daily sum of the thermal energy demand of one building (five apartments) and the average daily ambient temperature of Aberdeen are shown in **Figure 2** for a year. In addition, the hourly electrical demand in each season is shown in **Figure 2** for a two-person dwelling considering the calculated coincidence factor.

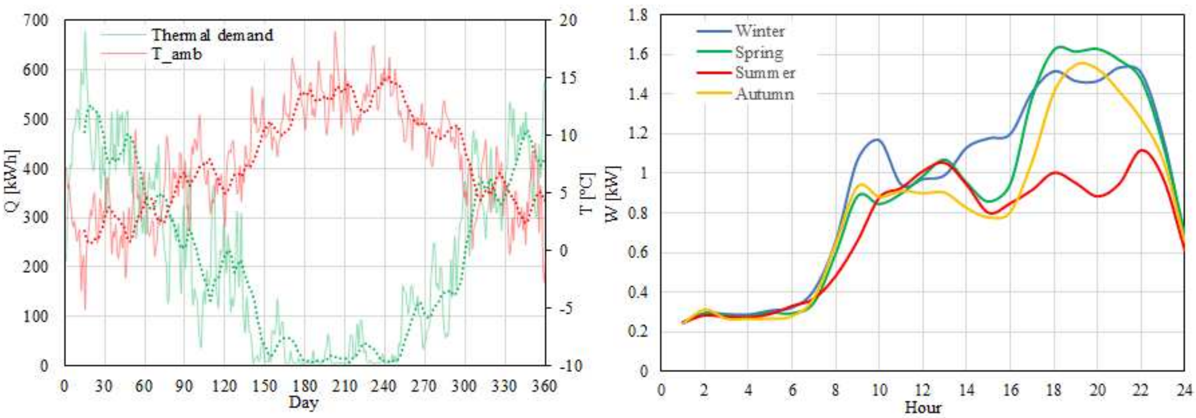

Figure 2: The daily thermal energy demand of one building and the average daily temperature of Aberdeen, Scotland, (left), and the seasonal hourly electrical power demand of a two-person dwelling according to (Fazeli & Gillott, 2013) and calculated coincidence factor (right).

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2.4 The water heating/cooling unit

The water heating/cooling unit consists of the water tank, the DC, the boiler, the water pump, and three control valves to adjust the circuit. These are needed to control the water tank temperature, provide HW and SH comfortably and reliably, and maintain the heat sink for the operation of the ORC system. The characteristics of the main components of the water heating/cooling unit adopted in the model are reported in **Table 3**. The DC and boiler are modelled using a constant capacity ratio and thermal efficiency respectively. The DC capacity ratio is adopted from the average seasonal value reported in the German standard to calculate the energy consumption of buildings (Fugmann et al., 2015).
In addition, the water outlet temperature of the DC is assumed 5 K higher than the ambient temperature taken from the specifications of commercial dry coolers. A constant OHTC is assumed to calculate the thermal losses of the water tank to the ambient, and heat transfer between the cooling water and the water in the tank using the internal spiral tube HE. The geometry of the spiral tube needed to calculate its heat transfer area is reported in **Table 3**. The heat transfer between the cooling water and the water in the tank is modelled using the finite volume method to consider the temperature profile of the water at the height of the spiral tube. This 1D model leads to a more accurate calculation of the cooling water outlet temperature compared to the uniform tank model.

Table 3: The characteristics of the main components of the water heating/cooling unit.

DC capacity ratio	0.045 [kWel/kWth]	OHTC of tank losses	1 [W.m^{-2}.K^{-1}]
Tank diameter	2.5 [m]	OHTC of the spiral tube HE	700 [W.m^{-2}.K^{-1}]
Water tank volume	700 [litre/apartment]	Diameter of the spiral tube	0.8×tank diameter
Boiler thermal efficiency	0.95	Height of the spiral tube	Tank height/3
Water pump isentropic efficiency	0.75	The pitch of the spiral tube	4.1 [cm]
$T_{ex,water,DC} - T_{amb}$	5 K	Spiral tube diameter	30 [cm]

The control logic of the water heating/cooling unit is reported in **Table 4**. The control logic consists of 5 rules to control the status of the boiler, the DC, and the control valves depending on the tank temperature at the new timestep and the status of the boiler and the DC in the previous timestep. A hysteresis of 5 K is considered in the controller to avoid frequent on-off commands in short intervals. The minimum and maximum tank temperatures are considered 50°C and 95°C respectively suitable for the users' comfort and to avoid boiling the water in the tank.

Table 4: The control logic of the water heating/cooling unit.

Rule	Conditions	Actions
1	$T_{tk,min} < T_{tk} < T_{tk,max}$ AND Boiler and DC are off	ORC cooling water passes through the tank Keep/turn the boiler and DC off
2	$T_{tk} \leq T_{tk,min}$	ORC cooling water passes through the tank Turn the boiler on
3	$T_{tk} \geq T_{tk,max}$	ORC cooling water passes through the DC Turn the DC on
4	$T_{tk} \leq T_{tk,min}$+5 AND Boiler is on	ORC cooling water passes through the tank Keep the boiler on
5	$T_{tk} \geq T_{tk,max}$-5 AND DC is on	ORC cooling water passes through the DC Keep the DC on

3 Results and discussion

The integrated system is modelled for one year with a timestep of 5 minutes considering the weather conditions of Aberdeen, Scotland, assuming a 24/7 operation of the GFRP recycling plant at the design throughput and operating conditions. The ORC unit is a 30 kW_{el}/175 kW_{th} system having a heat source with a constant mass flow rate and temperature. The ORC system operates in off-design conditions though due to variations of the heat sink conditions as the tank temperature changes, or the cooling water circuit that may change if the tank temperature reaches its pre-set maximum temperature. In this case, the cooling water bypasses the tank and goes through the DC resulting in a sudden drop in its temperature entering the condenser of the ORC system.

The system performances are presented using the net electric energy production of the ORC system, the net electric efficiency of the ORC system, and the net CHP efficiency of the ORC-CHP system as in Equation (3-5) respectively.

$$W_{net,ORC} = W_t - W_{p,ORC} - W_{DC} - W_{p,water} \quad (3)$$

$$\eta_{net} = \frac{W_{net.ORC}}{Q_{in,HF}} \quad (4)$$

$$\eta_{CHP} = \frac{W_{net,ORC}+Q_{delivered}}{Q_{in,HF}} \quad (5)$$

where $Q_{in,HF}$ is the thermal energy transferred to the ORC system calculated in the hot stream of the evaporator, and $Q_{delivered}$ is the thermal energy transferred to the users from the water tank. The net CO_2 emissions (*E*) and the operational costs of the integrated system are calculated using Equations (6 and 7). The sources and sinks of the CO_2 emissions and costs are associated with the rGF production in the GFRP recycling plant, replacing the production of vGF with rGF, avoiding landfilling of WT EoL, and users' thermal and electrical energy supply using the boiler and the interaction with the electricity grid (buying from it (-), and selling to it (+)).

$$E_{net} = \left(E_{th} + E_{el,eq}\right)_{rGF} + \left(E_{boiler} + E_{el,eq,grid-} - E_{el,eq,grid+}\right)_{users} - E_{vGF} \quad (6)$$

$$£_{net} = (£_{th} + £_{el})_{rGF} + \left(£_{boiler} + £_{el,grid-} - £_{el,grid+}\right)_{users} - £_{vGF} - £_{landfill} \quad (7)$$

The first step in assessing the impact of the integration of the GFRP recycling plant and the ORC-CHP unit is finding a suitable number of users. Therefore, the system is modelled with a different number of apartments coupled with the same ORC unit. As indicated in **Table 3**, the water tank volume varies with the number of apartments, the total thermal demand at each timestep changes linearly with the number of apartments, and the electrical demand alters considering the coincidence factor.

Various factors from different perspectives can be considered to identify the suitable number of users such as minimum use of fossil fuels (NG) by the users, the lowest net CO_2 emissions considering the users, the local power system and energy source, and the energy grid, or similar terms for operational costs. In this work, the conformity between the users' thermal energy demand and the system's thermal production in a year is taken as the indicator for choosing the suitable number of users (Moradi et al., 2023). The considered thermal conformity indicator (TCI) is a technical parameter that prioritises the conformity between thermal production and demand patterns. Hence, it may not minimise the emission nor the operational costs, but it compromises them to have more users. **472**

To this end, the nominal day of each month is found, in which the average daily temperature is the closest to the average monthly temperature. Then, the absolute difference between the produced thermal energy and users' thermal demand is calculated for each nominal day. These values are summed for the twelve nominal days to calculate the TCI. In addition, the total annual CO_2 emission of the integrated system is calculated considering the direct emission due to NG combustion and indirect emissions of electric energy consumption considering the characteristics of the Scottish grid emissions and specific emissions of vGF production reported in **Table 1**. Similarly, the operational costs of the integrated system are calculated considering the NG and electricity rates and the specific costs of producing vGFs plus their landfilling as reported in **Table 1**.

These calculations are conducted for residential users with and without the ORC-CHP system. Furthermore, the net emissions and costs are calculated for the integrated GFRP recycling-ORC-CHP plant, and for the case of vGF production and the buildings supplied with the electricity and NG grids. These parameters are presented in **Figure 3** for a different number of apartments. The integration with the CHP significantly reduces the net emissions and costs and valorises the GFRP recycling substantially.

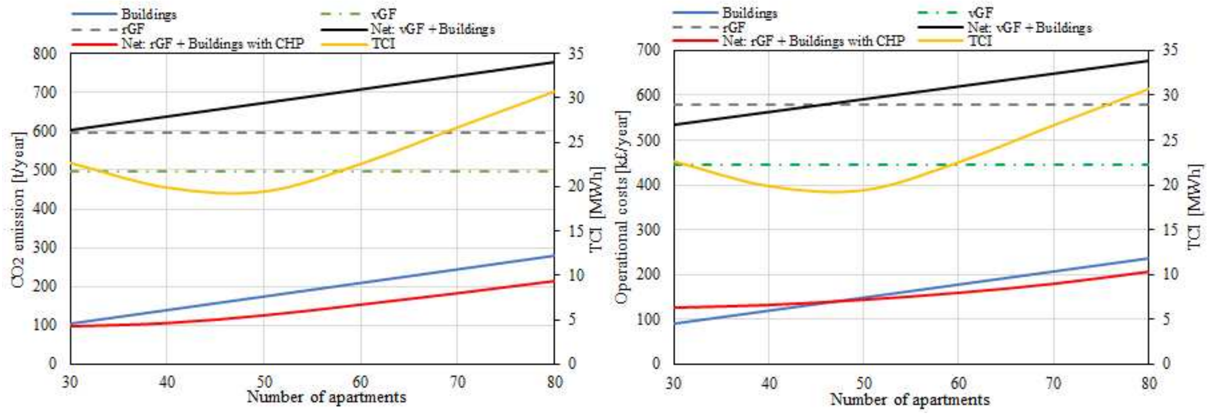

Figure 3: The annual emissions (left) and the annual operational costs (right) of the systems with different levels of integrity. TCI is presented in both figures.

The suitable number of apartments is considered 50 (10 five-floor buildings as in the model) for this system, which gives a TCI close to the minimum. It is a compromise between good thermal and electrical coverage and relatively low annual emissions and operational costs. It is also worth pointing out that the costs of the integrated system become lower than the buildings coupled with the energy grids, and the difference between the emission of the buildings coupled with the energy grids and the integrated system has increased and does not grow further significantly.

The thermal energy provided by the boiler, the excess electrical energy sent to the grid, and the electrical energy consumption of the DC are determining factors in the annual emissions and costs of the ORC-CHP system. The latter indicates the excess thermal energy produced by the ORC system that cannot be delivered to the users. These parameters are shown in **Figure 4** versus the number of apartments.

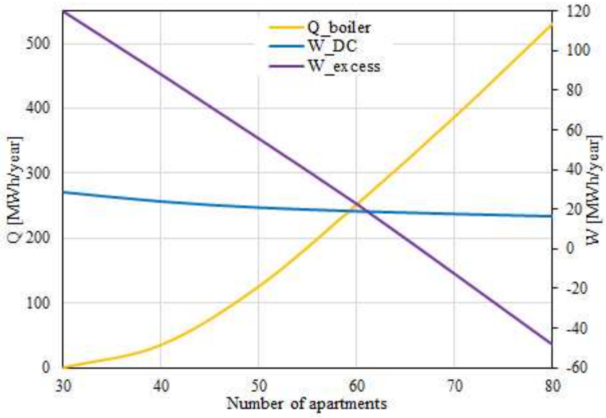

Figure 4: The annual thermal energy consumption by the boiler, excess electrical energy sent to the grid, and the electrical energy consumption of the DC for the different number of apartments.

The monthly thermal and electrical performances of the integrated GFRP recycling-ORC-CHP system are presented in **Figure 5** for 50 apartments in Aberdeen. The boiler is required in cold months to supply the users' demand, while the DC turns on in summer and mid-season to dissipate the thermal energy produced by the ORC system. The users' thermal demand profile varies significantly by season especially due to having negligible cooling demand in Aberdeen as shown in **Figure 2**. Both the boiler and DC are at service in mid-season, in which the thermal demand and production get close to each other resulting in steeper daily variations of the water tank temperature compared to the other months. The net produced electrical energy calculated based on Equation (3) is always higher than the electrical demand resulting in excess electricity being sent to the grid in all months. Finally, the net electric efficiency of the ORC system does not change significantly, while the CHP efficiency drops considerably in the summertime due to low thermal demand resulting in the produced heat being rejected to the ambient through the DC.

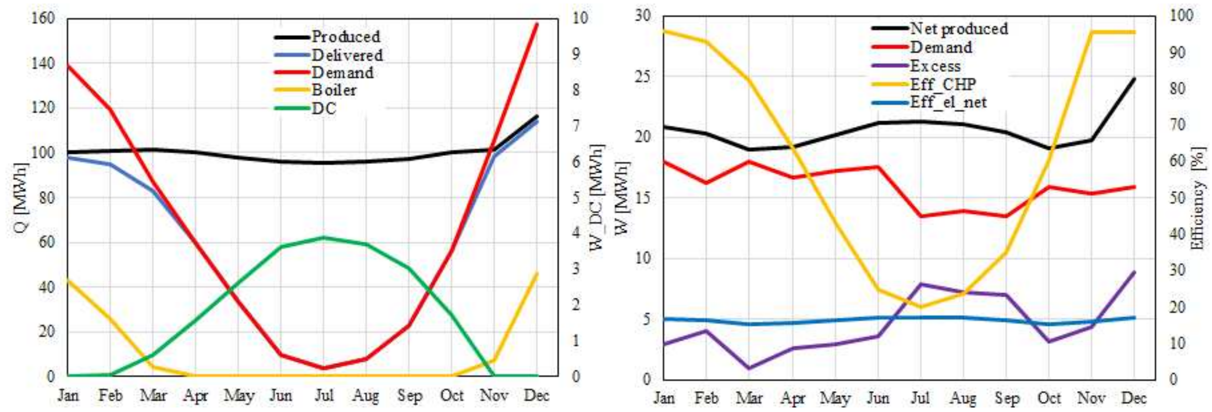

Figure 5: The monthly thermal (left) and electrical (right) performances of the ORC-CHP system for 50 apartments.

4 CONCLUSIONS

A pilot-scale GFRP thermal recycling plant is modelled according to the design conducted within (*PRoGrESS, 2022*, n.d.). The main end goal of the project is to devise a commercial solution for recycling the WT EoL aiming to replace vGFs with rGFs in less-demanding applications compared to WTs resulting in a sustainable way to dispose of the WT EoL. The sustainability is in terms of I) recycling WT EoL without allocating lands to it; II) reducing the CO_2 emissions of GFRP materials by replacing vGFs with rGFs; III) reducing the cost of the GFRP materials by replacing vGFs with rGFs.
To further encourage the sustainability of the GFRP recycling plant, its integration with the residential users using an ORC-CHP system is studied in this work. A 30 kW_{el}/175 kW_{th} ORC system is adopted as a WHR unit to generate electricity and heat. The generated heat is managed using the water heating/cooling unit to deliver to the users, partially stored in the water tank, or wasted to the ambient. The results show that the pilot plant can supply at least 10 buildings constituting 50 apartments with a 100 m^2 floor area located in Aberdeen, Scotland. The integration not only reduces the emissions and costs of the separate recycling plant and the buildings supplied by the electricity and NG grid significantly but also the much lower than vGF production stats. 474
Furthermore, the presented results and conclusions are for the pilot-scale plant with a conservative design and weather conditions of Aberdeen with no cooling demand. Hence, the benefits can be elevated in the case of commercial GFRP thermal recycling plants coupled with buildings with cooling demand in summer which can take more electric and thermal energy produced by the system in a year. Finally, the recycling process can be adopted for CFRP, which has significantly higher production costs and carbon footprint compared to GFRPs. Hence, the economic and environmental impacts of integration would increase a lot with CFRPs. However, the volume of WT EoL coming to the market encourage focusing on them to subside the associated environmental and sustainability issues in decomposing them.

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This book contains the compilation of works contributed to the *7th International Seminar on Organic Rankine Cycle Power Systems* (ORC 2023), held in Seville between the 4th and 6th of September 2023. The event was hosted by Universidad de Sevilla on behalf of the Knowledge Centre on Organic Rankine Cycle Technology (KCORC), incorporated in The Netherlands.

The ORC conference, organized biennially, stems as the only conference that is specific to ORC technology, therefore gathering a diverse community whose affiliation spans across all the interested stakeholders, not only in this particular technology but also and in a broader context, in the energy transition. Original equipment manufacturers, professional associations, end-users, investors, policy makers, academics, scientists feel at home at ORC 2023.

The almost 100 proceedings in this book cover a wide variety of topics, from fundamentals to system integration through component design, accounting for thermodynamic performance as well as component design. In addition to this, and as a new track in 2023, works on heat pump technology were also accepted in order to raise awareness of the strong ties between both technologies, specifically in energy storage applications.

This book provides an excellent overview of the current maturity of power systems based on Organic Rankine Cycle technology for applications as diverse as geothermal and waste heat recovery in industry or downstream of other prime movers (e.g., marine applications). It is also an excellent source of information to understand the current challenges faced by the technology, stemming from a very competitive market and increasingly stringent environmental regulations.

The organizers of ORC 2023 hope that the reader finds this work as exciting as the attendees to the conference and, maybe, make the decision to join the 8th edition to the conference in 2025.

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