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From Heat to Power: An Experimental Investigation of Waste Heat Recovery and Its Role in Reducing Environmental Pollution

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Abstract. A substantial portion of primary energy in contemporary conversion systems is lost as waste heat, leading to extra fuel use and associated greenhouse gas emissions. This review examines waste heat and waste heat recovery (WHR) technologies that could help mitigate environmental pollution from existing experimental literature and case study. The analysis of different heat reuse methods shows that WHR systems can recover a considerable amount of wasted thermal energy, thereby significantly reduce fuel usage and emissions. Research data indicates that using WHR in industrial facilities and HVAC systems can lower carbon dioxide emissions by 10% to 85% depending on specific contexts. For instance, upgrading boilers with WHR technology can achieve around 10% emission reduction, while energy-intensive industries using Organic Rankine Cycle (ORC) systems can reduce millions of tonnes of CO2 annually, depending on how large and energy-intensive the facility is. Overall, waste heat recovery represents a practical and expandable approach to creating cleaner and more efficient energy systems. However, future research needs to focus more on system durability and low-temperature waste heat utilization, since current WHR applications mainly target high-temperature heat sources.

Keywords: waste heat recovery, organic rankine cycle, absorption heat pump, emission reduction, energy efficiency

1. Introduction

Modern energy systems generate vast amounts of unused thermal energy. It is commonly known as waste heat and it is a byproduct of power generation [1]. Approximately 66% of primary energy input is lost as heat during usage [1]. The inefficiency in energy utility and subsequent wasted heat contributes to environmental pollution as wasted heat implies extra fuel must be consumed. This subsequently leads to greater greenhouse gas (GHG) emission and air pollutants. However, if waste heat could be recovered, thermal pollution can be mitigated. Thus, in nowadays context, recovering waste heat and converting it from heat to power has become increasingly important in improving energy efficiency [2,3]. In response to this emerging need, a variety of Waste Heat Recovery (WHR) technologies have been developed. Some common WHR mechanisms include using Organic Rankine Cycle (ORC) generators to produce electricity from low-to-medium temperature heat, or

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condensing heat exchangers that reclaim heat for re-usage [2,4]. The purpose of this essay is to investigate these WHR technologies, and the essay will focus on both experimental and case-study insights to evaluate how they quantitatively contribute to pollution reduction.

The paper is structured into three sections. First, it will provide a literature review of existing WHR approaches. Second, the essay will provide a discussion of experimental investigations and comparative analyses of WHR systems. The essay will conclude the remarks of these WHR technologies on their role in pollution mitigation.

2. Literature review

2.1. Waste heat sources and potential

Waste heat is inherent to any process that uses energy, due to the second law of thermodynamics which dictates that not all input energy can be converted to useful work [5]. Waste heat can be generated from various sources, including Industrial facilities, power plants, transportation engines, and commercial buildings [5,6]. These facilities all emit unused heat in exhaust gases, cooling water, or convective losses. Waste heat can be classified into different categories based on their temperature. High-grade waste heat is over 400 degrees. It is mostly sourced from furnaces or engines and it can be directly repurposed, whereas low-grade waste heat (e.g. warm effluents that is lower than 100 °C) is more challenging to utilise [7]. Nonetheless, all grade waste heat has the potential to reduce pollution due to its abundancy [8]. For example, Walter et al. expressed that more than 72% of global energy input has been lost as waste heat [1]. Such inefficiency implies the opportunity to cut emission and save energy from waste heat recovery technologies. In Jones, the author expressed that many United Kingdom power states have already engaged in mechanisms that divert waste heat to district heating networks [9]. The re-utilisation strategy applied by United Kingdom power states has reduced GHG emission by over 10 million tonnes per annum, which represents 2% of United Kingdom's national emission [9]. In the context of United States, if waste heat recovery technologies are applied in the entire food processing industry, waste heat recovered could yield annual savings of over 514,000 tonnes of GHG [9].

2.2. Technologies for waste heat recovery

According to Men et al., the most common and simple way to WHR is direct heat reuse through heat exchangers [10]. This WHR method capture sensible heat from exhaust streams to preheat boiler feedwater or combustion air. This subsequently improves furnaces' and boilers' energy efficiency [10]. For example, their investigation revealed that a conventional gas-fired boiler exhausting flue gas at 150-200 °C can be retrofitted with heat exchangers to cool the flue gas and recover latent heat from water vapour condensation. This process of extracting heat from flue gas and reduce boilers and furnaces' fuel consumption (through elevated energy efficiency) and thus contribute to emission reduction. However, Lee et al. does point out that such exchangers' energy efficiency can be limited by the water temperature of the heating system [11]. If the return water is not sufficiently cool, heat recovery is constrained [10,11]. Thus, if further efficiency in WHR is to be achieved, a more advanced system with components like air preheaters need to be installed to cool flue gas below its dew point. This can increase heat recovery efficiency to almost 100% [11].

Second, converting waste heat to electric power is an attractive means of utilising energy that would otherwise be lost. As abovementioned, traditional steam Rankine cycles are effective for high-temperature waste heat [7]. Medium- and low-grade heat sources are not efficiently exploited

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by water-steam due to low thermal efficiencies at these temperatures [7]. Instead, ORC systems have become a leading technology for heat-to-power conversion in the 80–350 °C range [2]. ORC systems use organic working fluids (e.g. refrigerants, hydrocarbons, siloxanes) that boil at lower temperatures than water, enabling them to generate power from relatively low-temperature heat sources [2]. ORCs today can achieve conversion efficiencies in the teens of percent (depending on source temperature) and are deployed at scales from tens of kW to multiple MW in industries ranging from steel and cement plants to biomass boilers and internal combustion engines [2]. For example, ORC power units are commercially recovering heat from steel mill electric arc furnace off-gas, diesel engine exhaust on ships, and even geothermal and solar thermal sources. Alternative thermodynamic cycles have also been explored. For example, the Kalina cycle (which uses a water-ammonia mixture as working fluid) can achieve slightly higher efficiencies by exploiting variable boiling temperature profiles [6,7]. ORC remains the predominant waste heat-to-power solution in practice due to its proven reliability and extensive field experience.

Another major class of WHR technologies involves "upgrading" waste heat to a higher temperature or utilising it for cooling. Heat pumps driven by mechanical or thermal energy can capture low-grade waste heat and "pump" it to useful high-grade heat. In industrial waste heat recovery, vapour-compression heat pumps (electric-driven) and absorption heat pumps (AHPs) (thermal-driven using, e.g., waste steam or direct firing) are common [10]. The idea is to use the waste heat as the evaporator input of the heat pump, so that for a given amount of input work, a larger amount of heat is delivered at the condenser for reuse. Absorption heat pumps use a refrigerant-absorbent pair (such as water – lithium bromide or ammonia–water) and can be directly fired by waste heat or flue gas; they are essentially refrigeration machines running in reverse to provide heating [12]. In a notable implementation, a double-effect LiBr–H_2O absorption heat pump integrated with a boiler can cool the return water to a much lower temperature than ambient, thereby significantly increasing heat recovery from flue gas [12]. Furthermore, Men et al. reviewed several such systems and found that absorption heat pumps can boost total heat recovery efficiency to around 80% in gas boiler applications, far above what a condensing heat exchanger alone could achieve [10]. By doing so, waste heat becomes a valuable heat source, reducing the need for burning additional fuel for heating needs.

2.3. Environmental benefits of waste heat recovery

In addition to improving energy efficiency, WHR technologies can also directly reduce pollutant emissions. For example, every unit of energy recovered from waste heat implies energy saving from additional fuel combustion [6,7]. Thus, WHR technologies can linearly reduce GHG emission and local pollutants like NO_x, SO_x, and particulate matter that would otherwise be emitted in the process of energy consumption. Chen et al. exemplified that an absorption heat pump integrated into a boiler system can reduce its GHG emission by 11.8%, meaning that pollutants emitted would also be reduced by that amount, if not more [6]. Other than reduced pollutant from energy saving, some WHR system can also actively remove pollutants. In systems where the waste gas comes into contact with a cooling medium, a portion of particulates and soluble pollutants are washed out. For example, Men et al. find that an open absorption heat pump coupled with a biomass-fired boiler can actively reduce flue gas pollutant emission by 33-44% over 2 years [10]. Similarly, a vapor pump boiler's humidification process can actively reduce the system's NO_x emissions by approximately 25.4% [10]. These active pollutant reduction scenarios indicates that WHR can improve air quality and reduce emission at the same time. Another example of WHR's environmental benefit is in water saving. For example, an absorption heat pump system that recovers both heat and water from flue

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gas and reduce water vapor emissions and supply liquid water back to the system [13]. This is particularly valuable in industries like power generation where cooling water usage and evaporative losses are concerns. More quantitative examples will be illustrated in the discussion section's Table 1.

3. Discussion

3.1. Experimental investigations of WHR technologies

To elucidate the practical performance of waste heat recovery systems, this section examines experimental and real-world case studies of selected WHR technologies. The focus is on quantifiable outcomes such as energy efficiency gains and pollution reduction. Table 1 provides a summary of diverse WHR applications and their environmental benefits, drawn from experimental data in the literature.

Table 1. Examples of Waste Heat Recovery (WHR) applications and their benefits in efficiency and emission reduction.

Application (Waste Heat Source)	WHR Technology Implemented	Outcome / Benefit Achieved (Quantitative)	Source
Oil Refinery (Aromatics unit) – high-temperature process heat (~300 °C)	Organic Rankine Cycle (ORC) power generation system	CO_2 reduced by 94,455 tonnes/year (via fuel savings); NO_x reduced by 1,418 t/yr; CH_4 by 312 t/yr (achieving significant GHG and pollutant cuts)	[4]
Cement Plant (Germany) – kiln exhaust ~300 °C	Rankine-cycle engine (ORC-type) for power generation	12% of plant's electricity demand met by recovered power; CO_2 emissions lowered by 7,000 tonnes/year (about 7% reduction in the plant's CO_2 output)	[9]
Data Center (Denmark) – server cooling heat ~50 °C	High-temperature heat pump feeding district heating network	33,100–33,200 tonnes CO_2/year avoided by substituting a natural gas boiler (representing 85% reduction in heating-related emissions)	[14]
Natural Gas Boiler (China) – flue gas ~150 °C	Vapor Pump Boiler system (humidifying air preheater + condensing exchanger)	NO_x emissions reduced by 25.4% and boiler efficiency improved 6–9 percentage points by enhanced heat recovery (flue gas exit 30 °C)	[10] [15]
Biomass Heating Plant – wood chip boiler flue ~120 °C	Open-cycle Absorption Heat Pump (LiBr–H_2O solution scrubbing flue gas)	Particulate matter emissions reduced by 33–44% (particles captured in absorber); +Recovered latent heat raised overall heat utilisation >75%	[10] [16]
Gas-fired Boiler (Lab study) – flue gas ~180 °C	Absorption Heat Pump (closed cycle, double-effect) coupled to boiler system	CO_2 emission reduced by 11.8% (due to ~10% increase in heat output per unit fuel); effective COP 2.1–2.2 for recovered heat	[10] [13]

Note: All examples are from the last decade. CO_2 reductions refer to indirect emission savings from fuel displacement.

ORC = organic Rankine cycle; NO_x = nitrogen oxides; CH_4 = methane; COP = coefficient of performance.

As shown in Table 1, all illustrated WHR technologies have the ability to improve energy efficiency across different settings and context. These examples provide several important observations that are listed below,

Magnitude of CO_2 Reduction: The carbon dioxide emission reduction achieved through WHR can be immense in volume, particularly in energy-intensive industries. The refinery ORC case illustrated over 10^5 tonnes emission reduced per year [4]. The emission reduced amount to annual emissions of tens of thousands of cars.

Local Pollutant Reductions: Technologies involving direct contact between waste gases and a cooling/absorbing medium can reduce local air pollution. Through reduced pollutants, biomass OAHP case has shown 33-44% reduction in particulate emissions [16]. In contrast, standalone ORC systems mainly influence pollutants only by reducing fuel consumption. They do not inherently remove pollutants from the exhaust stream. Therefore, pairing ORCs with existing pollution control equipment may be necessary, whereas systems like condensing scrubbers or absorption heat pumps inherently serve dual roles of heat recovery and flue gas clean-up.

Energy Efficiency and Economic Payback: Many WHR systems greatly improve the energy efficiency of the host process. In the gas boiler and VPB example, the heat recovery efficiency exceeded 85%, substantially higher than a basic condensing boiler which is around 70% [10,15]. This translated to an increase of approximately 6–9 percentage points in overall boiler efficiency and a very short economic payback [10]. Generally, the higher the fraction of waste heat recovered, the shorter the payback period because more fuel savings are realised.

Experimental investigations have also illuminated some challenges. For example, in the OAHP (open absorption heat pump) system, the contact with flue gas raises concerns about corrosion of equipment due to acidic condensate and the need for frequent maintenance to handle the absorbed pollutants [10]. This explains why open absorption systems have seen limited full-scale deployment. ORC systems, while relatively straightforward to integrate (since they can be added as external loops without altering the main process), require a steady waste heat source to run optimally [17]. Fluctuating heat sources may necessitate thermal buffering to maintain stable ORC operation. Moreover, the working fluid selection in ORC is crucial. Environmental regulations now push for low-GWP (global warming potential) refrigerants, so newer ORC installations favour benign fluids to minimise any potential climate impact from leaks.

Another trade-off is whether to use recovered heat on-site for heating (via heat exchangers/heat pumps) or to convert it to electricity. From an emissions perspective, the optimal path can depend on the local grid's carbon intensity. A recent analysis by Lal et al. (2022) found that using waste heat in decentralised electricity generation can yield larger CO_2 reductions (estimated national reductions 1.9–7.4%) compared to using the same waste heat in district heating (which gave <0.1% national CO_2 reduction in their scenario) [18]. This is because in regions where electricity is generated by burning fossil fuels, displacing grid electricity has a high carbon benefit [18]. In contrast, if the electricity grid is already low-carbon (e.g. renewables or nuclear), using waste heat for local heating may be equally or more beneficial. The choice of WHR utilisation must therefore consider the broader energy context.

3.2. Role of WHR in pollution reduction: comparative insights

Quantitative insights from experiments and case studies reaffirm that waste heat recovery has a meaningful role in pollution mitigation. A few comparative points are evident.

Carbon Emission Reductions: WHR typically yields proportional reductions in CO_2 emissions to the fraction of energy recovered. In practical terms, improvements of tens of percent in efficiency translate to similar percentage cuts in CO_2. For example, the absorption heat pump case achieving approximately 10% efficiency gain correspondingly cut CO_2 by 11.8% [10,13]. More dramatic is the data centre heat pump example, where using waste heat to displace fossil fuel heat led to an 85%

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reduction in heating-related CO_2 emissions [14]. These results show that WHR can be a key strategy for industries to meet carbon reduction targets, especially as global policies increasingly put a price on carbon or mandate GHG reductions. Notably, the magnitude of CO_2 saved in some cases is comparable to installing a mid-sized renewable power plant [4]. This indicates that WHR is a form of clean energy source in its own right, essentially harvesting energy that would otherwise be wasted.

Air Quality and Pollution Control: The ability of WHR to reduce air pollutant emission provide an additional reason for full-scale WHR adoption. According to Su et al., regulatory requirements for air pollutant control is often expensive [7]. Under regulatory requirements, many facilities must install expensive systems such as electrostatic precipitators to reduce NO_x. However, WHR provides a cost effective way to reduce NO_x. Both the VPB and the OAHP case exemplified WHR's capability to reduce particles such as NO_x whilst recovering heat and water [7]. Furthermore, condensing waste heat from flue gas can capture sulfuric acid mist (SO_3/H_2SO_4). This can substantially reduce visible plumes. Both examples of pollutant reduction imply WHR has the ability to contribute to improved air quality. Nevertheless, it is important to point out that WHR serve as a complementary measure for air pollution, it should not entirely replace existing pollution control measures and devices [12].

Energy Systems Integration: Another key role of WHR in pollution reduction is its ability to integrate into a broader energy system strategy and amplify its environmental results. For example, Jones expressed that WHR can reduce urban air pollution while saving energy at the same time [9]. This is exemplified by a Danish data centre providing heat to 6,900 homes while avoiding the emissions from those homes' heating systems [9]. Another integrated approach is using waste heat to drive carbon capture systems. While paradoxical, studies have shown how ORC power can offset the energy penalty of CO_2 at power plants, thereby indirectly reducing overall emissions [19]. These integrative solutions highlight that WHR is not just a single-plant efficiency measure. However, it can be part of circular economy and industrial symbiosis approaches.

Limitations and Future Research: Experimental research continues to address limitations that currently prevent full utilisation of waste heat potential. One limitation is temperature mismatch. Often the available waste heat is at a temperature that does not match any immediate need [8]. Technologies like thermochemical energy storage or high-temperature heat pumps (using novel working fluids) are being explored to bridge some of these gaps [20,21]. Another area is improving the durability of heat recovery systems in harsh environments [21]. Materials research for corrosion-resistant coatings and self-cleaning heat exchangers is ongoing, as fouling and corrosion are major issues that experiments frequently cite. Entransy analysis and exergy analysis in recent studies (like the 2025 data center review) are also providing deeper insight into where the largest irreversibility and losses occur in WHR systems, guiding future improvements.

In summary, the discussed experimental cases and comparative data substantiate that waste heat recovery is a practical and effective measure to reduce environmental pollution. Its contributions directly capturing pollutants in certain systems and indirectly reducing emissions by curtailing fuel consumption. The quantitative examples (Table 1) give confidence that these benefits are not merely theoretical but achievable in real industrial settings. Moving forward, broader implementation of WHR technologies can play a notable role in global efforts to improve energy sustainability and combat pollution.

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4. Conclusion

In conclusion, waste heat recovery has demonstrated strong ability to improve energy efficiency and environmental protection. The report has introduced and discussed various WHR technologies such as ORC power systems, condensing heat exchangers, heat pumps, and integrated hybrid solutions. These technologies have demonstrated the ability to convert waste heat into useful energy. Both the literature review section and the discussion section summarises that modern WHR systems can recapture a large proportion of waste heat and reduce fuel consumption and emission in the process. Quantitatively, WHR in industrial settings have shown CO_2 reduction ranging from 10% to 85% in different circumstances. At the same time, WHR technologies can effectively reduce pollutant emission such as NO_x, SO_x and particulates. These examples highlight WHR's capability to support environmental goals.

Nevertheless, technical challenges remain for waste heat recovery. Current and future research and development is yielding solutions to overcome these challenges. In nowadays context, waste heat recovery has become increasingly important to reduce energy loss in the process of energy consumption. Waste heat recovery technologies is not only an avenue to enhance energy efficiency and economic performance for industries. Rather, it is seen as an effective tools to preserve the environment. Proliferation of waste heat recovery technologies in all settings will become a key strategy to transit to a cleaner and more energy-efficient tomorrow.

References

[1] Walter, D., Bond, K., Lovins, A., Speelman, L., Gulli, C., & Butler-Sloss, S. (2024, June 4). The incredible inefficiency of the Fossil Energy System. RMI. Retrieved from https: //rmi.org/the-incredible-inefficiency-of-the-fossil-energy-system/

[2] Lecompte, S., Oyewunmi, O. A., Markides, C. N., Lazova, M., Kaya, A., Van den Broek, M., & De Paepe, M. (2017). Case study of an organic Rankine cycle for waste heat recovery from an electric arc furnace. Energies, 10(5), 649. https: //doi.org/10.3390/en10050649

[3] Firth, A., Zhang, B., & Yang, A. (2019). Quantification of global waste heat and its environmental effects. Applied Energy, 235, 1314–1334. https: //doi.org/10.1016/j.apenergy.2018.10.102

[4] Ma, Q., Chen, Y., Liu, A., & Jiang, Q. (2022). Benefit analysis of organic Rankine cycle power generation by using waste heat recovery in refinery. E3S Web of Conferences, 352, 02014. https: //doi.org/10.1051/e3sconf/202235202014

[5] Forman, C., Muritala, I. K., Pardemann, R., & Meyer, B. (2016). Estimating the global waste heat potential. Renewable and Sustainable Energy Reviews, 57, 1568–1579. https: //doi.org/10.1016/j.rser.2015.12.192

[6] Chen, W., Huang, Z., & Chua, K. J. (2022). Sustainable energy recovery from thermal processes: A review. Energy, Sustainability and Society, 12(46), 1–25. https: //doi.org/10.1186/s13705-022-00372-2

[7] Su, Z., Zhang, M., Xu, P., Zhao, Z., Wang, Z., Huang, H., & Ouyang, T. (2021). Opportunities and strategies for multigrade waste heat utilization in various industries: A recent review. Energy Conversion and Management, 229, 113769. https: //doi.org/10.1016/j.enconman.2020.113769

[8] Hao, Y., Zhou, H., Tian, T., Zhang, W., Zhou, X., Shen, Q., … Li, J. (2025). Data centers waste heat recovery technologies: Review and evaluation. Applied Energy, 384, 125489 https: //doi.org/10.1016/j.apenergy.2025.125489

[9] Jones, N. (2019, March 5). Waste heat: Innovators turn to an overlooked renewable resource. Yale Environment 360. Retrieved from https: //e360.yale.edu/features/waste-heat-innovators-turn-to-an-overlooked-renewable-resource

[10] Men, Y., Liu, X., & Zhang, T. (2021). A review of boiler waste heat recovery technologies in the medium–low temperature range. Energy, 237, 121560. https: //doi.org/10.1016/j.energy.2021.121560

[11] Lee, C.-E., Yu, B., & Lee, S. (2015). An analysis of the thermodynamic efficiency for exhaust gas recirculation-condensed water recirculation-waste heat recovery condensing boilers (EGR-CWR-WHR CB). Energy, 86, 267–275 https: //doi.org/10.1016/j.energy.2015.04.042

DOI: 10.54254/2755-2721/2026.MH31523

[12] Van de Bor, D. M., Ferreira, C. A. I., & Kiss, A. A (2015). Low grade waste heat recovery using heat pumps and power cycles. Energy, 89, 864-873 https: //doi.org/10.1016/j.energy.2015.06.030
[13] Hou, J., Che, D., Liu, Y., & Jiang, Q. (2018). A New System of Absorption Heat Pump Vs. Boiler for Recovering Heat and Water Vapor in Flue Gas. Energy Procedia, 152, 1266-1271. https: //doi.org/10.1016/j.egypro.2018.09.180
[14] Zhou, X., Zhang, W., Shen, Q., Wu, T., & Li, J. (2022). High-temperature heat pumps for data center waste heat recovery. HVAC Journal, 52(8), 117–123.
[15] Wei, M., Fu, L., Zhang, S., & Zhao, X. (2019). Experimental investigation on vapor-pump equipped gas boiler for flue gas heat recovery. Applied Thermal Engineering, 147, 371–379. https: //doi.org/10.1016/j.applthermaleng.2018.07.069
[16] Cai, X., Wang, Z., Han, Y., & Su, W. (2024). Study on the Performance of a Novel Double-Section Full-Open Absorption Heat Pump for Flue Gas Waste Heat Recovery. Processes, 12(10), 2181. https: //doi.org/10.3390/pr12102181
[17] Gou, X., Zhang, R., Xu, G., & Zhao, D. (2020). Comparative study of low temperature denitration performance of Mn–Ce/ACFA–TiO_2 catalysts under oxy-fuel and air-fuel combustion flue gases. Energy Reports, 6, 1545–1552 https: //doi.org/10.1016/j.egyr.2020.06.005
[18] Lal, R. M., Tibrewal, K., Venkataraman, C., Tong, K., Fang, A., Ma, Q., Wang, S., Kaiser, J., Ramaswami, A., & Russell, A. G. (2022). Impact of Circular, Waste-Heat Reuse Pathways on $PM_{2.5}$-Air Quality, CO_2 Emissions, and Human Health in India: Comparison with Material Exchange Potential. Environmental science & technology, 56(13), 9773–9783. https: //doi.org/10.1021/acs.est.1c05897
[19] Mariaca, A. G., Llera-Sastresa, E., & Moreno, F. (2022). Application of ORC to reduce the energy penalty of carbon capture in non-stationary ICE. Energy Conversion and Management, 268(10), 116029. https: //doi.org/10.1016/j.enconman.2022.116029
[20] Hamid, K., Sajjad, U., Ahrens, M. U., Ren, S., Ganesan, P., Tolstorebrov, I., Arshad, A., Said, Z., Hafner, A., Wang, C.-C., Wang, R., & Eikevik, T. M. (2023). Potential evaluation of integrated high temperature heat pumps: A review of recent advances. Applied Thermal Engineering, 230, 120720. https: //doi.org/10.1016/j.applthermaleng.2023.120720
[21] Bobbo, S., Lombardo, G., Menegazzo, D., Vallese, L., & Fedele, L. (2024). A Technological Update on Heat Pumps for Industrial Applications. Energies, 17(19), 4942. https: //doi.org/10.3390/en17194942