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The Impact of Heating Systems on Society and Nature: New Opportunities Based on Blockchain Technology

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Abstract: The paper assesses the importance of the models used to determine the efficiency and the environmental impact of heating products like heating pumps (HP). An appropriate model of evaluation may help identify the presence of greenhouse gases and reduce their influence. The paper's novelty resides in the way the hidden sides linked to greenhouse gases' presence, are identified and eliminated.
The research methodology considers an environmental model linked both to the Global Emission Model for Integrated Systems on energy efficiency indicators and to the break-even analysis for greenhouse gases. The model gives hints on reducing the high costs of upgrading the living conditions in residential buildings. The results illustrate the environmental and societal impact and the social potential and highlight the technical implications for such operating systems. They incite optimizing the Heat Hybrid Pumps' design within decentralized energy systems to strengthen energy networks' flexibility and environmental convenience. The research straightens out the understanding of heat pump mechanisms and delineates the efficiency of their increasing use through the blockchain technology outlining its future potential for people and society's health and benefit.

Keywords: Telemedicine, Healthcare, Digital Transformation, Public Policy, Best Practice

JEL Codes: I00, L38, D80, L86

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1. Introduction

Energy is essential to ensure the population's comfort and generate the market and society's well-being. Both production and consumption put increasing pressure on the environment: gas emissions, land use, waste generation, and fuel waste (Jay et al., 2018). These tensions accelerate climate change, damage the natural ecosystems, and affect the humans by dramatic adverse effects on health. When climate change accelerates, finding clean alternatives to fossil fuels is more urgent than ever. Due to the ongoing climate transformations and the ever-increasing environmental pollution caused by emissions, the energy conversion processes take place at a higher speed (Miara, 2013). The transition to a green society comes along with a higher and urgent need to integrate the principles of the circular economy to reduce expenses and soften the changeover for society and environmental benefit. The uncertainty of consequences needs

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to be understood those hidden political and strategic sides of energy logistics (Hulme, 2014). For example, Russia has created a giant image of its oil and gas exports throughout Europe; however, for their domestic needs, the country uses massive amounts of energy and coal, under a fake political logo of stability between competitiveness of natural gas exportation and internal needs satisfaction. These days, under the war uncertainty and danger, one could see the collateral sides of energy production and consumption switched towards other fuels – coal, nuclear, and Black Sea natural gas, to expose less possible nature and people. However, this study disregards the political touch and keeps a strong eye on the link between the energy logistics and the society benefits.

There is no doubt that the energy transition processes ask holistically for attention, in all energy sectors (electricity, heat, logistics, and mobility). Converters are called to cover the area of heat and electricity in a more efficient manner than ever. Given the situation, Heat Pumps (HPs) looks to be the chosen tool; they take the biggest part of the energy from a renewable energy source in the form of air, water, and geothermal energy and transform it for the benefit of people. Electricity from renewable sources drives the heat pumps. Their friendly influence on the environment depends on several factors (Staiger & Tanțău, 2015): a) the use of electricity as the primary energy source; b) the refrigerant used in the heat pump, c) the technical quality and construction of the heat pump especially of the refrigeration circuit, d) the mode of operation of the HPS, especially the input and output parameters and the handling of the refrigerant and recycling (Hulme, 2014). The modern HPS can serve as an energy storage solution, able to compensate for possible power fluctuations caused by renewable energy sources in the future. Heat pumps work with refrigerants. The refrigerants are liquids used during the refrigeration cycles as collateral processes within the heat pump functioning. When they are toxic and flammable, the refrigerants can cause ozone layer depletion; this requires action under specific regulations issued by authorities. However, when HPs are considered, the refrigerators' characteristics must be defined by low toxicity, non-flammability properties, zero ozone depletion potential, very low global warming potential, excellent thermodynamic properties, and low energy requirements.

Apart from different types of heating and cooling systems, refrigerants work similarly in the heat pumps: they pass between the main components of the compressor, condenser, expansion device, and evaporator and remove unwanted heat from one location to another. The common types of refrigerants will have a low boiling point compared to water. This will make evaporation shorter and the use of thermal energy, reduced. With adequate refrigerant, the modern HPS is considered a better tool to use (Hulme, 2014). HP systems (HPS) need both proof of concept and the possibility of evaluating their activity with respect to their emission products. A main direction to evaluate the HPS impact is to analyze the greenhouse gas emissions of such systems (Bayer et al., 2012). Within the scientific context, the emissions are evaluated through the anthropogenic greenhouse effect (Lelieveld et al., 2019). The essential greenhouse effect is caused by greenhouse gases (carbon dioxide – CO_2, water vapors – H_2O, methane – CH_4, chlorofluorocarbon – CFCs) and ozone (O_3). Those five major greenhouse gases account for about 96% of the direct radiative forces acting by long-lived greenhouse gas increases since 1750. While those five long-live and mixed greenhouse gases increased dramatically during the last decades (Lelieveld et al., 2019), the CO_2 concentration suffers changes consequently (Ramaswamy, 2018) through fossil energy sources' burning. Nowadays, the world's CO2 levels are higher than ever (Stern and Kaufmann, 2014). For example, the 400-ppm level represents a 40 % increase in carbon dioxide since the start of the industrial revolution. The rise of anthropogenic greenhouse gas production (Drake, 2014) in particular CO_2 from electricity generation, thermal heat generation, mobility, and halogenated hydrocarbons has an extremely large negative impact on the environment (Lei et al., 2022), as various studies (KEA, 2017) and statistics show (Butler and Montzka, 2017). Environmental costs are, economically, highly relevant (Howard, 2014) as the *Stern Report* demonstrated (Stern & Kaufmann, 2014) their rising is estimated yearly, only from climate change, up to 20% of the global gross domestic product. While the European Union's efforts focus on strengthening the leadership and meeting the long-term goal of the Paris Agreement, at national levels, there are still discontinuities in implementing the most adequate and mature model both in the political decision and in the administrative capacity.

The environmental estimations show that only the German greenhouse gas emissions cost 164 billion € while other sources (IEA, 2022) put the costs higher because of hundreds of thousands of deaths caused by environmental pollution. As a part of the Paris Agreement and the European Green Deal, the European Climate Law sets both European and national targets to reach climate neutrality by 2050 and reduce greenhouse gas (GHG) emissions by 55% by 2030 compared to 1990 (Staiger & Tanțău, 2017a). Germany, for example, integrally submitted the national energy and climate plan for this decade. It keeps going on with long-term energy and climate plans and strategies to reduce greenhouse gas emissions (2019). Thus, Germany amended several times its climate law and committed to climate neutrality by 2045 and to greenhouse gas emission reductions by 2030 of -65 % compared to 1990 levels (Tiemeyer et al., 2020; UBA, 2023). For such consequences, the use of heat pumps could bring more benefits to any economy and society as well.

2. The HPS Model Impact on society and the environment

The HPs use electricity for their process; the internal Carnot process necessarily uses operational refrigerant (Staiger and Tanțău, 2016). Hence, the HP impact on the environment deserves to be analyzed in connection with the HP's refrigerant used (Fritsche and Gress, 2015). Beyond the electricity used for HPS operation from fossil fuel sources, the considered model, here, brings to light the advantage of promoting alternative renewable energy sources. In practice, there are several scenarios possible when the refrigerant goes into the atmosphere and reacts with more dangerous emissions such as CO_2. The refrigerant concentration could be up to 13,214 times higher than that of the CO_2 gas (table 1); for example, when refrigerant pipes broke, leakages could appear in the pressure sensors, switchers, evaporators from the heat exchanger or expansion valve (UBA, 2019). The higher emissions values correspond to the global warming potential (GWP) factor of the specific refrigerant material compared with the standard CO_2 emissions (table 1). The technical innovations with refrigerants are turning to natural substances to lower the global GWP (Staiger & Tanțău, 2017b).

Table 1 – Refrigerant materials and their GWP_i

Material	**GWP 100**
Carbon dioxide	1
Refrigerant	
R404A	3922
R407C	1774
R410A	2088
R508A	13214

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Such collateral aspects direct our analysis towards an assessment model to compare the efficiency and the HPS environmental impact when using today's heating applications in residential buildings. The comparison shows both positive and negative environmental aspects of operating heat pumps. The aspects can be assessed differently, depending on the energy source and the refrigerant. The impact on society and people's health is huge and could be quantified by examples. Therefore, the main purpose of this paper focus on an assessment model that compares the efficiency and environmental impact of HPS when using today's heating applications in residential buildings. The comparison shows both positive and negative environmental aspects of operating heat pumps. The aspects can be assessed differently, depending on the energy source and the refrigerant. They have a huge impact on our society and people's health. This influence is always better quantified by examples. The present environmental model emphasizes and relies on two key components, such as a) the HP that operates as a Carnot circuit based on different renewable energy sources Q_{free} provides energy for both operating HPS and various sources of energy Q_{cost}; b) the refrigerant operating the system generates itself an environmental impact (EI_{Refrig}). Farther Staiger and Tanțău's interpretation (2017a), the societal environmental impact for a classical model HPS is presented in fig.1:

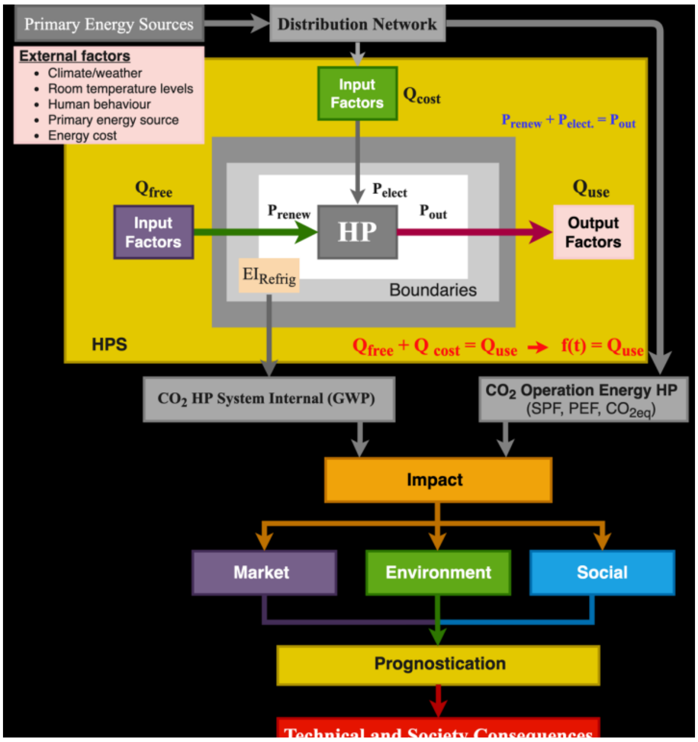

Figure 1 – The impact of HPS against people, market, and environment

The technical literature (Staiger and Tanțău, 2017b) takes into consideration the HPs' efficiency and criteria, such as: the average quantity of energy and the primary energy consumption emissions, according to standard building models.

The paper outlines reports used to make a statement about the efficiency and the energy distribution in the boundaries of HPS. The data is used according to the model to calculate and evaluate standard building energy consumption and emissions. The refrigerant used in a closed loop of the heat pump is

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included also in the calculations. Different emissions calculated are forecast-ed for refrigeration systems. The conclusions referring to the societal environmental impact are compared, from a technical side, with today's alternative systems. The analysis emphasizes the Carnot cycle process' advantage in electricity consumption as the driving force within a standard HPS. This electricity is generated from different primary energy sources - oil, gas, wood chips, and renewable electricity from a PV system, that impact, more or less the environment, depending on their nature. The environmental impact depends, also, on the refrigerant and HPS type, size, and design.

3. Materials and methods

The methodological starting point finds its roots in the *Global Emission Model for Integrated Systems* – GEMIS and other different system indicators, such as the *Coefficient of Performance* (COP), the *Seasonal Performance Factor* (SPF), or the CO_2 emissions. According to them, we recall an environmental impact model for HP with a new tool (Fritsche and Gress, 2015), capable of also enabling the comparison with different energy sources and internal refrigerant materials (Staiger and Tanțău, 2017b). The integration of GEMIS data hosted by the International Institute for Sustainability Analysis and Strategy (Fritsche and Gress, 2015) helped to determine the energy and material flows, together with the transport systems. A major contribution of this methodology is based on the estimation of the environmental impact of HPS under different energy working conditions and possible refrigerant materials.

To determine the CO_2 emission of the HP (CO_{2HP}) and compare the results when using different primary energy sources, several indicators are considered to determine the HP's efficiency, based on the Carnot cycle process:

- *Coefficient of Performance* for a HP (COP_{HP}) shows the amount of energy necessary to run the HP to determine the CO2 emission of the HP (CO_{2HP}) and compare the results by using different primary energy sources – *The HPS Greenhouse Gas Emission* depends on both the electricity production to operate, and the refrigerant gases (GWP) used internally in the HP Cycle in order to help calculating the *CO_2 impact of the refrigerant* (CO_{2HPR}).

- the *Seasonal Performance Factor* (SPF) represents the HPS efficiency for longer periods of time. Considering that most of the studies find significant deviations of SPF from ± 25% up to ± 50%, an average variation (-25 to +25 %.) helped to get a good estimation for the environmental impact of real HP systems (fig.2).

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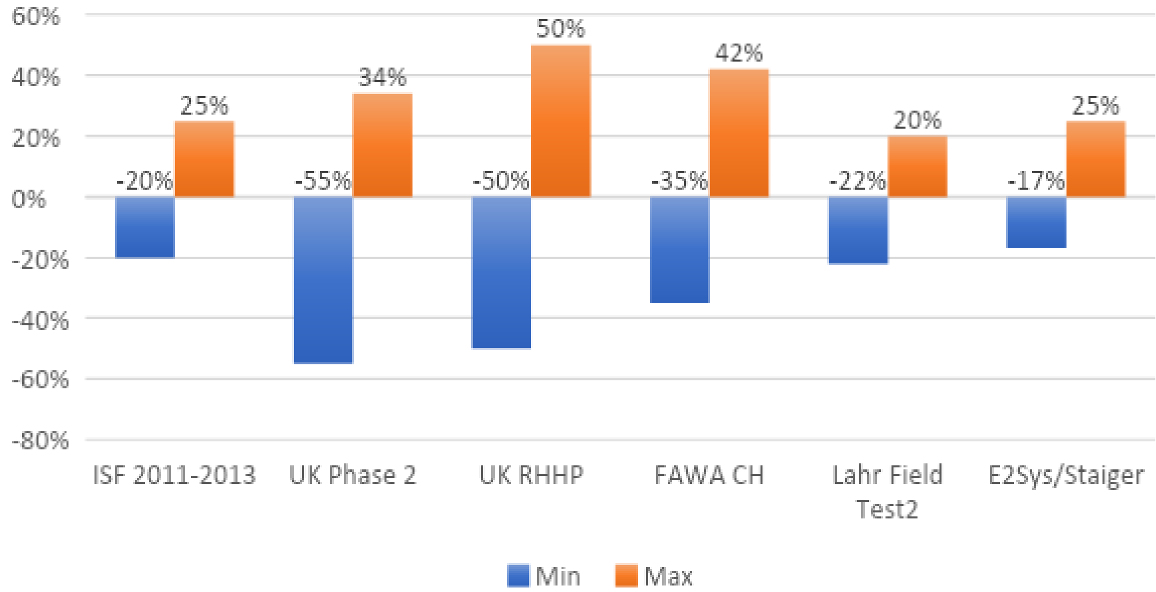

Figure 2 – Field Test Deviations of SPF (% between Min/Max) for an HPS

The analysis based on the environmental impact model shows the alternative heating systems as more ecological and friendly. The relation between the minimum efficiency of a Heat Pump SPF and the type of energy used for running an HPS aims to reduce the CO_2 emissions and the GWP of the whole system. The applied results, based on the environmental impact model, have as a reference the *CO_2 savings (CO_{2i})* between alternative heating and HPS.

(1) $CO_{2i}=CO_{2eqi}–CO_{2eq}HPSPF$

Where: Q_{out} is the thermal energy coming out of the HP and Q_{elec} is the amount of energy necessary for running the HP. In order to determine the CO_2 emission of the HP (CO_2HP) and to compare the results in the case of using different primary energy sources the following equations are proposed:

(2) $CO_{2HP}=\sum Q_{eleck}Wh*CO_{2e}\ [CO_{2kgk}Wh]$

Where: CO_{2eq} is the CO_2 emissions equivalent which is specific for each primary energy source (UBA, 2019) as seen in Table 2.

The HPS Greenhouse Gas Emission depends not only on the production of the electricity to operate but also on the refrigerant gases (GWP) which are used internally in the Heat Pump Cycle. The equation (3) calculates the *CO_2 impact of the refrigerant* (*CO_{2HPR}*).

(3) $CO_{2HPR}=GWPr[CO_{2kg}]*m\ [kg]$

Where GWP_r is the global warming potential of the refrigerant materials (Table 1) and *m* is the mass of the refrigerant in the HP.

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Table 2 – CO_2 Equivalent for Different Energy Sources
Source: KEA 2020, INAS 2020

Energy Sources **(Reference final energy)**	**CO_2eq (CO_2kg/kWh)**
Heating Oil	0.329
Natural Gas	0.25
Liquid Gas	0.28
wood-Pellets	0.03
Wood chips	0.02
Lock	0.02
Electricity (German Mix)	0.57
Brown Coal	1.16
Hard Coal	0.95
PV	0.05

For a better estimation of an efficiency that is changing over time the static indicator COP is changed with the dynamic indicator *Seasonal Performance Factor* (SPF). As a result, the efficiency of the HP System for a larger period (normally one year) has to be estimated by the – seasonal performance factor (SPF). Also, the energy Q_{out} and Q_{elec} (Figure 1) will be added up over the period:

(4) $$SPFHP=\sum Q_{out}\,[kWh]\sum Q_{elec}\,[kWh]$$

From various studies on heat pump systems for residential buildings, the following variations of annual employment figures can be observed (fig. 2). Considering that all major research studies find significant deviations of SPF from ± 25% up to ± 50%, in our model, we select for calculation, an average variation for the SPFk from -25 to +25 %. That gives a good estimation of the environmental impact of real HP systems (fig.3).

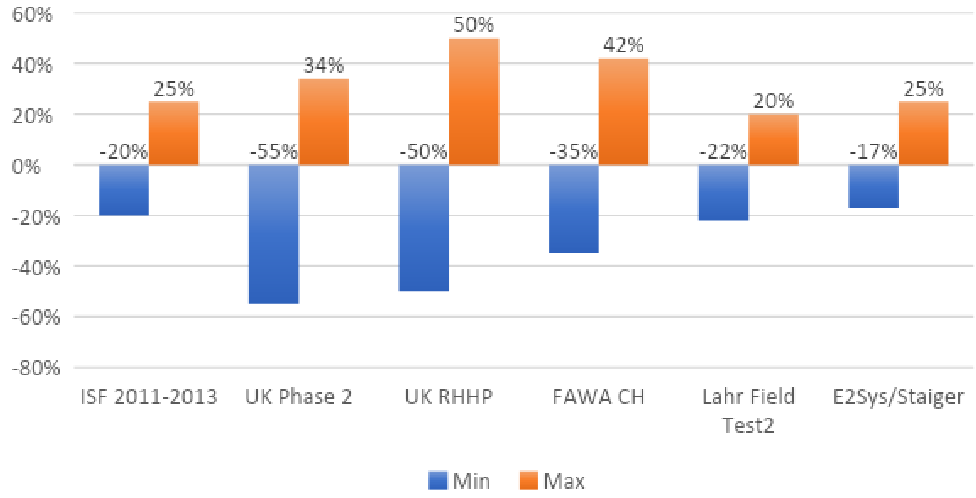

Figure 3 – Field Test Deviations of SPF (% between Min/Max) for an HPS

The analysis based on the environmental impact model helps to determine the more ecological and friendly alternative heating systems. This model shows the relation between the minimum efficiency of a Heat Pump SPF and the type of energy used for running a HPS considering the objectives to reduce the CO_2 emissions and the GWP of the whole system. The applied result of our analysis, based on the environmental impact model, has as a reference *the CO_2 savings* (CO_{2i}) between alternative heating and HPS.

(5) $$CO_{2i}=CO_{2eqi}-CO_{2eq}HPSPF$$

The environmental impact of using electricity in HPS or alternative heating appliances is crucial. In today's electricity production environments, the CO2eq parameter is normally a mix of all different energy sources for producing electricity.

In the second part of the analysis, the importance of the environmental impact model in the case of evaluation of the potential CO_2 emissions both for Q_{elec} and for refrigerant (CO_{2eqr}) is underlined.

(6) $$CO_{2i}=CO_{2eq}-(CO_{2eq}HP+CO_{2eqrj})SPFk$$

This happens when the CO2eqrj has values that depend on the refrigerant material, on the mass in the Heat Pump, on the lifecycle of the Heat Pump, and the related energy amounts over the lifecycle in kWh. The values can vary between 0 kg CO_2/kWh and up to 0.1 kg CO_2/kWh. The variation depends on the refrigerant's type, charge, and validity period, together with the power of the heat pump.

3.1. CO_2 emission through electricity HP operation and GWP through a refrigerant

HP refrigerants have a GWP of up to 6.000 depending on the type. The analysis is developed on a standard commonly used refrigerant (R407/R404).

The corollary of the research shows that the live time of the refrigerant in a HP before it disappears is 10 years.

Definition of the CO_{2eqrj} factor:

The base is the total energy produced from the HP in comparison to the total energy produced from fossil systems: refrigerant live time is 10 years, 1400h/ year operation hour, average size of HP 12kW, refrigerant GWP 3800 and 2.5kg refrigerant.

Calculation procedure for GWPF:

(7) $$CO_{2eqr} = GWP * mP * t * livetime[kgCO2kWh]$$

100% loss @ $CO_{2eqr=}$3800*2.512*1400*10 = 0.056 kgCO2 /kWh

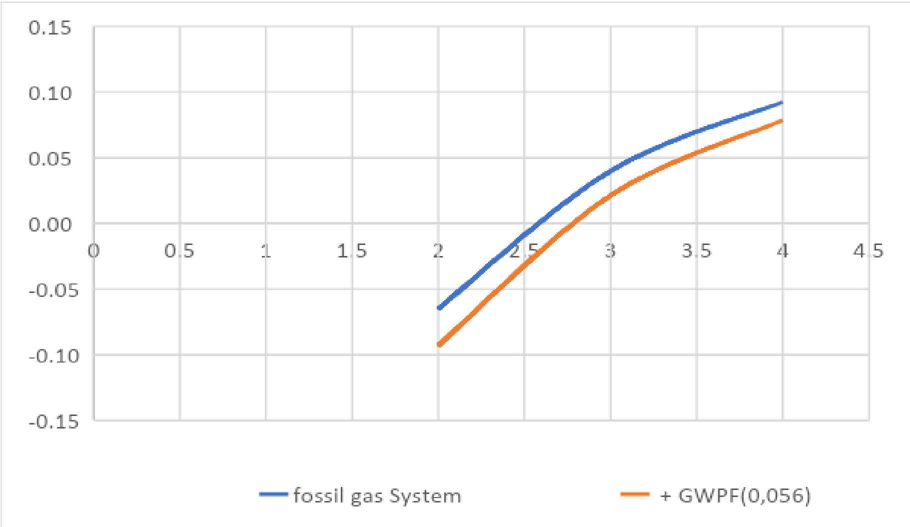

Figure 4 – CO_{2eqr} Factor in HPS versus Fossil Gas System (FGS)

For this specific analysis, our result indicates that an HP System with CO_{2eqr} factor in comparison with a Fossil Gas Heating System (blue curve). The break-even point for saving CO_2 emissions is 2.6 (SPF). With a GWPF from 0.056 the SPF must be > 2.8. Accordingly, the Break-even Analysis for the SPF, it can be determined the point of positive environmental impact in the case of HPS compared with other heating systems. For example, comparing an HPS with a fossil-driven heating system, the saving potential could be calculated based on the SPF for different types of input energy sources (CO2eq parameter). A calculation is similar to the contribution margin with a fixed cost part and a variable part can be derived for the calculation CO_2 savings in percentage or value depending on the SPF of an HP system. The fix part is for example an alternative heating system (fossil) with a defined CO_2 amount (CO_2 kg)/kWh. The variable part would be the electricity CO2 equivalent factor depending on the efficiency of the HP System (SPF).

The mathematical description is derived as:

(8) $$y = a - bx$$

- *a* = CO_2 equivalent for alternative heating system @ fix part
- *b* = CO_2 equivalent for the electricity (electricity mix) @ HP system operation energy variable

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- *x* = Seasonal performance factor for a working HP System

Calculating the GWP potential for the refrigerant following abstraction will be used for estimation. The formula (Drake, 2014) can be used, and a new fixed part will be derived. This fixed part is the environmental impact of the refrigerant (CO_{2eqr}) over the working life of the HPS.

The mathematical derivation is:

(9) $$y=a-(b+c)x$$

(10) **c = CO_{2eqr} means CO_2 impact for the refrigerant substance as calculated**

The applied result, based on the environmental impact model, has as a reference the *CO_2 savings* (CO_{2i}) between alternative heating and HPS. So, the environmental impact of using electricity in HPS or alternative heating appliances is crucial. In today's electricity production environments, the CO2eq parameter is normally a mix of all different energy sources for producing electricity. The analysis outlines also the importance of the environmental impact model when potential CO2 emissions for both Q_{elec} and refrigerant (CO_{2eqr}) are underlined. Here the values, varying between 0 kg CO_2/kWh and up to 0.1 kg CO2/kWh, depend on the refrigerant's type, the charge, and its validity period together with the power of the heat pump. The calculation of the GWP potential for the refrigerant can be used for the estimation of the environmental impact of the refrigerant (CO_{2eqr}) over the working life of the HPS.

4. Results and Discussion

The analysis, based on the environmental societal impact model, helps to determine the valuable alternative heating systems as more ecologically friendly and precise impact. The model analyses the relation between the minimum efficiency of a Heat Pump System (SPF) and the type of energy used for running an HP, considering the objectives to reduce both CO_2 emissions and GWP of the whole system. The results point out the SPF importance in the process of selecting HPS, under the assumption of reducing the environmental impact. The results show that if SPF is higher than 1 the HPS emissions are lower compared to the emissions from the electricity. They also reveal that for a variance of ± 25%, the SPF must be minimum 1.9, respectively 3.2 for a positive environmental impact, compared to a fossil gas heating system. The CO_{2eq} figures are compatible with the GEMIS System on which is based (fig.5):

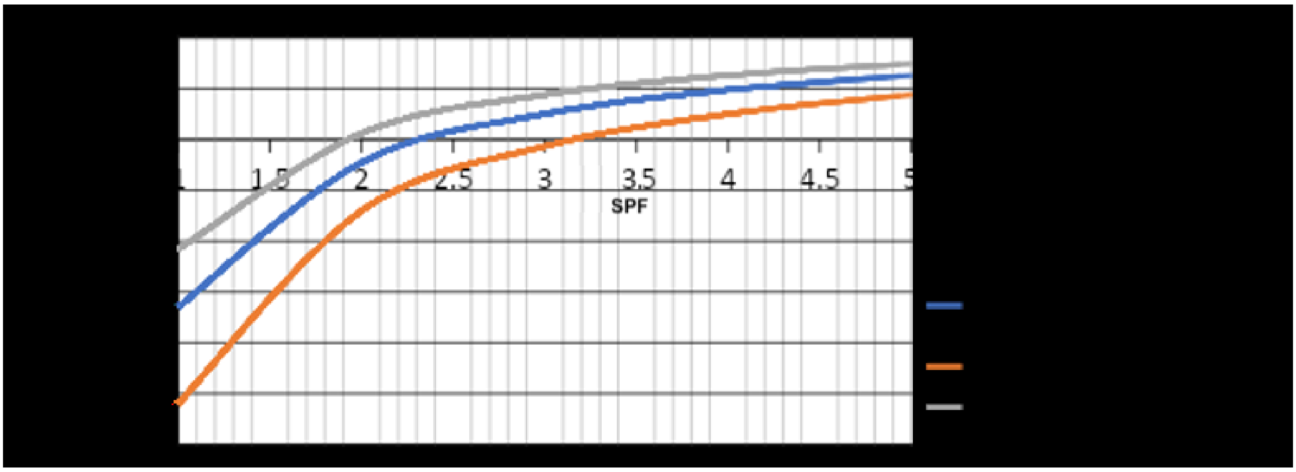

Figure 5 – Comparison of Gas Heating System and HPS with SPF variances of ± 25%

For this specific analysis, the result indicates that for a SPF higher than 2.4 the HPS has less CO_2 emissions as a Fossil Gas System. To have less CO_2 emission as a *Wood Chip System* the HPS has to have a SPF of more than 3.2. These results were obtained from the GEMIS CO_{2eq} data for fossil gas and wood chips.

After testing equation (4) with the GEMIS CO2eq for electricity (CO_{2eqel} = 0.57 kg CO_2/kWh) the results indicate that if SPF is higher than 1 the HPS emissions are lower compared to the emissions from the electricity. The specific analysis results show that for a variance of ±25% the SPF must be a minimum of 1.9, respectively 3.2 for a positive environmental impact, compared to a fossil gas heating system.

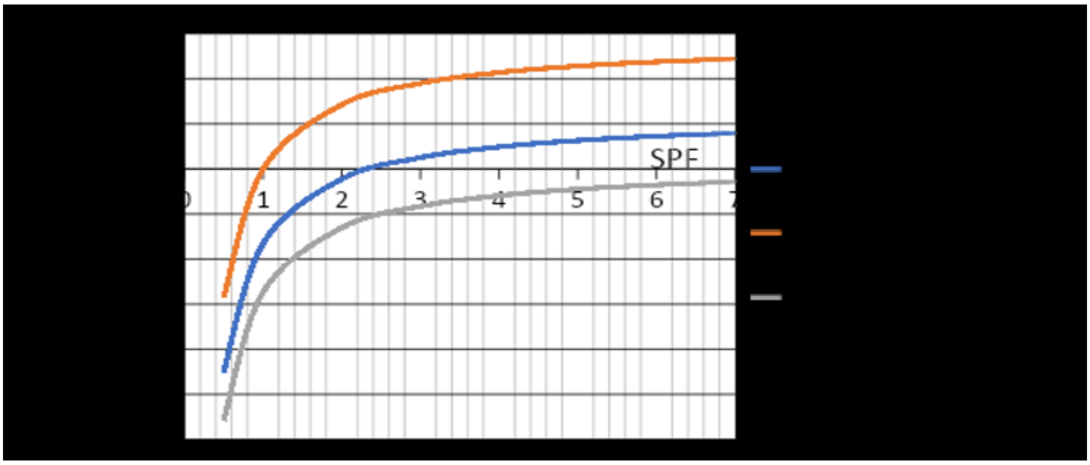

Figure 6. CO_2 and SPF Comparisons between Different Heating Systems and HPS

In order to have a better visualization of the efficiency HPS, the Break-even analysis for SPF could be used as it indicates the starting point of the environmental impact for a HPS is positive. The CO_{2eq} figures are compatible with the GEMIS System on which is based (Figure 4). Studies on normal domestic buildings show possible greenhouse gas impact through refrigerant substances in standard HPS. The calculations show that for a nearly zero energy building as defined by the EU Regulation of 2019 (EU 2012c) it could be heated with a fossil gas system for over 6 years with the amount of CO_2 emission released from the refrigerant (Fritsche and Gress, 2015) in the HP Circle if there is a leakage over 10 years. Using a HPS with standard electricity, the CO_2 emission is calculated with a CO_{2eq} figure of 0.56 kg/kWh. With the high demand for PV usage and batteries' storage more systems could run with a *smart grid system* from a renewable Energy source with 10 times less emissions compared to a standard HPS.

The societal impact, analyzed from environmental hazards, can vary widely. Climate change will increase the incidence of infections, lung disease, allergies, water scarcity, food shortages, resource scarcity, and heat deaths. An economic assessment of climate change can be estimated by today's different studies (Tanțău and Staiger 2017). The central part of the GEA/UBA model and calculation is the estimation of environmental costs and climate damage (UBA, 2019). They account for most of the costs of evaluating fossil-fuel power generation. The damage will occur partly in the distant future and globally. The extent of the damage is also uncertain and dependent on today's climate policy. We recommend using a cost rate of € 180 2016 /tCO_{2eq} for the year 2016. As climate change damage is intergenerational damage, a sensitivity analysis is recommended – with a value of 640 € /t CO_{2eq} in 2016 since this reflects an equal weighting of the benefits of present and future generations (Staiger and Tanțău, 2017b).

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Table 3 – UBA Recommendations on climate costs
Source: GEA, 2019 (UBA, 2019)

Pure Time Preference Rate	**Climate cost in €/ton CO_2/year**		
	2016	**2030**	**2050**
1% Pure Time Preference Rate	180	205	240
0% Pure Time Preference Rate	640	670	730

For example, a pure time preference rate of 1% means that the next generation's damage (in 30 years) is only 74% of the losses incurred by the generation after the next generation (in 60 years) is only 55% considered. At a pure time, preference rate of 0%, on the other hand, today and future damages are equally weighted (Staiger and Tanțău, 2017b).

The simplest comparison of economic environmental impact would be a so-called score based on the greenhouse gases emitted in weight kg or ton, or an energy-related value in kWh of energy required and weight of CO_2 emissions in gr., kg, or tons. According to EHPA Report 2018 (EHPA, 2018), the 1.13 million HP sold in 2017 generated 17.4 TWh of useful heat, of which 10.9 TWh from a renewable source. The SFP average of 2.6 for all different types of HPS was calculated and compared to CO2 saving potential. The EHPA data is 2.8 Mio ton CO_2 (EHPA, 2018). The calculations show that different greenhouse gases and energy quantities are calculated and linked to the current environmental costs.

Table 4 – The HPS economic impact on today's European market with 10 million units

System	**CO_2 Mio. tons**	**Cost Mio. €/y**	**Savings Environmental Cost Mio. €/a compare gas**
Gas boiler system	45.8	8244	0
HPS 2.8 lower	41.1	7400	844
HPS 2.6 see EHP2019	37.2	6700	1544
HPS 3.8 middle	28.3	5092	3152
HPS 4.7 upper	22.6	4068	4176
Pellets (Biomass) system	19.0	3420	4824
HPS 2.8 with PV/Wind	3.3	594	7650

The data show also the possible environmental savings compared to a gas-fired heating system (Tanțău and Staiger, 2017). About 70% of the heating system will run on natural gas in the EU (Tanțău and Staiger, 2017). The range of environmental cost savings varies greatly depending on the efficiency of the heat pumps and the possible loss of refrigerant. The HPS is ideal if the primary energy from a renewable energy source such as wind or photovoltaic is used (Tanțău and Staiger, 2017). As primary energy, the new heating systems require electric power instead of liquid and gaseous fossil energy sources (Tanțău and Staiger, 2017). Here, new electric generators must be made available at short notice. At the same time, *life cycle assessment* (LCA) calculations must be based on heat pumps as well to compare the advantages of HPS as these usually have higher energy consumption for production, maintenance, and disposal (Kuleto et al., 2022). To advance discussions, several indicators are considered to determine HP efficiency based on the Carnot cycle process: This assessment technique has been utilized to design new HPS in decentralized

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energy systems that must be more environmentally friendly and may significantly increase the flexibility of future energy networks.

The decentralized nature of the energy industry makes it a promising application area for blockchain technology (Bucea-Manea-Țoniş, 2021). Power energy systems are being built with a more decentralized structure than in the past. Because a central authority may not exist or may not be respected by all stakeholders, managing such a system in a centralized manner becomes difficult. By facilitating trusted collaboration in the absence of a trusted central authority, blockchain is a promising method to tackle this problem.

This assessment model has been used for designing new HPS in decentralized energy systems that have to be more environmentally friendly and could contribute widely to making future energy networks more flexible. The research demonstrates the usefulness of such a model for HPS as, depending on the primary energy source used, HP can emit less greenhouse gases than the fossil energy conversion process. HPs consist of different technologies such as refrigeration technology, electrical engineering, and heating technology. To make them operate efficiently and in a friendly manner, the systems need appropriate designs and correct maintenance. After the lifetime of the system, the devices and their hazardous gases must be disposed of correctly and returned to the economic cycle. The saving potential of around 1000 kg to 4000 kg/per system depends on the quality of the HPS. If the gas disappears out of a present HP 5000 – 8000 kg on CO_2 equivalent will be emitted to the environment. Today's HPS environmental cost analysis could save about 80 – 400 €/year, according to the UBA calculation principles. Considering the possible variations concerning greenhouse gas emissions, the potential savings should be considered exactly. Here, at the same time, a life cycle assessment analysis should be carried out as compared to conventional systems.

Depending on the HPS, further negative environmental impacts can be subtracted over the lifetime and could question the environmental compatibility of heat pumps. The old installed systems still existing on the market and other split heating and cooling systems hanging on the buildings' walls all around the world will increase their dramatic impact on the environment. With the latest technology of heat pumps, there will be a positive impact on the environment. New heat pumps should run from a primary energy source with the help of a renewable electricity supply. This would be the ideal environmental case. With more HPs installed, more electrical power is necessary. This can make the task of reducing greenhouse gases more problematic depending on the type of generator.

The model can be used to measure/predict the minimum level of the SPF for an HPS that could generate less CO_2 emission than other alternate heating systems such as (Gas Heating Systems, Wood Chips Heating Systems). The model takes also into account that the SPF factor can vary between +/-25% and allows the simulations of the CO_2 emissions impact also for these extreme values of the HPS efficiency.

Considering the implementation of the HPS 'use so that the impact generates environmental and societal benefits will help increase the interest in any fundamental issues linked to natural resources and viable alternatives, based on impact indicators of a) the use of production costs to forecast turnovers, tariffs and technological impact for electric and thermal energy, b) the sensitivity analysis of the economic efficiency for investment projects, c) the risk analysis for resources and funding sources of energy projects' investments. When such analysis is ignored, the consequences can generate disasters in the medium and long term. A healthy society needs a healthier environment, and better policies in education and business to cope with the strategic objectives.

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Maintaining a low level of primary energy consumption is imposed both by the consequences of technological change and by the volatility of energy production and services. The construction of efficient buildings equipped with modern heating systems and the use of modernized electric cars combining innovative technologies with the demand-side process (plug-in hybrids, electric vehicles, heat pumps) is a major innovation conglomerate. This will contribute to the realization and consolidation of partnerships between political, executive, legislative, technological, and commercial environments for the protection of the environment and the provision of adequate life sentences suitable for all citizens.

5. Energy industry transformation: From digital to blockchain logistics

Digital transformation (DT) involves a series of digital innovations that assign to decision-makers more information, and intelligence and provide an improvement in terms of efficiency. DT's specific technologies – Artificial Intelligence (AI), Automation, Big Data and analysis of large volumes of data, Blockchain, Cloud Computing, or the Internet of Things (IoT) – are disrupting some economic sectors that until now had a traditional approach. Both the energy sector and the electricity one has developed similar kind of impacts in the last 120 years – in a centralized way and mostly using non-renewable sources. New technologies are of great importance for specific societal problems and with the help of these new technologies new business models are developed, a very large potential for the energy sector also involves blockchain technology. Blockchain is the underlying technological process that can perform digital verification, with multiple applications such as cryptocurrencies, security enhancements, or distributed electricity markets (The European Parliament, 2010).

5.1. Blockchain Technology's Impact on Energy Industry

For the energy industry, the exponential reduction in the price of distributed generation systems, especially PV, is making energy decentralization a reality. Although the current level of decentralization does not include a computerized and standardized mechanism for documenting and managing respective achievements (Bucea-Manea-Ţoniş, 2021) blockchain technology can intervene in fundamental issues that DT involves – security and trust. The main applications of blockchain in the energy sector are:

(1) Energy transacting – One of the clearest and strong purposes for a computerized record innovation like blockchain is to give a dependable and productive stage for executing and recording exchanges (and for following proprietorship as resources change hands on different occasions before settlement). With blockchain, exchanges can be recorded and settled immediately, with no requirement for a middle person and practically no requirement for compromise since all gatherings are utilizing a similar stage. As a matter of fact, nothing remains to be accommodated since there is just a single framework and one passage for the exchange, which is shared by all gatherings. Likewise, a blockchain section can incorporate executable PC code that mirrors the provisions of the agreement — making a "shrewd agreement" that consequently approves exchanges without the requirement for human mediation. Blockchain's reasonableness as a proficient and solid shared exchange stage could be applied to both physical and monetary exchanges across the full range of energy items. In the power area explicitly, as conveyed energy assets keep on entering the framework, blockchain can empower distributed execution between end clients. These confined ex-changing organizations could mitigate foundational shortcomings, for example, transmission line misfortunes, blockage, and unstable cost arrangement. The heat pump supports blockchain-based cross-border demand response coordinated with the Distribution System Operators (DSO), Transmission

System Operators (TSO), and aggregators. The trading strategies influence energy sharing and performance and the potential of distributed layer and peer-to-peer (P2P) trading strategies for heating and cooling is presented by Li et al. (2021). The authors created a distributed heating system and used peer-to-peer techniques – the main goal of each peer was to maximize profit.

(2) Regulatory compliance and reporting – Regulatory compliance is progressively requiring energy and assets organizations to give huge measures of information that can be examined to distinguish resistance and other administrative issues. With current innovations and strategies, assembling and tidying up the necessary information is an immense weight. There's likewise a critical gamble that the information could fall into some unacceptable hands and be abused, uncovering delicate corporate data, and putting an organization in a difficult situation. Blockchain might actually take out a large portion of these issues, empowering straightforwardness by permitting controllers to safely get to clean, sealed information at the source, while simultaneously permitting organizations to hold severe command over what data is accessible and who is permitted to get to it. A significant advantage of utilizing a blockchain-based stage to impart data to controllers is that it would make a standard information design for key areas of industry, which is something just inaccessible right now.

The white certificate (WhC) scheme is a market-based mechanism for incentives to improve energy efficiency and is an essential incentive mechanism that is applied in some Australian states (New South Wales and Victoria) and several European countries (Denmark, France, Italy) (Fawcett et al., 2019). The national regulatory authority (e.g., the Ministry of Environment) sets an energy efficiency target for each of the obligated distributors and is a government institution. the distributor has two options, a) to install energy efficiency interventions in the energy production facilities, or b) to acquire white certificates for the market. Currently, the WCS is suffering from a lack of transparency in the verification process and measurement (Khatoon et al., 2019), in addition to a lack of credible information sources (Stede, 2017). The blockchain-based systems provide a reliable database is ensured by the benefits of the distributed ledger system, such as data integrity, availability, accessibility, and efficient reading.

(3) Resource improvement across areas – In both the oil and gas and power and utilities areas, one of the chief difficulties is settling on resource enhancement choices in an exceptionally siloed climate where separate elements each have a serious motivator to hold their cards near the vest. In the present expanded undertaking climate, the association with a large number of providers, sellers, and counterparties drives up intricacy and cost. Blockchain can assist organizations with checking consistency from their providers and at last lessen costs. By empowering straightforwardness that permits every element to uncover just the data that is fundamental for cooperation, while covering basic restrictive data that is a wellspring of the upper hand, a computerized record innovation, for example, blockchain makes it workable for the business to lessen costs while further developing unwavering quality and conveyance proficiency. Blockchain may likewise override the job of significant transmission mediators by working with the coordination and conveyance of force across expansive geologies on a minimal expense and mechanized premise. Tokenisation can address both supply and demand-side issues to accelerate investments into energy efficiency interventions related to Energy Service Companies (ESCO) projects, likewise WhC, there are some private permissioned blockchains like Hyperledger Fabric or Ethereum Proof-of-Authority are most suitable for this (Schletz et al., 2020).

(4) Global Supply Network – The start-to-finish cycle of getting hydrocarbons out of the ground, changing over it into a usable structure, and afterward conveying it to clients includes various advances and a wide range of players, from significant energy organizations to government controllers to individual specialist co-ops, and in the middle between. Right now, the situation and data to help these means are frequently profoundly disconnected and siloed, making it almost difficult to get a complete perspective on what's going on and keeping organizations from upgrading the cycle.

6. Conclusion

Europe is taking action to cope with global warming and to prevent catastrophic climate change. European recommendations deserve the attention of political decision-makers who have to contribute to the implementation of terrorism. The energy performance of buildings ought to be determined based on a typical methodology with objective variables that consider territorial climatic contrasts and which incorporate, notwithstanding thermal attributes, different variables that assume an undeniably significant part, for example, heating, cooling systems ventilation, heat recuperation, zone control, utilization of environmentally friendly power sources, latent heating and cooling components, concealing, indoor air quality, suitable regular light estimations, protection and lighting systems, building plan and checking and control systems. Also, the development of information technology has brought about changes in business models, especially the innovation of the digital revolution, the convergence of technologies, and their potential for change in the economic and social spheres. Efforts need to be common so that all the actors involved feel part of the creation of the new world that every citizen or businessperson needs so much.

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8. References

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