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An Extension of HVAC-AHU System Using PROMETHEE Method

*Vidhya Prasanth, M. Ramachandran, Kurinjimalar Ramu
REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India.
*Corresponding author Email: prasanthvidhya69@gmail.com

Abstract. An HVAC system is an indoor climate control system that combines heating and cooling equipment of various types. The Air Handling Unit (AHU) is the central component of a central air conditioning system. HVAC systems are used to provide comfort to the inhabitants of a building or to protect goods or objects placed in a space, and include mechanical, electrical, and I&C components. They remove dust and other particles from both outdoor and room air, and adjust temperature and humidity to provide chilled air through pipes to individual rooms. PROMETHEE is a ranking system used for assessing and enriching priority, and its interactive help provides descriptive complementary geometric analysis known as PROMETHEE methods. The PROMETHEE method determines the best solution from the analysis by calculating the distance between solutions and the negative-ideal solution. In this analysis, the shorter the distance and the longer the negative-ideal solution, the better the ranking. However, the comparison of these distances was not considered significant. The results show that the Heating and Cooling Split Systems received the first rank, while the Packaged Heating and Air Conditioning System received the lowest rank. Specifically, the Heating and Cooling Split Systems ranked first, the Duct-Free (Mini-Split) ranked second, the Hybrid Split System ranked third, and the Packaged Heating and Air Conditioning System ranked fourth.

1. Introduction

HVAC stands for heating, ventilation, and air conditioning. This system provides heating and cooling for residential and commercial buildings. HVAC systems can be found everywhere from single-family homes to submarines. They provide environmental comfort and are increasingly popular in new construction. These systems bring fresh air from outside to provide excellent indoor air quality. The air flow through an HVAC system can help eliminate smoke, odors, heat, dust, and other gases, and provide temperature control and oxygen supplementation. The heart of an HVAC system is the air handling unit (AHU), which collects air from outside and inside chambers. The AHU removes dust and other particles, adjusts temperature and humidity, and pipes comfortable and refreshing air conditioning to the rooms using blowers and heat exchangers. The PROMETHEE assessment is a priority ranking system for enrichment, with its descriptive complementary geometric analysis known as PROMETHEE methods. The PROMETHEE method calculates the best solution based on factors such as fan efficiency, heat recovery efficiency, cooling efficiency, electricity supply control, fan coil units, and volumetric capacity. The rating options include Heating and Cooling Split Systems, Hybrid Split System, Duct-Free (Mini-Split), and Packaged Heating and Air Conditioning System. The analysis shows that Heating and Cooling Split Systems received the highest ranking, while Packaged Heating and Air Conditioning System received the lowest ranking.

2. HVAC Heating, Ventilation and Air Conditioning systems / AHU air handling unit

There are three predominant capabilities of an HVAC device: ESP compatibility, indoor air quality, and temperature control. Your heating and air conditioning system may seem complex and elaborate, but you'll soon realize this when it stops working. In your HVAC system, there are parts which include air return, filter, exhaust outlets, pipes, electrical components, and external units such as the compressor, the coils, and the blower. Air return is where the ventilation cycle begins. This includes air being pulled through the filter and then fed into the main system. Debris and dust can easily accumulate in filters, so be sure to sprinkle your intake frequently and put a filter in place. The second air return area is where the air is drawn in. To keep your system running, make sure you change your filters regularly. Exhaust outlets are another part of your system. Exhaust generated by the heating system vents through your chimney flue or vent stack, which should be inspected annually and tuned if necessary. Your pipes allow hot or cooled air to pass through the channels. To keep everything in working order for years, check whether the batteries are dead or a breaker is due to malfunction. This part of your system can be a bit tricky, but most likely, any problems will appear here first. If something isn't working perfectly, check your thermostat. When referring to the outdoor unit, someone might mention the compressor, which is responsible for replacing the compressor liquid and sending it to coils. If something is wrong, check your compressor. This is mostly for multiple system failures. The coils are usually external, and air passes through them with little help from the coolant. Another part of the unit is cooling. Check your coils annually. If they freeze, check your filter and/or coolant level. The blower unit heats through the core, attracting air, and creating wind. HVAC systems meet the real demand of the environment but may not be complete. Hence, indoor environment, hygiene, and well-being of the occupants are fundamentally related from the point of

view of energy efficiency HVAC control strategies. There is a need to develop techniques for new technologies that manipulate the environment for the well-being of citizens. Ground source heat pumps for HVAC systems, robust control of pipeline uncertainty, dehumidification systems, heat storage for environments, and ventilation design in HVAC systems demand for ground space technologies. Parameters such as 'new building ventilation technologies' and 'room vent & ventilation 2018' must be added to build. This special issue, which provides insight into developments in the current state of the art HVAC technology, aims to achieve the principal goal of creating new technologies for the well-being of citizens. [2]. It seems that the research is focused on optimizing the cooling output of an air handling unit (AHU) through data-driven approaches. The models used in the research are created using data mining algorithms, and different sample dynamic models are studied to improve the performance of the AHU system. HVAC systems are known to consume a significant amount of electricity, and energy conservation is a critical concern. AHU systems are complex, nonlinear, and have several constraints, making system modeling a challenge for optimization. The cooling output of the cooling coil on the AHU side is a major load on the system, and it is affected by several controllable variables, including the cooling coil valve function, supply air fan velocity, and general air supply temperature. The research proposes a hybrid HVAC system that includes a natural gas micro generator, a natural gas boiler, and an electric air-cooled water refrigerant. The proposed dynamic system is compared to a traditional HVAC unit through simulations. It appears that some parts of the text are cut off or incomplete, making it difficult to understand the context of the discussion. However, based on the information provided, it seems that the text is discussing various types of HVAC systems and their efficiency in terms of energy consumption and cost. Different SDEC (Solar Decathlon) systems are compared through economic analysis, and it is found that incorporating photovoltaic and heat collector systems result in the best outcomes. The text also mentions the use of AHU (air handling unit) systems with heat pump and desiccant wheel arrangements, as well as the application of optimization techniques such as sequential quadratic programming and genetic algorithms to reduce cost functions and improve efficiency.

It seems that the thesis is discussing an analytical optimization method to reduce energy consumption in HVAC systems by adjusting the supply air temperature. The method involves modifying the go back air and outside air dampers, and without terminal reheat, cooling a single zone under operation systems, or in indoor areas serving single-pipe systems season with or without reheating AHU will run on settings. The thesis also mentions the importance of evaluating HVAC efficiency and the connection between the HVAC system and building structure. Furthermore, the thesis suggests that using skilled control strategies can help achieve better internal thermal comfort while also improving the system's energy efficiency. The AHU hot section linear version is obtained around the precise running condition, but it cannot ensure a first-class approximation under various running performances. Compared to a typical proportional-integral-derivative (PID) controller used in air conditioning (HVAC) systems, the proposed scheme is different in task conditions and external disturbances in maintaining even supply air temperature. The results confirm that it can provide excellent performance [6]. The selection process for the heat recovery unit used within the AHU integration determines the needs and preferences. In the case of a flat plate heat recovery unit, additional heat based on processing balance the exchanger is selected, without using integration procedures. To heat the building, a water heating system is used. DHW (domestic hot water) from the AHU in the heat exchanger return water is used for the air heater [7]. An ABB EU 2000 air handling unit is an ABB product. The unit consists of six modules: the hull, inclusive of air heater, air cooler, rotary propellers, and rotary huge motor modules. Due to the copper content, the air heater, air cooler, and two motors are treated as separate components. The following categories of impacts include air handling unit global warming, ozone depletion, acidification, nutrient enrichment, photochemical ozone formation, aquatic toxicity to humans, airborne toxicity to humans, acute toxicity to ecosystems, and aquatic toxicity, hazardous waste, radioactive waste, sludge, ash, and scale waste. Further inventory reduction is included in the following categories: lignite, brown coal, natural gas, coal, aluminum, iron, manganese, and copper and zinc-low crude oil [8]. For the purpose of predicting energy consumption, absorption refrigerant inlet values are ambient air conditions, dry bulb temperature, relative humidity, cold water supply temperature, and inlet cooling temperature of AHU. Input values are ambient air conditions, dry bulb temperature, humidity, and distribution is absorption, etc. Seasonal data for year, month, day, and time were used for selecting the air temperature coolant for air conditioners [9]. The Air Handling Unit (AHU) is a fundamental unit for composition and (cross) transport of pollutants in the zone based on logical perspective. Economic or spatial constraints may prevent the proper updating of air conditioning systems. The properties of different zones, such as resident density or distribution, equipment, and single-tenant doors, cannot be changed even if they receive air supply from the same AHU. The air conditioning system typically includes a standard block cooling only insulated pipe supply pipes and ceiling plenum withdrawal, where fresh air from outside is introduced directly to the AHU inside the room. Even if the same AHU is shared between two zones, different thermal environments can be created due to factors such as the opening of windows or the actions of occupants. For houses with indoor closets, an HVAC split system is ideal, where the condenser and compressor are housed in an external cabinet and a furnace and air conditioner are included in the conventional HVAC system. On the other hand, a hybrid split system has a furnace and a heat pump. If you prefer a zoned air conditioning system, a mini-split air conditioner without plumbing is a good choice. The fan efficiency is the ratio of the power of the fan for air to the input power. Packaged air conditioners, which include compressors, coils, and air handlers, are also available on a limited basis. Fan performance, both standard and total performance, can be calculated from the data using CFM (fan flow rate), PT (total pressure), and PS (static pressure). Heat recovery ventilation (HRV), also known as mechanical ventilation heat recovery (MVHR), is a heat exchanger coil with a fan that is used to transfer heat between two sources in the ventilation system. Cooling capacity is the amount of heat that can be removed by the device over time from a cold place. Electricity is the main objective of distribution that provides power to the load from a single source, and its voltage, current, and frequency are alternating. Thus, electricity is sometimes referred to as electrical energy converters. Volumetric capacity is the discharge

capacity through maximum thickness while driving divided by circulation, which is determined by in situ thickness measurement for 100 cycles. [10].

3. PROMETHEE

The Priority Ranking for Assessment Saturation Methodology and PROMETHEE are interactive and descriptive complementary geometric analysis methods used in mathematics and sociology. PROMETHEE was developed in the early 1980s and has since been extensively refined. This system is used in decision-making across sectors such as business, government institutions, transport, health, and education, in different types of decision-making environments all over the world. Instead of simply pointing out results, the PROMETHEE method helps decision-makers understand the problem and find alternatives. It identifies and measures clusters and key alternatives and provides a detailed and logical structure to highlight the integration of actions and paradoxes inherent in decision-making. Natural stream networks are impacted by urbanization, leading to scarcity during rainy seasons, especially on high gradients, when proper transmission and drainage systems are absent. Urban stream and shower hotel management processes require evaluation. The PROMETHEE method uses the Analytic Hierarchy Process (AHP) to determine the importance of criteria and comparison criteria for standardized judgment when introducing ambiguous change. The PROMETHEE method is used in conjunction with AHP to provide advanced decision-making in a production environment. However, due to the fundamentally unpredictable nature of expert ideas and various regional factors that may influence results, the accuracy of PROMETHEE method results in drainage system studies, such as the SWMM stormwater model, should be carefully considered. Various models and multiple ratings with five criteria are used to decide on just six car models. The PROMETHEE method proves its ability to analyze and evaluate car models based on common criteria. Finally, in the low north of Greece, the enthalpy alternatives PROMETHEE method was used to evaluate proposed projects in a geothermal village community of four. As economic activities in the region are limited, there is a growing need for new jobs beyond the traditional agricultural sector, such as providing accommodation [13]. PROMETHEE is a well-known decision-making support system that provides multifaceted support with customized intelligence to assist in decision making. The system can either provide an absolute ranking or rank alternatives relative to one another, and it involves all experts in the decision-making process to minimize complexity. Despite its unpredictability due to its reliance on expert opinion, the PROMETHEE method can handle various factors that may affect stormwater drainage, making it an effective tool for increasing accuracy [14]. The study found that the drainage system in the area is incapable of accommodating changes in flood patterns. While rainfall does not occur during the return period of one year, some sub-catchments experience flooding during flood years, highlighting the need for a perfectly designed flow to prevent urban flooding. PROMETHEE is a French MCDM system introduced in 1982 by France and Vincke and expanded by France and Marché. It ranks alternatives based on a defined pair sequence and calculates incoming and outgoing flows to derive area rankings. PROMETHEE methods use advanced techniques to calculate net flows and include alternatives to obtain rankings [15]. The PROMETHEE technique is highly effective in handling numerical data with reasonable accuracy, but it may not work well for most energy-efficient projects, especially in the early stages of development where data may be approximate. PROMETHEE overcomes this challenge by converting data into extended fuzzy numbers, making it more precise and manipulable. [16].

4. Analysis and Discussion

Fan Efficiency it is seen that Heating and cooling split systems is showing the highest value for Packaged heating and air conditioning system is showing the lowest value. Heat Recovery Efficiency it is seen that Duct free (Mini-split) is showing the highest value for Hybrid split system is showing the lowest value. Colling Capacity it is seen that Duct free (Mini-split) is showing the highest value for Hybrid split system is showing the lowest value. Electrical power supply control it is seen that Duct free (Mini-split) is showing the highest value for Heating and cooling split systems is showing the lowest value. Fan Coil Units it is seen that Duct free (Mini-split) is showing the highest value for Heating and cooling split systems is showing the lowest value. Volumetric Capacity it is seen that Duct free (Mini-split) is showing the highest value for Heating and cooling split systems is showing the lowest value.

TABLE 1. HVAC/AHU system

	Fan Efficiency	**Heat Recovery Efficiency**	**Colling Capacity**	**Electrical power supply control**	**Fan Coil Units**	**Volumetric Capacity**
Heating and cooling split systems	95	59	97	10	20	18
Hybrid split system	87	60	92	15	25	20
Duct free (Mini-split)	90	74	100	20	35	30
Packaged heating and air conditioning system	82	69	89	17	30	25

Max	95	74	100	20	35	30
Min	82	59	89	10	20	18
max-Min	13	15	11	10	15	12

Table 1 shows the Alternative: Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Evaluation Preference: Heating and cooling split systems, Hybrid split system; Duct free (Mini-split), Packaged heating and air conditioning system. Shows the maximum and minimum output of each value.

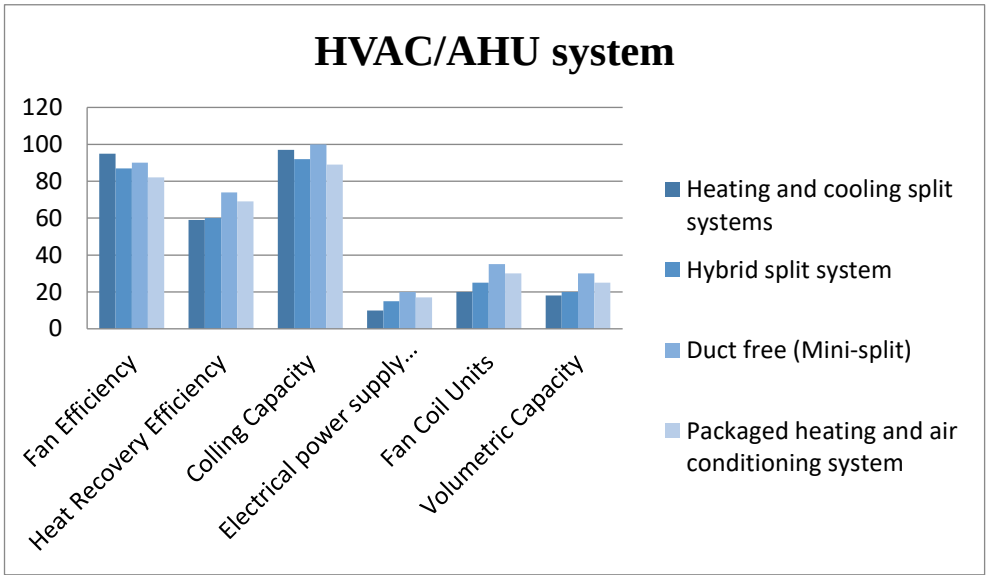

FIGURE 1. HVAC/AHU system

Figure 1 shows that HVAC/AHU system Alternative value Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Evaluation Preference value Heating and cooling split systems, Hybrid split system, Duct free (Mini-split), Packaged heating and air conditioning system.

TABLE 2. Normalized matrix of Sensitivity analysis PROMETHEE

	Fan Efficiency	**Heat Recovery Efficiency**	**Colling Capacity**	**Electrical power supply control**	**Fan Coil Units**	**Volumetric Capacity**
Heating and cooling split systems	0	-0.25424	-0.03371	-1	-0.75	-0.66667
Hybrid split system	-0.09756	-0.23729	-0.08989	-0.5	-0.5	-0.55556
Duct free (Mini-split)	-0.06098	0	0	0	0	0
Packaged heating and air conditioning system	-0.15854	-0.08475	-0.1236	-0.3	-0.25	-0.27778

Table 2 shows the Normalized matrix of Sensitivity analysis PROMETHEE the Alternative: Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Evaluation Preference: Heating and cooling split systems, Hybrid split system; Duct free (Mini-split), Packaged heating and air conditioning system. Normalization is shown in the above tabulation. Table 2 shows the default matrix of Prometheus for the sensitivity analysis shown in the table above.

TABLE 3. Pair Wise Comparison

	Fan Efficiency	**Heat Recovery Efficiency**	**Colling Capacity**	**Electrical power supply control**	**Fan Coil Units**	**Volumetric Capacity**
D12	0.097561	-0.01695	0.05618	-0.5	-0.25	-0.11111

D13	0.060976	-0.25424	-0.03371	-1	-0.75	-0.66667
D14	0.158537	-0.16949	0.089888	-0.7	-0.5	-0.38889
D21	-0.09756	0.016949	-0.05618	0.5	0.25	0.111111
D23	-0.03659	-0.23729	-0.08989	-0.5	-0.5	-0.55556
D24	0.060976	-0.15254	0.033708	-0.2	-0.25	-0.27778
D31	-0.06098	0.254237	0.033708	1	0.75	0.666667
D32	0.036585	0.237288	0.089888	0.5	0.5	0.555556
D34	0.097561	0.084746	0.123596	0.3	0.25	0.277778
D41	-0.15854	0.169492	-0.08989	0.7	0.5	0.388889
D42	-0.06098	0.152542	-0.03371	0.2	0.25	0.277778
D43	-0.09756	-0.08475	-0.1236	-0.3	-0.25	-0.27778

Table 3 shows the Pair Wise Comparison of table 2 the Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Comparing each row with other row on the tabulation.

TABLE 4. Preference Value

	0.2336	**0.1652**	**0.3355**	**0.1021**	**0.0424**	**0.1212**	**SUM Value**
D12	0.02279	0	0.018848	0	0	0	0.041639
D13	0.014244	0	0	0	0	0	0.014244
D14	0.037034	0	0.030157	0	0	0	2
D21	0	0.0028	0	0.05105	0.0106	0.013467	0.077917
D23	0	0	0	0	0	0	0
D24	0.014244	0	0.011309	0	0	0	0.025553
D31	0	0.042	0.011309	0.1021	0.0318	0.0808	0.268009
D32	0.008546	0.0392	0.030157	0.05105	0.0212	0.067333	0.217487
D34	0.02279	0.014	0.041466	0.03063	0.0106	0.033667	0.153153
D41	0	0.028	0	0.07147	0.0212	0.047133	0.167803
D42	0	0.0252	0	0.02042	0.0106	0.033667	0.089887
D43	0	0	0	0	0	0	0

Table 4 shows the Performance value of the Wise Comparison of table 2 the Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. When compare to all others. And the last one is the sum of the same row.

TABLE 5. Sum of Performance Value

	M1	**M2**	**M3**	**M4**	**SUM**	**positive flow**
M1	0	0.041639	0.014244	2	2.055882	0.685294
M2	0.077917	0	0	0.025553	0.10347	0.03449
M3	0.268009	0.217487	0	0.153153	0.638649	0.212883
M4	0.167803	0.089887	0	0	0.25769	0.085897
SUM	0.513729	0.349012	0.014244	2.178706		
Negative Flow	0.171243	0.116337	0.004748	0.726235		

Table 5 shows the sum of all rows and column are applied on the last row. The sum of all row of performance value is arranged above tabulation and the diagonal values are zero.

TABLE 6. Positive flow, Negative flow, Net flow

	positive flow	**Negative Flow**	**Net flow**
Heating and cooling split systems	0.685294	0.171243	0.514051
Hybrid split system	0.03449	0.116337	-0.08185
Duct free (Mini-split)	0.212883	0.004748	0.208135
Packaged heating and air conditioning system	0.085897	0.726235	-0.64034

Table 6 shows ranking for the Heating and cooling split systems, Hybrid split system; Duct free (Mini-split), Packaged heating and air conditioning system. In the above tabulation the Heating and cooling split systems is in the first rank and the second rank is Duct free (Mini-split) and the last rank is packaged heating and air conditioning system.

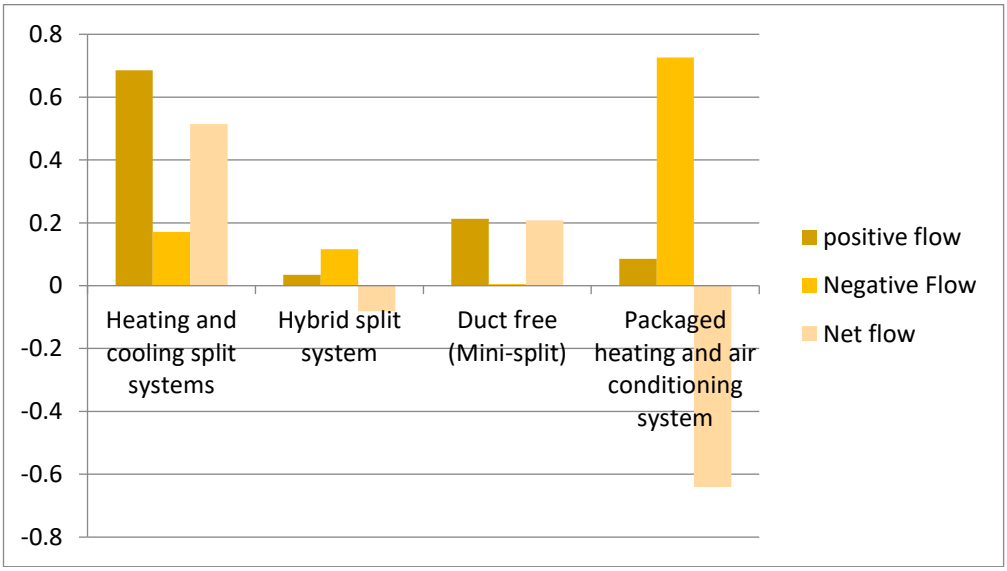

FIGURE 2. Positive flow, Negative flow, Net flow

Figure 2 shows the graph for Positive flow, Negative flow, and Net flow. The Net flow value is Positive for the Heating and cooling split systems, Duct free (Mini-split). Positive flow of camera 4 is high and negative value of Hybrid split system, packaged heating and air conditioning system is high.

TABLE 6. Rank

	Rank
Heating and cooling split systems	1
Hybrid split system	3
Duct free (Mini-split)	2
Packaged heating and air conditioning system	4

Table 6 shows the rank for the HVAC/AHU system depend on the Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Ranking for the Heating and cooling split systems, Hybrid split system; Duct free (Mini-split), Packaged heating and air conditioning system. the final result of this paper the Heating and cooling split systems is in 1st rank, the Hybrid split system is in 3rd rank, the Duct free (Mini-split) is in 2nd rank, the Packaged heating and air conditioning system is in 4th rank and The final result is done by using the PROMETHEE method.

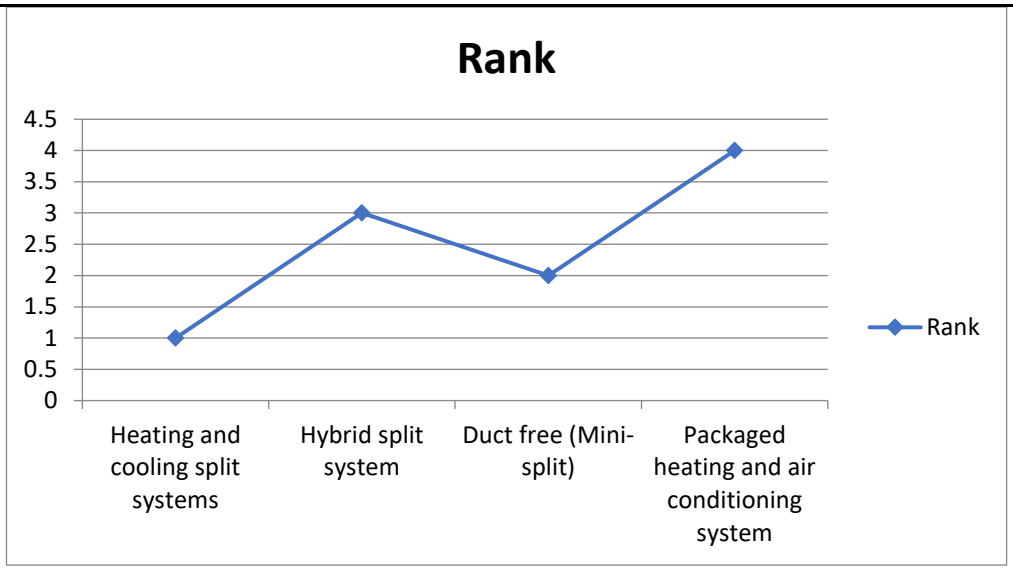

FIGURE 3. Rank

Figure 3 shows the rank for the HVAC/AHU system depend on the Fan Efficiency, Heat Recovery Efficiency, Colling Capacity, Electrical power supply control, Fan Coil Units, Volumetric Capacity. Ranking for the Heating and cooling split systems, Hybrid split system; Duct free (Mini-split), Packaged heating and air conditioning system. the final result of this paper the Heating and cooling split systems is in first rank, the Hybrid split system is in Third rank, the Duct free (Mini-split) is in Second rank, the Packaged heating and air conditioning system is in fourth rank.

5. Conclusion

An HVAC system with indoor climate control is a collection of various types of equipment installed to provide heating and cooling. The Air Handling Unit (AHU) is the heart of the central air system. PROMETHEE's priority ranking system for enrichment of evaluations and its descriptive complementary geometry analysis for interactive assistance are well-known as PROMETHEE methods used for analysis. The rating for the HVAC/AHU system depends on fan efficiency, heat recovery efficiency, cooling efficiency, power supply control, fan coil units, and volumetric efficiency. The ranking for the heating and cooling split system, hybrid split system, ductless (mini-split) system, and packaged heating and air conditioning system is done based on several factors. Heating and cooling split systems are ranked first, ductless (mini-split) systems are ranked second, hybrid split systems are ranked third, and packaged heating and air conditioning systems are ranked fourth.

References

[1]. Babaei, Sahar, Reza Ghazavi, and Mahdi Erfanian. "Urban flood simulation and prioritization of critical urban sub-catchments using SWMM model and PROMETHEE II approach." Physics and Chemistry of the Earth, Parts A/B/C 105 (2018): 3-11.

[2]. Venkata Rao, R., and Bhisma K. Patel. "Decision making in the manufacturing environment using an improved PROMETHEE method." International Journal of Production Research 48, no. 16 (2010): 4665-4682.

[3]. Kumar, Ashish, Somenath Roy Chowdhury, Tulika Chakrabarti, Hemanta K. Majumdar, Tarun Jha, and Sibabrata Mukhopadhyay. "A new ellagic acid glycoside and DNA topoisomerase IB inhibitory activity of saponins from Putranjiva roxburghii." Natural Product Communications 9, no. 5 (2014): 1934578X1400900523.

[4]. Anand, Gapesh, and Rambabu Kodali. "Selection of lean manufacturing systems using the PROMETHEE." Journal of modelling in management (2008).

[5]. Mohammed Zabeeulla, A. N., and Chandrasekar Shastry. "Automation of Leaf Disease Prediction Framework based on Machine Learning and Deep Learning in different Crop Species." JOURNAL OF ALGEBRAIC STATISTICS 13, no. 3 (2022): 3098-3113.

[6]. Krishna Kumar, T. P., M. Ramachandran, and Vimala Saravanan. "A Risk Assessment of Emergency management using (WASPAS) MCDM Method." Recent trends in Management and Commerce 2, no. 3 (2022): 36-43.

[7]. Corrente, Salvatore, Salvatore Greco, and Roman Słowiński. "Multiple criteria hierarchy process with ELECTRE and PROMETHEE." Omega 41, no. 5 (2013): 820-846.

[8]. Gutu, Birhanu, Genene Legese, Nigussie Fikadu, Birhanu Kumela, Firafan Shuma, Wakgari Mosisa, Zelalem Regassa et al. "Assessment of preventive behavior and associated factors towards COVID-19 in Qellam Wallaga Zone, Oromia, Ethiopia: A community-based cross-sectional study." PloS one 16, no. 4 (2021): e0251062.

[9]. Manjunath, C. R., Ketan Rathor, Nandini Kulkarni, Prashant Pandurang Patil, Manoj S. Patil, and Jasdeep Singh. "Cloud Based DDOS Attack Detection Using Machine Learning Architectures: Understanding the Potential for

Scientific Applications." International Journal of Intelligent Systems and Applications in Engineering 10, no. 2s (2022): 268-271.

[10]. Krishna Kumar TP, M. Ramachandran, Chandrasekar Raja, Ashwini Murugan, "Understanding of E-Learning Programs using WPM MCDM Method", REST Journal on Banking, Accounting and Business, 1(2), (2022):13-19

[11]. Goumas, MetVLYGEROU, and V. Lygerou. "An extension of the PROMETHEE method for decision making in fuzzy environment: Ranking of alternative energy exploitation projects." European Journal of Operational Research 123, no. 3 (2000): 606-613.

[12]. Kumawat, Gaurav, Santosh Kumar Vishwakarma, Prasun Chakrabarti, Pankaj Chittora, Tulika Chakrabarti, and Jerry Chun-Wei Lin. "Prognosis of Cervical Cancer Disease by Applying Machine Learning Techniques." Journal of Circuits, Systems and Computers 32, no. 01 (2023): 2350019.

[13]. Pham Van, Tuan, Dung Vo Tien, Zbigniew Leonowicz, Michal Jasinski, Tomasz Sikorski, and Prasun Chakrabarti. "Online rotor and stator resistance estimation based on artificial neural network applied in sensorless induction motor drive." Energies 13, no. 18 (2020): 4946.

[14]. Kumar, M. Senthil. "Energy Efficient Techniques for Transmission of Data in Wireless Sensor Networks." (2015).

[15]. Mareschal, Bertrand, and Yves De Smet. "Visual PROMETHEE: Developments of the PROMETHEE & GAIA multicriteria decision aid methods." In 2009 IEEE International conference on industrial engineering and engineering management, pp. 1646-1649. IEEE, 2009.

[16]. Farooqui, Nafees Akhter, Amit Kumar Mishra, and Ritika Mehra. "Concatenated deep features with modified LSTM for enhanced crop disease classification." International Journal of Intelligent Robotics and Applications (2022): 1-25.

[17]. Krishna Kumar TP, Vimala Saravanan, M. Ramachandran, Manjula Selvam, "A Market Segmentation Assessment Weighted Scoring for Using WSM Method An Study for Different Market", REST Journal on Banking, Accounting and Business, 1(3), (2022):1-8

[18]. Kogila, P. "Prevention of home accidents among mothers of toddler." The Journal of Nursing Trendz 8, no. 3 (2017): 15-17.

[19]. Nielsen, Steen. "Management accounting and the concepts of exploratory data analysis and unsupervised machine learning: a literature study and future directions." Journal of Accounting & Organizational Change (2022).

[20]. Tajammul, Mohd. "An Method Relies on Penalties can Solve the Macro-and Micro Fire House Placement Issue." In 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), pp. 205-211. IEEE, 2022.

[21]. Rathor, Ketan, Sushant Lenka, Kartik A. Pandya, B. S. Gokulakrishna, Susheel Sriram Ananthan, and Zoheib Tufail Khan. "A Detailed View on industrial Safety and Health Analytics using Machine Learning Hybrid Ensemble Techniques." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1166-1169. IEEE, 2022.

[22]. Brans, Jean Pierre, and Bertrand Mareschal. "The PROMETHEE methods for MCDM; the PROMCALC, GAIA and BANKADVISER software." In Readings in multiple criteria decision aid, pp. 216-252. Springer, Berlin, Heidelberg, 1990.

[23]. Kumar, M. Senthil, and Ashish Chaturvedi. "Energy-Efficient Coverage and Prolongs for Network Lifetime of WSN using MCP." (2012).

[24]. Krishna Kumar TP, M. Ramachandran, Kurinjimalar Ramu, Ashwini Murugan, "Analysis of Reverse Logistics System using COPRAS MCDM Method", REST Journal on Banking, Accounting and Business, 1(4), (2022):31-37.

[25]. Mishra, Amit Kumar, and Shweta Paliwal. "Mitigating cyber threats through integration of feature selection and stacking ensemble learning: the LGBM and random forest intrusion detection perspective." Cluster Computing (2022): 1-12.

[26]. Sinha, Ashish Kumar, Ananda Shankar Hati, Mohamed Benbouzid, and Prasun Chakrabarti. "ANN-based pattern recognition for induction motor broken rotor bar monitoring under supply frequency regulation." Machines 9, no. 5 (2021): 87.

[27]. Mukherjee, Tulika, Tapas Sarkar, Piyali Paul, Ajit K. Chakraborty, Parasuraman Jaisankar, and Siba Brata Mukhopadhyay. "Putralone, a novel 10α-hydroxy-25-nor D: A friedo-oleanane triterpenoid from Putranjiva roxburghii." Natural Product Communications 7, no. 4 (2012): 1934578X1200700424.

[28]. Feng, Feng, Zeshui Xu, Hamido Fujita, and Meiqi Liang. "Enhancing PROMETHEE method with intuitionistic fuzzy soft sets." International Journal of Intelligent Systems 35, no. 7 (2020): 1071-1104.

[29]. Tasisa, Yirgalem Bekele, and Kogila Palanimuthu. "Psychosocial Impacts of Imprisonment among Youth Offenders in Correctional Administration Center, Kellem Wollega Zone, Ethiopia." Medico-legal Update 21, no. 2 (2021).

[30]. Vanitha, K. "Summary of Either A Report on Methodologies Can Amend Routing'Protection a Servqual." In 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), pp. 557-561. IEEE, 2022.

[31]. Kamali, Ali-Mohammad, Milad Kazemiha, Behnam Keshtkarhesamabadi, Mohsan Daneshvari, Asadollah Zarifkar, Prasun Chakrabarti, Babak Kateb, and Mohammad Nami. "Simultaneous transcranial and transcutaneous spinal direct current stimulation to enhance athletic performance outcome in experienced boxers." Scientific Reports 11, no. 1 (2021): 19722.

[32]. Rathor, Ketan, Keyur Patil, Mandiga Sahasra Sai Tarun, Shashwat Nikam, Devanshi Patel, and Sasanapuri Ranjit. "A Novel and Efficient Method to Detect the Face Coverings to Ensurethe Safety using Comparison Analysis." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1664-1667. IEEE, 2022.

[33]. Mahamkali, Aditya. "Health Care Internet of Things (IOT) During Pandemic–A Review." Journal of Pharmaceutical Negative Results (2022): 572-574.

[34]. Farooqui, Nafees Akhter, Amit Kumar Mishra, and Ritika Mehra. "Automatic crop disease recognition by improved abnormality segmentation along with heuristic-based concatenated deep learning model." Intelligent Decision Technologies Preprint (2022): 1-23.

[35]. Soares, Giselle A., Tanima Bhattacharya, Tulika Chakrabarti, Priti Tagde, and Simona Cavalu. "Exploring pharmacological mechanisms of essential oils on the central nervous system." Plants 11, no. 1 (2022): 21.

[36]. Krishna Kumar TP, M. Ramachandran, Chinnasami Sivaji, Chandrasakar Raja, " Financing practices of Micro and Small Entrepreneurs using WSM MCDM Method", REST Journal on Data Analytics and Artificial Intelligence, 1(4), (2022):18-25.

[37]. Marinoni, Oswald. "A stochastic spatial decision support system based on PROMETHEE." International Journal of Geographical Information Science 19, no. 1 (2005): 51-68.

[38]. Tuzkaya, Gülfem, Bahar Sennaroglu, Zeynep Tuğçe Kalender, and Meltem Mutlu. "Hospital service quality evaluation with IVIF-PROMETHEE and a case study." Socio-Economic Planning Sciences 68 (2019): 100705.

[39]. Kumar, M. Senthil, and Ashish Chaturvedi. "A novel enhanced coverage optimization algorithm for effectively solving energy optimization problem in WSN." Research Journal of Applied Sciences, Engineering and Technology 7, no. 4 (2014): 696-701.

[40]. Cao, Shi-Jie, Chuck Wah Yu, and Xilian Luo. "Heating, ventilating and air conditioning system and environmental control for wellbeing." *Indoor and Built Environment* 29, no. 9 (2020): 1191-1194.

[41]. Nautiyal, Aditi, and Amit Kumar Mishra. "Machine learning approach for intelligent prediction of petroleum upstream stuck pipe challenge in oil and gas industry." Environment, Development and Sustainability (2022): 1-27.

[42]. Singh, Shubhendra P. "Exploration on a Low Power Accuracy Configurable Radix-4adder." In 2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT), pp. 1-5. IEEE, 2022.

[43]. Fulmare, Nilima Salankar, Prasun Chakrabarti, and Divakar Yadav. "Understanding and estimation of emotional expression using acoustic analysis of natural speech." International Journal on Natural Language Computing (IJNLC) 2, no. 4 (2013): 37-46.

[44]. Kusiak, Andrew, and Mingyang Li. "Cooling output optimization of an air handling unit." *Applied Energy* 87, no. 3 (2010): 901-909.

[45]. Kumar, Ashish, Somenath Roy Chowdhury, Kumar Kalyan Jatte, Tulika Chakrabarti, Hemanta K. Majumder, Tarun Jha, and Sibabrata Mukhopadhyay. "Anthocephaline, a new indole alkaloid and cadambine, a potent inhibitor of DNA topoisomerase IB of Leishmania donovani (LdTOP1LS), isolated from Anthocephalus cadamba." Natural Product Communications 10, no. 2 (2015): 1934578X1501000221.

[46]. Palanimuthu, Kogila, Eshetu Fikadu Hamba Yigazu, Gemechu Gelalcha, Yirgalem Bekele, Getachew Birhanu, and Birhanu Gutu. "Assessment of Stress, Fear, Anxiety and Depression on COVID-19 Outbreak among Adults in South-Western Ethiopia." Prof.(Dr) RK Sharma 21, no. 1 (2021): 440.

[47]. Angrisani, G., C. Roselli, M. Sasso, and F. Tariello. "Dynamic performance assessment of a solar-assisted desiccant-based air handling unit in two Italian cities." *Energy Conversion and Management* 113 (2016): 331-345.

[48]. Paliwal, Shweta, Amit Kumar Mishra, Ram Krishn Mishra, Nishad Nawaz, and M. Senthilkumar. "XGBRS Framework Integrated with Word2Vec Sentiment Analysis for Augmented Drug Recommendation." Comput. Mater. Contin 72 (2022): 5345-5362.

[49]. Gali, Manvitha, and Aditya Mahamkali. "A Distributed Deep Meta Learning based Task Offloading Framework for Smart City Internet of Things with Edge-Cloud Computing." Journal of Internet Services and Information Security 12, no. 4 (2022): 224-237.

[50]. Wang, Gang, and Li Song. "Air handling unit supply air temperature optimal control during economizer cycles." *Energy and Buildings* 49 (2012): 310-316.

[51]. Kumar, Ashish, Ketan Rathor, Snehit Vaddi, Devanshi Patel, Preethi Vanjarapu, and Manichandra Maddi. "ECG Based Early Heart Attack Prediction Using Neural Networks." In 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 1080-1083. IEEE, 2022.

[52]. Soni, Rajkumar, Prasun Chakrabarti, Zbigniew Leonowicz, Michał Jasiński, Krzysztof Wieczorek, and Vadim Bolshev. "Estimation of life cycle of distribution transformer in context to furan content formation, pollution index, and dielectric strength." IEEE Access 9 (2021): 37456-37465.

[53]. Boopathi, Mythili, Sachin Gupta, Mohammed Zabeeulla AN, RUPAL GUPTA, Vipul Vekriya, and Arvind Kumar Pandey. "Optimization algorithms in security and privacy-preserving data disturbance for collaborative edge computing social IoT deep learning architectures." (2023).

[54]. Kumar, R. Dinesh, C. Sridhathan, and M. Senthil Kumar. "Performance Evaluation of Different Neural Network Classifiers for Sanskrit Character Recognition." Business Intelligence for Enterprise Internet of Things (2020): 185-194.

[55]. Zhu, Jianhua, Qinmin Yang, Jiangang Lu, Binhui Zheng, and Chuan Yan. "An adaptive artificial neural network-based supply air temperature controller for air handling unit." *Transactions of the Institute of Measurement and Control* 37, no. 9 (2015): 1118-1126.

[56]. Agarwal, Ajay, and Amit Kumar Mishra. "Ontology-Based System for Robotic Surgery–A Historical Analysis." Semantic Web for Effective Healthcare (2021): 159-174.

[57]. Bhatnagar, Prasoon, Deepak Vyas, S. K. Sinha, and Tulika Chakrabarti. "Stability indicating HPLC method for simultaneous estimation of entacapone, levodopa and carbidopa in pharmaceutical formulation." J Chromatogr Sep Tech 6, no. 304 (2015): 2.

[58]. Rathor, Ketan, Anshul Mandawat, Kartik A. Pandya, Bhanu Teja, Falak Khan, and Zoheib Tufail Khan. "Management of Shipment Content using Novel Practices of Supply Chain Management and Big Data Analytics." In 2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), pp. 884-887. IEEE, 2022.

[59]. Khan, Zuhaib Ashfaq, Hafiz Husnain Raza Sherazi, Mubashir Ali, Muhammad Ali Imran, Ikram Ur Rehman, and Prasun Chakrabarti. "Designing a wind energy harvester for connected vehicles in green cities." Energies 14, no. 17 (2021): 5408.

[60]. Aswini, S., S. Tharaniya, RJ Joey Persul, B. Avinash Lingam, and P. Kogila. "Assessment of Knowledge, Attitude and Practice on Immunization among Primi Mothers of Children." Indian Journal of Public Health Research & Development 11, no. 3 (2020): 583-587.

[61]. Misevičiūtė, Violeta, Kęstutis Valančius, Violeta Motuzienė, and Genrika Rynkun. "Analysis of exergy demand for air heating of an air handling unit." *Energy Efficiency* 10, no. 4 (2017): 989-998.

