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Design of High-Performance Permanent Magnet Synchronous Motor for All-Electric Aircraft Propulsion System Using TOPSIS Method

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Abstract. *In order to achieve high performance, a novel method is proposed in this paper. It involves solving an optimization problem by reducing the energy consumption of an aircraft in determining the optimum production positions of the an "electric aircraft propulsion system" during the climb and cruise phases. The embarkation and embarking phases must be successful given the limitations. The suggested approach is used to design the propulsion system of a specific two-seat electric aircraft for testing reasons. Over the past ten years, "electric and hybrid electric propulsion" for aero planes has drawn a lot of attention. Although studies have increasingly shown the possibilities for overall gains in fuel efficiency or missions' fluidity of new aircraft types, the primary driving for industrial interest has been to minimize emission from combustion exhaust gasses and noise. This research examines a hypothetical new kind of base jumper lift mission aircraft. The possibility of electric hybridization for this purpose is examined in comparison to traditional conventional propulsion systems. The TOPSIS method uses comparing the best solution to establish order preference. It's one of the numbers of co choice (MCDM) methods that is now use most. The TOPSIS approach was primarily created to work with data that only had real values. Since it might be challenging to produce accurate estimation of alternatives with regard to local criteria in many situations, these estimations are frequently regarded as gaps. The TOPSIS method has been extended for intervals in a few studies, although these developments are based on various heuristic methods for defining adaptive and maladaptive optimal solutions. True values or ranges that cannot be reached in the matrix provide these ideal answers. In this research, we offer a new direct way to interval expansion of a TOPSIS method that is free of heuristics assumptions and constraints of existing approaches because this is in conflict with the basics of the original TOPSIS method.*

Keywords: *electric and hybrid electric propulsion, internal combustion engine (ICE), MCDM.*

1. INTRODUCTION

With the traditional non-electric system being replaced by a "more electric system" to improve effectiveness and decrease weight, fuel costs, and carbon emissions, "electric aircraft propulsion" is gaining more and more attention. A number of businesses have already created electric hybrids that can go hundreds of miles and one- or "two-passenger electric aircraft propulsion" for short-haul flights. Future electric airplane propulsion is projected to make extensive use of high-speed electric motors. The excellent mechanical power required of electric propulsion is its most difficult aspect. Today, electric systems can be employed for fuel pumping, wing ice protection, environmental management, and aircraft propulsion. These new methods will make future aircraft more fuel-efficient and quieter, which will improve conditions for everyone while also lowering maintenance costs thanks to the utilization and adaptability of electric power. One of the most crucial technologies for highly electrified aircraft is power electronics. All of the advantages of "high-electric aircraft" would not be achievable without the use of electrical machines to convert and regulate electrical energy. However, the work environment for power electronics in space applications can be difficult, and there are still a lot of areas that can be improved in terms of the size, length, cost, and voltage stability converters and the systems that they are a part of. The operating environment in an Aeroplan is harsher, and the trading hours and life expectancy are longer than in "many industrial and automotive applications". Hwang and Yoon created TOPSIS as a method for establishing ordering efficiency by similarity to a best solution (MCDM issues). The fundamental tenet of the technique is that the alternative should be picked if it is closest to the positive ideal and farthest from the negatives one. The weights of the estimators that criteria are exactly known in conventional MCDM approaches. The judgements of the candidates and the rankings of the variables are provided by actual values in the traditional TOPSIS technique. In numerous disciplines, the traditional TOPSIS technique has been applied with success. [4] provides a thorough analysis of the TOPSIS method's uses. However, taking into account local criteria, it might be challenging to precisely ascertain the true values of something like the evaluation of alternatives, and as a result, these assessments are frequently given as confusing values. Although some articles in the literature focus on fuzzy versions of the TOPSIS approach, these extensions are lacking since the best answers are frequently provided in the statistical model as real principles (not fuzzy variables) or unreachable fuzzy values.

2. ELECTRIC AIRCRAFT PROPULSION

The development of a completely electric passenger airliner requires significant advancements in electric powertrain technology, even though "electric aircraft" with fewer seats may be feasible in the future. Thus, concepts for big hybrid-electric aircraft will be put into use starting in the middle of the 2030s. They can vary in hybridization depending on how conventional turbo engines are integrated into the propulsion system. The flight time endurance of several instances of "all-electric light aircraft" is around two person-hours. For instance, it makes it feasible for EPS to play the position of master trainer, which entails sending an instructor and a student pilot on a one-hour mission. The maximum tolerance for transportation or passenger duties is typically 1 hour, which is insufficient. Future developments in renewable technology can easily be incorporated into currently designed aircraft to provide battery electric drives, boosting performance, lowering costs, but broadening role and mission appropriateness to new markets without needing new design and production. To support this new growth, it must be demonstrated that electric propulsion technology, both present and future, is viable. For today's light aircraft with traditional "internal combustion engine (ICE)" propulsion, the battery's energy density must grow by at least five times [7]. Although new battery storage is predicted to develop in the coming, it is presently possible to expand power and durability possibilities while keeping some of the main benefits of EPS through use of incorporated hybrid systems. The increased energy density for hydrocarbon fuel is used in HEP aircraft, and ICE is used in place of electrochemical battery storage. We demonstrate that by employing a combined thrust-thermal-aerodynamic model to optimize electric flight trajectories, the adverse impacts of these temperature constraints can be largely offset. We look at continuous itineraries for the X-57 flying under temperature restrictions to show this. We demonstrate that thermal limitations modify the geometry of the trajectory and have a significant impact on overall performance by contrasting thermally restricted optimal trajectories with unconstrained optimal trajectories. Few prior studies have taken into account both problems at once, despite the fact that extensive work has been done on pose estimation and thermally regulated "aircraft propulsion system analysis for electric aircraft". Doman thought about the best operating altitudes for the plane under the constraints of fuel tank temperature. Alianak and Allison point out that if thermal concerns are not properly taken into account during the original design process, military aircraft's gross take-off weight may increase significantly. Though its model does not have temperature controls because of the waste heat from the propulsion system, electric passenger Aeroplan's do exist. Without specifically taking into account thermal restrictions, integrative operation evaluation & designing of just a "hybrid electric aircraft" were demonstrated. Christie studied the performance of several cooling systems for dissipating extra heat produced by "electric propulsion" components and came to the conclusion that one of the key determinants of cooling efficiency is the heat exchanger's surface area.

3. MATERIALS AND METHOD

According to TOPSIS, the final alternative should be the one with the lowest distance to the ideal solution and the greatest distance to the opposite of the ideal solution. The best solution with the best feature values and the negatives ideal solution produced by the poorest are computed if each attribute has a monotone growing (or decreasing) utility function. The alternatives with the smallest Distance function from the optimum alternative was chosen from a geometrical perspective. Because the TOPSIS method's premise is rational and easy to comprehend, as well as its straightforward mathematical form and calculation, it was chosen as the best RP process in this study. This technique can lessen the complexity of the numerous technical elements, the financial expense, and the challenge of choosing RP methods for a particular part or a product. TOPSIS technique procedure published. In this study, fuzzy numbers, including cardinal numbers, are included in the result data. However, because it cannot accept linguistic values given as triangular fuzzy numbers, the traditional "TOPSIS method" cannot be applied. It has been altered to handle extended test results for fuzzy sets as a result. In many application fields, numerous fuzzy TOPSIS algorithms have recently been created. When manufacturing capacity was surpassed, the manufacturer (supplier) employed fuzzy topsy for ordering selection and pricing. In decision analysis, Cheng and Tsao (2008) expanded the TOPSIS technique based on intermission fuzzy sets. Firms used the fuzzy AHP and multiple Criteria models to determine which ones were the most significant before arriving at the final partner rating. In order to handle non - linear and non-humongous quadratic programming systems with block angular structure, Abo-Sinna, Mohammed, and Ibrahim (2008) expanded the method of order prioritization through a converged optimal solution. The best training process aircraft for the Taiwanese Air Force Academy was chosen using fuzzy TOPSIS by Wang and Chang in 2007. For fuzzy multicriteria decision making (FMAGDM), Li (2007) created the compromise ratio (CR) approach, which is a crucial component of a decision support tool. For fuzzy inter making decisions and solving (FMCGDM) in a fuzzy context, Yang and Lee (2007) generalized

TOPSIS. For the multivariate assessment of industrial robotic systems, a fuzzy hierarchy TOPSIS model was presented. In Gran Canaria Island, three hotels that are part of a significant organization were dynamically evaluated for service quality using surveys by Benitez, Martn, and Roman in 2007. In addition to a nonlinear optimization solution approach, Wu and Elhak (2006) suggested a fuzzy Numbers depending on alpha level sets. Fuzzy TOPICS methodology was utilised by Chen, Lin, and Huang (2006) to address the issue of supplier selection in the supply chain system.

4. RESULT AND DISCUSSION

TABLE 1. Electric Aircraft Propulsion

	Number of seats	Engine power (kW)	Fuselage length (m)	MTOW (kg)
Antares DLR-H2	1.00	42.00	7.40	660.00
Electra via Electro club	2.00	37.00	6.40	700.00
Electra via Electro light	1.00	19.00	7.60	300.00
IFB hydro genius	2.00	72.00	8.11	850.00
Yuneec-Flight star E-Spyder	1.00	20.00	5.03	226.00
Yuneec 430	2.00	40.00	6.98	470.00
	B	B	NB	NB

Show the Table 1 electric aircraft propulsion for Analysis using the TOPSIS Method. The alternatives are Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430. The evaluation parameters are Number of seats, Engine power (kW), Fuselage length (m) and MTOW (kg).

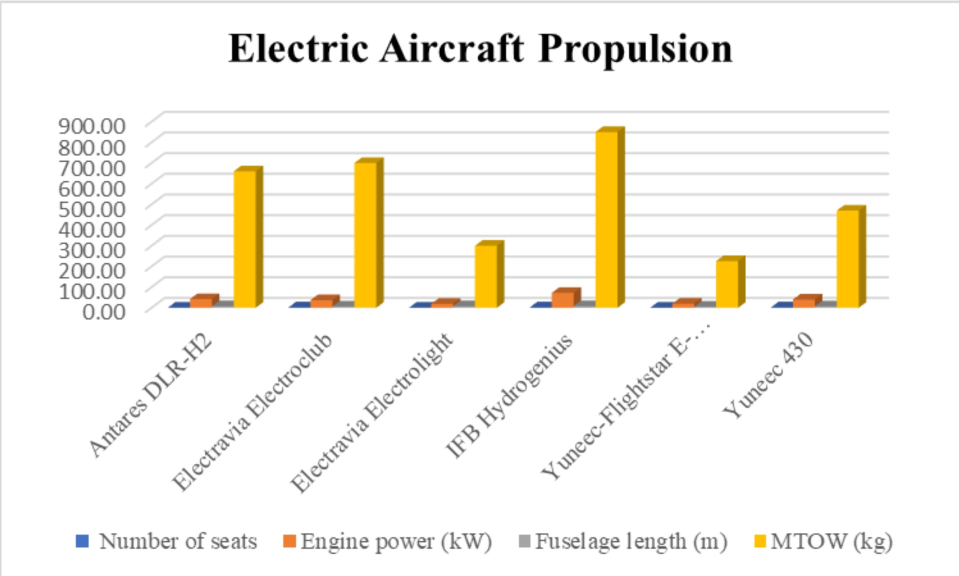

FIGURE 1. Electric Aircraft propulsion

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TABLE 2. Square and Root of Value

	Number of seats	Engine power (kW)	Fuselage length (m)	MTOW (kg)
Antares DLR-H2	1.0000	1764.0000	54.7600	435600.0000
Electra via Electro club	4.0000	1369.0000	40.9600	490000.0000
Electra via Electro light	1.0000	361.0000	57.7600	90000.0000
IFB hydro genius	4.0000	5184.0000	65.7721	722500.0000
Yuneec-Flight star E-Spyder	1.0000	400.0000	25.3009	51076.0000
Yuneec 430	4.0000	1600.0000	48.7204	220900.0000

Table 2 shows the Square and Root of Value electric aircraft propulsion for Analysis using the TOPSIS Method. The alternatives are Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430.

TABLE 3. Normalized Data

	Normalized Data			
Antares DLR-H2	0.2582	10.8444	0.4321	0.4655
Electra via Electro club	0.5164	9.5534	0.3737	0.4937
Electra via Electro light	0.2582	4.9058	0.4438	0.2116
IFB hydro genius	0.5164	18.5903	0.4736	0.5995
Yuneec-Flight star E-Spyder	0.2582	5.1640	0.2937	0.1594
Yuneec 430	0.5164	10.3280	0.4076	0.3315

Table 3 shows the Normalized Data electric aircraft propulsion for Analysis using the TOPSIS Method Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430, Number of seats, Engine power (kW), Fuselage length (m) and MTOW (kg) the Normalized Value.

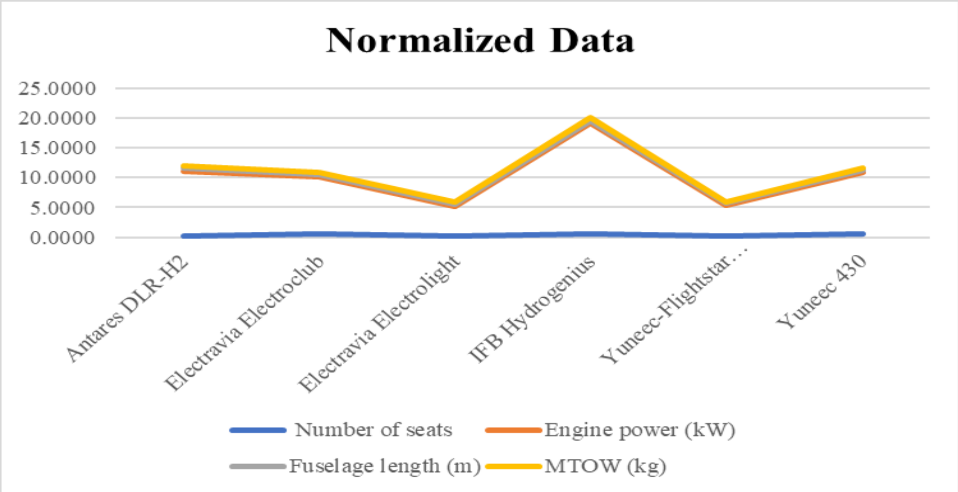

FIGURE 2. Normalized Data

Shows the figure 2 Normalized Data electric aircraft propulsion for Analysis using the TOPSIS Method Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430, Number of seats, Engine power (kW), Fuselage length (m) and MTOW (kg) the Normalized Value.

TABLE 4. Weight

	Weight			
Antares DLR-H2	0.25	0.25	0.25	0.25
Electra via Electro club	0.25	0.25	0.25	0.25
Electra via Electro light	0.25	0.25	0.25	0.25
IFB hydro genius	0.25	0.25	0.25	0.25
Yuneec-Flight star E-Spyder	0.25	0.25	0.25	0.25
Yuneec 430	0.25	0.25	0.25	0.25

Shows the table 4. electric aircraft propulsion weight is same the weight 0.25.

TABLE 5. Weighted normalized decision matrix

	Weighted normalized decision matrix			
Antares DLR-H2	0.0645	2.7111	0.1080	0.1164
Electra via Electro club	0.1291	2.3883	0.0934	0.1234
Electra via Electro light	0.0645	1.2264	0.1109	0.0529
IFB hydro genius	0.1291	4.6476	0.1184	0.1499
Yuneec-Flight star E-Spyder	0.0645	1.2910	0.0734	0.0399
Yuneec 430	0.1291	2.5820	0.1019	0.0829

Table 5 shows weighted normalized decision matrix for Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430. To figure out the weighted normalized decision matrix, we used the formula (2).

TABLE 6. Positive Matrix

	Positive Matrix			
Antares DLR-H2	0.1291	4.6476	0.0734	0.0399
Electra via Electro club	0.1291	4.6476	0.0734	0.0399
Electra via Electro light	0.1291	4.6476	0.0734	0.0399
IFB hydro genius	0.1291	4.6476	0.0734	0.0399
Yuneec-Flight star E-Spyder	0.1291	4.6476	0.0734	0.0399
Yuneec 430	0.1291	4.6476	0.0734	0.0399

Table 6 shows Positive Matrix for Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430. In various Positive Matrix in Maximum value 4.6476, Minimum value 0.0399.

TABLE 7. Negative matrix

Antares DLR-H2	0.0645	1.2264	0.1184	0.1499
Electra via Electro club	0.0645	1.2264	0.1184	0.1499
Electra via Electro light	0.0645	1.2264	0.1184	0.1499
IFB hydro genius	0.0645	1.2264	0.1184	0.1499
Yuneec-Flight star E-Spyder	0.0645	1.2264	0.1184	0.1499
Yuneec 430	0.0645	1.2264	0.1184	0.1499

Table 7 shows Negative Matrix for Antares DLR-H2, Electra via Electro club, Electra via Electro light, IFB hydro genius, Yuneec-Flight star E-Spyder and Yuneec 430. In various Negative Matrix in Maximum value 1.2264, Minimum value 0.0645.

TABLE 8. SI Plus, Si Negative, Ci and Rank

	SI Plus	Si Negative	Ci	Rank
Antares DLR-H2	1.9394	1.4851	0.4337	2
Electra via Electro club	2.2609	1.1643	0.3399	4
Electra via Electro light	3.4220	0.0973	0.0276	6
IFB hydro genius	0.1189	3.4217	0.9664	1
Yuneec-Flight star E-Spyder	3.3572	0.1353	0.0387	5
Yuneec 430	2.0662	1.3588	0.3967	3

Shows the table 8. Si plus, Si negative, Ci and rank. SI Plus maximum value Electra via Electro light=3.4220 and Minimum value IFB hydro genius=0.1189. Si negative used maximum value IFB hydro genius=3.4217 and minimum value Electra via Electro light=0.0973. Ci maximum value IFB hydro genius= 0.9664 and minimum value Electra via Electro light=0.0276. The final result of ranking IFB hydro genius is got first rank and Electra via Electro light is got lowest ranking.

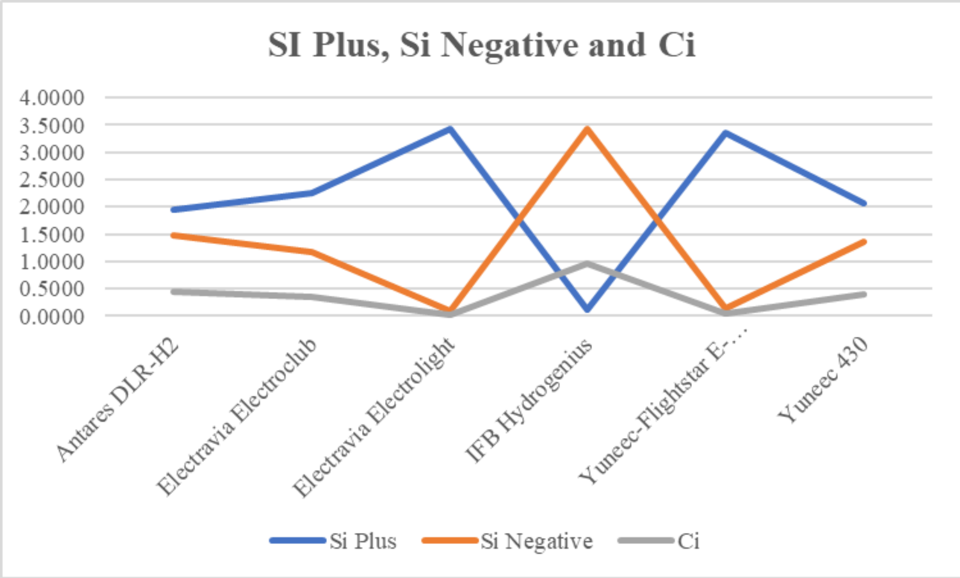

FIGURE 3. Si Plus, Si negative and Ci

Shows the figure 3 Si plus, Si negative, Ci. SI Plus maximum value Electra via Electro light=3.4220 and Minimum value IFB hydro genius=0.1189. Si negative used maximum value IFB hydro genius=3.4217 and minimum value Electra via Electro light=0.0973. Ci maximum value IFB hydro genius= 0.9664 and minimum value Electra via Electro light=0.0276.

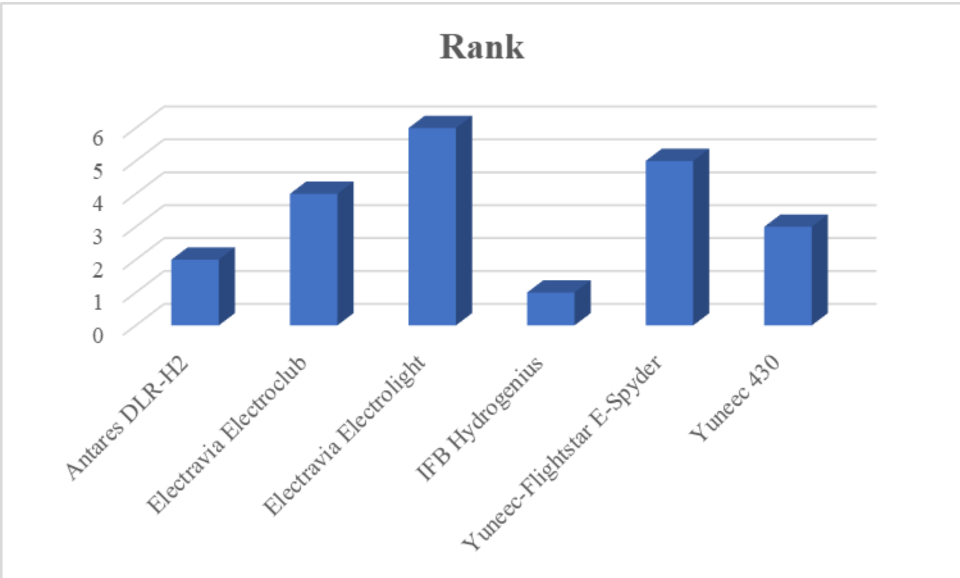

FIGURE 4. Final result of rank

Shows the figure 4. electric aircraft propulsion in using TOPSIS method. IFB hydro genius is got first ranking and Electra via Electro light is got lowest ranking.

5. CONCLUSION

Understanding whatever mechanical topology justifies the "electric propulsion" of Manna can be done well by starting with the models that were used in this article. These models will be more reliable in more practical system configurations for "electric propulsion" as a result of additional study and improvement. The problems of creating all-electric aircraft propulsion are also discussed in this paper along with some of the methods and technology that have been established for electric aircraft propulsion. Although these technologies have enough ability to only slightly increase an aircraft's overall performance, the fuel expenses they can save over the course of the aircraft's lifetime and the number of pollutants they emit can be significantly reduced. The reliability of power electronics, the weight of electric machinery, as well as the storage and transfer for electrical energy, all need to be improved in order to put these principles into practice. The combined TOPSIS-DoE proposal is based on a straightforward analysis of the experimental design, requiring few mathematical calculations. In this work, a polynomial is fitted to empirical observations in multiple regression analysis using the TOPSIS and DoE to find significant components. The cost, time, and number of computations in applying the TOPSIS model were significantly lowered by the regression meta-model. Comparing TOPSIS meta-model application to other MADM approaches like AHP, DEA, ELECTRE, SAW, and GRA, it is incredibly straightforward and simple to implement. The decision maker is known to find these MADM approaches challenging as the number of features to consider grows. For instance, the TOPSIS-DoE programmed used in this work only necessitates six computational steps, whereas the AHP application, which has the same properties and addresses the same industry choice issues, necessitates more computational processes. The TOPSIS-DoE application needs same series of moves irrespective of the number of features in the process, but the AHP assessment requires additional computational steps as more attributes are added to the selection process. IFB Hydrogenous is got first ranking and Electra via Electro light is got lowest ranking.

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