ePropelled Recognized for

2021

Product Leadership

North American
Automotive Electric Motor Industry
Excellence in Best Practices

FROST & SULLIVAN

Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each Award category before determining the final Award recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. ePropelled excels in many of the criteria in the North American Automotive Electric Motor space.

AWARD CRITERIA

Product Portfolio Attributes	Business Impact
Match to Needs	Financial Performance
Reliability and Quality	Customer Acquisition
Product/Service Value	Operational Efficiency
Positioning	Growth Potential
Design	Human Capital

Match to Needs

Legislations for reducing emissions and greenhouse gases in several countries across the world have led to an increase in the use of electric powertrains, with the share of xEVs reaching 12% globally in 2020. Electric motors play a critical role as propulsion units for zero-emission mobility. Motors are inherently more efficient than an internal combustion (IC) engine. However, there is still scope for improvements in electric motor efficiency and material reduction. While the industry's focus was initially on battery technology and on reducing its cost, it is now also on developing electric motors in response to the increased demand. With the electric motor increasingly taking up the role of the primary propulsion unit, its performance and efficiency now represent significant areas of interest for OEMs and suppliers alike.

> *"ePropelled's technology has already been demonstrated in applications such as water pumps, unmanned aerial vehicles (UAVs), electric vertical take-off & landing aircraft (eVTOLs), and electric two-wheelers, other than passenger vehicles (PVs) and light commercial vehicles (LCVs)."*
>
> ***- Bharath Kumar Srinivasan, Sr. Industry Analyst***

Established in 2018 and headquartered in Massachusetts, USA, ePropelled is leveraging its core competency in electromagnetic technology and software control for electric motors and inverter drives. It has several patents in these fields, which allows ePropelled to increase the efficiency of electric motors.

A more efficient electric motor helps reduce battery size, and thereby the cost, for the same vehicle range; with the battery making up 30 to 35% of the cost of an electric vehicle, battery size reduction is crucial. Alternately, such improved motors can also enable cost-efficiency by providing more range for the same battery size. Or the OEM can choose a combination of the two, resulting in both cost reduction and increased driving range.

Reliability and Quality

Reliability and quality are key components to the success of a product or technology and eventually in sustaining the OEM-supplier relationships. A compromise in this area increases warranty claims to the OEM, and prolonged issues could negatively affect the OEM's brand value and hamper the OEM-supplier relationship.

ePropelled's Dynamic Torque Switching (eDTS) system has 3 parts—the motor windings, the switch matrix, and the software—and the company ensures all parts score highly on both reliability and quality. The windings are designed for switching between series, parallel, or different configurations. However, the manufacturing process is the same as that of standard windings used in today's electric motors. This ensures that the component's reliability and quality are not affected.

The switch matrix, while having a custom design, is essentially a semiconductor switch that does not involve moving parts or complex manufacturing processes. It is the only physical part used in this system that is not required in standard motors.

> *"ePropelled's unique solution of altering and optimizing the winding usage maximizes the efficiency potential for a given motor design using software control."*
>
> ***- Bharath Kumar Srinivasan, Sr. Industry Analyst***

The final component is the software, which ensures high-efficiency motor operation with the switch matrix controlled by the inverter drive. Based on the vehicle torque/power demand, the software in the inverter drive decides which winding combination to use from the available switch maps.

In essence, eDTS controls the combination of windings with software and the switch matrix. The electric motor design is standardized, and therefore the reliability of these components is unaffected.

Product Value

In general, OEMs consider powertrain strategies, cost, ease of adoption, and CO2 benefits when adopting technology. However, in the current scenario, with several governments and regulatory bodies imposing stringent restrictions to ensure sustainability, Frost & Sullivan notes that the penalties for not meeting the challenging emission/fuel economy targets also need to be factored in when considering the cost of technologies. Frost & Sullivan analysts recognize that ePropelled's true value to the customer is the efficiency improvements that enable increased driving range and overall cost reduction.

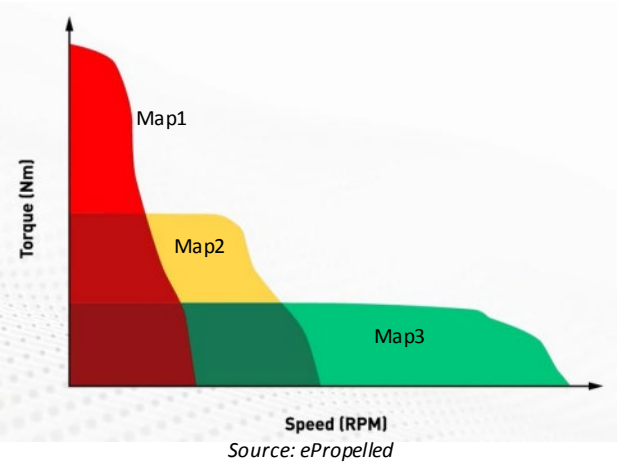
Compared to other systems provided by competitors, the eDTS system can increase the range of the vehicle by 15% due to the increased motor efficiency. Alternately, it can reduce the battery size, resulting in direct cost savings, and enable an associated vehicle weight reduction of 5%, which leads to a further increase in range.

The high efficiency of the motors allows a reduction in the amount of active materials (magnets, copper and electrical steel) used in the motors, and also reduces the overall weight of the motor by up to 10%, which enables further cost reductions. Frost & Sullivan's own research confirms that the above combinations help ePropelled meet the target performance – all while keeping the costs down and price its products competitively.

ePropelled has installed a 60kW eDTS solution on a Tata Tiago EV to demonstrate its capabilities and prove it is ready for today's market. It achieved efficiency improvements of at least 15% over the standard configuration.

Positioning

ePropelled's eDTS solution is a unique offering that combines software and hardware to enhance overall efficiency. It improves the system actively by constantly checking the requirements and status to adjust the switch matrix. It also enhances it passively with its material reductions.



Source: ePropelled

While an electric motor is inherently more efficient than an IC engine, the efficiency maps are similar. Typically, the highest efficiency is for a specific combination of torque and rpm. Moving away from this combination reduces the efficiency of the electric motor.

ePropelled's patented eDTS system allows the electric motor to operate with multiple efficiency maps. Each map is comparable to the output performance of a specific gear when using a gearbox, but with each map retaining the high-efficiency area. Software control enables it to be designed to have as many zones or gears as required within the torque and speed limits.

Frost & Sullivan analysts believe that where eDTS clearly shines above its competitors is in its software, which achieves the above with a standard motor and windings, with the addition of a single component, the switch matrix, allowing for reconfigurable windings. This unique combination results in unmatched performance and efficiency improvements (irrespective of the motor type).

Growth Potential and Customer Acquisition

ePropelled's technology is aimed at electric motors, and while the technology is finding increased automotive usage, it is already being used in other applications. ePropelled's technology allows it to diversify its offerings, thus enabling it to expand its market presence and reduce dependency on a single market. Additionally, eDTS can also be applied to any motor design, from permanent magnet motors to reluctance motors, with the key additions being the switch matrix and the software control for the same.

ePropelled's technology has already been demonstrated in applications such as water pumps, unmanned aerial vehicles (UAVs), as well as passenger vehicles (PVs).

Conclusion

ePropelled's unique solution of reconfiguring and optimizing the winding usage maximizes the efficiency potential for a given motor design using software control. And with material reductions arising from this efficiency improvement with the addition of a switch matrix, it is also highly cost-effective. These enhancements provide an opportunity to reduce battery size, thus saving costs while still maintaining or increasing driving range.

ePropelled is able to nicely offer these benefits today using existing manufacturing processes, instead of offering only potential savings or requiring complex production techniques that have not been fully developed yet. With its strong overall performance, ePropelled earns the 2021 Frost & Sullivan Product Leadership Award.

What You Need to Know about the Product Leadership Recognition

Frost & Sullivan's Product Leadership Award recognizes the company that offers a product or solution with attributes that deliver the best quality, reliability, and performance in the industry.

Best Practices Award Analysis

For the Product Leadership Award, Frost & Sullivan analysts independently evaluated the criteria listed below.

Product Portfolio Attributes

Match to Needs: Customer needs directly influence and inspire the product portfolio's design and positioning

Reliability and Quality: Products consistently meet or exceed customer expectations for performance and length of service

Product/Service Value: Products or services offer the best value for the price compared to similar market offerings

Positioning: Products serve a unique, unmet need that competitors cannot easily replicate

Design: Products feature innovative designs, enhancing both visual appeal and ease of use

Business Impact

Financial Performance: Strong overall financial performance is achieved in terms of revenues, revenue growth, operating margin, and other key financial metrics

Customer Acquisition: Customer-facing processes support efficient and consistent new customer acquisition while enhancing customer retention

Operational Efficiency: Company staff performs assigned tasks productively, quickly, and to a high-quality standard

Growth Potential: Growth is fostered by a strong customer focus that strengthens the brand and reinforces customer loyalty

Human Capital: Commitment to quality and to customers characterize the company culture, which in turn enhances employee morale and retention

About Frost & Sullivan

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The Growth Pipeline Engine™

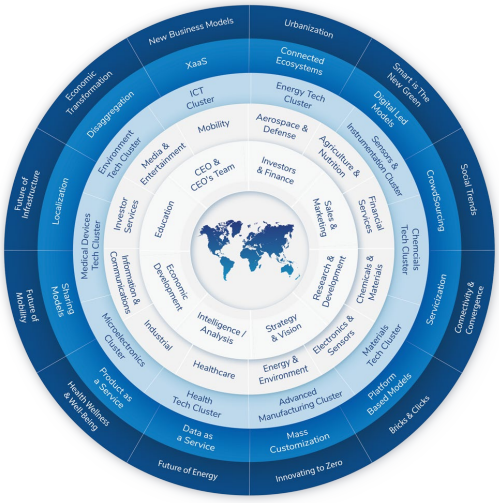
Frost & Sullivan's proprietary model to systematically create ongoing growth opportunities and strategies for our clients is fuelled by the Innovation Generator™.
Learn more.

Key Impacts:

- **Growth Pipeline:** *Continuous Flow of Growth Opportunities*
- **Growth Strategies:** *Proven Best Practices*
- **Innovation Culture:** *Optimized Customer Experience*
- **ROI & Margin:** *Implementation Excellence*
- **Transformational Growth:** *Industry Leadership*

The Innovation Generator™

Our 6 analytical perspectives are crucial in capturing the broadest range of innovative growth opportunities, most of which occur at the points of these perspectives.



Analytical Perspectives:

- Mega Trend (MT)
- Business Model (BM)
- Technology (TE)
- Industries (IN)
- Customer (CU)
- Geographies (GE)