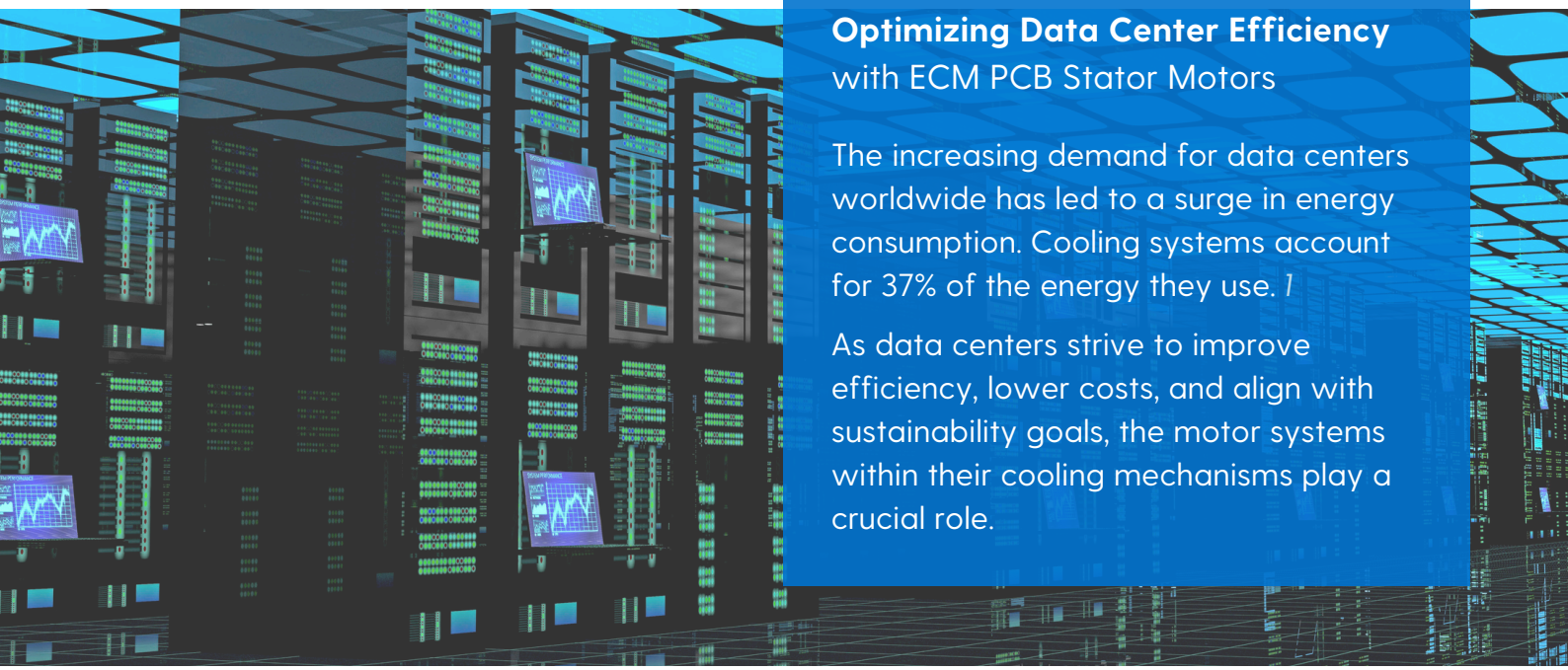
ecm PCB STATOR TECH

CASE STUDY



Optimizing Data Center Efficiency with ECM PCB Stator Motors

The increasing demand for data centers worldwide has led to a surge in energy consumption. Cooling systems account for 37% of the energy they use. *1*

As data centers strive to improve efficiency, lower costs, and align with sustainability goals, the motor systems within their cooling mechanisms play a crucial role.

SUMMARY

Traditional motor solutions often fall short in addressing energy efficiency, weight, modularity, and supply chain diversification. Optimizing for one design criteria may come at the cost of another. With the capabilities of PrintStator and motors designed with ECM's PCB Stator architecture,, customers can strategize their design around many parameters. This case study highlights the impacts of ECM technologies in advancing data center operations.

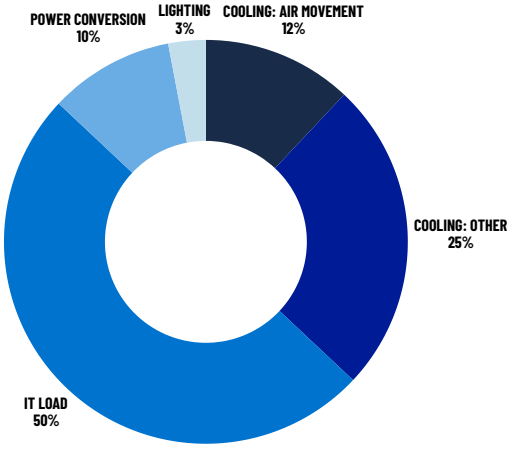


***Figure 1: Breakdown of Data Center Power Usage** i*

CHALLENGES IN DATA CENTER EFFICIENCY

Energy Consumption

Data centers consumed 130 TWh of electricity in 2022, accounting for 2.5% of total U.S. energy usage. This figure is projected to triple by 2030.*ii* Cooling systems alone are responsible for 37% of this energy usage, making them a critical area for efficiency improvements.*iii*

The growth of data centers is outpacing the additional deployment of energy they need from utility companies. Premium efficiency motors, like those powered by ECM's PCB Stator platform, play a critical role in addressing this gap by reducing the overall power demand of cooling systems. Data center designers can optimize their operations within the existing energy provision rather than requesting costly upgrades from utilities. In retrofit scenarios, improved efficiency across arrays of cooling fans can further alleviate the need for additional power, reducing strain on the electrical grid infrastructure.

Reliability and Downtime Costs

Data centers require continuous operation from an uninterruptible power supply (UPS) to maintain uptime and avoid financial losses from downtime. Power outages, which usually stem from the UPS, account for 43% of downtime for data centers.*iv* Traditional motors often fall short in reliability and redundancy, posing significant risks and burdens if unable to properly cool data center electronics.

Material and Resource Constraints

Copper, which is essential for motor manufacturing, faces increasing demand and skyrocketing prices due to electrification trends. The market price of copper has risen from $6,400/ton to $9,000/ton in four years.*v* Motors engineered using ECM's PCB Stator design use up to 80% less copper than a traditional iron-core, radial-flux motor by eliminating winding inefficiencies and harnessing the advancements of PCB manufacturing capabilities.*vi*

Design and Operational Inefficiencies

- Off-the-shelf motor solutions limit customization, leaving many businesses unable to optimize motors for specific operational conditions.

- Many traditional motors require active cooling systems, increasing weight and size while reducing overall efficiency.
- Inefficient heat dissipation in conventional motors often leads to higher operating temperatures, which risk damage to data center servers.

Speed, Vibration, and EMI Management

Data centers rely on precise speed control of cooling fans for optimal performance and to reduce unnecessary power expenditures. They must also manage system vibrations and electromagnetic interference (EMI) to protect sensitive equipment.[vii] During operation, the copper windings of traditional motors vibrate and create unwanted electromagnetic interactions. These forces can be disruptive and lead to noise and mechanical wear. PCB Stator technology designed by ECM substantially reduces motor EMI and vibrations by embedding the copper windings directly into the PCB substrate.

Shipping and Maintenance Cost

The shipping cost and transportation emissions of electric motors depend on their weight and volume. Replacement and maintenance in the field requires more labor for heavier and bulkier motors. Motors built using ECM's PCB Stator platform are substantially lighter than traditional motors, due to eliminating unnecessary copper weight and cooling elements. The thinner package of these motors also allows for easier transportation and alleviates complex maintenance situations.

OVERCOMING CHALLENGES IN DATA CENTER EFFICIENCY

ECM vs. Competitors

A comparative analysis of ECM's 3.7kW PCB Stator motor against a competing axial flux PCB Stator air-core motor and a competing radial flux induction motor highlights ECM's advantages across key performance metrics:

Metric	ECM Axial Flux PCB Stator Motor	Competing Axial Flux PCB Stator Motor	Competing Radial Flux Induction Motor
Power	3.7kW	3.7kW	3.7kW
Speed	1800 RPM	1800 RPM	1800 RPM
Efficiency	IE5	IE5	IE5
Length (mm)	**138**	221	347
Diameter (mm)	362	417	303
Weight (kg)	**22.2**	41.5	45.4
kW per kg	**0.17**	0.09	0.08
kW per m³	**261**	114	148
Air Shipping Cost*	**0.50**	0.95	1.00
Ground Shipping Cost*	**0.35**	0.95	1.00
Ocean LCL Cost*	**0.41**	0.93	1.00

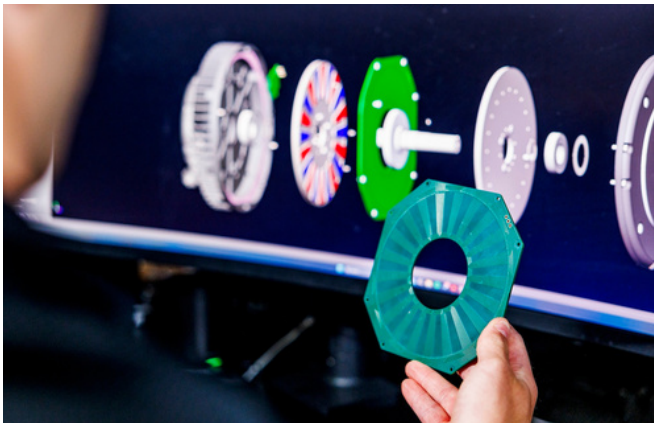
Table 1: Side-by-side comparison to competing axial flux air core PCB Stator motor and competing radial flux motor

***Note:** Shipping costs are shown as percentages relative to the competitive radial flux motor, set as the 100% baseline. For example, ECM's air shipping cost is 50%, while the competitive axial flux PCB Stator motor's is 95%.

UNIQUE ADVANTAGES OF MOTORS DESIGNED WITH ECM'S PCB STATOR ARCHITECTURE

Customizability with PrintStator

ECM's PrintStator software enables businesses to design motors tailored to their specific operational needs, ensuring optimal performance and efficiency. Businesses can design their motors around their systems rather than adapting their systems to fit the motor.



Lightweight and Compact Design

- Motors using ECM's PCB Stator design weigh nearly 50% less than competing solutions due to the lack of iron in the core and the absence of active cooling systems, enabled by patented thermal heat pipe technology.
- A key benefit of ECM's PCB Stator technology is its lightweight design. Traditional electric motors can easily exceed the safe manual handling weight limits defined by safety regulations. According to many occupational health and safety guidelines, 25 kg (approximately 55 lbs) is the maximum weight one person should lift without mechanical assistance. Exceeding this threshold increases the risk of injury and often necessitates multiple personnel or lifting equipment, driving up labor costs.[viii]
- Compact form factors reduce shipping costs and improve ease of installation.

Increased Energy Flexibility for Data Centers

Motors developed with ECM's software and PCB Stator hardware enable data centers to maximize the energy available within their allocated capacity. This is particularly valuable in regions where utilities face delays in deploying new power infrastructure. Improved energy efficiency across cooling systems ensures that data centers can expand operations without incurring additional power upgrade requests or delays, allowing for faster scalability.

Continuous Operation

Motors designed through ECM's PCB Stator technology are designed for robust, continuous operation, ensuring high reliability and minimizing downtime risks in mission-critical environments like data centers.

Efficient Heat Dissipation

ECM's patented thermal management solutions effectively dissipate heat without additional cooling systems, improving reliability and energy efficiency.

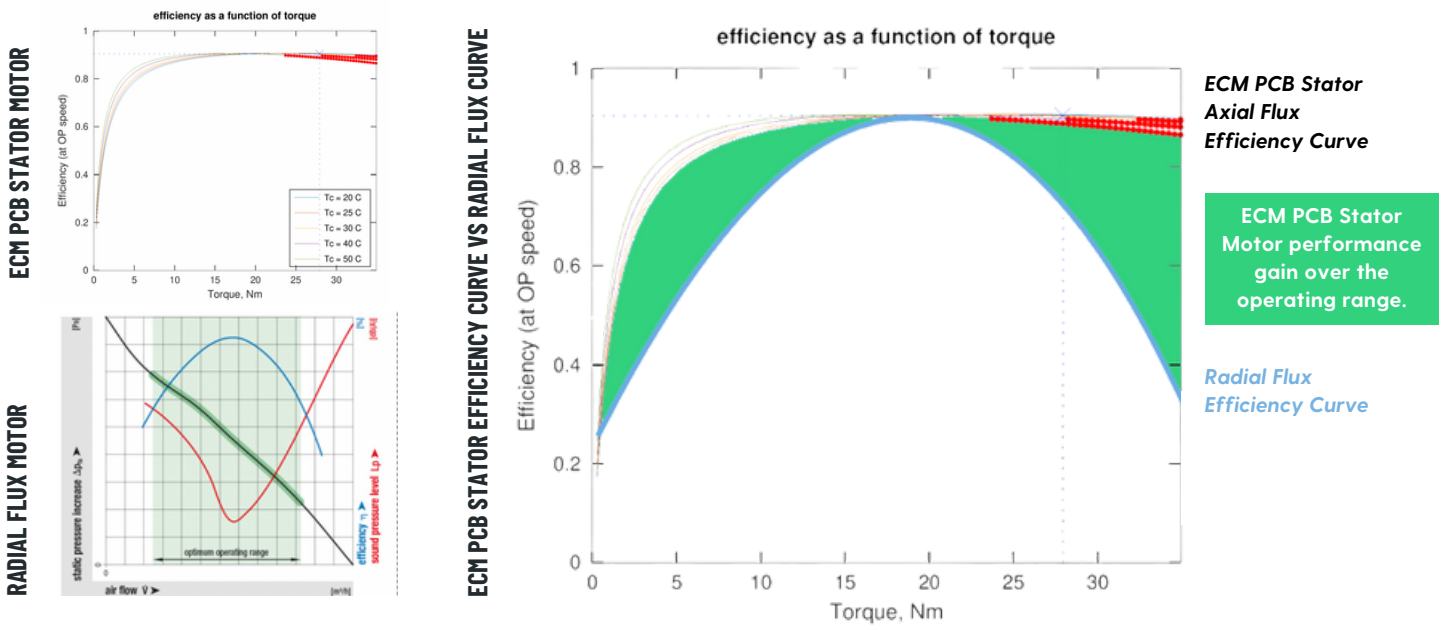


Figure 2: ECM PCB Stator Axial Flux vs. Radial Flux Efficiency Comparison

Precision and Vibration Management

- Motors engineered with ECM's PCB Stator architecture provide precise speed control for optimal data center performance.
- Enclosed composite structures in ECM coils reduce acoustic noise and vibrations caused by forces acting on conventional stator windings.
- ECM's zero-cogging motors eliminate mechanical excitation of connected structures, addressing a key source of noise and vibration in traditional motors.

Ease of Maintenance

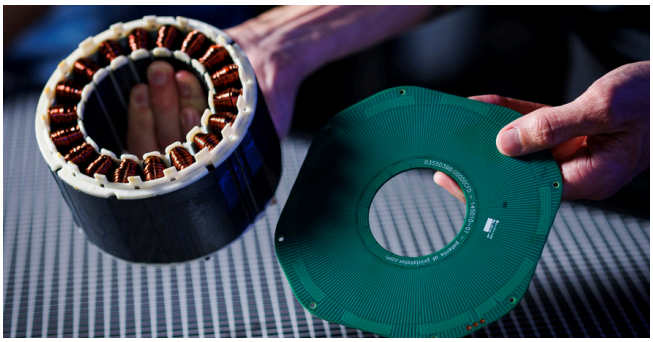
- ECM's lightweight PCB Stator solutions enable easier access and handling during maintenance.
- Modular designs allow for single-component replacements, reducing downtime and labor costs.

Flat Efficiency Curve *(2)*

Motors designed with ECM's platform maintain high efficiency across a wide range of operating conditions, optimizing performance at off-peak times and reducing energy consumption.

Sustainability

- With ECM's flexible customization, motors can be designed to exact operating points and curves, meaning less power wasted during operation.
- ECM's PCB Stator design uses up to 80% less copper and other raw materials than traditional motors, addressing supply chain constraints and reducing environmental impact.



- Motors built with ECM's architecture reduce building structural requirements, specifically when used in fan arrays in data centers and other air-moving applications.
- ECM's rotor design allows for easy recycling of magnets, supporting sustainability goals.
- As ECM's technology removes the requirement for traditional motor winding lines, more businesses are taking control of their supply chains and assembling the motors in their facilities alongside their current production lines, leading to better control and eliminating shipping costs of heavy motors between facilities.

CONCLUSION

The rapid growth of data centers demands innovative solutions to address rising energy costs, the divergence between energy supply growth and demand growth, environmental pressures, and supply chain challenges. Motors built with ECM's PCB Stator technology offer a compelling alternative to traditional motor systems by delivering superior efficiency, sustainability, and adaptability. By enabling data centers to operate efficiently within existing utility provisions, ECM's technology not only reduces energy costs but also support the sector's rapid expansion. With advancements in customization, reliability, heat dissipation, and vibration management, ECM engineered PCB Stator motors are the ideal choice for modern data centers.

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