

REETHink: Driving Magnetics Beyond Rare Earths

Exploring Rare-Earth-Free Motor Technologies for Next-
Generation EV Traction

Offering:
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Problem Statement -

Electric vehicles depend heavily on **rare-earth permanent magnets** (NdFeB, Dy, Tb) for high-performance traction motors. These magnets enable unmatched **torque density**, **compactness**, and **efficiency**, making them the industry standard. However, this reliance creates a single-point dependency on a limited class of materials. There is a pressing need to investigate alternative motor technologies that can reduce or eliminate this dependence.

Challenges - Environmental Impact | Market Risks | Strategic Risks

Approach -

- Key performance requirements for an EV motor.
- Scouted published inventions on rare-earth-free motor technologies, focusing on ferrite-based and magnet-free designs.
- Selected marketed EV motors as baseline benchmarks.
- Evaluated all designs on standardized metrics: torque, power, efficiency, thermal stability, mechanical strength.
- Differentiated technologies by fit: “High Fit” and “Medium Fit” based on closeness to baseline performance and practical applicability.

SHORTLISTED SOLUTIONS

S. No.	Technology	Torque (Nm)	Power (kW)	Efficiency (%)
BASELINE		<u>215</u>	<u>106</u>	<u>~95</u>
<u>TESLA*</u>		<u>440</u>	<u>220</u>	<u>97</u>
<u>BYD*</u>		<u>310</u>	<u>150</u>	<u><89</u>
1	<u>Switched Reluctance (SR) Motor</u>	<u>340 – 400</u>	<u>50 – 70</u>	<u>92.2 – 95.4</u>
2	<u>Ferrite PMSM — evaluated under driving cycles</u>	<u>270</u>	<u>80</u>	<u>92.8 – 94.1</u>
3	<u>Spoke-type PMSM with ferrite magnets — skewed rotor slots</u>	<u>270</u>	<u>80</u>	<u>95</u>
4	<u>Induction machine</u>	<u>235.6</u>	<u>37</u>	<u>91.76</u>
5	<u>PMASynRM with ferrite magnets</u>	—	<u>37</u>	<u>96.8</u>

- * Tesla and BYD serve as standards for the EV motors in the market as motors containing rare earth metals.
- Tata Nexon EV is used as the baseline as it is a top-selling EV with a PMSM using NdFeB magnets, making it ideal for assessing rare-earth dependence and comparing rare-earth-free motor alternatives.

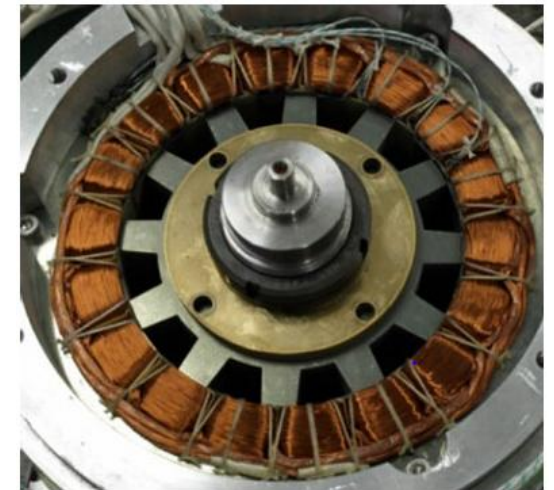
Baseline / Benchmark Data	High Fit	Medium Fit
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1. Development of a Rare-Earth-Free Switched Reluctance (SR) Motor

Technology Brief – A **magnet-free design** that produces torque through rotor alignment with energized stator poles. With only copper windings in the stator and a steel rotor, it is simple, robust, and **immune to demagnetization**.

Although SRMs usually face torque ripple and noise issues, but this tech introduces **optimized geometry and control strategies** to significantly improve performance.

Demonstrated rare-earth-free viability, achieving Prius-class output and efficiency through advanced magnetic design and material optimization, proving SR motors can rival NdFeB PMSMs in practical EV use.



Developed Switched
Reluctance motor

Torque (Nm)	340-400
Efficiency (%)	92.2 – 95.4
Power (kW)	50-70
Demagnetization / Temperature Stability	No Magnets
Mechanical Strength	Robust, Low Noise
Torque Ripple / Clogging	Improved > Conventional SRM

Technology developed by - Department of Electrical and Electronic Engineering, Tokyo Institute of Technology, Tokyo

2. “Rare-Earth-Free Electric Motor Design for EV Traction Comparing Overall Vehicle Efficiency Considering Driving Cycle”

- **Ferrite-based CFSM (Concentrated Flux Synchronous Machine)** developed for EV traction.
- **Cost Advantage:** Reduces motor cost by eliminating high-priced rare-earth magnet materials.
- **Outcome: Strong second-tier candidate**, validated under driving cycle performance.

Torque	270 Nm
Efficiency	~92.8 %
Power	80 kW
Mechanical Strength	Robust under high current and low-temperature conditions.
Torque Ripple / Clogging	~8.8 - 38.9%

[Source](#)

3. “High Performance Low Cost Electric Motor for Electric Vehicles Using Ferrite Magnets”

- **Ferrite spoke-type PMSM** with skewed rotor slots for ripple reduction.
- **Cost advantage:** Uses cheap ferrite magnets, rotor support with stainless steel instead of exotic alloys.
- **Outcome:** Strong torque & efficiency, a most **promising second-tier candidate**.

Torque	270 Nm
Efficiency	~95 %
Power	80 kW
Mechanical Strength	Stable upto 15000 rpm
Torque Ripple / Clogging	Reduced by 2-3%

[Source](#)

4. “Comprehensive Comparative Study on Permanent-Magnet-Assisted Synchronous Reluctance Motors and Other Types of Motor”

- **Standard asynchronous machine design with 48 stator slots and 44 rotor bars.**
- **Cost Advantage – Lower** than permanent magnet induction motors.
- **Outcome: Viable for low-mid power EVs.**

Torque	235.6
Efficiency	91.76 %
Power	37 kW
Mechanical Strength	1500 rpm
Torque Ripple / Clogging	11.23%

[Source](#)

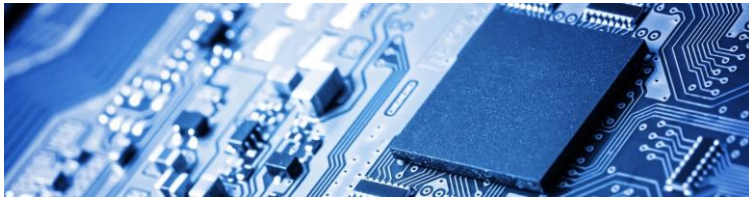
5. “Experimental Evaluation of a Rare-Earth-Free PMASynRM With Ferrite Magnets for Automotive Applications”

- **Ferrite-based PMASynRM prototype**, experimentally validated.
- Motor designed to prevent irreversible demagnetization and withstand mechanical stress up to 10,000 rpm.
- **Outcome:** High efficiency & stability; **promising second-tier design**, bridging lab and real-world.

Torque	N/A
Efficiency	96.8 %
Power	37 kW
Mechanical Strength	Stable upto 10,000 rpm
Torque Ripple / Clogging	Moderate

[Source](#)

Hourglass is a research partner helping companies turn emerging trends into actionable growth strategies



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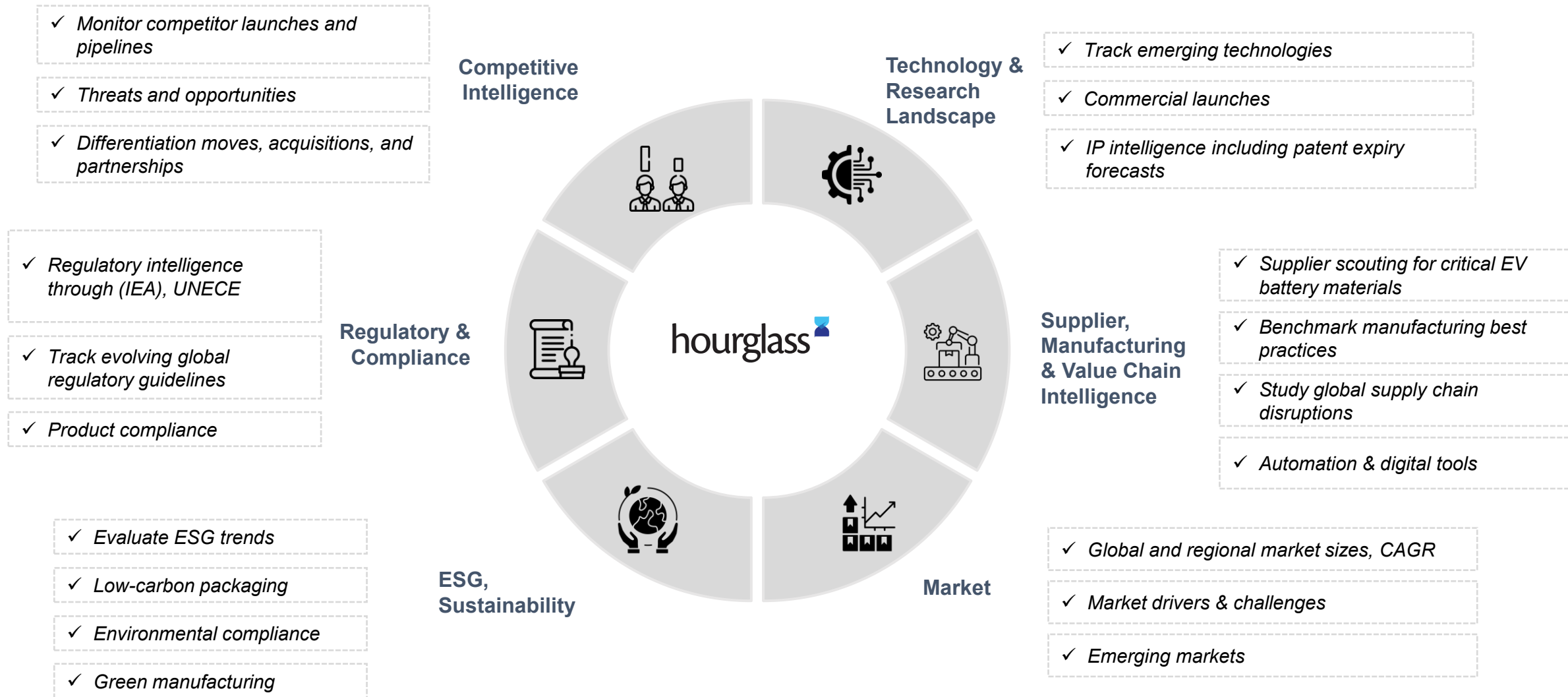


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