

AAKRUTI Global

Shaping Imagination 2024



Theme: Green Energy generation, transmission and storage

Team: Delta

Team ID: AG24-1400610

College: IIT INDORE

Product: HexaEnergy Tyre



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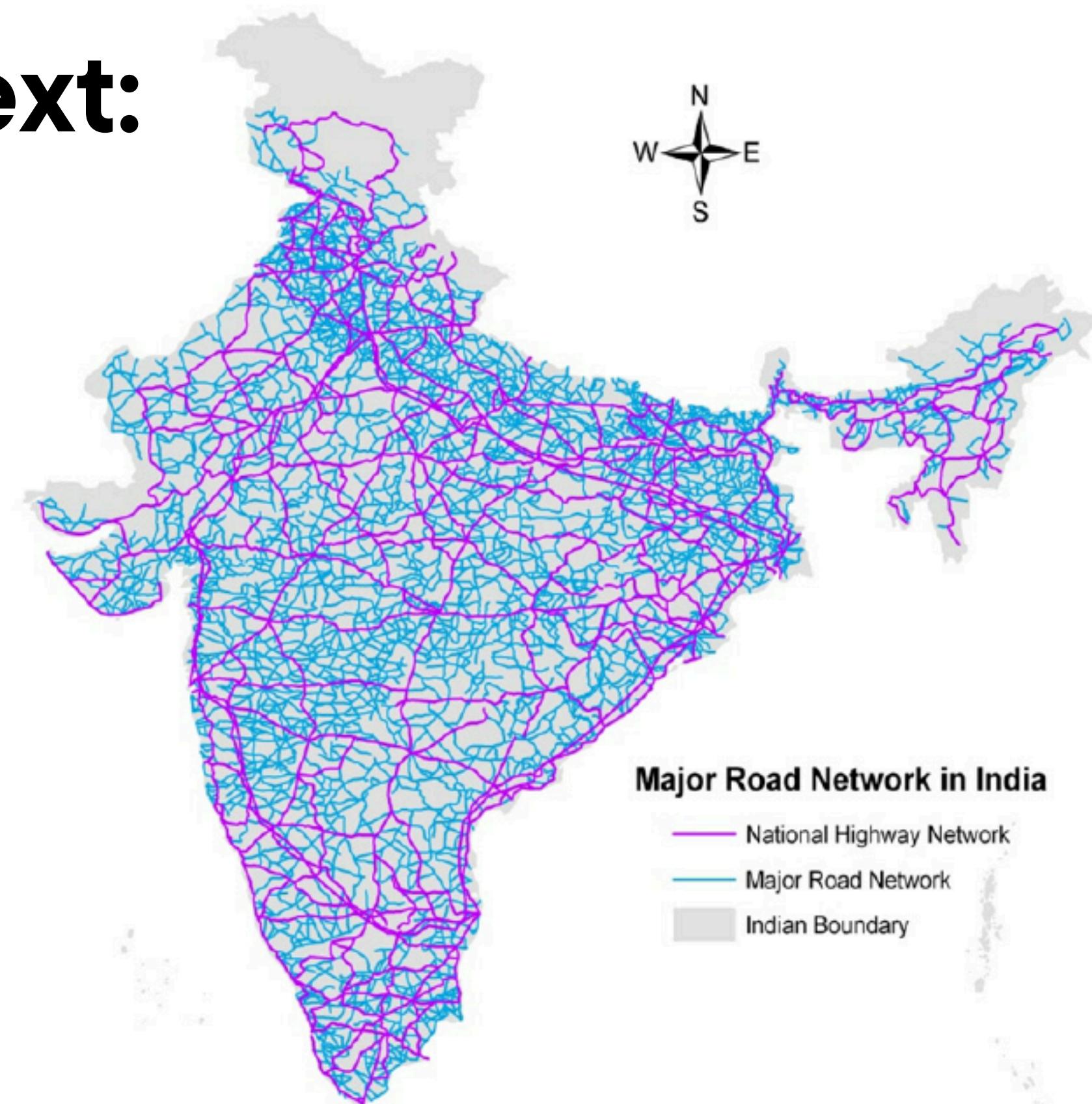


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Within in the Indian Context:

- High Traffic Density
- Suboptimal Road Conditions
- Rapid Expansion of Roadways
- Eco-friendly focus



- Traditional tires mainly serve to give traction and movement
- There is a huge loss of energy in form of heat and friction
- Current challenge lies in harvesting a secondary source of energy from vehicle components in real time
- Tires being in constant motion, have huge potential for this



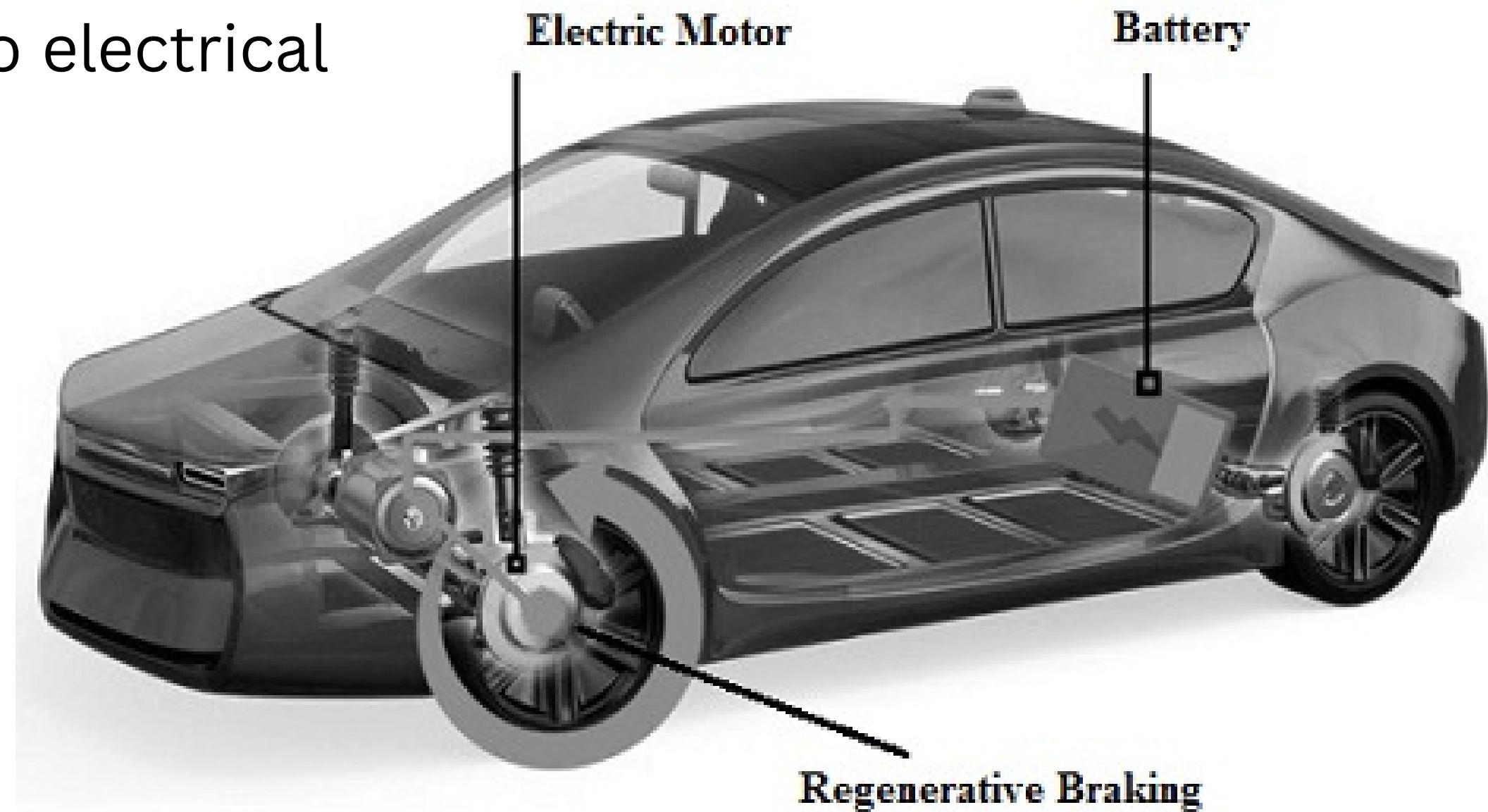
Market Research Findings

- Drivers and Automotive manufacturers are seeking for energy efficient, low maintenance and easy-to-integrate solution
- Comfort, Durability and Quiet operation
- Market survey highlights a gap for energy generating tires



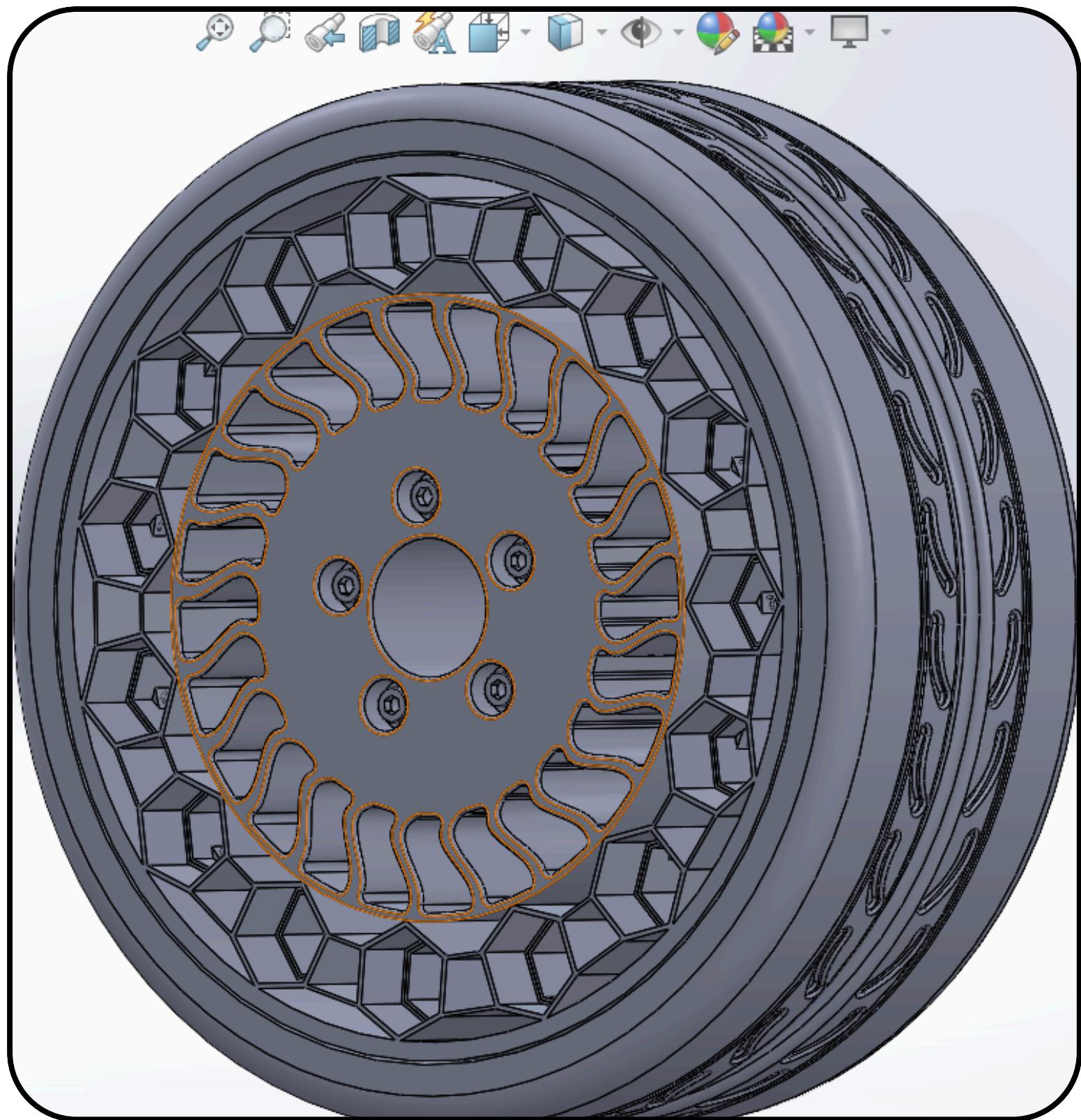
One of the current solution which focus on sustainable energy production is **Regenerative Braking System** which converts KE to electrical energy

- Highly dependent on Driving Conditions
- Limited Energy Generation
- High maintenance
- No continuous Generation



HexaEnergy Tires

- Hexagonal internal structure enhances both mechanical stability and energy conservation
- Effective Load distribution and Efficient usage of material
- Non pneumatic tires and mechanical efficiency guarantees lower maintenance, longer life span
- Larger surface area for better energy capture



HexaEnergy Tires

- TENG integrated tire addresses the need for continuous energy generation
- High power density from small displacement
- Light-weight and flexible integration to the hexagonal structure within tires
- Capable to power auxiliary electronic systems, sensors and HVAC system



Product Design Specifications

Components Required

- Slip Ring
- TENG
- HoneyComb Frame (TPE)
- Central Frame

Technical Requirement

HexaEnergy Tyre utilizes the principle of **Triboelectric Nanogenerators** to convert mechanical energy into electrical energy.



Design Process

Why HoneyComb structure?

- Efficiently use the space
- Higher fatigue resistance
- Aesthetics

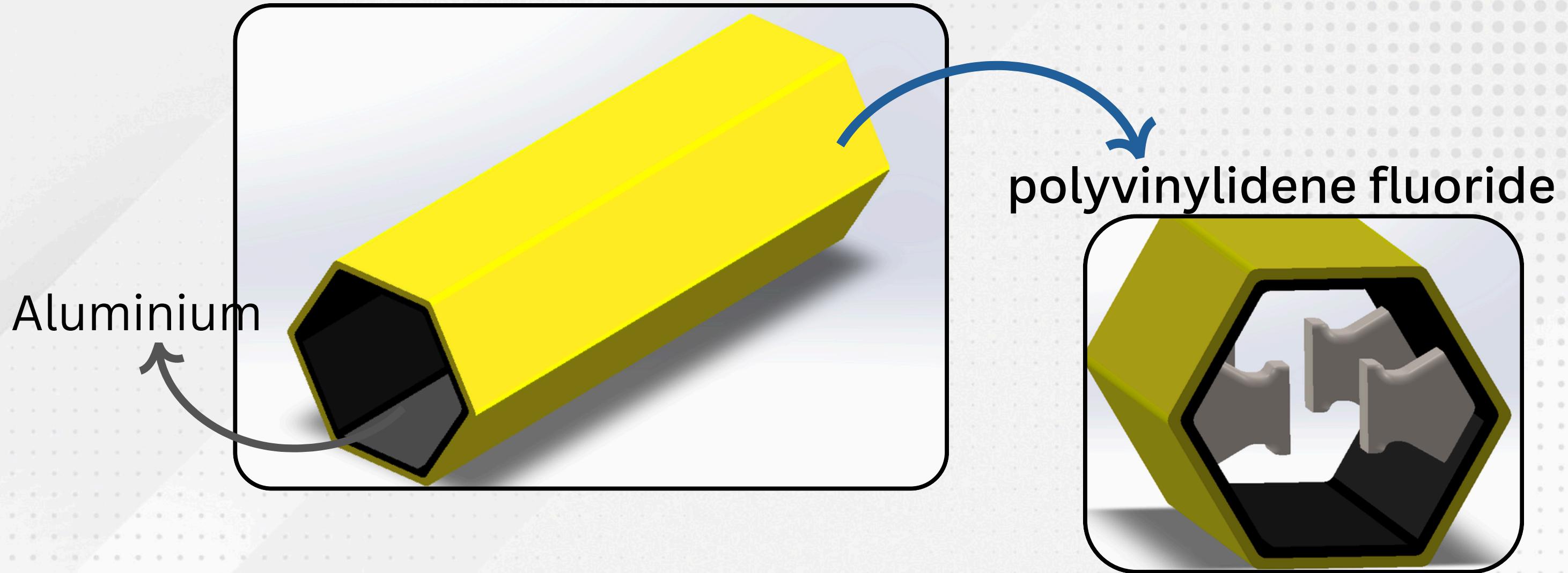


Why S-Shaped section?

This provides the Structural compliance to the tyre as the stiffness is increased by the TENG



TENG:



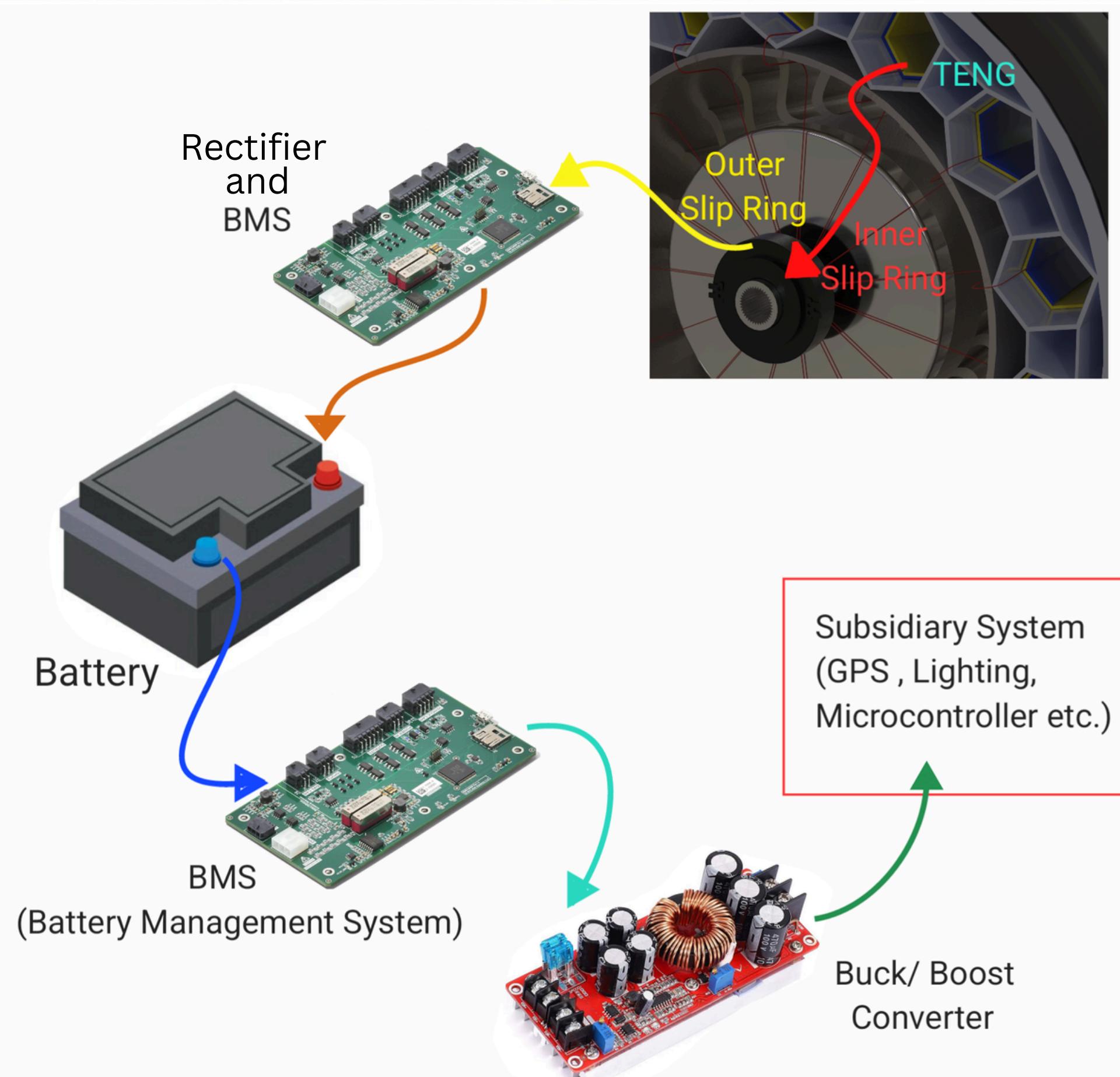
- Compression of the TENG occurs due to the impulses and self weight.
- Both the layers comes in contact and again separates.
- It Induces electricity due to electron transfer between the layers of triboelectrically positive(Aluminium) and triboelectrically negative surface(PVDF).
- Stopper mechanism for reduction of fatigue.

Energy Transmission:

Power is transmitted through a slip ring mechanism to avoid tangling of wires.
Slip Ring consists of 2 rings:

- **Inner Ring:**
 - Rotating Contact
 - Attached to TENG components embedded within tire
 - Generated power transferred from TENG to slip ring system
- **Outer Ring:**
 - Stationary Contact
 - Attached to Knuckle
 - Transfers Generated power to Storage Battery

Transmission from TENG to Subsidiary System

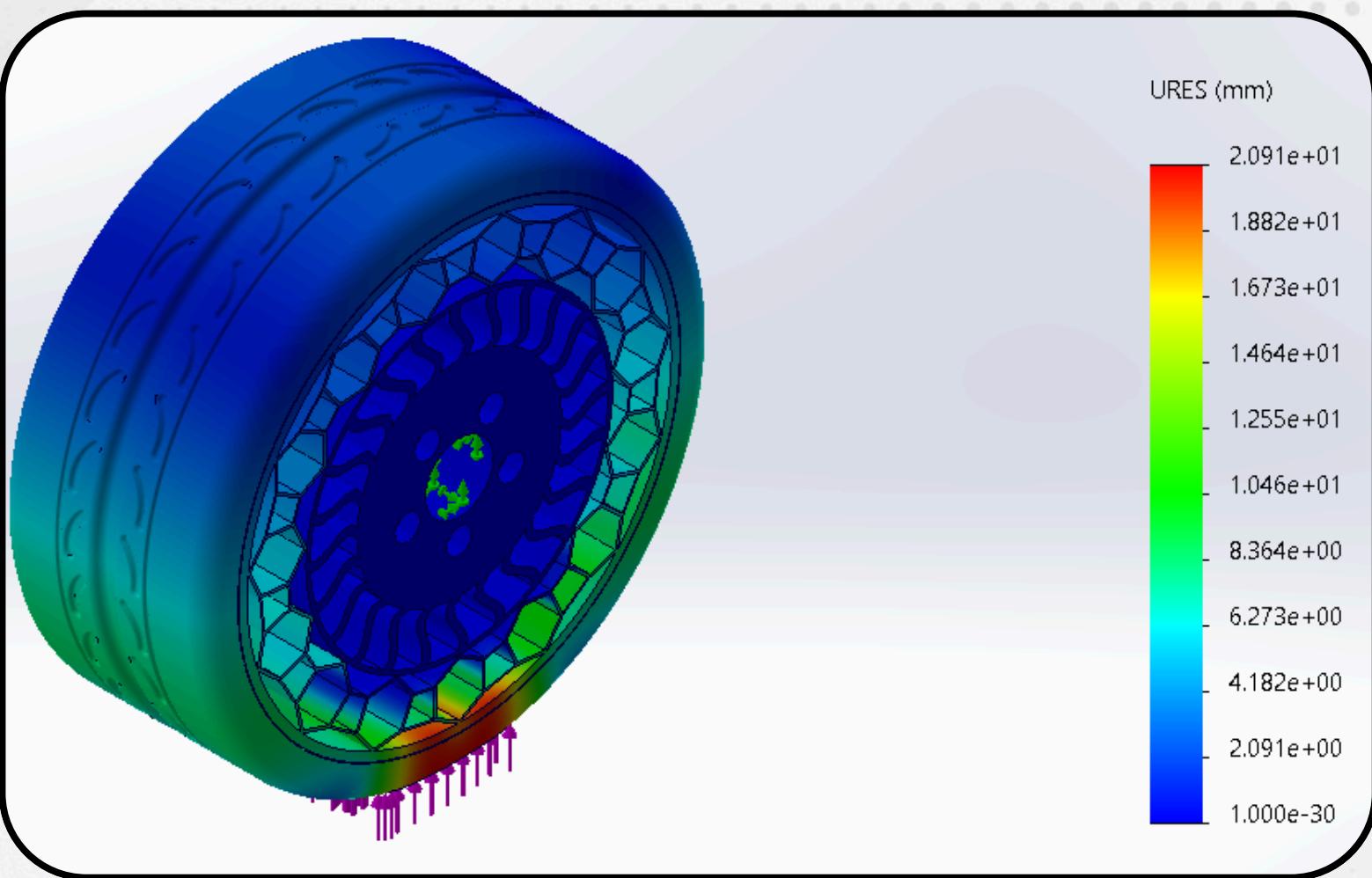


Product Simulation

FORCE APPLIED: 17000N
FIXED AT THE CENTER

MATERIALS USED:

1. TPE FOR THE HONEYCOMB STRUCTURE
2. STAINLESS STEEL FOR THE CENTRAL FRAME
3. VULCANISED RUBBER FOR OUTER SURFACE



OUTPUT DISPLACEMENT: 21 mm

TPE: THERMOPLASTIC ELASTOMERS

SUSTAINABILITY IMPACT TEST

The image shows a CAD application interface with two main windows. The top window is titled "Find Similar Material" and displays a table of material properties for various steels. The bottom window is titled "Environmental Impact" and shows four circular icons representing different material options, each with a percentage reduction from the original. A third window, partially visible on the right, shows a similar material selection table for rubber materials.

Find Similar Material

Materials	Material Class	Elastic modulus N/m ²	Poisson's ratio N/A	Shear modulus N/m ²	Thermal expansion /K	Mass density kg/m ³	Thermal conduct W/(m·K)
Alloy Steel (SS)	Steel	2.1e+11	0.28	7.9e+10	1.3e-05	7700	50
1023 Carbon Steel She...	Steel	2.05e+11	0.29	8e+10	1.2e-05	7858	52
201 Annealed Stainless ...	Steel	2.07e+11	0.27	7.7e+10	1.7e-05	7860	16.3
A286 Iron Base Superal...	Steel	2.01e+11	0.31	7.7e+10	1.65e-05	7920	15.1
AISI 1010 Steel, hot rolle...	Steel	2e+11	0.29	8e+10	1.22e-05	7870	51.9
AISI 1015 Steel, Cold Dr...	Steel	2.05e+11	0.29	8e+10	1.2e-05	7870	52
AISI 1020	Steel	2e+11	0.29	7.7e+10	1.5e-05	7900	47
AISI 1020 Steel, Cold Rol...	Steel	2.05e+11	0.29	8e+10	1.17e-05	7870	51.9
AISI 1035 Steel (SS)	Steel	2.05e+11	0.29	8e+10	1.1e-05	7850	52
AISI 1045 Steel, cold dra...	Steel	2.05e+11	0.29	8e+10	1.15e-05	7850	49.8
AISI 304	Steel	1.9e+11	0.29	7.5e+10	1.8e-05	8000	16
AISI 316 Annealed Stainl...	Steel	1.93e+11	0.3		1.6e-05	8000	16.3
AISI 316 Stainless Steel ...	Steel	1.93e+11	0.27		1.6e-05	8000	16.3
AISI 321 Annealed Stainl...	Steel	1.93e+11	0.27		1.7e-05	8000	16.1
AISI 347 Annealed Stainl...	Steel	1.95e+11	0.27	7.7e+10	1.7e-05	8000	16.3
AISI 4130 Steel, anneale...	Steel	2.05e+11	0.285	8e+10		7850	42.7
AISI 4130 Steel, normaliz...	Steel	2.05e+11	0.285	8e+10		7850	42.7
AISI 4340 Steel annealed	Steel	2.05e+11	0.285	8e+10	1.23e-05	7850	44.5

Environmental Impact

Manufacturing Process: Milled
Units: SI - N/m² (Pa)

Material Financial Impact: Selected Original

Environmental Impact Test Results:

- Selected vs Original: -20%
- Selected vs Original: -26%
- Selected vs Original: -21%
- Selected vs Original: -66%

Accept Edit Cancel Help

Materials

Materials	Material Class	Elastic Modulus in X N/m ²	Poisson's Ratio in XY N/A	Mass Density kg/m ³	Tensile Strength in X N/m ²
Natural Rubber	Rubber	10000	0.45	960	2e+07
PE High Density	Plastics	1.07e+09	0.4101	952	2.21e+07
PE Low/Medium Density	Plastics	1.72e+08	0.439	917	1.327e+07
Polybutadiene (PB)	Plastics	2.07e+09		970	2.7e+07
Polyethylene Cross-Linked	Plastics	6e+08		950	1.8e+07
PE High Density Film	Plastics	1.86e+09		950	3.1e+07
PE Low Density Film	Plastics	1.29e+09		918	1.7e+07
PP Homopolymer	Plastics	1.79e+09		933	3.3e+07
Rubber	Other Non-metals	6100000	0.49	1000	1.37871e+07
Water	Other Non-metals			1000	
SANTOPRENE	Rubber			980.9	
SBR	Rubber	940	2.454e+08		

Environmental Impact

Manufacturing Process: Custom
Units: SI - N/m² (Pa)

Material Financial Impact: Selected Original

Environmental Impact Test Results:

- Selected vs Original: -99%

Accept Edit Cancel Help

Power Generation

Displacement (d): 21 mm (21×10^{-3} m)

Force (F): 17000 N

Frequency (f): 300 Hz (20×15 Hz)

Permittivity of PVDF (ϵ): 2.1×10^{-11} F/m

Surface Charge Density (σ , Al-PVDF): 25 $\mu\text{C}/\text{m}^2$

Contact Area (A): $9558 \text{ mm} \times 6 = 57348 \text{ mm}^2 = 57.348 \times 10^{-3} \text{ m}^2$

Formulae

$$C = \epsilon \cdot A / d$$

$$Q = \sigma \cdot A$$

$$V = Q / C$$

$$P = [(C \cdot V^2) / 2] \cdot f$$

Final power generated : 5.4 W



Product Reflection

Benefits of the Product

- Harness vehicle's self-weight and road deformities to generate electricity.
- Electricity is used to run microcontrollers, lighting, and other subsidiary systems.
- Reduced reliance on external power sources.
- Airless tyres: Easy for Maintenance over traditional tyres.



Constraints:

- Wear and Tear of Tires
- Complexity in Manufacturing
- Energy Storage and Management
- Integration with Existing Systems



Impact of HexaEnergy Tyres

1. Optimized Energy Usage

- Efficient power generation , minimal waste and energy loss

2. Reduced Environmental Impact

- Eco-friendly materials and processes ; lower carbon footprint

3. Educational and Economic Opportunities

- Skill development , innovation and job creation in emerging sectors

4. Encouragement of Technological Advancements

- Drives innovation in energy harvesting and development of new technologies

Sustainability

- Fuel Consumption Reduction: TENG tires generate electricity from movement, reducing the need for engine power and saving fuel.
- Lower Carbon Emissions: By using less fuel, TENG tires help decrease greenhouse gas emissions, contributing to cleaner air.
- Energy demand reduced, lowering environmental impact.
- Stainless Steel (100% recyclable) and AISI 1020 steel are recyclable materials.
- Aluminum: reduction of 95% energy required to produce new aluminum.
- Polyvinylidene fluoride (PVDF) is easily recyclable without much loss of its mechanical properties.

Bill of Materials

Component	▼	Price/unit (Rs.)	▼	No. of Units	▼	Total Price (Rs.)	▼	Link	▼
Tyre:									
Vulcanized rubber		100/kg		5.82 kg		582		https://www.indiamart.com/kgn-rubber-enterprises/rubber-seal.html?utm_source=Enqmail&utm_medium=Email&utm_campaign=New%20Product%20Alert&utm_content=Tyre%20Components&utm_term=Vulcanized%20rubber	
TPE (Thermoplastic Elastomer)		150/kg		2.85 kg		427.5		https://www.indiamart.com/proddetail/thermoplastics-elastomer-tpe-9474966612.html	
AISI 1020 Steel		54/kg		12.69 kg		685.26		https://www.indiamart.com/proddetail/sae-aisi-1020-steel-round-bar-7227991088.html	
Slip Ring		4500/unit		1 unit		4500		https://www.indiamart.com/proddetail/wind-turbine-slip-ring-13865987212.html	
M18 Nut-Bolts		17/unit		5 unit		85		https://www.indiamart.com/proddetail/18mm-ms-hex-nut-bolt-14090354591.html?srsltid=14090354591	
TENG:									
Aluminum		270/kg		808.65 g		218.7		https://www.indiamart.com/proddetail/aluminum-marine-products-2850674554673.html	
polyvinylidene fluoride(PVDF)		800/kg		424.8 g		339.84		https://www.indiamart.com/proddetail/ptfe-sheet-2854676884897.html	
Stainless Steel (for Stopper)		210/kg		107.55 g		22.47		https://www.indiamart.com/proddetail/ss-304-wire-20171194955.html	
Net Price						6860.77			

Business Plan

Scenario	%Margin	Total Sales (in K)	Total Revenue (in L)	Total Cost (in L)	Profit (in L)
Partnership	0.15	39.1	5471.8104	4559.842	911.9684
Inflation	0.05	34	4996.0008	4163.334	832.6668
Marketing	0.1	37.4	5233.9056	4361.588	872.3176
Manufacturing efficiency	0.2	34	3806.4768	3172.064	634.4128

By 2028, Indian truck tire market may reach a demand of 34 million units.

Market Share (just entered) = 0.1%

Annual Sales = 0.34 lakh

Cost per unit(BOM, storage, transport etc) = **11662 INR**

Selling Price per unit (profit 20%) = **13995 INR**

Total Revenue = **47.5 Cr**

Total Cost =**39.6 Cr**

Profit = 7.9 Cr

Thank you!!