

## Rare Earths Required

NEXT GENERATION PERMANENT MAGNET MOTOR

**Tesla's revolutionary new MAGNET  
will ruin China's Rare Earth  
leverage over the world #17**

0g

Rare Earth 1

0g

Rare Earth 2

0g

Rare Earth 3

Lower Cost & Higher Efficiency Drive Units Using Zero Rare Earths

T S L A L I V E

First published March 2023

# Tesla's new magnet is revolutionary

- ✓ Tesla's Investor Day 2023 announced a new magnet for use in their permanent magnet motors
- ✓ It is revolutionary because it achieves **the following 3 things in combination:**
  1. It uses zero rare earth elements and
  2. It is less costly to make implying rare earth is not substituted with other costly elements and
  3. It has >>higher efficiency<<
- **Note:** Higher efficiency implies a magnet with higher magnetic strengths than a magnet with rare earth elements say  $\text{Nd}_2\text{Fe}_{14}\text{B}$  at 30 to 55 MGOe **This is new and revolutionary**
- Tesla cannot lie about this at an official event for investors

## Used abbreviations:

MGOe is mega gauss-oersteds, measures magnetic strength

Nd is Neodymium, Fe is ferrum=iron, B is Boron

Source and attribution: <https://www.youtube.com/watch?v=Hl1zEzVUV7w&t=2982s>

## Rare Earths Required

NEXT GENERATION PERMANENT MAGNET MOTOR



0g

Rare Earth 1

0g

Rare Earth 2

0g

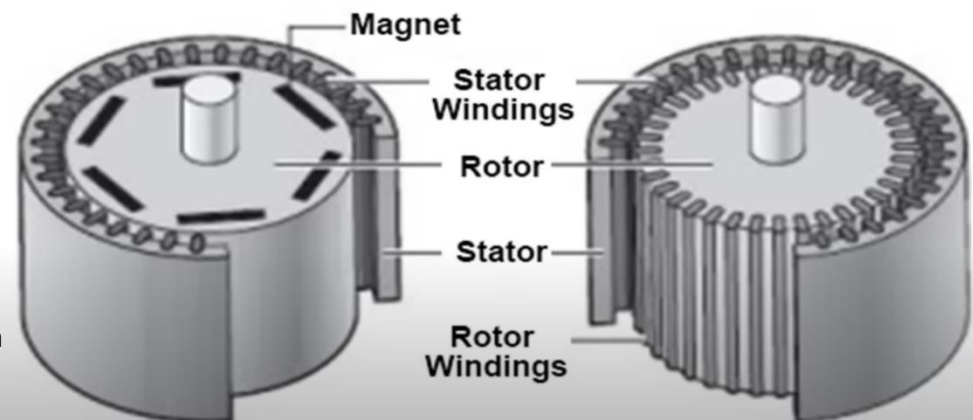
Rare Earth 3

Lower Cost & Higher Efficiency Drive Units Using Zero Rare Earths

TESLA LIVE

## Permanent Magnet

## Induction



# Why is Tesla's magnet gargantuan news?

- ✓ It is big news because **electric motors and electricity generators can now be made at less cost and will have higher efficiency**
- ✓ So future BEVs will cost less and have longer range and more power
- ✓ Also wind turbines will be able to make more electricity at lower cost
- ✓ Wind turbines are already the lowest cost electricity available at 2 to 3 cents per kWh in good locations and make over 55% of power in Denmark
- ✓ Countless of other products use strong magnets like heat pumps, refrigerators, air-conditioning system, vacuum cleaners and industrial machinery
- ✓ These products will be cheaper and use less electricity because of this new Tesla magnet that will be copied by other companies who wish to stay in business

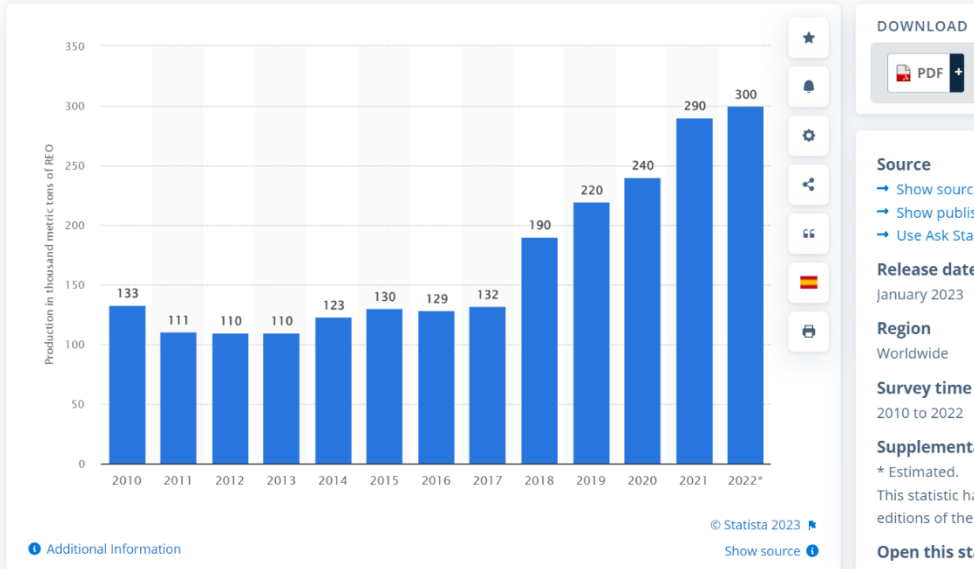


Source and attribution: <https://pixabay.com/>

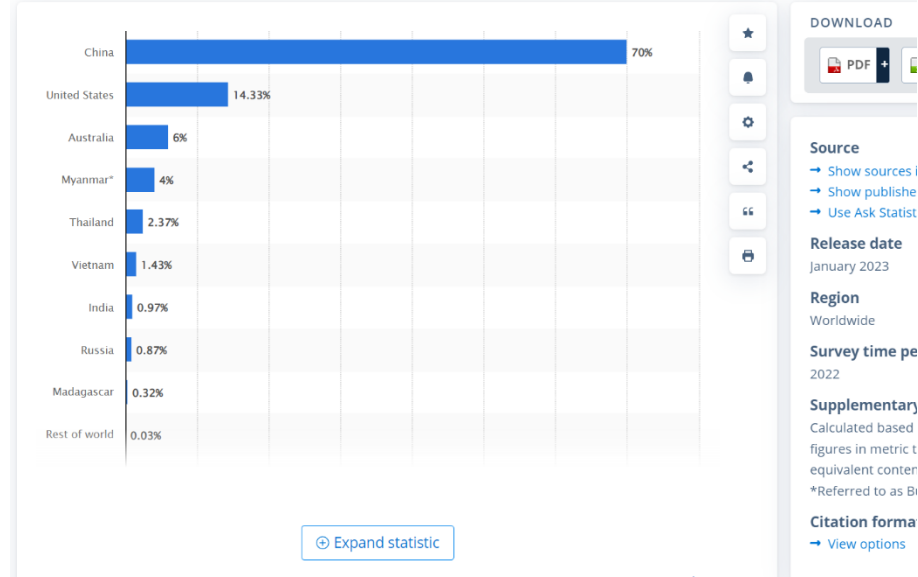


# Tesla's magnet also has geopolitical impact

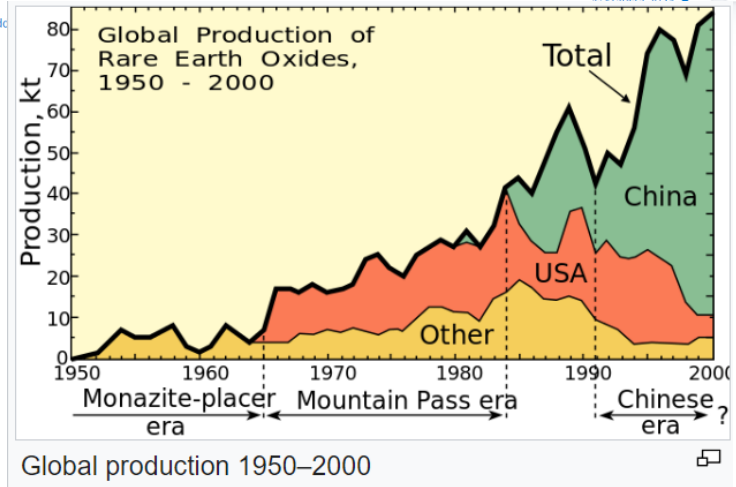
Mine production of rare earth elements worldwide from 2010 to 2022  
(in 1,000 metric tons REO)



Distribution of rare earths production worldwide as of 2022, by country



- ✓ The world has seen more than doubling of demand from 2017 to 2022 because more BEVs and wind turbines are produced
- ✓ China mine 70% of all rare earth elements
- ✓ China do 85% of rare earth processing/refining
- ✓ China manufactures over 90% of the world high-strength rare earth permanent magnets



Source and attribution: : <https://www.statista.com/statistics/1187186/global-rare-earth-mine-production/>



# Tesla's new magnet is also secretive

- ✓ Tesla's Investor Day 2023 did not announce what elements are used in their new magnet
- ✓ For current permanent magnet motor Tesla said it used 3 rare earth elements but no mention of which kind only their quantity
- ✓ I googled the web to see if anyone had good ideas about what the new Tesla magnet is made of but nothing as of march 2023
- ✓ Recall  $\text{Nd}_2\text{Fe}_{14}\text{B}$  magnets are most common used rare earth magnet with 30 to 55 MGOe
- ✓ Most common non-rare earth magnets are ferrite magnets (rust  $\text{Fe}_2\text{O}_3$  mixed with other elements) at 4 MGOe
- ✓ Best non-rare earth in development is Iron nitride  $\text{Fe}_{16}\text{N}_2$  type material at 10 to 30 MGOe from startup Niron Magnetics with an expected market launch in 2024 and 2025
- ✓ Tesla's new magnet can't be any of the above because the MGOe is too low to make a more efficiency magnet need to be over 50



2023 Investor Day

Rare Earth Elements

H	Rare Earth Elements																He	
Li	Be											B	C	N	O	F	Ne	
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo	
		*	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		**	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

\* Light Rare Earth Element      \*\* Heavy Rare Earth Element

NUMBER	SYMBOL	ELEMENT
21	Sc	Scandium
39	Y	Yttrium
57	La	Lanthanum
58	Ce	Cerium
59	Pr	Praseodymium
60	Nd	Neodymium
61	Pm	Promethium
62	Sm	Samarium
63	Eu	Europium
64	Gd	Gadolinium
65	Tb	Terbium
66	Dy	Dysprosium
67	Ho	Holmium
68	Er	Erbium
69	Tm	Thulium
70	Yb	Ytterbium
71	Lu	Lutetium

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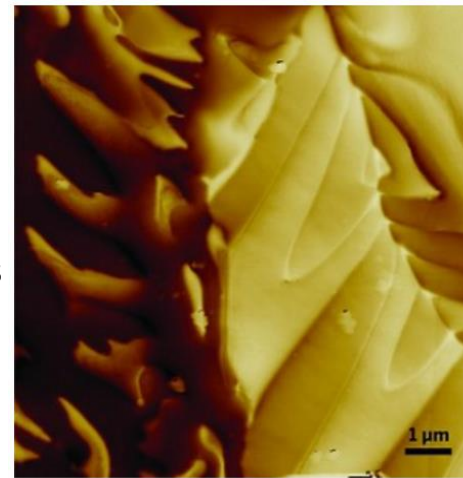


# Tesla's new magnet could be tetrataenite

- ✓ In my search for what Tesla's new magnet could be **my best bet is synthesized tetrataenite**
- ✓ Tetrataenite is an ultra rare, iron nickel alloy, found in meteorites
- ✓ It has been theorized that these meteorites makes tetrataenite by cooling slowly over millions of years in weightless space to from the unique crystalline structure that is tetrataenite
- ✓ Researchers all over the world have been trying to synthesize tetrataenite for decades because of its high magnetic strength
- ✓ **Microscopic samples** have been synthesized by radiating Fe-Ni alloys with neutrons or electron beams
- ✓ **Bulk production of tetrataenite** is reported for first time ever in an academic paper from October 2022 where Fe-Ni alloys are forming tetrataenite in seconds using conventionally cast methods with presence of trace amounts of phosphor P and carbon C. The authors now question the slow cooling hypothesis
- ✓ This is spot on Tesla's known fields of expertise. They got the worlds best metallurgical team and they are also experts in conventional cast production
- ✓ We will find out if my bet on Tesla magnet is right when Munro Live do the tear down of Tesla's new motor



Credit: Rob Lavinsky,  
<https://www.irocks.com/>



Credit: Ames Lab

The ordering of magnetic domains (light and dark patterns in this magnetic force microscopy image) is a type of magnetic signature that characterizes tetrataenite, an Fe-Ni alloy found in this meteorite-derived sample.

Source and attribution: <https://en.wikipedia.org/wiki/Tetrataenite> and <https://commons.wikimedia.org/wiki/File:Tetrataenite-138026.jpg#/media/File:Tetrataenite-138026.jpg>



# The economics of Tesla's new drive unit

- ✓ Tesla said their upcoming permanent magnet drive unit can be made for about **1000 USD** including cost for needed power electronics and gear box
- ✓ Tesla new drive unit is **likely about the same as the 208 kW (279 hp) power** that are used in the permanent magnet rear drive unit for the most current Model 3
- ✓ Munro & Associates CEO Cory Steuben estimate a **similar drive unit normally cost 2000 USD** so big deal if Tesla can do it for 1000 USD in future
- ✓ The **500g rare earth saving** that Tesla mentions is most likely neodymium that cost 106 USD per kg currently so a **50 USD saving per drive unit**
- ✓ That do not explain the possible 1000 USD price reduction but Tesla also mention **75% reduction in use of silicon carbide** for needed for power electronics
- ✓ **Most savings** will come from more efficient production machinery that Tesla is developing for it factories, 50%
- ✓ **Musk has said Tesla main product is the unique factories it builds** that require 10X more engineering time than Tesla's end products
- ✓ **For Tesla getting rid of rare earth magnets is mainly about eliminating a huge supply chain risks**

## Our Next Drive Unit Will Be Even More Scalable

Powerful In-House Software  
KEY SIMULATION TOOLS DEVELOPED BY TESLA



75%	ANY	50%	~\$1,000
Reduction In Silicon Carbide	Battery Chemistry Accepted	Reduction In Factory Footprint	All-In Cost

Neodymium (CNY/T) 730000.0000000

CNY to USD Currency converter result:

**730000 CNY =**  
**106124.7 USD**

By today rate (2023-03-21) CNY to USD equal 0.145376



Source and attribution: <https://en.wikipedia.org/wiki/Tetrataenite> and <https://commons.wikimedia.org/wiki/File:Tetrataenite-138026.jpg#/media/File:Tetrataenite-138026.jpg>



# Sources/attribution for previous slides

- Tesla 2023 Investor Day, Powertrain technologies 52:40: <https://www.youtube.com/watch?v=Hl1zEzVUV7w&t=2982s>
- Distribution of rare earths production worldwide as of 2022, by country: <https://www.statista.com/statistics/270277/mining-of-rare-earths-by-country/>
- Mine production of rare earth elements worldwide from 2010 to 2022: <https://www.statista.com/statistics/1187186/global-rare-earths-mine-production/>
- Although it has only about one-third of the world's rare earth reserves, China now accounts for 60% of global rare earth mined production, 85% of rare earth processing capacity, and over 90% of high-strength rare earth permanent magnets manufactured: <https://www.brinknews.com/china-is-moving-rapidly-up-the-rare-earth-value-chain/#:~:text=Although%20it%20has%20only%20about,rare%20earth%20permanent%20magnets%20manufactured.>
- For Neodymium (NdFeB) Magnets the BHmax will range, in general, from 30 MGOe to 55 MGOe: <https://smmagnetics.com/blogs/news/understanding-magnet-grades-and-magnet-tables>
- Rare Earth Elements periodic table: <https://sciencenotes.org/rare-earth-elements/>
- Iron nitride Fe<sub>16</sub>N<sub>2</sub> type material at 10 to 30 MGOe from startup Niron Magnetics, also source for ferrite magnets at 4 MGOe: <https://spectrum.ieee.org/permanent-magnet-tesla#toggle-gdpr>
- Researchers from the University of Cambridge have discovered a new way to create a possible replacement for rare earth magnets. How to synthesize Tetrataenite in bulk: <https://www.innovationnewsnetwork.com/potential-rare-earth-magnet-replacement-discovered/26597/>
- Academic paper reporting bulk scale production of tetrataenite for first time in October 2022: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9811435/>
- What is tetrataenite: <https://en.wikipedia.org/wiki/Tetrataenite>
- Microscopic image of tetrataenite: <https://cen.acs.org/articles/91/i1/Powerful-Pull-New-Magnets.html>
- YouTube channel MunroLive: <https://www.youtube.com/c/MunroLive>
- 208 kW (279 hp) for Tesla Model 3 rear end motor: [https://en.wikipedia.org/wiki/Tesla\\_Model\\_3#Specifications\\_table](https://en.wikipedia.org/wiki/Tesla_Model_3#Specifications_table)
- CEO of Munro Associates Cory Steuben estimate the cost of a comparable non-Tesla made drive unit is 2000 USD see video timestamp 10:10: <https://www.youtube.com/watch?v=5fe548XvavY>
- Price of neodymium: <https://tradingeconomics.com/commodity/neodymium>

