Rare Earths – Facts & Figures

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The European Commission ranked 14 raw materials as the most critical metals as part of the activities of the "Raw Materials Initiative". This group of 14 raw materials contains the whole group of the rare earths elements.

Rare earths are used today in the production of many consumer goods such as computers, LCD screens and digital cameras as well as in "green technologies" such as wind turbines, electric cars and energy efficient lighting.

The group of the rare earth elements is sub-divided in the heavy rare earth elements (HREE) and the light rare earth elements (LREE):

Heavy rare earth elements (HREE)

Y	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
yttrium	gadolin-ium	terbium	dyspro-sium	holmium	erbium	thulium	ytter-bium	lutetium

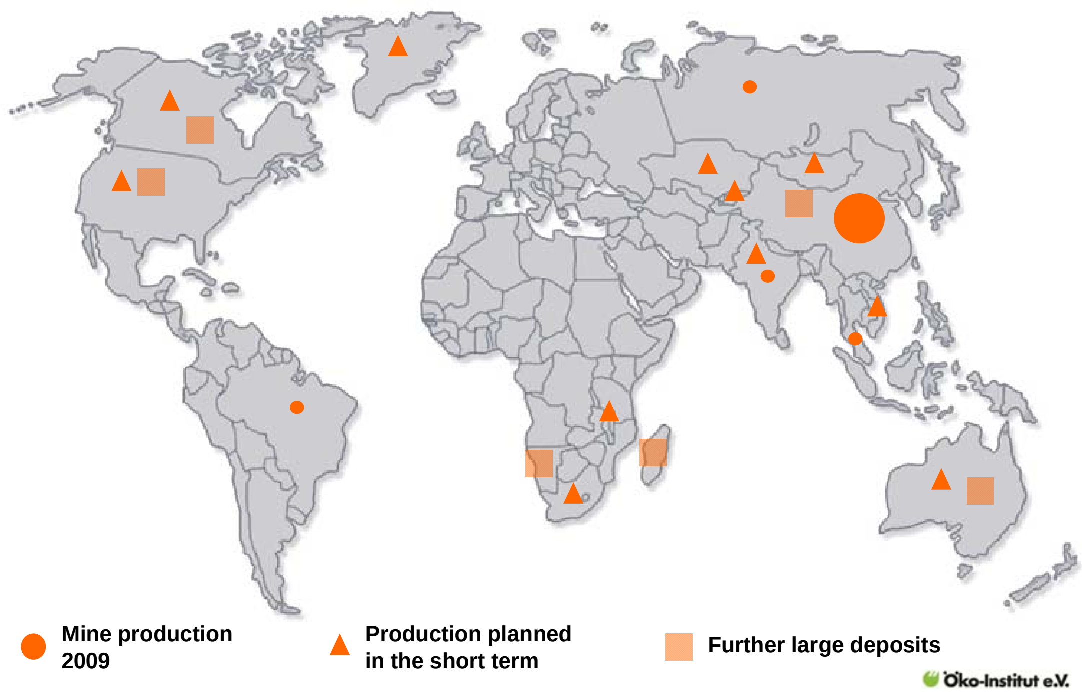
Light rare earth elements (LREE)

Sc	La	Ce	Pr	Nd	Pm	Sm	Eu
scan-dium	lantha-num	cerium	praseo-dymium	neo-dymium	prome-thium	samar-ium	euro-pium

1. Rare Earths – Reserves and Mine Production Worldwide

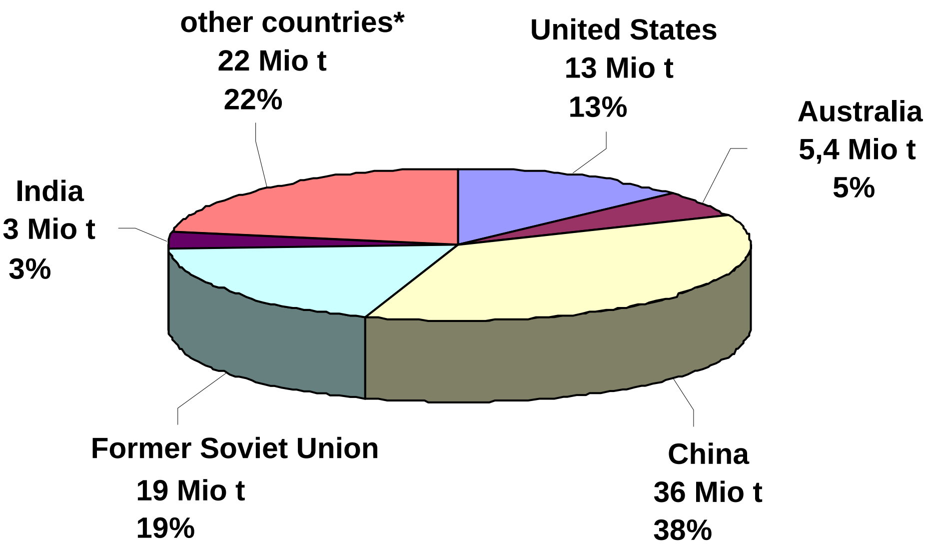
The U.S. Geological Survey (USGS) estimates the **global reserves** of the sum of all rare earth oxides which could be economically extracted in future to be at **99,000,000 tons**. The **global production** in 2009 is estimated be **124,000 tons**.

Overview of current and planned short-term mine production as well as further large deposits



Though China produces more than 95 percent of the global production, their share of the reserves is much lower at 38 percent. The main reserves outside of China occur in the United States, Australia, the states of the former Soviet Union and other states as shown in the next figure.

Global rare earth reserves by country (in million tons; data from USGS 2010)



* Other countries: Canada, Greenland, Brazil, Malaysia, South Africa, Malawi, Vietnam

World Mine production of rare earths in 2009 (USGS 2010)*

Country	tons of rare earth oxide (REO)	Share
China	120,000	97 %
India	2,700	2.1 %
Brazil	650	0.5 %
Malaysia	380	0.3 %
Kyrgyzstan	n.d.	
Total	**124,000**	**100 %**

* These data from USGS do not include the illegal Chinese production of up to 20,000 t and smaller Russian production volumes.

At present, only few amounts of rare earths are coming from other countries than China. Due to the high demand for rare earths and the decreasing Chinese exports, there are many activities aiming at the opening of new mines outside of China.

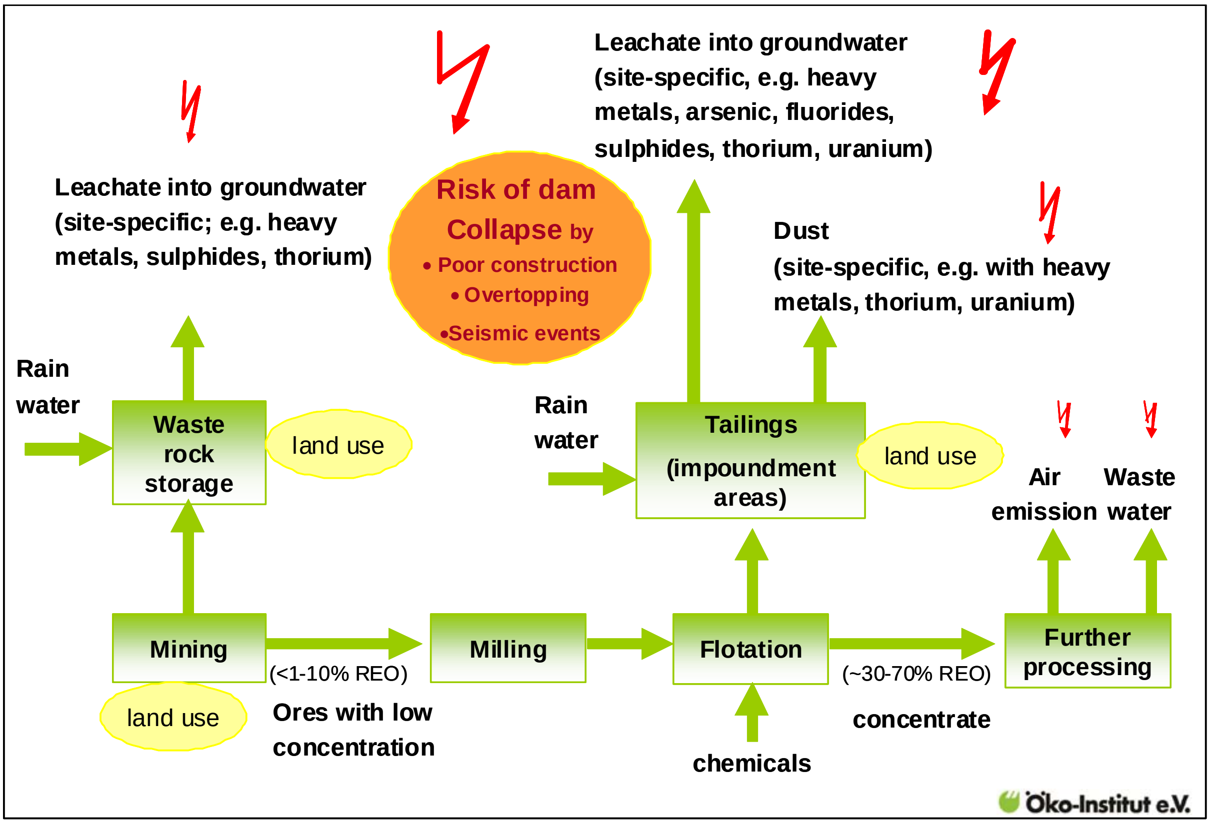
The **most advanced mining projects outside of China** are:

- the re-opening of the Mountain Pass mine in California (Molycorp Minerals) and
- the new rare earth mine at Mt Weld in Australia (Lynas) with processing in Malaysia.

2. Environmental aspects of rare earth mining

The main environmental risk in rare earth mining are the huge amounts of tailings, which are a **toxic waste** being stored in artificial ponds surrounded by the tailing dam. A dam failure as it happened in Hungary in 2010 to the tailings from an alumina factory leads to destructive site-specific emissions such as thorium, uranium, heavy metals, acids and fluorides. Furthermore, most rare earth deposits contain **radioactive materials** which impose the risk of radioactive dust and water emissions.

Risks of rare earth mining without or with insufficient environmental protection systems



The Chinese government intends to reduce the environmental harm in the coming years by installing environmental technologies in the large mines and by reducing the numerous small illegal mines. China also aims at higher efficiencies in mining and processing and is running some research projects on a sustainable rare earth economy.

The most advanced mine projects outside China at the Mountain Pass in the United States and at Mt. Weld in Australia will provide environmental protection systems. However, the global pressure for a cheap and steady rare earth supply might lead to further new mines outside of China with inacceptable environmental standards. One example of potential concern about environmental damage is the plan for a joint mining of uranium and rare earths in Greenland. The interested mining company intends to store the tailings in a natural lake with connection to maritime waters.

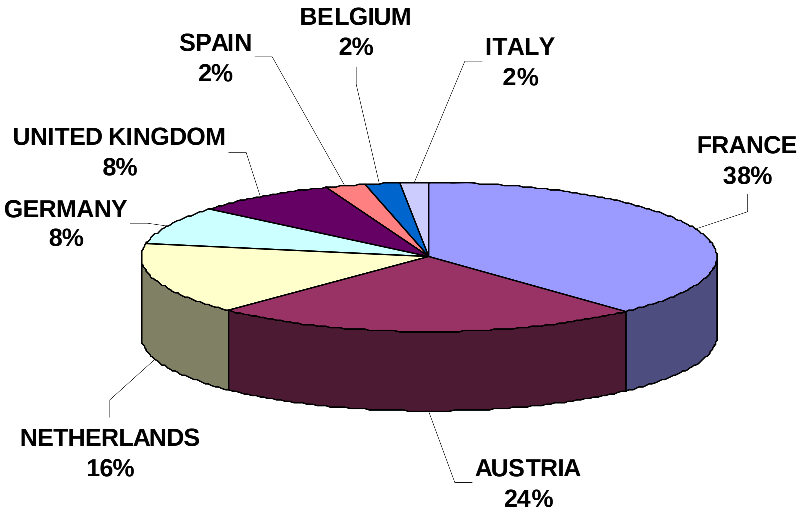
3. Exports, Imports, Processing and Applications

The **export volume of rare earths** from China increased gradually from 1979 until 2006, where the volume reached a peak with 57,400 tons and then declined from 2007 onwards. In 2010 the export rates decreased by 29 percent compared to 2008. Additionally, illegal exports from China amount up to 20,000 tons per year.

The **major importers of rare earth** compounds in 2008 were Europe, USA and Japan. The figures mean a total of 78,000 tons of imported rare-earth compounds in 2008. Hereby, around 90 % are imported from China.

	Imports	Share of imports from China	Compounds included in the statistic	Data source
EU 27	23,013 t	90 %[1]	Metals, intermixtures or interalloys of rare-earths, Sc and Y Compounds of rare-earth metals, mixtures of these metals, Y or Sc	Eurostat 2010
USA	20,663 t	91 %	Rare-earth and Y compounds, Rare-earth metals, Mixtures of rare-earth chlorides, Ferrocerium and other pyrophoric alloys	USGS 2010c
Japan	34,330 t	91 %	Cerium-, Lanthanum- and Yttrium Oxide, other cerium compounds, others	Trade Statistics Japan 2010

Imports of rare earth compounds by the European member states
(from outside the EU-27)

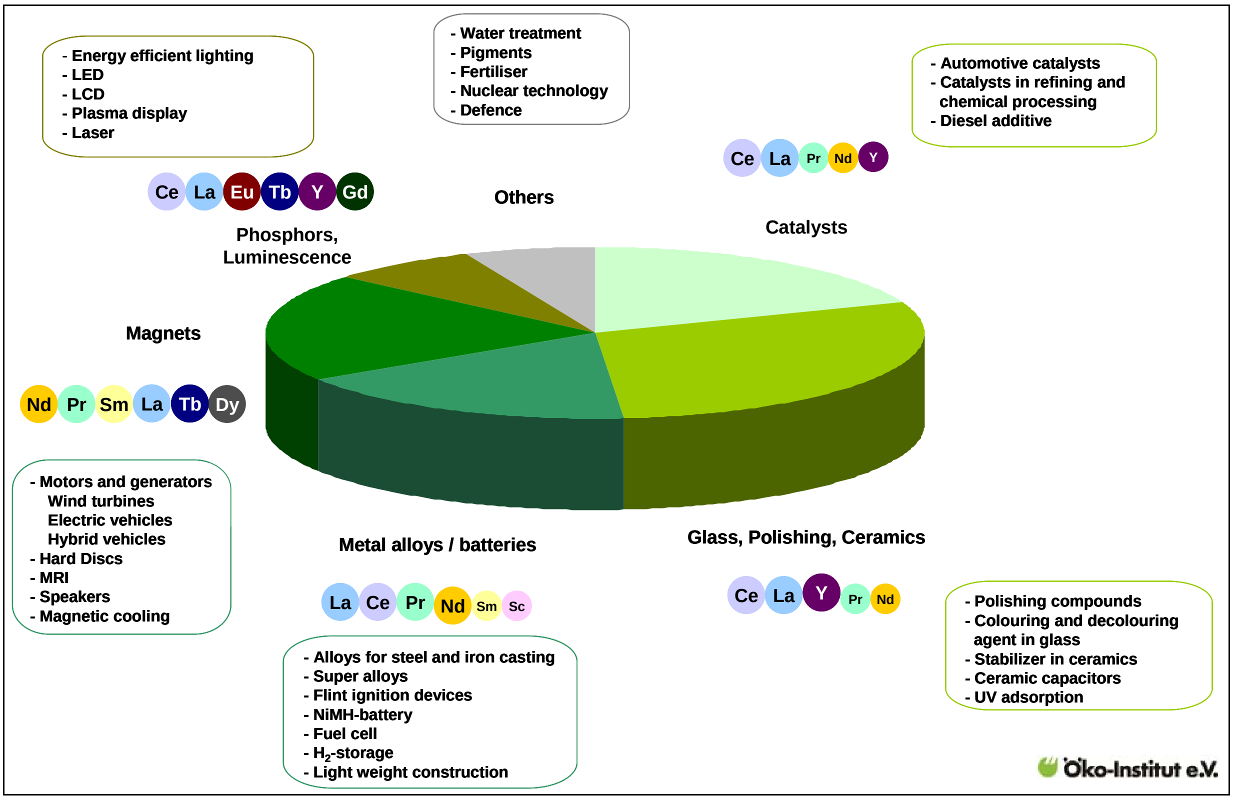


European companies importing rare earth components are mainly involved in manufacturing processes for semi-finished or finished products which contain rare earths like magnets, alloys, automotive catalysts etc.

Most of the core rare earth refining and processing activities are located in China and some small-scale processing is done in Japan. One example for the dominance of the Chinese rare earth processing is the fact that China is the only country holding production capacities for all stages of the permanent magnet production chain.

[1] The statistics from Eurostat provides no data on the origin of the imports to Austria. The share of Chinese imports to total imports of all EU-27 members besides Austria is 90%.

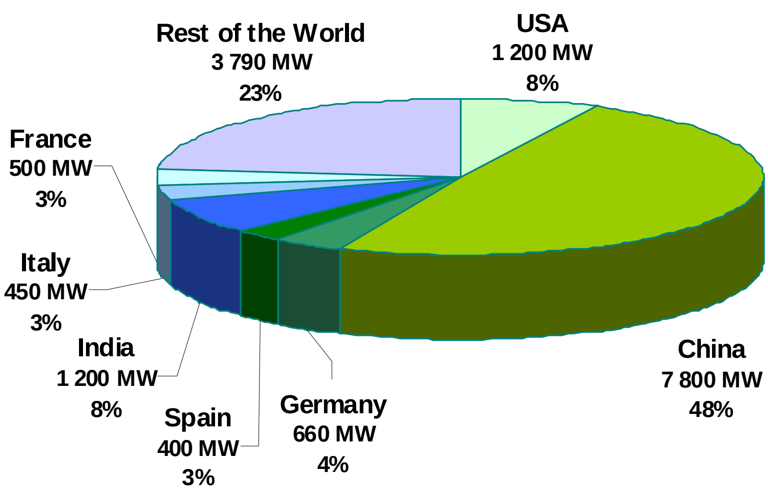
Main application fields of rare earths



A closer look: rare earths in wind turbines

Rare earths are part of neodymium magnets (Nd-magnets). These permanent magnets are the strongest available magnets and can be used in generators of wind turbines. 14 percent (or about 1/6) of newly installed wind turbines on the market already use Nd-magnets. They work without gear, which makes them robust and a good candidate for off-shore applications.

In 2010, the global capacity of wind power was already 175 GW. For the future use of rare earths, the **global growth rate of wind turbines** is a crucial driver The next figure shows the newly installed wind power capacity in the first half of 2010 (WWEA 2010):



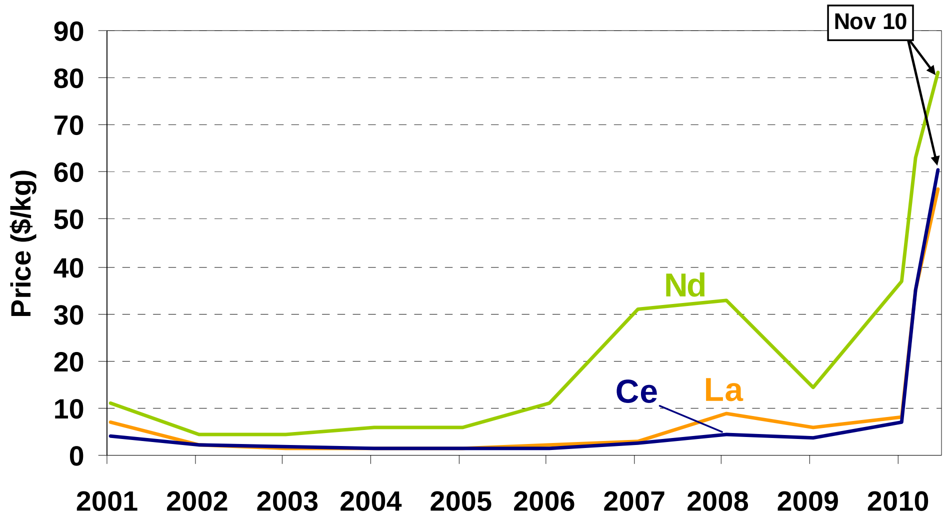
Already now, almost half of the new capacities are implemented in China and Chinese wind power is expected to grow further tremendously.

To date it is not clear which direction the technology development will take. The potential supply shortages of terbium, dysprosium and neodymium might slow down the dissemination of turbines with neodymium magnets and might lead to a shift to alternative turbine types. A reinforced research on a higher reliability of traditional techniques with gear would support this substitution. Furthermore, a higher efficiency in the whole magnet production chain as well as recycling from used magnets could contribute to a sustainable use of these valuable raw materials.

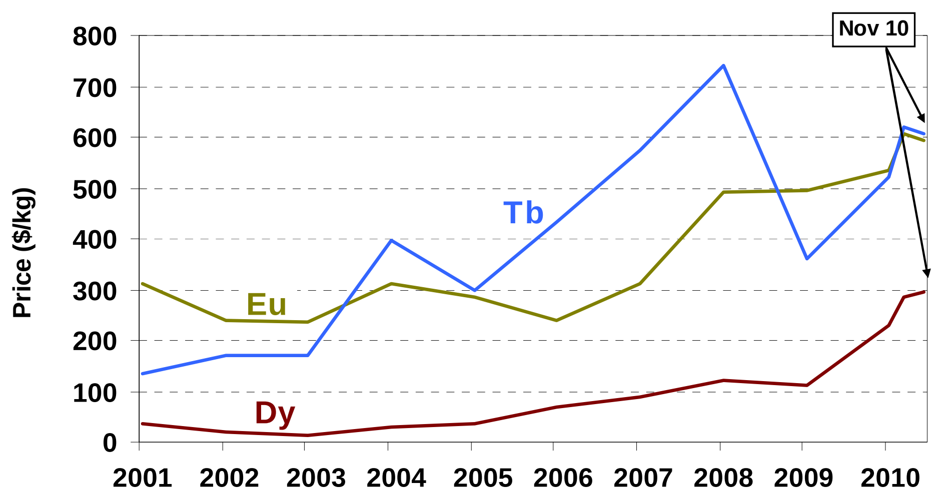
4. Development of Prices

The figures below show a moderate price development until the end of 2009 and the steep increase due to the increasing global demand and the reduction of Chinese exports in the second half of 2010. The steep price increase does not only affect the rare earths for which supply shortages are forecasted but also less scarce elements such as cerium.

Price development of selected "cheap" REE (Oxide) in recent years



Price development of selected "expensive" REE (Oxide) in recent years



5. Strategy for a sustainable rare earth economy

The expected supply shortages of up to seven rare earth elements (dysprosium, europium, lanthanum, neodymium, praseodymium, terbium, yttrium) until 2014 and the current high prices provide for the first time the incentive to promote an efficient use of rare earths, to develop substitution options and to implement a recycling scheme for rare earths in Europe. Building-up a recycling scheme provides a number of advantages:

- The secondary rare earths potential arises in Europe
- Lower dependency on foreign material supply
- Building up of know-how on rare earth processing
- No radioactive wastes arising in secondary rare earth processing
- Environmental benefits concerning air emissions, groundwater protection, acidification, eutrophication and climate protection

Eight steps towards an efficient rare earths recycling

1) Establishment of a **European Competence Network on Rare Earths** with all relevant stakeholders such as recyclers, manufacturers, public authorities, politicians and researchers is essential for a successful implementation.
2) Start of **basic research activities** in order to gain knowledge about rare earth refining and processing in Europe and become more independent from Asia.
3) Start a **European Material Flow Analysis** to close significant data gaps and to gain a broader knowledge on the material flows in Europe related to rare earths.
4) **Identification of initial products** to be recycled, e.g. waste from the magnet and lighting production, magnets from used electric motors, used lamps and displays, reuse of large magnets and spent catalysts.
5) Design of **collection and pre-treatment schemes** for rare earth containing waste which have to be integrated in already implemented waste management procedures.
6) **Development of pilot recycling plants** necessary for learning on complex recycling processes. This also comprises research activities.
7) Correspond to **financial issues**: The long-term investment in recycling plants as well as the uncertainty of the future price development for primary rare earths bears high risks for investors. The European Investment Bank (EIB) could reduce large risks for investors.
8) Creation of a **legal framework**: Screening on gaps in legal framework concerning existing recycling schemes and adaptation of the legal EU framework in order to optimize post consumer rare earths recycling.

If we start now, we can implement an efficient European recycling scheme for rare earths within a minimum of five to ten years.

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