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Critical raw materials for electrolyser production

Possible shortages due to Russia‘s unprovoked invasion of Ukraine

Berlin, 22 July 2022

Scope of the publication

Materials for electrolyser production

In this publication, we consider the **possible impacts of the Russian invasion** of Ukraine on electrolyser production in Germany. In particular, we concentrate on metals mined in Russia which will be necessary for electrolyser production.

As we **focus on electrolysers**, possible shortages in other industrial sectors and product supply chains are not considered. Additionally, we make no statements about the dependency of the German industry as a whole on the metals analysed.

In principle however, one would need to assume that the actions of quasi-monopolies as well as a sudden break-off of individual supplier countries will always have impacts on the supply of critical raw materials to German industry.

The discontinuation of imports from Russia can also lead to an intensification of **existing dependencies**, for example on platinum or rare earth metals.

Materials

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- nickel
- titanium
- iridium
- palladium
- platinum
- scandium

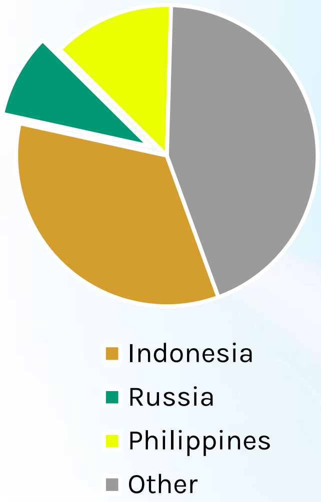
- aluminium
- zirconium
- cerium
- yttrium
- …

Many different materials are used for the production of electrolysers. Critical raw materials for which Russia **either has a significant share** of the global production volume or for which there are **few alternative import countries**, are outlined in yellow.

Production shares

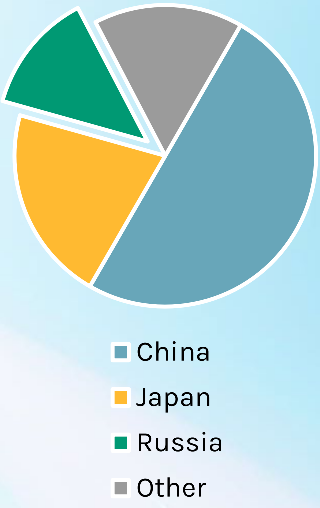
Russia in global comparison

Nickel



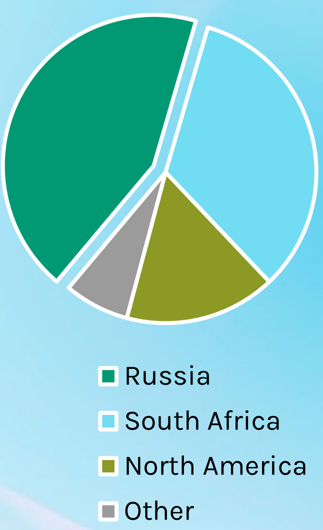
[DERA-1]

Titanium



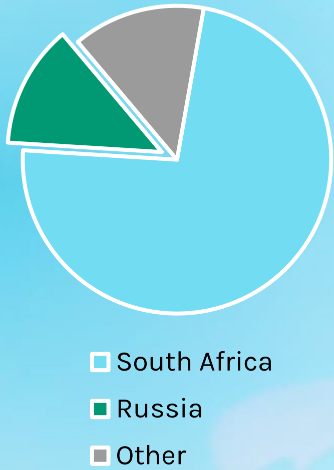
[INT-1]

Palladium



[STA-1]

Platinum



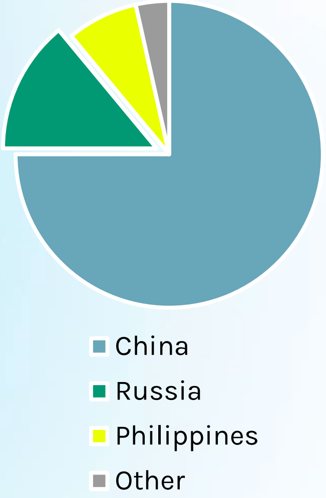
[BGR-2]

Iridium

Yearly fluctuating production from different sources

- By-product of platinum and palladium
- Russia second largest producer after South Africa

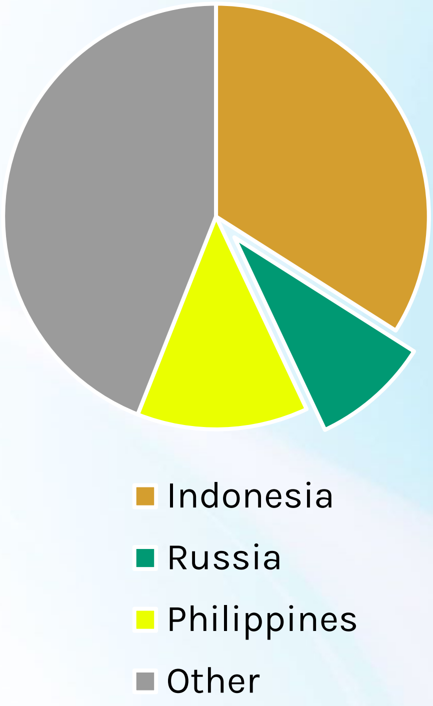
Scandium



[DERA-1]

Nickel

Total output distribution



- Global production in 2019: 2.54 million tonnes
  - Indonesia ~ 34 %
  - Philippines ~ 13 %
  - Russia ~ 9 %
- Used in alkaline electrolysis (A-EL) for the anode, cathode, bi-polar plates and in the anode-side transport layer, in SO-EL for the cathode
- About 420 g/kW needed for electrolytic cells
- Reference: [DERA-1]

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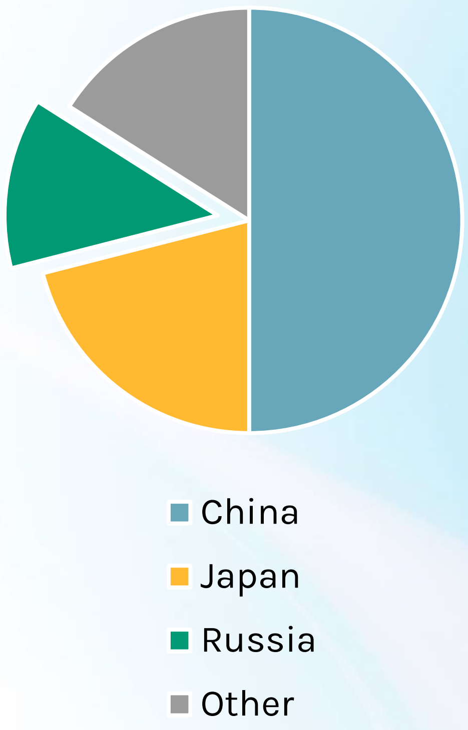
Titanium

Total distribution of sponge titanium production



- Used in PEM-EL for anode and cathode
- Approximately 28 g/kW needed [DERA-1]
- Substitution in electrolyser production not foreseeable [IPA-1]
- Titanium sponge is only produced in a few countries
- Distribution of global production in 2020 [INT-1]:
  - China ~ 50 %
  - Japan ~ 21 %
  - Russia ~ 13 %
- Secondary ferro-titanium from scrap metal as possible future source [INT-1]

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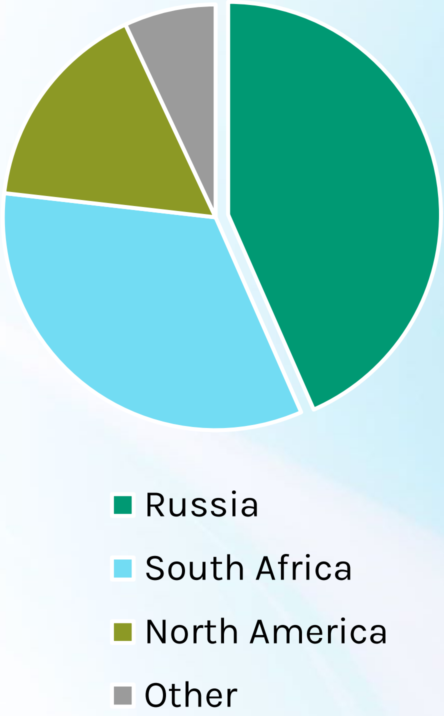
Palladium

Total output distribution



- Used for electrodes, in electronics and as a catalyst [EDE-1]
- In 2018, Russia mined 43 % of the global output [RND-1]
- According to the German Federal Environmental Agency, the demand for palladium in the „Green Economy 2025“ scenario will increase to more than 4 times the production of 2013 by 2025. [UBA-1]
- Pure deposits largely exhausted; only mined with platinum [EDE-1]

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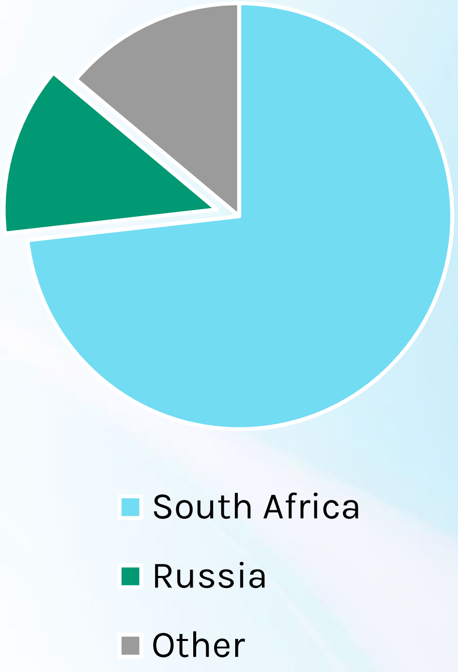
Platinum

Total output distribution



- In A-EL and PEM-EL used as cathode coating [DERA-1]
- Substitution in electrolyser production not foreseeable [IPA-1]
- Amount required: 0.01 g/kW
- Global mining production in 2013: 188 tonnes [BGR-2]
  - Russia ~ 13 %
  - South Africa ~ 73 %
- Demand is expected to more than double by 2050 [UBA-1]

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Iridium

- Currently considered as irreplaceable for anodes in PEM-FC [DERA-1], projected future requirements: < 0.1 g/kW

- By-product of platinum and palladium production
  - On-demand production: low production volumes
  - Iridium supply sources vary annually as a result
  - Reliable data unfortunately seldom available

- Global production volume: 6-10 tonnes per year
  - South Africa supplies 80-85 % of iridium globally [DERA-1]
  - Russia second largest supplier, but does not publish accurate figures [INT-1]

- Global demand: 10-40 tonnes per year predicted by 2040 [DERA-1]
- Outlook: deposits in Canada and Scandinavia could be made accessible

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Secondary platinum recovery

Large shares of platinum are used in vehicle catalytic converters. With the increasing penetration of electric mobility, automotive sector demand for platinum will decrease in the future.

With the development of a **circular economy**, more secondary platinum will be recovered from end-of-life vehicles. This will largely meet the needs of vehicle catalytic converters.

As a result, the mining of platinum would be in **direct economic competition** with secondary platinum. This would impair global platinum mining.

Iridium is a **constituent in platinum ores**. Reductions in platinum mining would thus also lead to the decreasing production and availability of iridium. Reference: [INT-1]

Recycling of electrolysers at the end of their life cycle will be necessary. However, due to the lifespans of electrolysers, recycled critical raw materials will not significantly contribute to covering demands at the beginning of the ramp-up phase.

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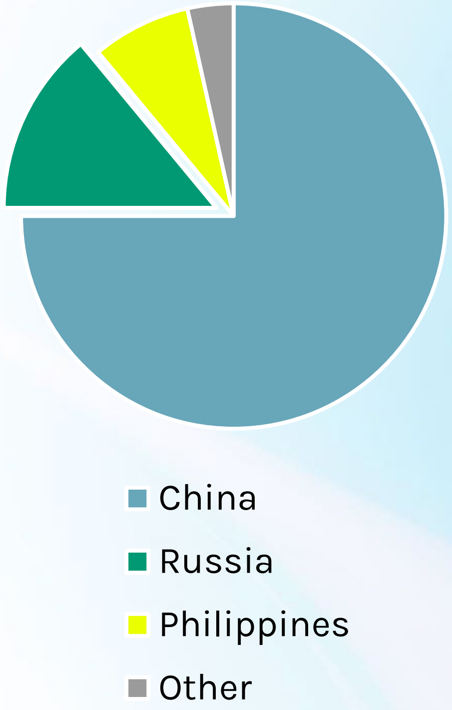
Scandium

Total output distribution



- Scandium-stabilised zirconia used in SO-EL and SO-FC
- Amount required: 0.1 g/kW
- By-product of extraction of titanium, tungsten, tin, rare earth and zirconium deposits as well as bauxite, nickel and uranium deposits.
- Higher conductivity and stability at low operating temperatures than the yttrium alternative
- Demand (up to 24 tonnes in 2040) will exceed current production levels, but there are some deposits (e.g. in Australia) where mining has not yet begun or extraction rates can be increased
- Around 14-16 tonnes per year worldwide
- High country concentration of production:
  - China 10 tonnes (from extraction of titanium and zirconium)/ > 75 % of global volume, variable utilisation
  - Russia 1-2 tonnes (from uranium production)
  - Philippines 1 tonne (from nickel and cobalt ores)

Reference: [DERA-1]

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Quantities

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Production needs for electrolysers

Critical raw material	g/kW (kg/GW)	Current global production volume per year	Percentage of current global production for 1 GW EL
Iridium	0.1 (100)	6-10 tonnes	1 – 2 %
Platinum	0.01 (10)	188 tonnes	5×10^{-3} %
Titanium	28.3 (28,300)	4.8 million tonnes	6×10^{-4} %
Scandium	0.1 (100)	14-16 tonnes	0.6 – 0.7%
Nickel	423.1 (423,100)	2.54 million tonnes (2019)	2×10^{-2} %
Palladium	?	215 tonnes	?

The European Union defined the goal of achieving **40 GW of electrolysis capacity** by 2030. If only PEM-EL were used for this, around 4,000 kg of iridium would be required, which corresponds to about **40 to 67 % of (current) global annual production**.

Conclusions

- Russia does not dominate any of the key raw material markets for electrolysers considered above.
- Temporary shortages due to high and rapidly growing demand are still possible, since new critical raw material deposits can often require years of preparation before extraction begins.
- Products and technologies could compete for the same materials (e.g. fuel cells and electrolysers).
- Depending on the flexibility of the market (e.g. due to long-term delivery commitments), the discontinuation of one producer could already lead to temporary bottlenecks.
- For some critical raw materials, one-sided dependencies are extremely difficult to avoid.
- Research and development is necessary to find rare critical raw material substitutes which
    - are easily accessible or can be produced in large quantities,
    - allow for high efficiencies and holding times.

References

Reference	Source
DERA-1	Mineralische Rohstoffe für die Wasserelektrolyse, DERA
BGR-1	Steckbrief Palladium, BGR
RND-1	Dependencies raw materials from Russia, RedaktionsNetzwerk Deutschland
BGR-2	Steckbrief Platin, BGR
IPA-1	Tom Smolinka, Studie IndWEDe, Fraunhofer ISE, p. 126-127
EDE-1	Palladium, Fachvereinigung Edelmetalle
STA-1	Statistic mineproduction palladium, Statista
UBA-1	Final report, German Federal Environment Agency
BRG-1	Mineralinfo scandium, BRGM
INT-1	Tremareva, V., Schmitz, M., DERA, personal interview, 4 April 2022

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