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Critical raw materials and their role in the European aerospace and energy sectors

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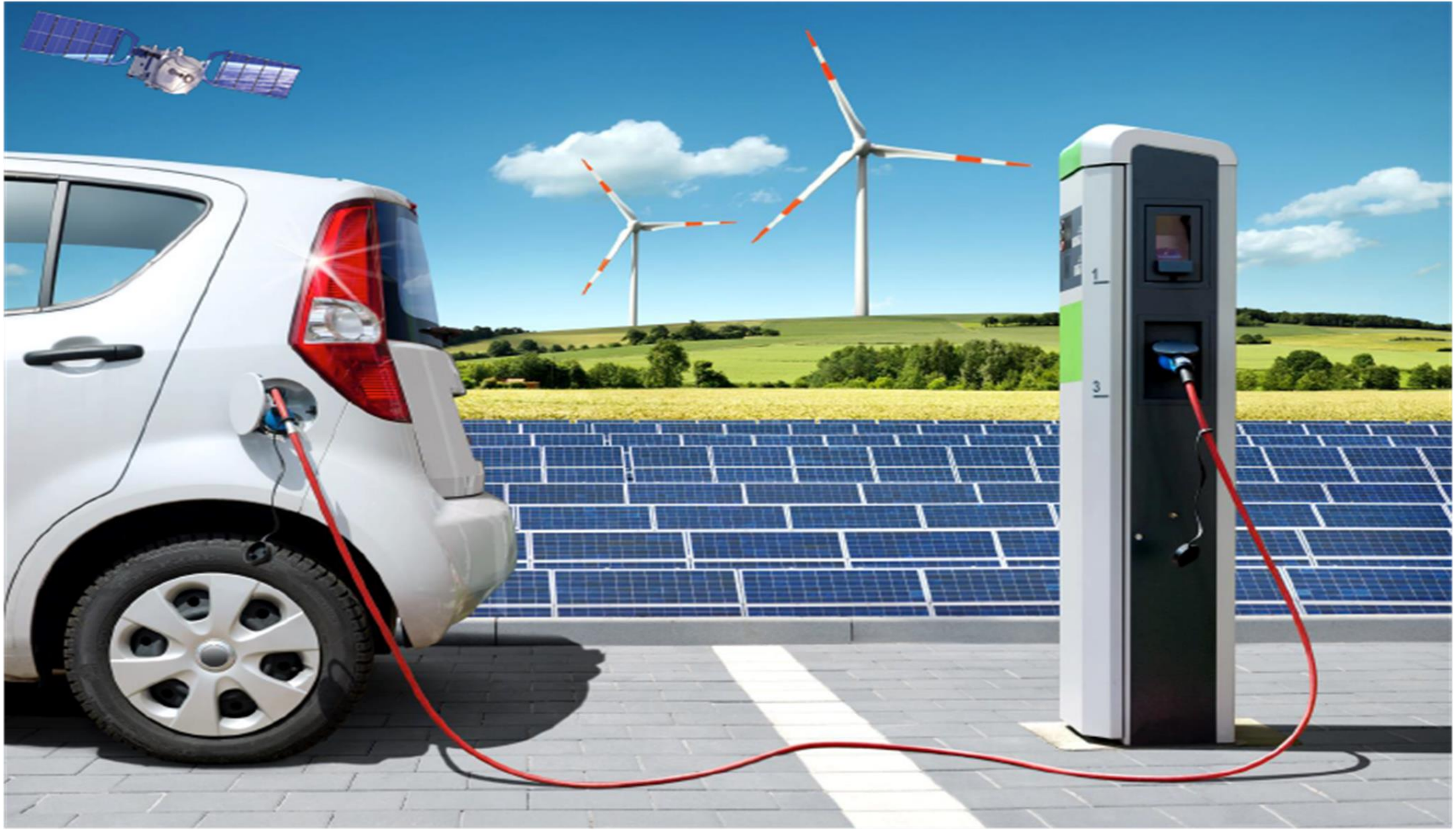

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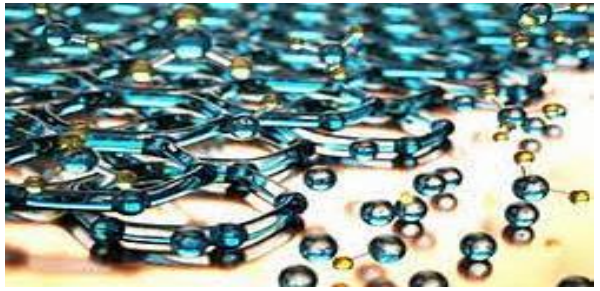
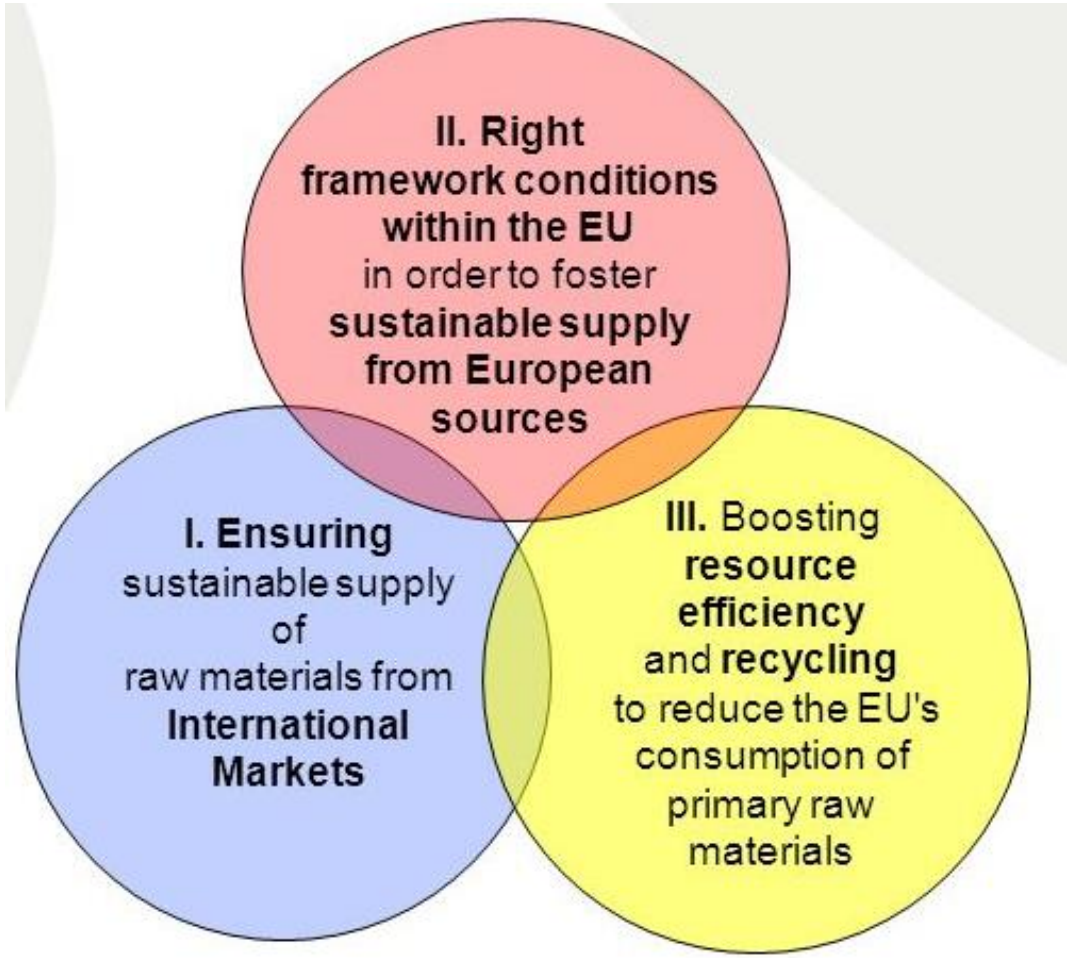
Innovation fields related to space sector

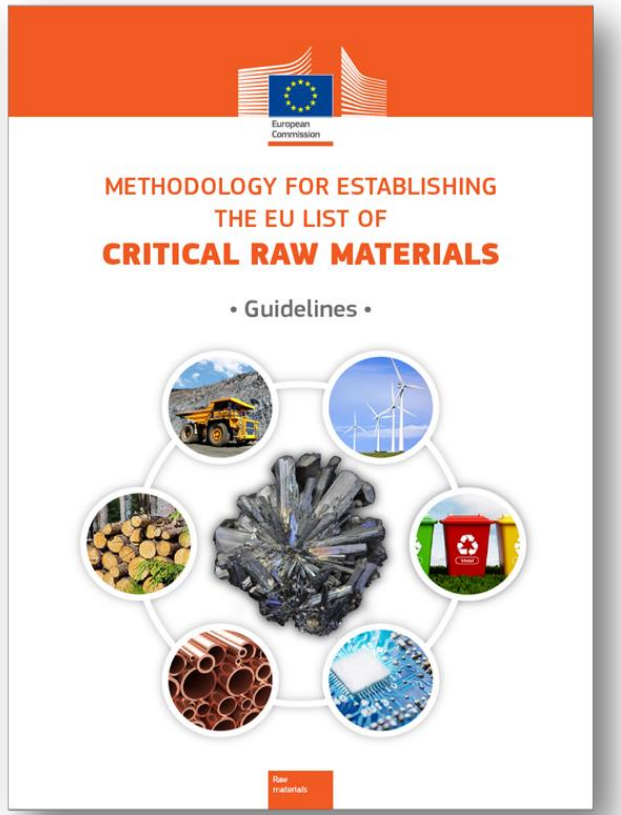
- **Embedded power storage and distribution systems** (e.g. batteries and low power supercapacitors)
- **Advanced, smart materials** for satellite applications
- High performance components for harsh environments for satellite payload
- Enhanced global navigation solutions and location based services
- High throughput satellite communication



EU policy on Critical Raw Materials (CRMs)

Raw Materials Initiative





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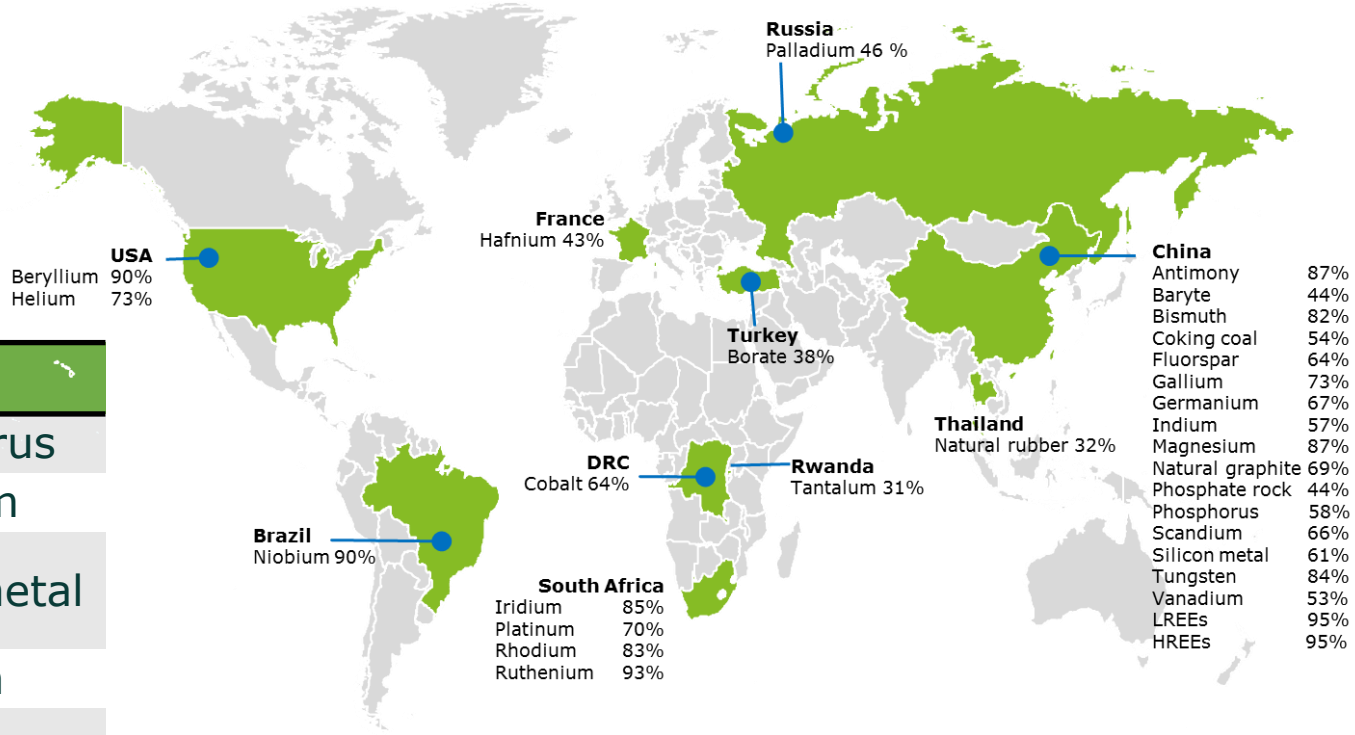
Country concentration of CRMs' supply

3rd list of Critical Raw Materials (CRMs) for the EU economy

2017 CRMs			
Antimony	Fluorspar	LREEs*	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural Rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs *	PGMs*	Vanadium
Coking coal	Indium	Phosphate rock	

*HREEs=heavy rare earth elements, LREEs=light rare earth elements, PGMs=platinum group metals



Commission's Communication on the 2017 list of Critical Raw Materials for the EU, COM(2017)490, 13 September 2017

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JRC study: materials supply chain issues for deployment of low-carbon technologies

WIND

Wind turbines
- Neodymium
- Praseodymium
- Dysprosium

Blades
- Composites (CFC)

SOLAR

PV Modules
- Silicon
- Silver
- Copper
- Indium
- Gallium
- Selenium
- Cadmium
- Tellurium

ELECTRIC VEHICLES

Batteries
- Lithium
- Cobalt
- Graphite

Electric traction motors
- Neodymium
- Praseodymium
- Dysprosium

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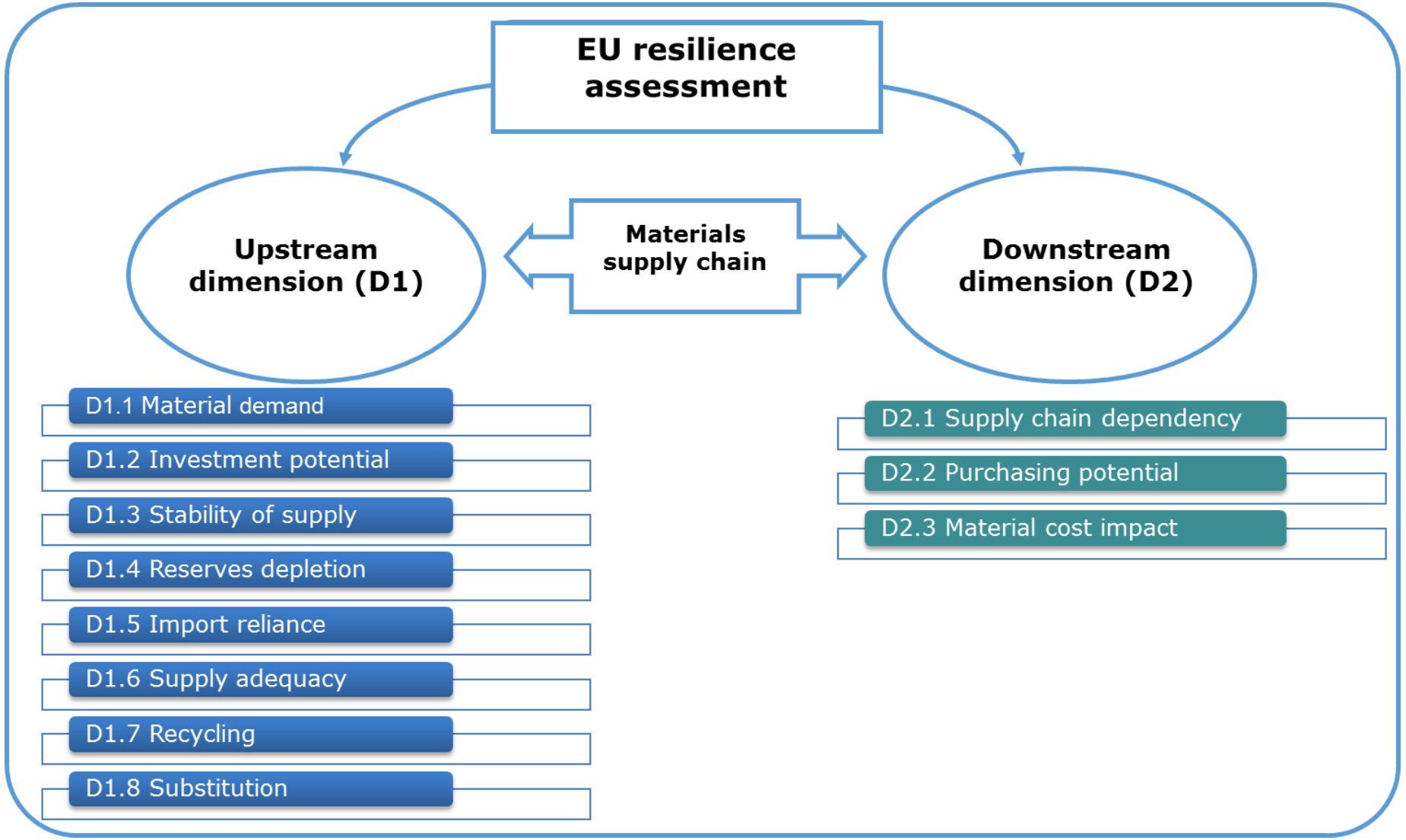
JRC methodology to assess EU resilience to supply of materials



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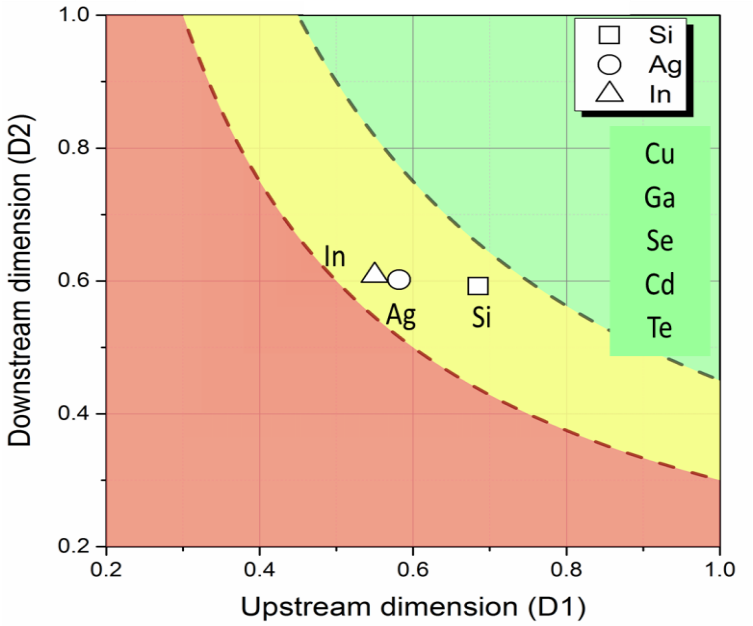
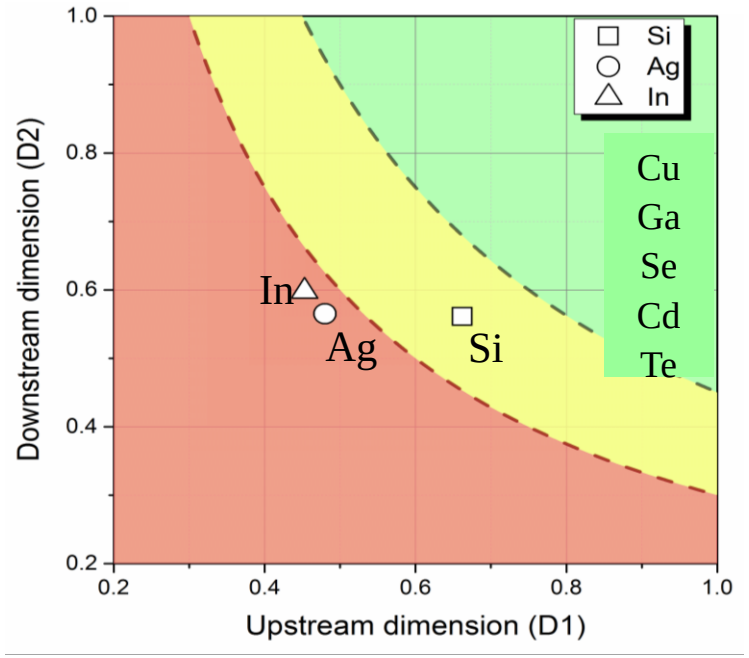
Resilience of PV technology to potential materials supply shortages

2015

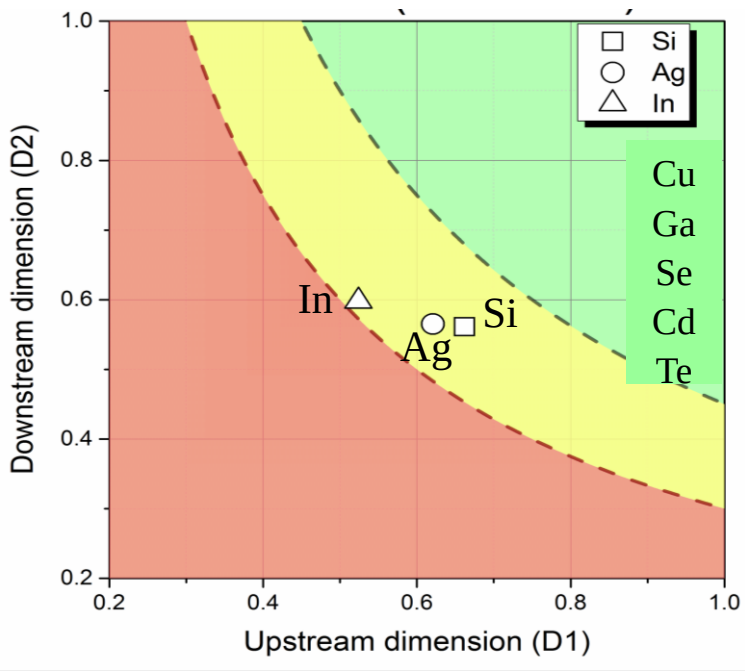


2030

~~Mitigation measures~~ X



Mitigation measures ✓



- Recycling
- Substitution
- Domestic production

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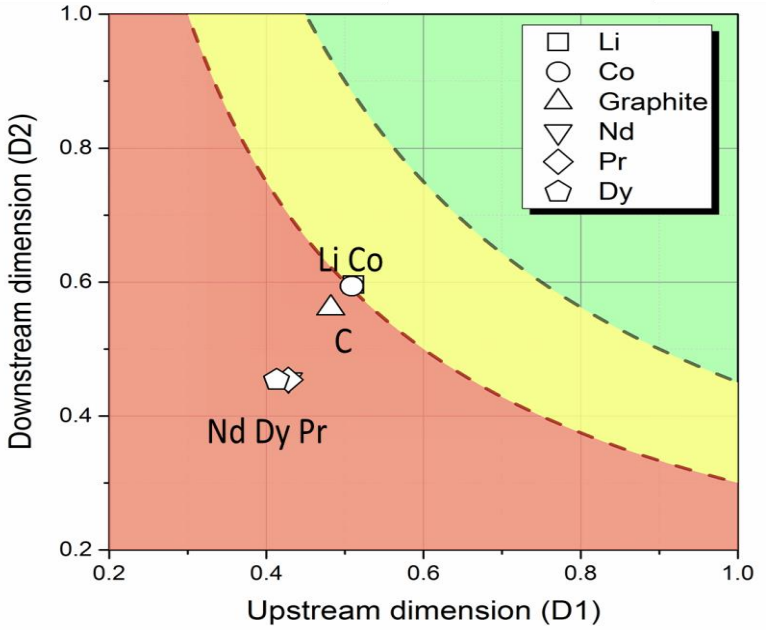
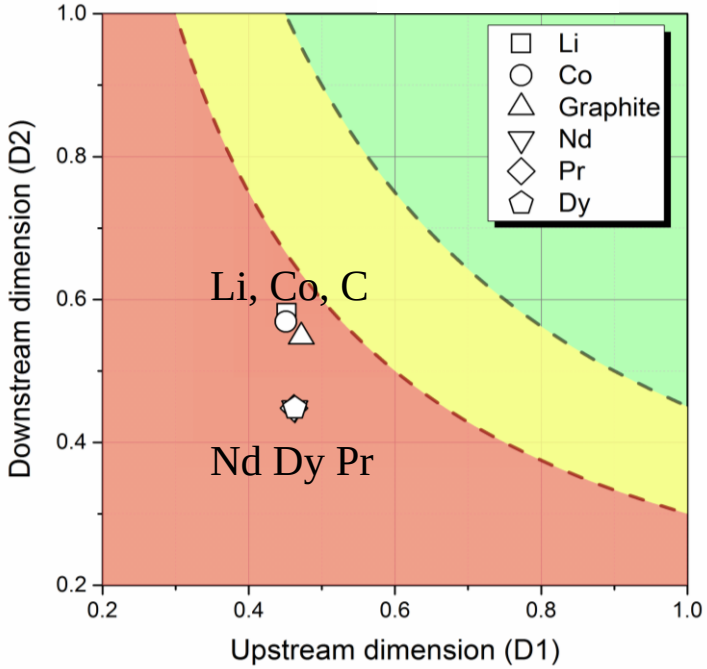
Resilience of electric vehicles to potential materials supply shortages

2015

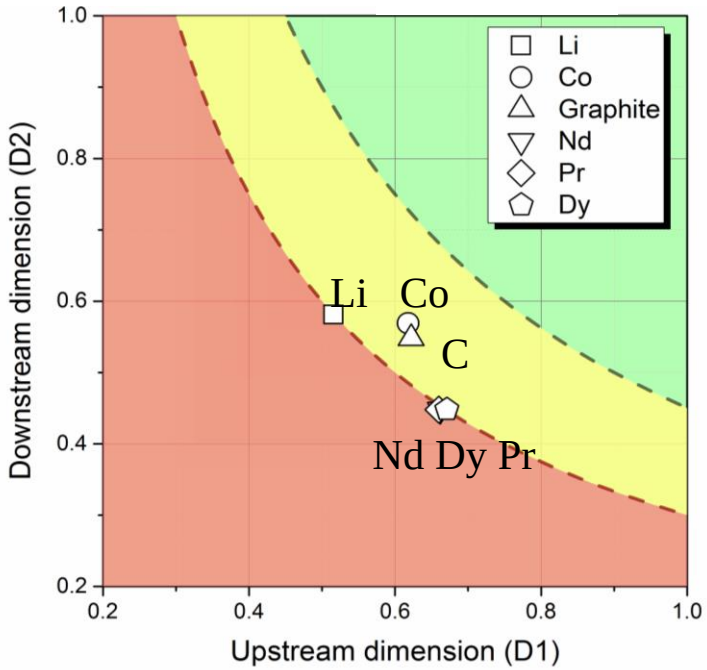


2030

~~Mitigation measures~~ X



Mitigation measures ✓



- Recycling
- Substitution
- Domestic production

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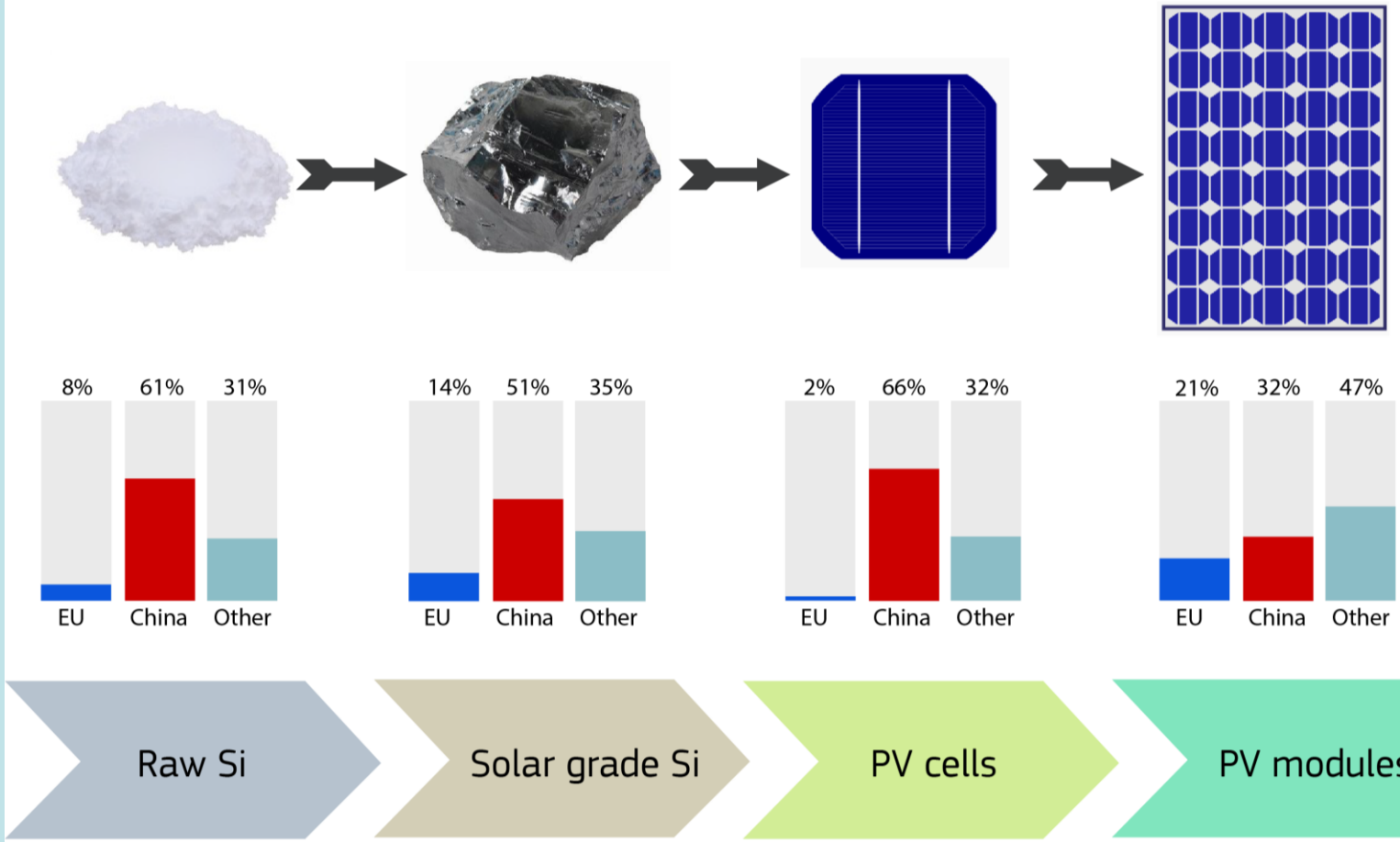
Supply chain dependency for solar energy

- EU is highly dependent on raw & processed materials & components
- China is the major supplier of materials and components for solar PV



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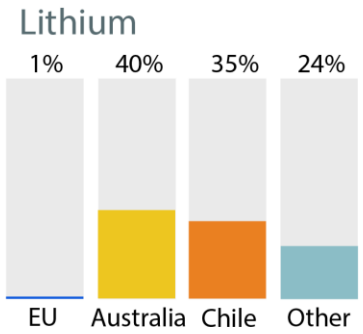
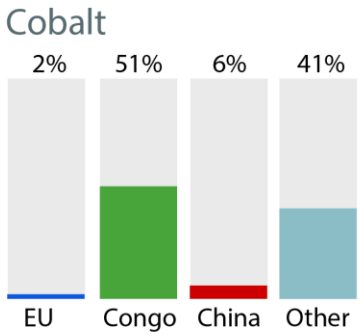
Supply chain dependency for batteries in electric vehicles

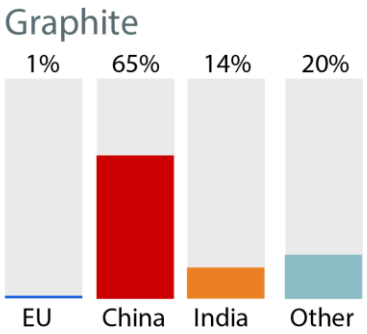
Raw materials

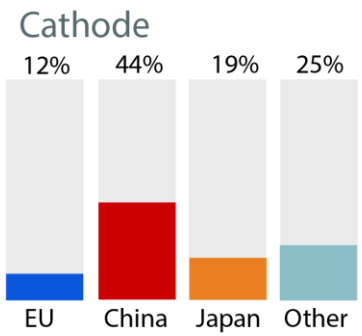
Processed materials

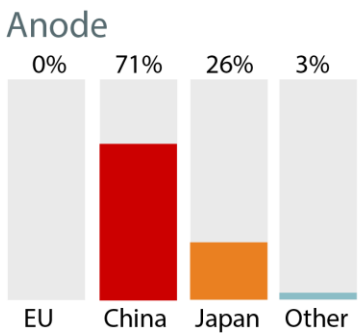
Cells/ Modules

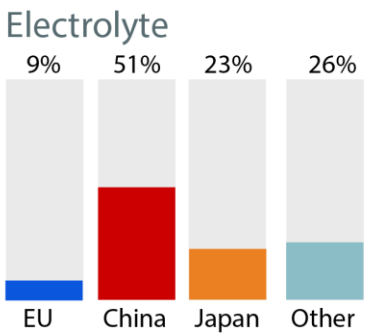


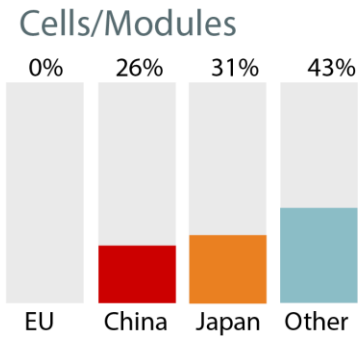


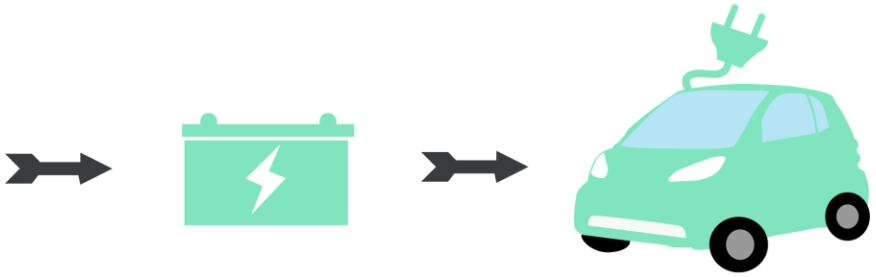












High dependence on both materials & components for Li-ion batteries!

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Materials for batteries and PV systems: Key messages

- **The EU is heavily dependent on imports for the supply of key raw materials** in batteries and PV
- The demand for **Li**, **Co** and **graphite** may increase between **25 and 45 times** depending on the EV deployment scenario.
- The **EU is strongly dependent on manufacturing capacities downstream** for both batteries and PV technologies!

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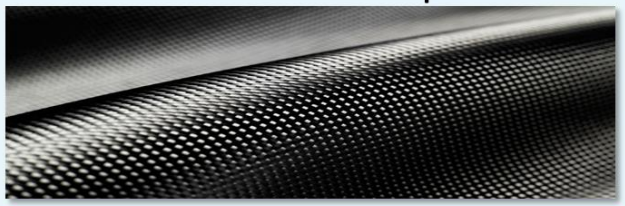
The importance of materials manufacturing

Lightweight metals and alloys

Industrial players located in EU

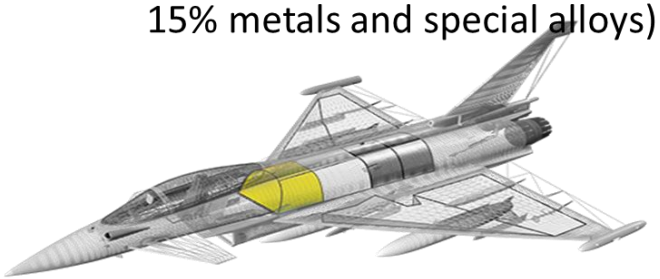
Carbon fibre composites



USA and Japan top producers

Dual-use applications

Eurofighter Typhoon
(70% composites
15% metals and special alloys)



Airbus A350XWB
(53% composites
33% metals and special alloys)

Europe needs to strengthen manufacturing capacities of composite materials!

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Space sector: A preliminary JRC overview

SELECTED APPLICATIONS

Frame, Propulsion, Connectors, Electronic systems, Power supply, Telescope, Structure, Antenna, Telemetry

SUB-SYSTEMS

Sensors, Solar panels, Nozzle, Radiators, Batteries, Reflectors, Detectors, Processors

COMPONENTS

RAW MATERIALS
Al, Be, Ag, Ga, Cu, Ge, Ti, Li, As, Au, In..

PROCESSED AND SEMI-FINISHED MATERIALS

Carbon fibres, Aluminium alloys, Reinforced plastics, Titanium and metallic alloys, Gallium arsenide, …

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Resource consumption in LCA

The accounting of resource flows (including of CRMs) is at the core of LCA.

Among the methods to capture the impacts in the area of protection of natural resources, the **Abiotic Depletion Potential** (ADP) is the most known.

It focuses on the fixed stock paradigm and relates to the extraction rate of a certain material versus mineral reserves (estimated according to different criteria).

There is no unanimous agreement in the LCA scientific community, or among the LCA users, about the ADP calculation and interpretation

Resource consumptions in LCA

Antimony (a CRM) is used as reference material (i.e. Impacts measures in terms of $kg_{Sb\ eq.}$) in ADP indicator

Characterisation factors have been calculated for substances related to many CRMs and non-critical materials.

Example: Germanium is a CRM relevant for space applications (e.g. in solar cells and infrared optics)

Consumption of 1kg of Ge is equivalent to 19 tonnes of Sb (in reserve base model).

Characterisation factors for Abiotic Depletion Potential indicator

Substance	cas no.	group	***ADP_i (kg antimony eq. / kg extraction) [reserve base]***
aluminium (Al)	7429-90-5	element	2.53E-05
antimony (Sb)	7440-36-0	element	1.00E+00
arsenic (As)	7440-38-2	element	2.40E+00
barium (Ba)	7440-39-3	element	3.37E-03
beryllium (Be)	7440-41-7	element	3.95E+00
bismuth (Bi)	7440-69-9	element	4.49E+00
boron (B)	7440-42-8	element	5.28E-03
bromine (Br)	7726-95-6	element	
cadmium (Cd)	7440-43-9	element	1.11E+00
chlorine (Cl)	7782-50-5	element	
chromium (Cr)	7440-47-3	element	1.96E-05
cobalt (Co)	7440-48-4	element	2.56E-02
copper (Cu)	7440-50-8	element	2.50E-03
gallium (Ga)	7440-55-3	element	
germanium (Ge)	7440-56-4	element	1.95E+04
gold (Au)	7440-57-5	element	3.60E+01
indium (In)	7440-74-6	element	5.55E+02
iodine (I2)	7553-56-2	element	2.22E-03
iron (Fe)	7439-89-6	element	1.66E-06
...			

Extracted from: ***van Oers et al.*** *(2002)*

Further work on resource consumption in LCA

Linked with Commission's Product Environmental Footprint Initiative

Focus: identify where the losses, decreasing the availability of resources, actually occur – **the "dissipative use" concept**

- Attribution of impacts to those life cycle stages which are the source of dissipative use
- Acting on two levels: Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA)
- Abiotic resources: there is some understanding in the scientific community and industrial stakeholders that the concept of «dissipation» should be explored, also in the context of circular economy
- A novel consistent approach is being developed, also with JRC

CRMs in Life Cycle Assessment and Circular Economy: Key messages

- Tracking CRMs in products is **relevant** and is connected to LCA activities
- **On-going research** to better address resources (including of CRMs) in LCA
- **Improving circularity of CRMs**, especially in ground activities (e.g. by minimizing dissipation, increasing recycling/reuse) will lower overall life-cycle impacts

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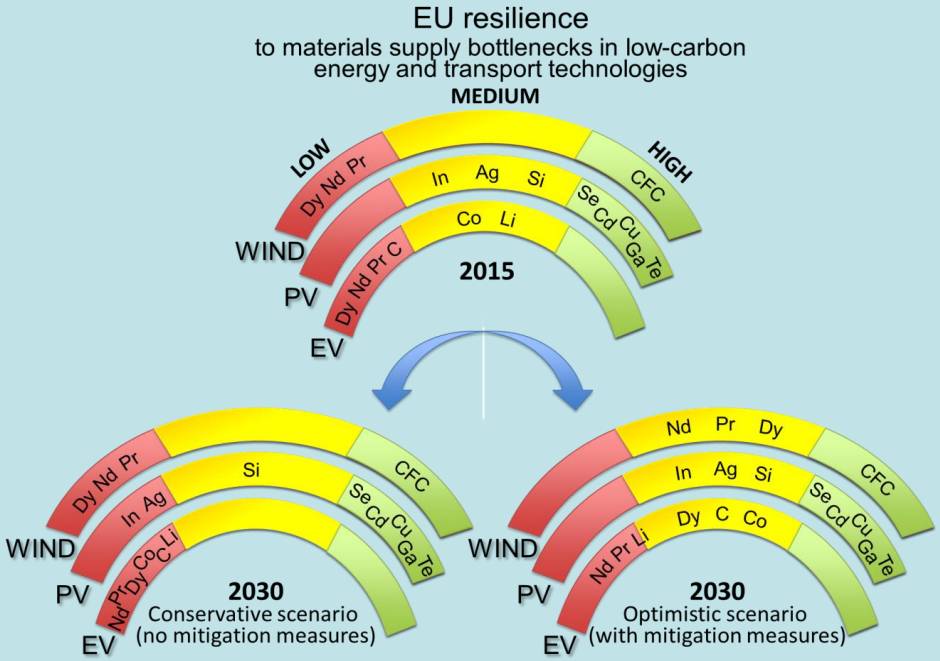
Conclusions

The EU is vulnerable to supply bottlenecks of several key materials needed in various applications, e.g. in photovoltaic, electric vehicle technologies, electronics. Unless mitigation measures are taken, the EU resilience to potential supply issues will deteriorate substantially by 2030.



Recycling – important short term mitigation;
Substitution – longer term potential

Supply chain and its diversification are essential!

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Thank you

Any questions?

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