SETAC EUROPE 29th ANNUAL MEETING
26–30May 2019 I Helsinki, Finland
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How critical raw materials could influence LCA impact categories in renewable energy systems

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Introduction & Background

Critical raw materials (CRM) are those raw materials which are economically and strategically important for the world economy, have a high-risk associated with their supply, and there is a lack of viable substitutes and recycling processes.

Twenty-six CRM have been identified as critical in Europe from a long list of candidates [1].

Renewable energy systems, like wind turbines or photovoltaic modules, have particular metals or rare earths in their components that could be included in these CRM (Figure 1).

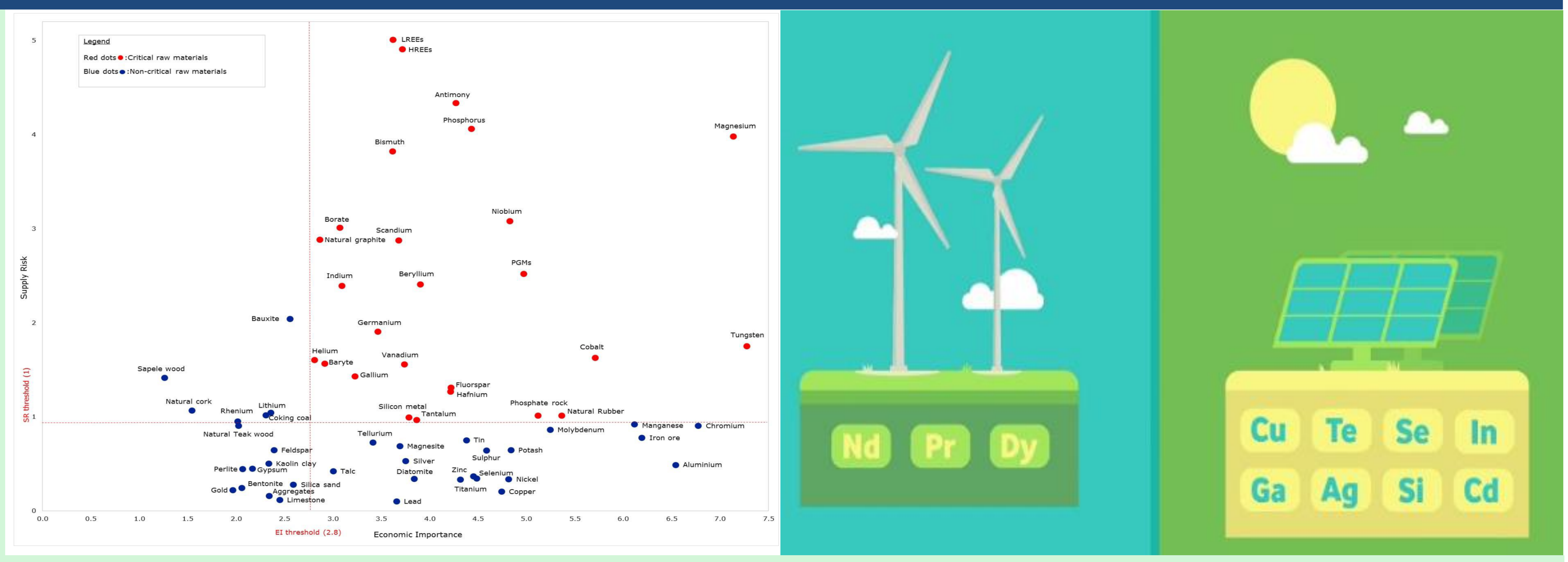

Figure 1. *CRM list in Europe (2017) and those selected for wind and PV technologies [1-2].*

Materials & Methods

Several prospective studies have stated different potential scenarios of the situation of CRM in the next 10-20 years.

After a deep analysis, several actions to improve the sustainability and the circular economy from a life-cycle approach have been defined, such as substitution or recycling of CRM. This work aims to identify the potential influence on different LCA impact categories, like those related to toxicity or resource depletion.

Different scenarios have been defined in the following table for each technology.

WIND				SOLAR PHOTOVOLTAIC			
Element/s	**Action**	**Scenario**	***Ref.***	**Element**	**Action**	**Scenario**	***Ref.***
Neodymium 60 Nd; Praseodymium 59 Pr	Increase efficiency: 29%	**A**	*[3]*	Indium 49 In	Recycling: 20%	**D**	*[3]*
Dysprosium 66 Dy	Reduction mass: 67%	**B**	*[3]*	Silver 47 Ag	Recycling: 5%	**E**	*[3]*
Dysprosium 66 Dy; Neodymium 60 Nd	Substitution by **Co-Ce alloys**: 100/20%	**C**	*[3-4]*	Silver 47 Ag	Substitution by **Cu:** 50%	**F**	*[3]*

Results

Figure 2 presents the percentage of impact reduction on Resources Depletion considering the three scenarios related to wind. EPS2015d characterization method [5] has been used because of the consideration of characterization factors for rare earths in this impact category.

Figure 3 also presents the percentage of impact reduction in both impact on Human Toxicity, non-cancer effects (HTnc) (except scenario D) and Resources Use, Mineral and Metals (RUmm) from the Environmental Footprint characterization method.

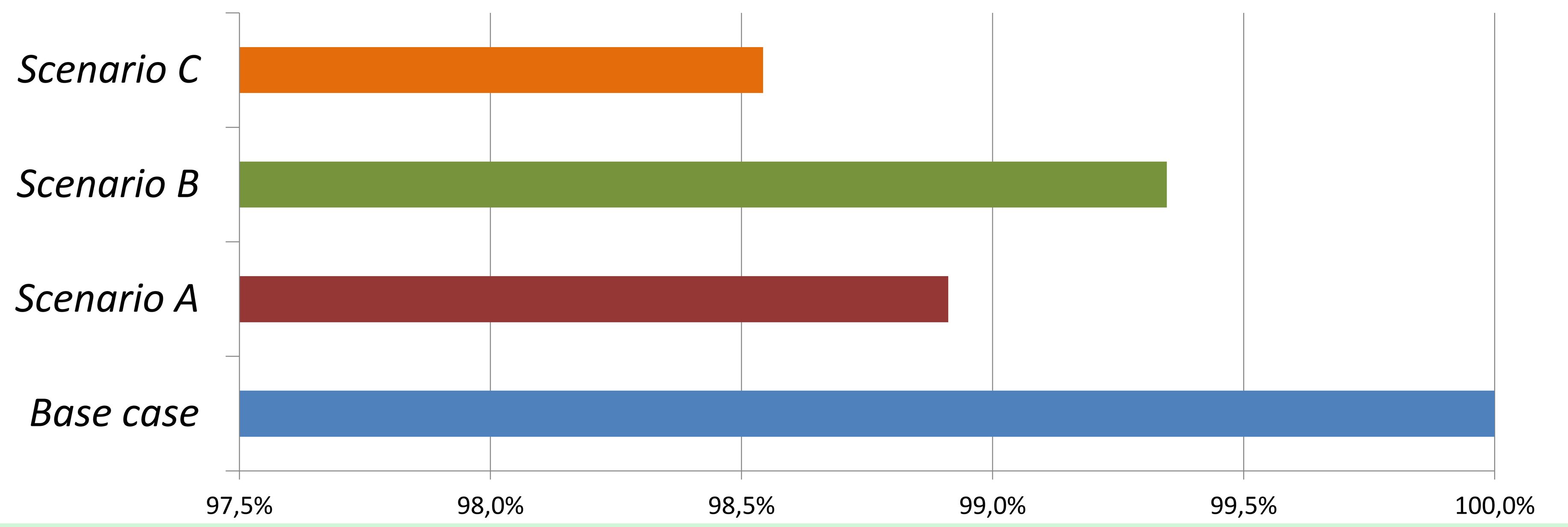

Figure 2. *Reduction values in Resources Depletion category in wind technologies scenarios.*

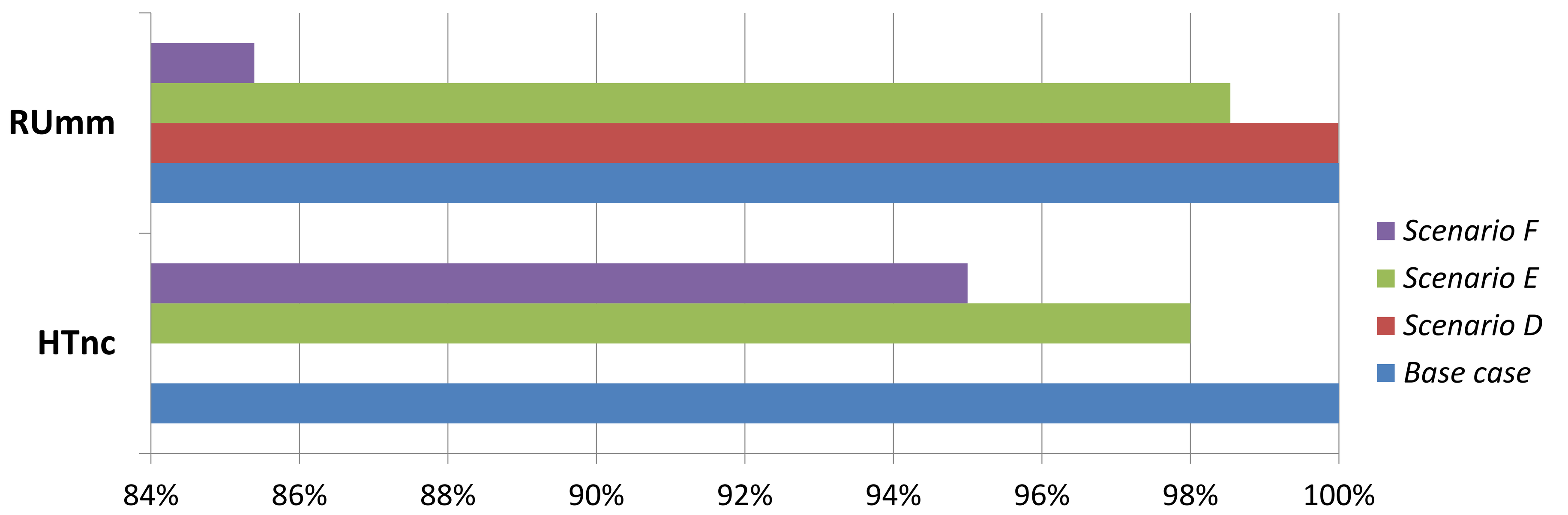

Figure 3. *Reduction values in RUmm and HTnc categories in solar PV technologies scenarios.*

Discussion & Conclusions

It is important to examine the resource scarcity from the perspectives of both supply and demand. Substitution could be a relevant mitigation option which can alleviate the pressure on the supply of CRM in the short term by easing future demand. Regarding the recycling, further developments in large scale processes must be done in order to maximize process efficiencies.

This theoretical results could affect to other impact categories because of the pollution transfer effect. Finally, improvements on CRM characterization factors or even a new impact category should be considered linked to the methodology for selecting the official list of CRM proposed by the European Commission.

References

[1] European Commission. *Study on the review of the list of critical raw materials.* Final report study. 2017. http://rmis.jrc.ec.europa.eu.
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[3] Blagoeva DT, Alves Días P, Marmier A, Pavel CC. *Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU. Wind power, photovoltaics and electric vehicle technologies, time frame: 2015-2030.* EUR 2828192, doi:10.2790/08169.
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[5] https://www.ivl.se/english/startpage/pages/our-focus-areas/environmental-engineering-and-sustainable-production/lca/eps.html

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