

# REE4EU



## **Integrated High Temperature Electrolysis and Ion Liquid Extraction for a Strong and Independent European Rare Earth Elements Supply Chain**

**Market Analysis**

**Nader Akil, PNO Innovation**

**Exploitation Workshop -Brussels 24 April 2019**

# »» Market analysis - Main Objective

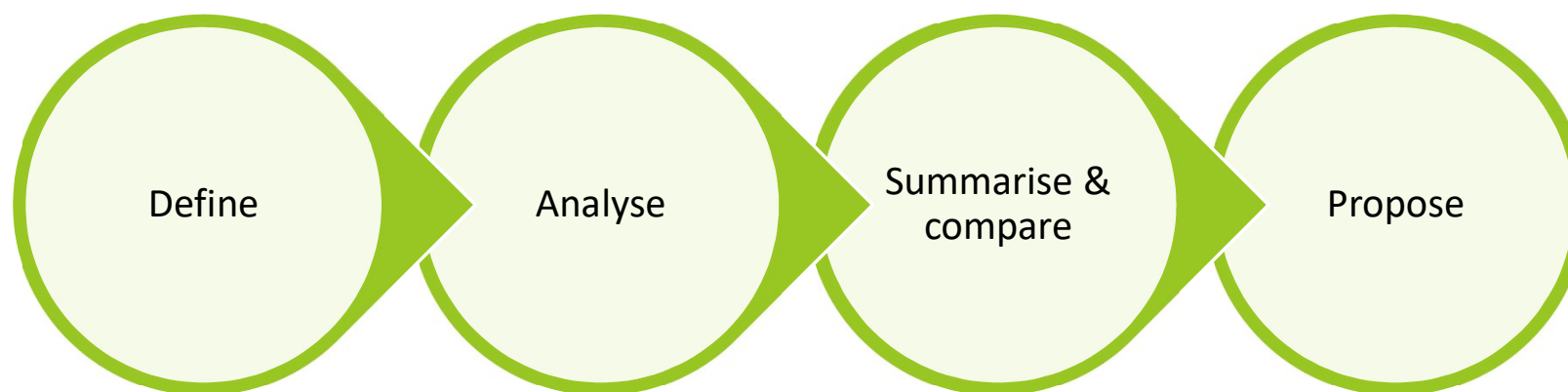


## Objective

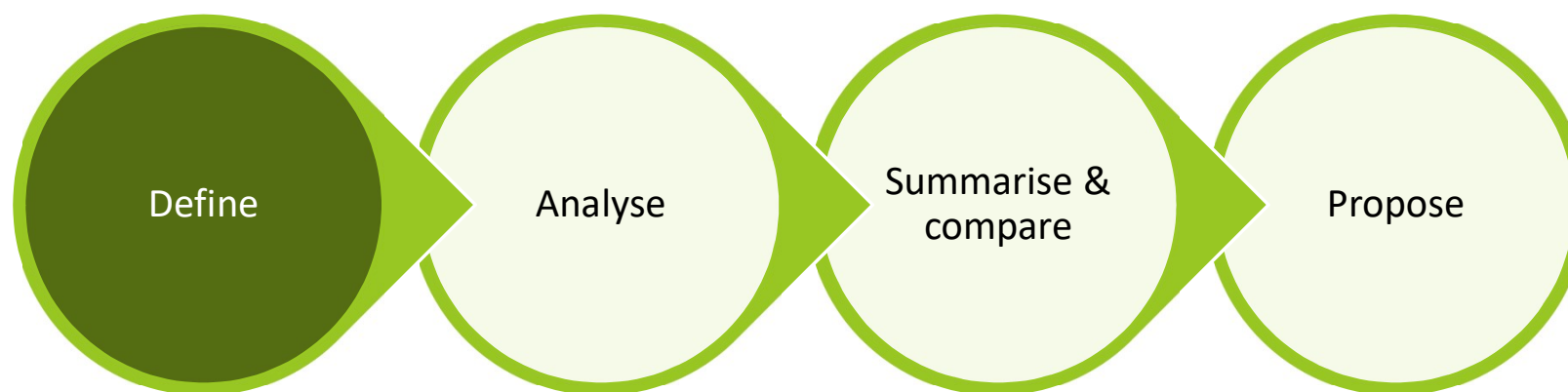
*Provide the REE4EU consortium and other stakeholders with a better understanding of the uncertainties associated with the supply and value of EoL products*



# »»» Analysis of future EoL product market



# »»» Analysis of future EoL product market



# »»» End of Life products as REE recovery feedstock



Starting point  
was...

ERECON

Hard disk drives (HDDs), DVD and CD players

Automotive applications

Motors in industrial applications

Loudspeakers

Air conditioning compressors

Magnetic separators

Mixed electronics

Electric bicycles

Wind turbines

Milestone report by the **European Rare Earths Competency Network** (2015)

**STRENGTHENING THE EUROPEAN RARE EARTHS SUPPLY-CHAIN**  
Challenges and policy options

*applications that were identified by the ERECON network for which recycling may present a significant opportunity*



# »» End of Life products as REE recovery feedstock



Still there are  
pending  
questions ...

ERECON

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Automotive applications

Motors in industrial applications

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Magnetic separators

Mixed electronics

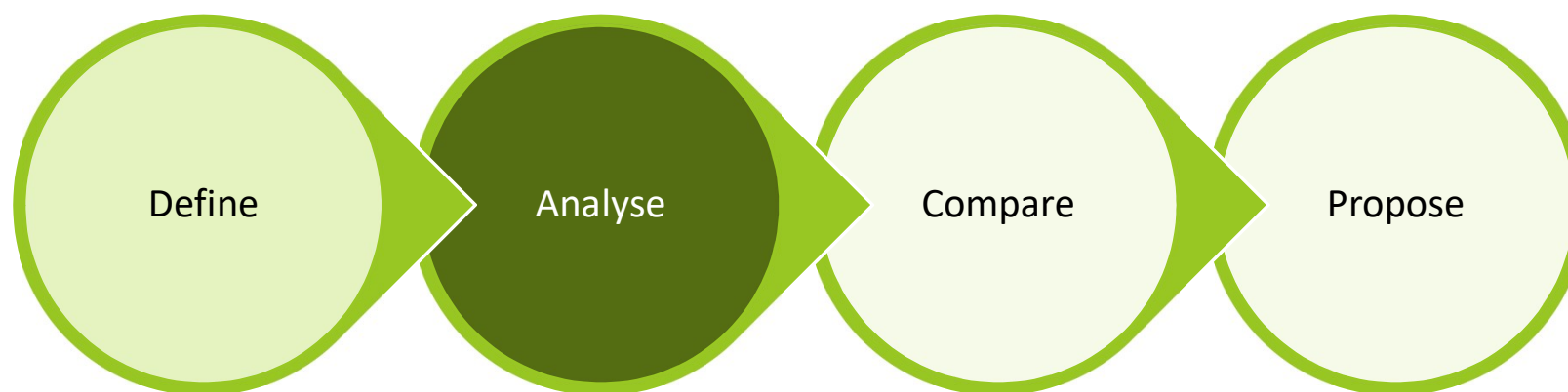
Electric bicycles

Wind turbines

- ✓ What is the amount of REE in those products ?
- ✓ When will they be available at significant quantities?
- ✓ Are they dispersed or concentrated in Europe?
- ✓ What are the collection measures available?
- ✓ What are the technical barriers to use them as input in a future large scale REE recovery venture?
- ✓ ....



# »»» Analysis of future EoL product market

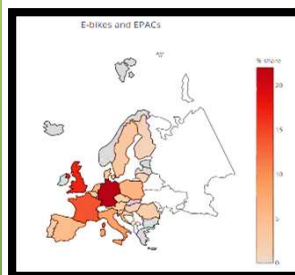


# Secondary REE – market segmentation



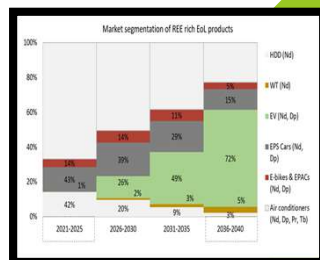
## Segmentation by application

Dedicated summaries giving an overview of the application, theoretical estimation of available REEs in the EU, projected supply trends, technical and systemic barriers, expert insight, etc.



## Segmentation by geographic resource potential

% of secondary REEs products at EU country level to allow for a preliminary mapping of “hot regions”. Possibility to identify country “clusters” for which a common recycling strategy could be considered.



## Segmentation by temporal resource allocation

Indication of relative EoL product supply changes taking into account their different lifetime and technological maturity. Particularly, relevant for a future mixed recycling scenario with different EoL products





# Exemplary market segment: EoL HDDs



## Application

- **Function:** data storage in desktop/laptop computers
- **Description:** dimensions, source of supply, etc.
- **Type of magnets:** sintered magnets & resin bonded magnets



## REE content in HDDs

- **Elements:** Neodymium (Nd)
- **Magnet per unit:** 2 - 20 g of NdFeB alloy
- **Element per EoL product unit:** approx. 0,5 g and 6 g of Nd for a laptop and a desktop computer, respectively

## Availability over time

- **Availability:** production of HDDs as End of Life products (World & Europe)
- **REE potential :** estimation of annual theoretical quantity of REE that can be harvested from EoL HDDs in Europe
- **Future trends of supply:** the HDD market is expected to shrink



# Exemplary market segment: EoL HDDs

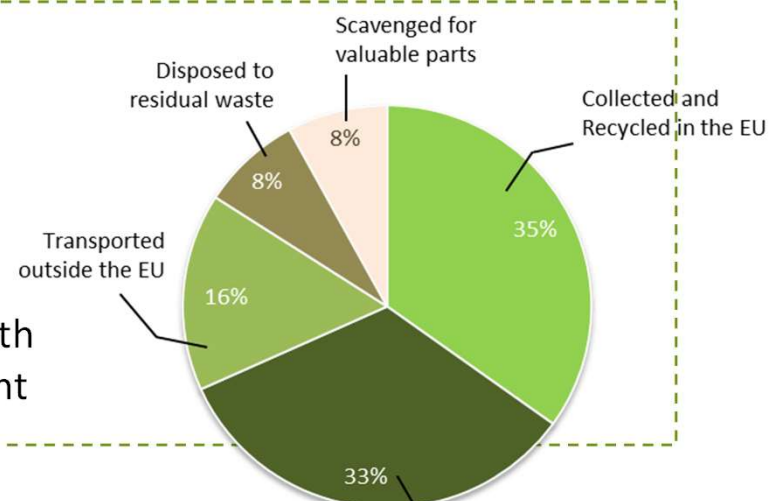


## Collection measures & collection rates

- **Regulations pertinent to their recycling:** Directive 2002/96/EC manufacturers are obliged to handle collected WEEE
- **Collection rates (actual or estimated)** : 30% of the generated WEEE is collected in Europe
- **Industry case studies:** Dell, HP

## Barriers to recycling

- Unclear legislation
- Transport of EoL HDDs out of Europe
- Design features incompatible with conventional recycling equipment

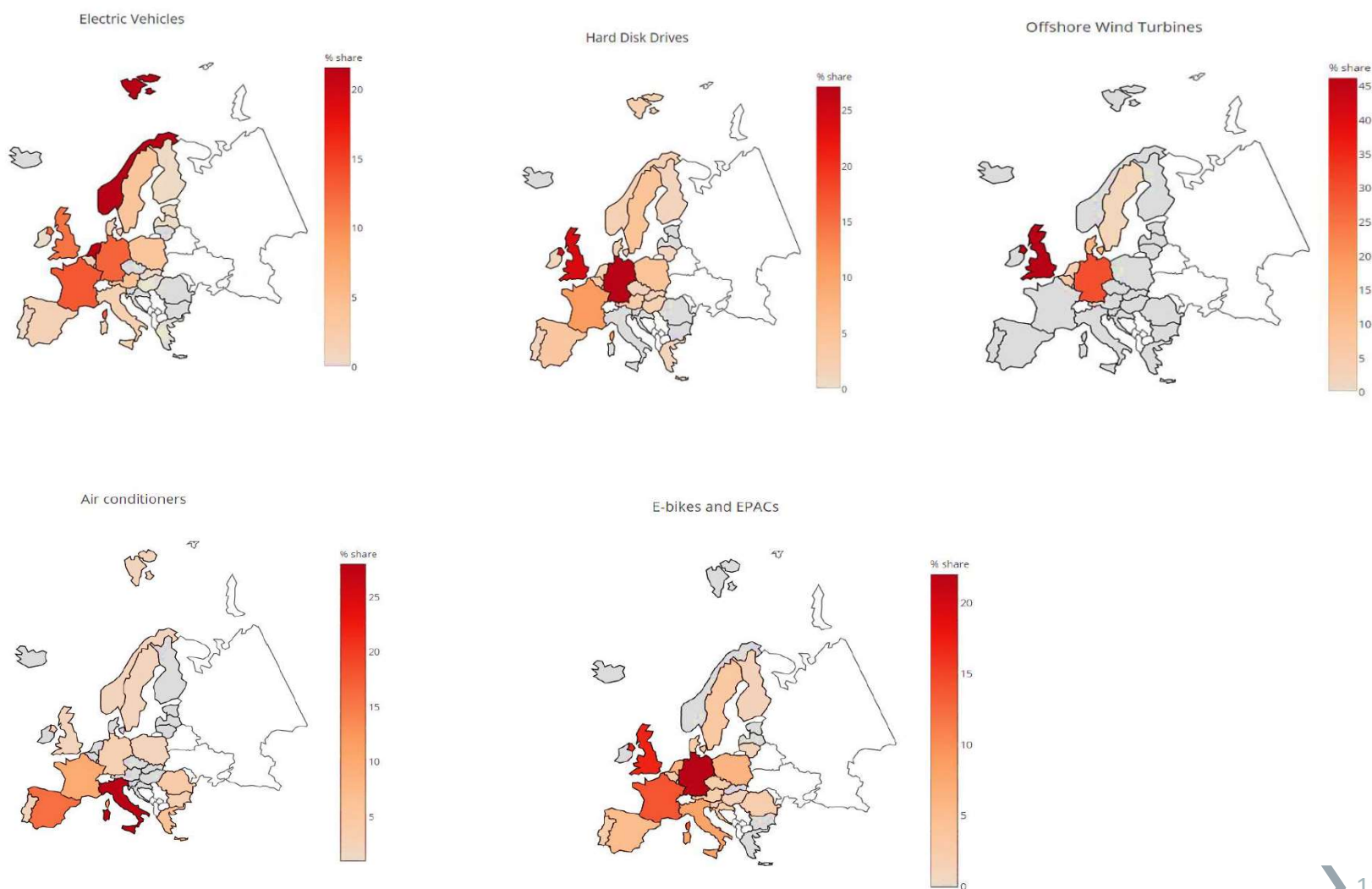


## Expert insight

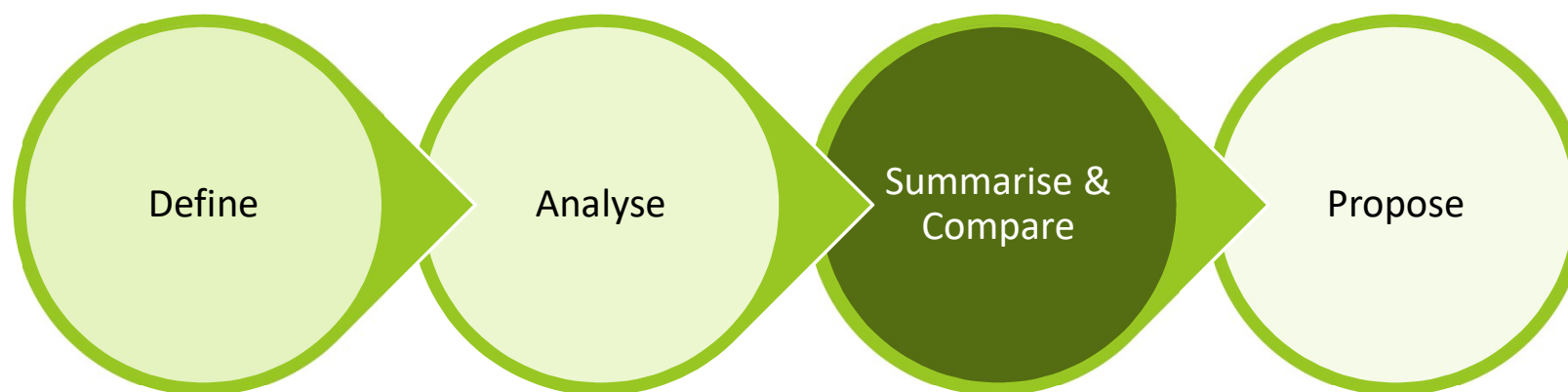
- Interviews with stakeholders (e.g. recyclers, component manufacturers, etc.)



# Geographic resource potential



# »»» Analysis of future EoL product market



# End-of-life product market assessment



- Hard disk drives from laptops/desktops
- Electric drive motors for EVs
- Offshore wind turbines
- Industrial motors
- Magnetic separators
- Hard Disk Drives from laptops/desktops
- Electric vehicles, e-bikes and Electric Power Assisted Cycles (EPACs)

Quantitative assessment

Qualitative assessment



# Quantitative market assessment

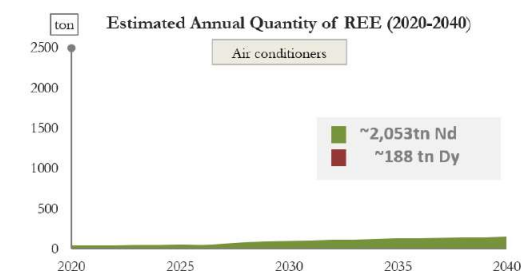
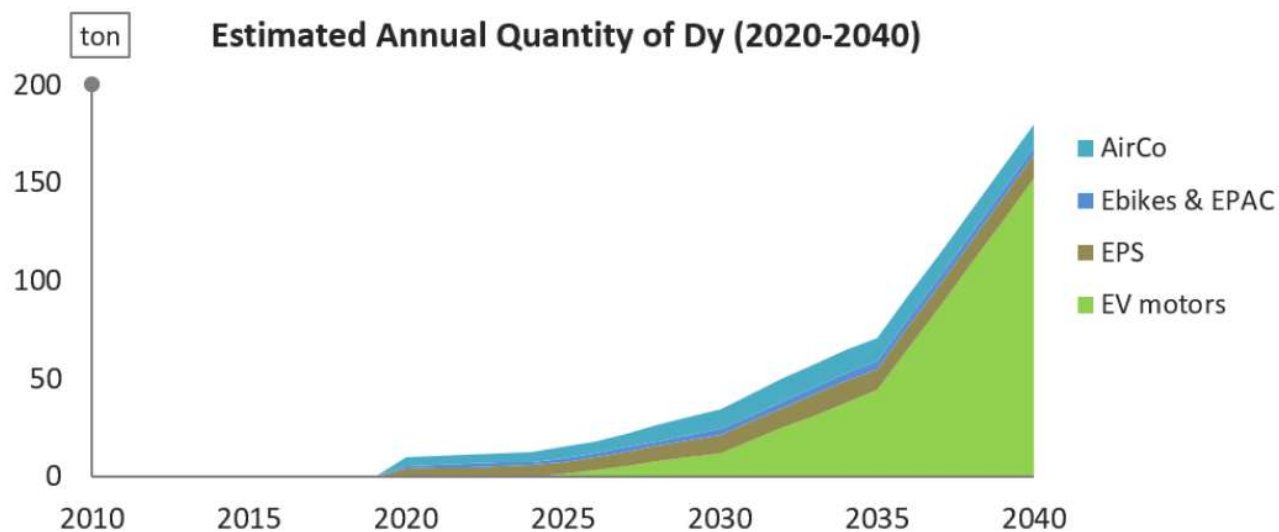
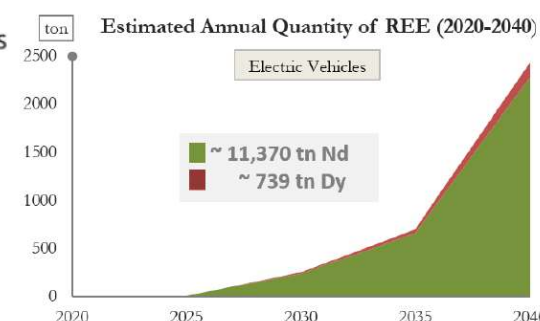
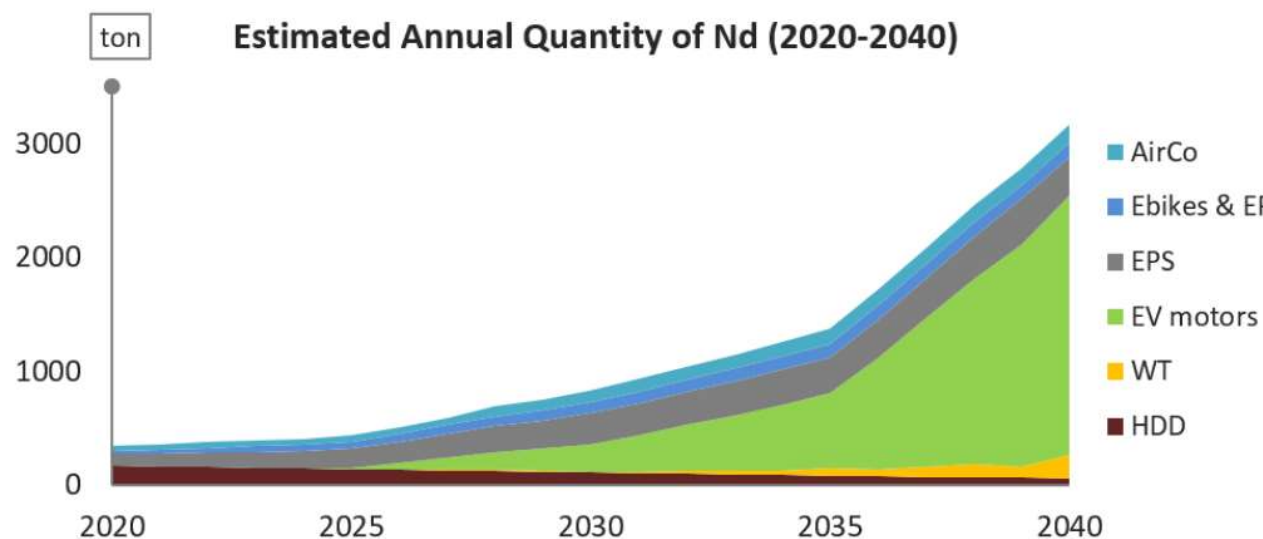


- Hard disk drives from laptops/desktops
- Electric drive motors for EVs and Hybrid cars
- Offshore wind turbines
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## Quantitative assessment

- REE content per EoL product unit
- Expected availability from 2020-2040
- Monetary value of REE content (2020-2040)

# Quantitative assessment of EoL products







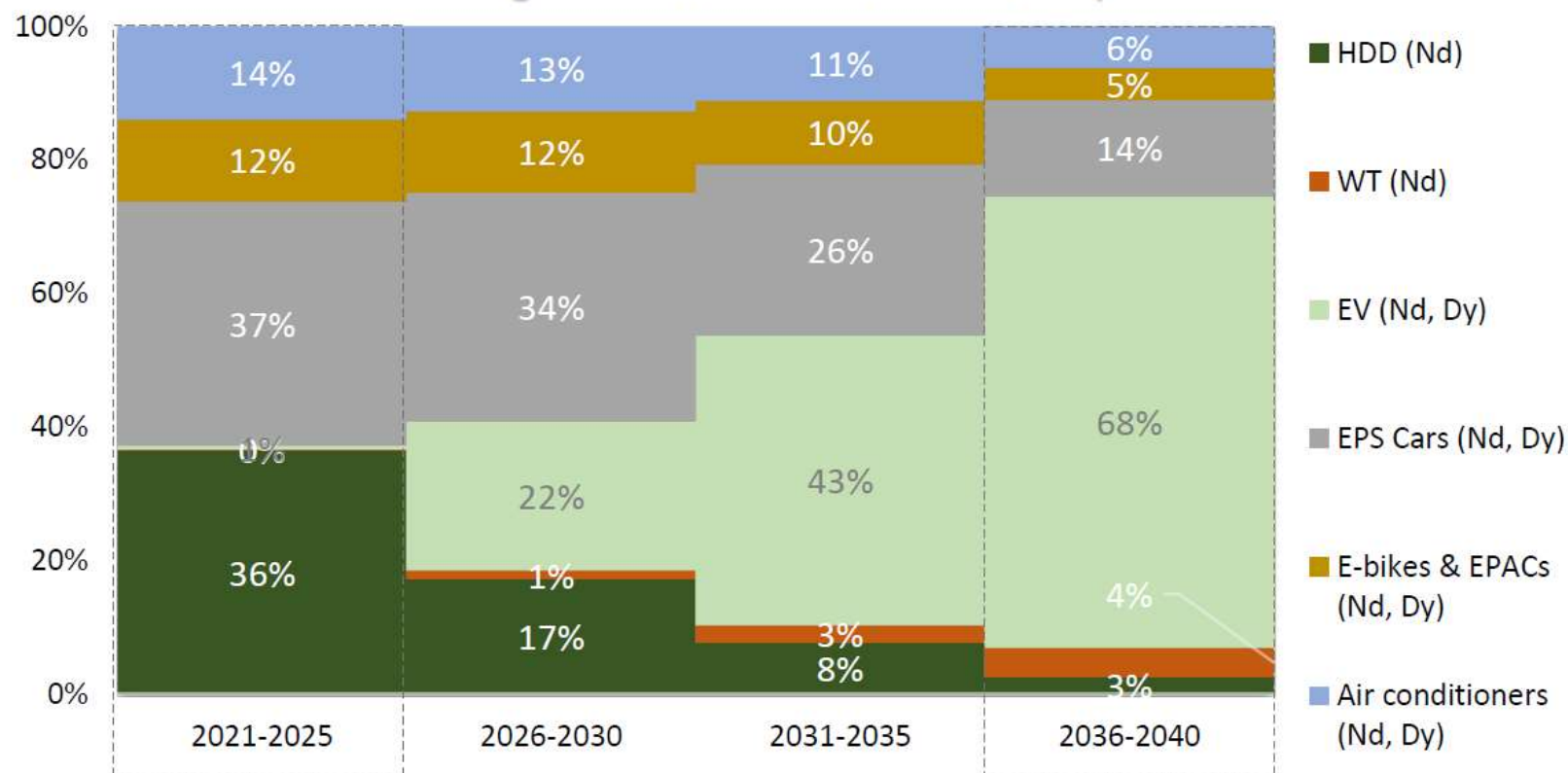
# Progressive diversification of secondary REE market (2020-2040)



REE4EU

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Market segmentation of REE rich EoL products





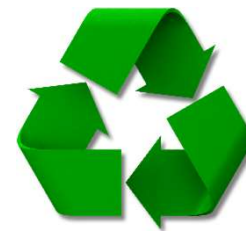
# Qualitative market assessment



- Hard disk drives from laptops/desktops
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## Qualitative assessment

Factsheets summarising key information (complementing numeric data)



*Ease of disassembly?*

*Legislation in place?*

*EoL in the EU or second life out of it ?*

# »»» EoL product as an REE supply source: factsheet



Qualitative attribute	Score
A. Maturity of regulations	<ul style="list-style-type: none"> <li>• Absence of communications/ directives</li> <li>• Communications</li> <li>• Directives</li> </ul>
B. Availability of collection schemes	<ul style="list-style-type: none"> <li>• No reported scheme</li> <li>• Collections scheme(s) under development</li> <li>• Existing scheme</li> </ul>
C. Design compatibility with EoL PM recovery	<ul style="list-style-type: none"> <li>• Challenging extraction of REE-rich components</li> <li>• Fairly difficult extraction of REE-rich components</li> <li>• Easy extraction of REE-rich components</li> </ul>



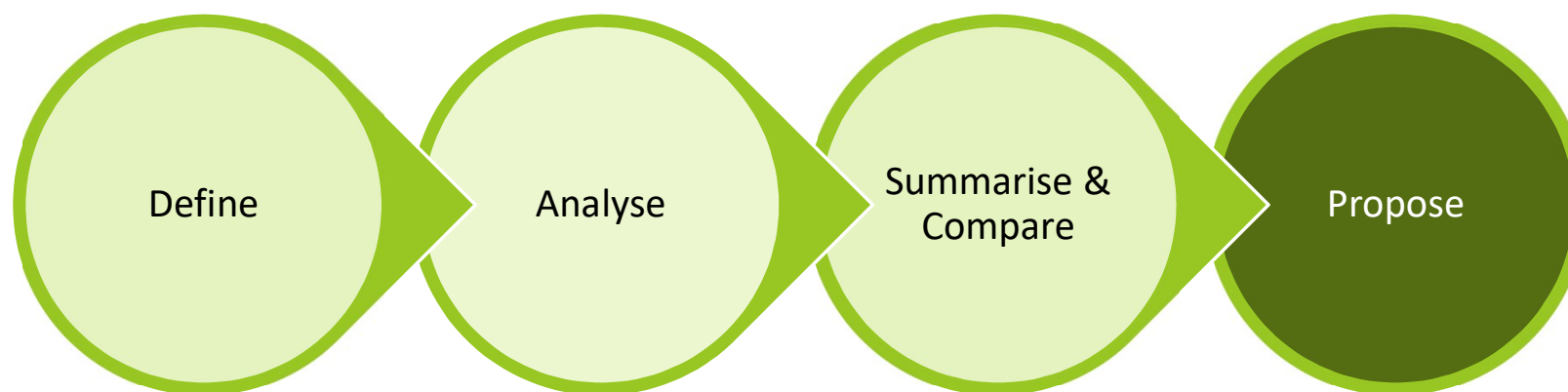
# >>> EoL product as an REE supply source: factsheet



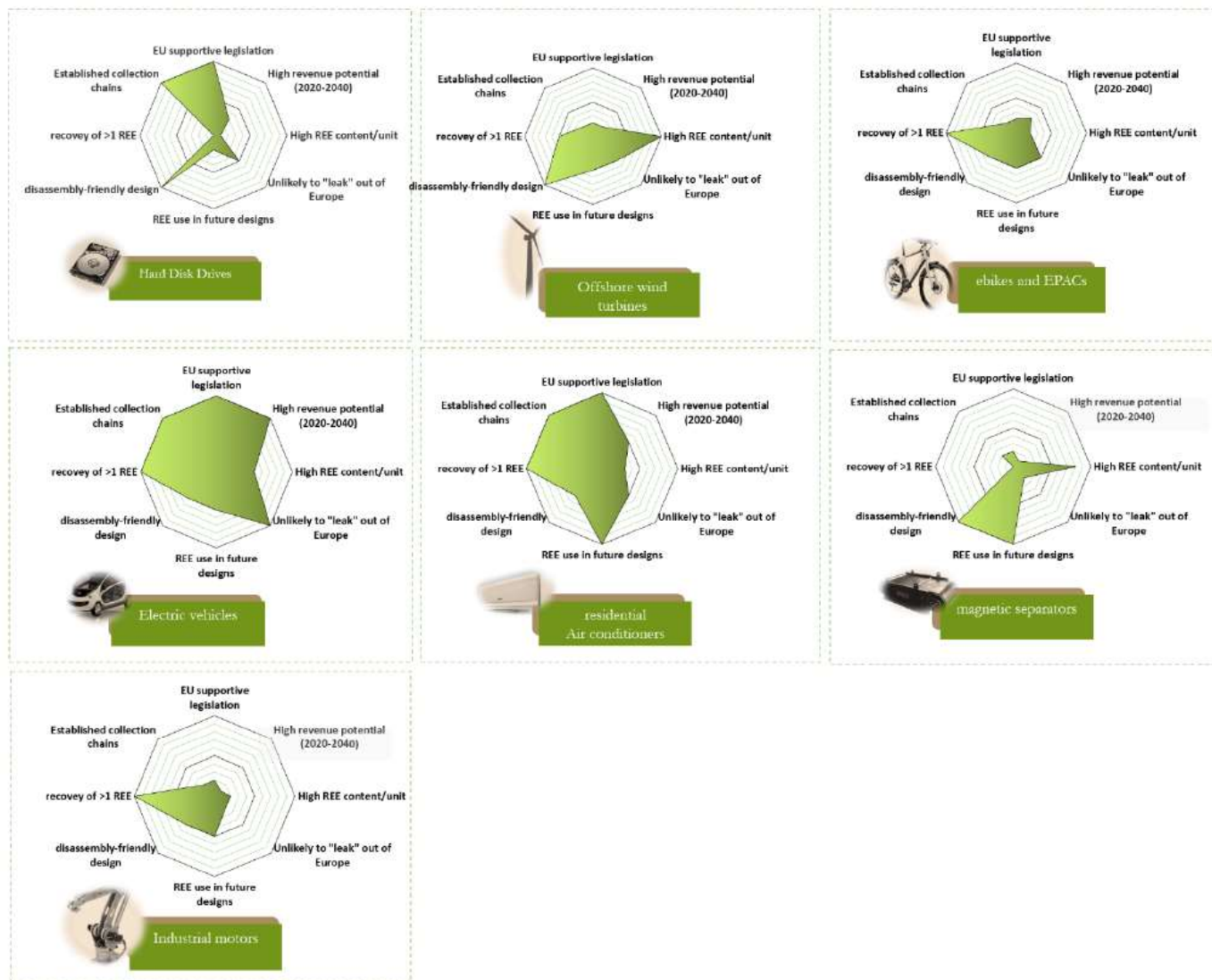
Qualitative attribute	Score
<b>D. Risk for REE reduction/elimination</b>	<ul style="list-style-type: none"> <li>• Existing cost-competitive, alternatives with equal or superior performance</li> <li>• Substitution possible with higher cost and/or poorer performance</li> <li>• Currently no commercial substitutes</li> </ul>
<b>E. Probability of second life out of EU Vs end-of-life in EU</b>	<ul style="list-style-type: none"> <li>• High probability for second life out of EU</li> <li>• Fair probability for second life out of EU</li> <li>• Low probability for second life out of EU</li> </ul>
<b>F. Co-recycling potential for more than one REE</b>	<ul style="list-style-type: none"> <li>• EoL product only contains one REE in significant quantity (others in trace amounts)</li> <li>• EoL product contains more than one REE</li> </ul>



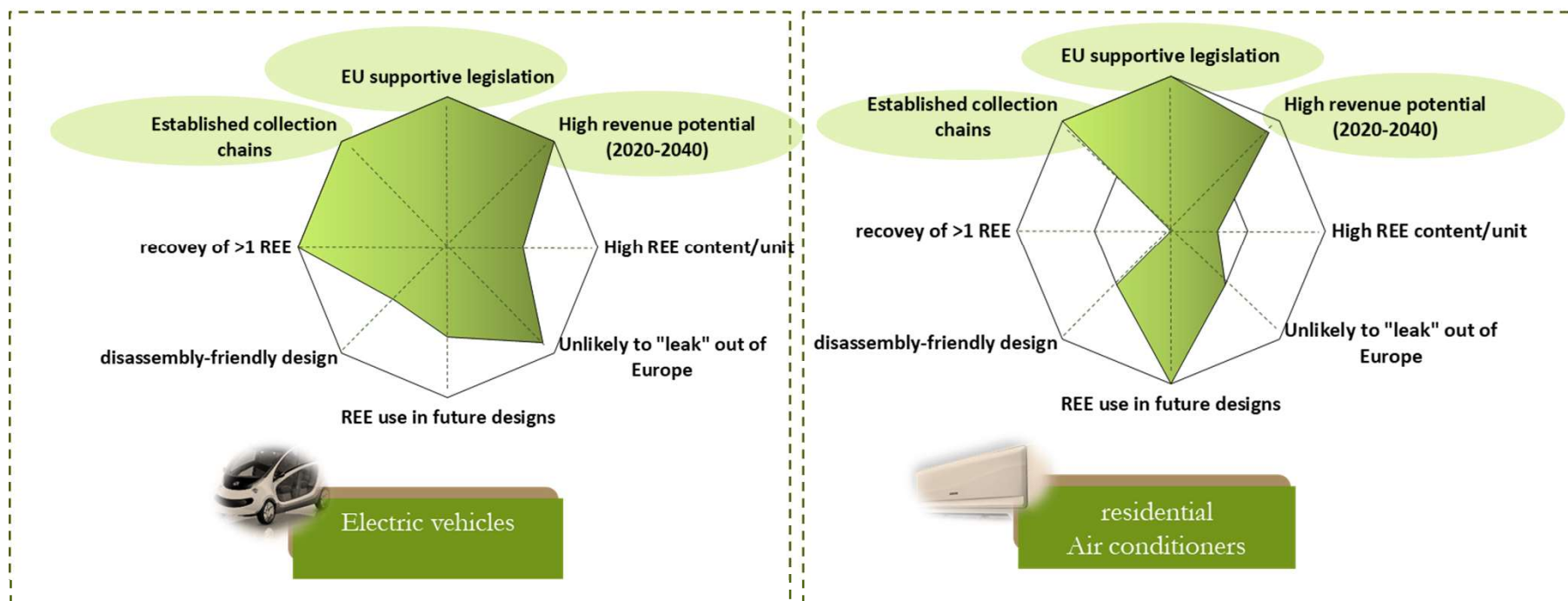
# »»» Analysis of future EoL product market



# Hard Disk Drives



# Fit-for-REE recovery ?

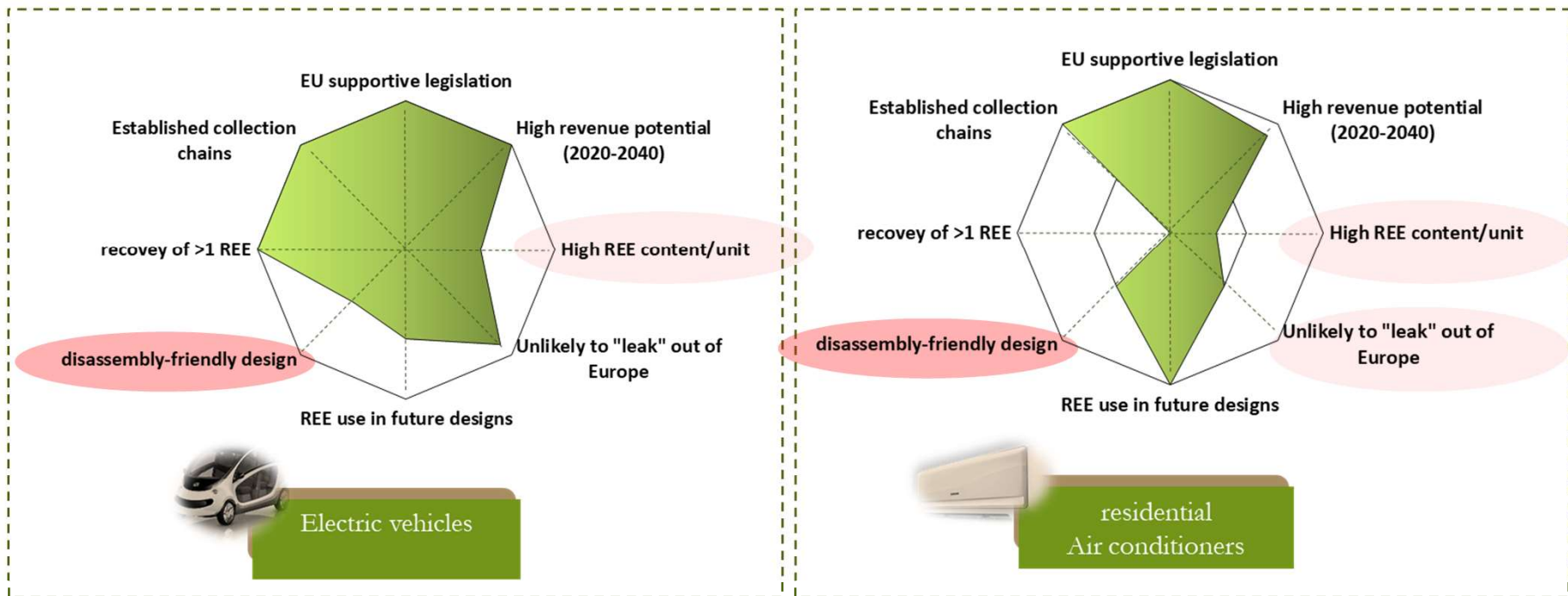


- Not all magnet-containing end-of-life products are equally recyclable
- EoL consumer products, in particular **EVs** and **residential air conditioners** are more likely to become the feedstock of choice for a future REE recovery plant





# Fit-for-REE recovery ?



Same technical barriers to overcome as in 2015

*"In many ways, the **extraction step is the biggest hurdle** to the recycling of NdFeB, but it is often overlooked. If the material cannot be extracted from the electronics in a manner that is economically viable, then the downstream processes for re-manufacture are irrelevant; the process will already be too expensive"(ERECON, 2015)*

# » Acknowledgment of contribution



Mr. Bert Witkamp



Mr. Sverker Sjölin



Mr. Rolf Blank



Mr. Laucournet Richard





## »»» Where to download the full report



The REE4EU Market Analysis Report is a **public document** and can be downloaded from the REE4EU website [www.REE4EU.eu](http://www.REE4EU.eu)





Thank you

