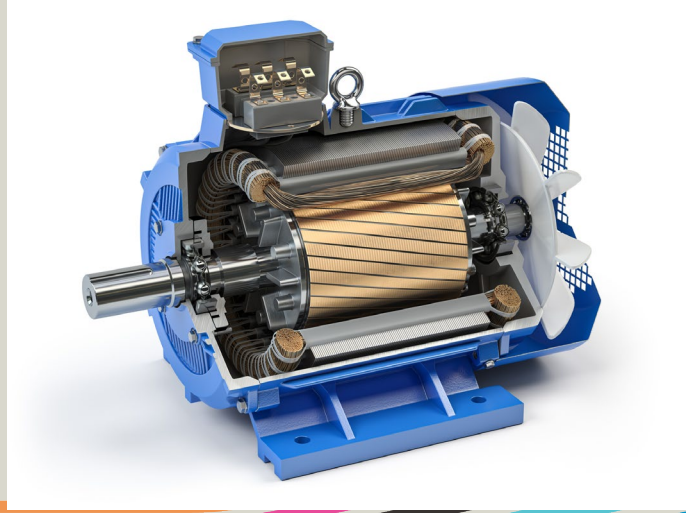
CWIEME BERLIN | 14-16 MAY 2024 MESSE BERLIN

By Hyve

How to Comply with a Potential Upgrade of the Ecodesign Regulation for Stationary Motors?

International Copper Association Europe

Institute for Systems and Robotics Lisboa



berlin.cwiemeevents.com

Agenda

Ecodesign regulation for motors

Technology options to improve energy performance

Comparing IE3 vs IE4: energy savings, cost, use of materials, LCA

Considerations relative to permanent magnets

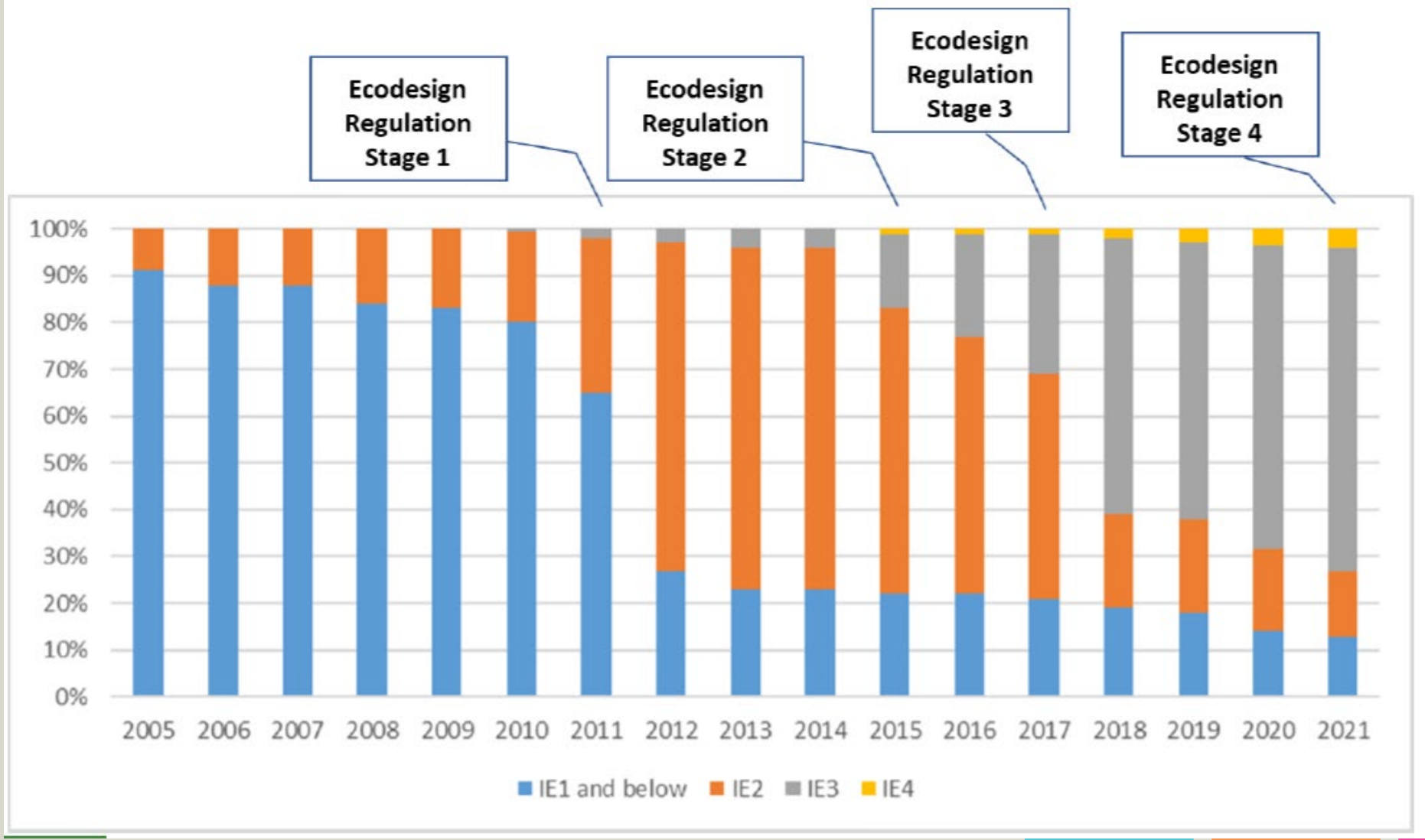
Conclusions and recommendations

Ecodesign regulation

Requirements for various motor categories

Motor	Power range	Reg 640/2009		Reg 2019/1781	
Type	kW	01/01/2015	01/01/2017	01/07/2021	01/07/2023
S3	0,75-7,5	IE2	IE3		
M3	7,5-75	IE3			
L3	75-375	IE3			IE4 (75-200 kW)
S3v	0,75-7,5	IE2		IE3	
M3v	7,5-75	IE2		IE3	
L3v	75-375	IE2		IE3	
XS3, XS3v	0,12-0,75			IE2	
XL3, XL3v	375-1000			IE3	
8 poles	0,75-1000			IE3	
Ex eb	0,12-1000				IE2
XS1, S1	>0,12				IE2

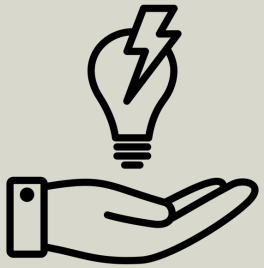
Ecodesign regulation: impact on sales



Data: CEMEP, through www.eu-more.eu project

Regulation review: avenues

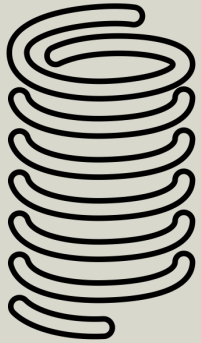
Resource efficiency requirements



Stricter requirements for motors and VSDs

Adding other motor types to the scope, including permanent magnets

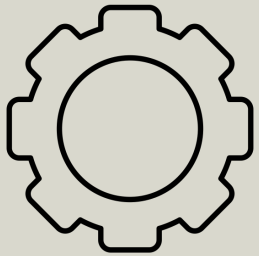
Improving energy performance of induction machines



↑↑ stator windings cross-section

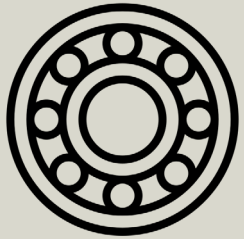
More steel and copper is needed.

However, this can be counter-balanced by lower electricity generation requirements

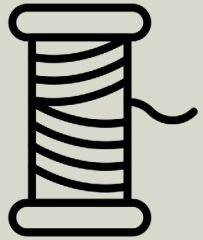


↑↑ quality e-steel

↓↓ lamination thickness



↑↑ quality bearings



Winding techniques

Shift from aluminium to copper rotor

Alternative technologies

Fixed speed

Induction technology preferred
(cost, reliability)

Variable speed

Synchronous reluctance

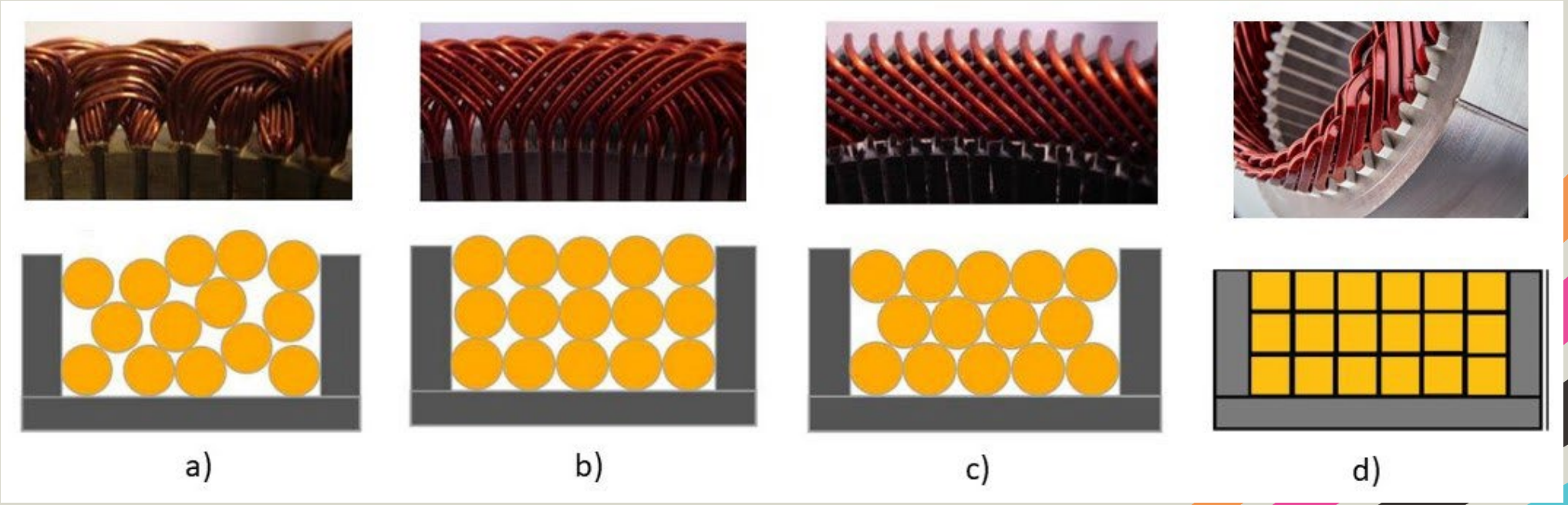
Permanent magnet synchronous

Induction

☺ Higher efficiency at partial load
☺ Near zero rotor losses

☹ Costly
☹ Use of rare earths

Winding techniques



a) round wires, random	Slot fill factor ~55%	No need to increase frame size with higher fill factors
b) round wires, on top of each other	Slot fill factor ~65%	
c) round wires, orthocyclic layers	Slot fill factor ~75%	
d) rectangular wires	Slot fill factor ~85%	

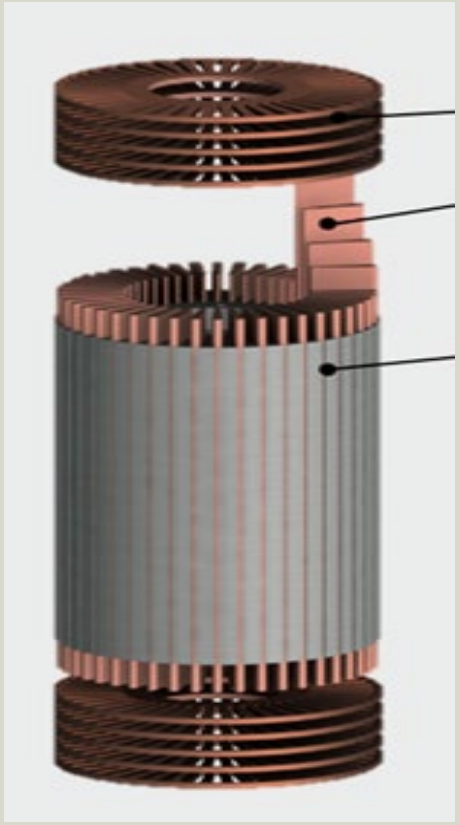
Copper rotor

Copper has 65% higher conductivity than aluminium.

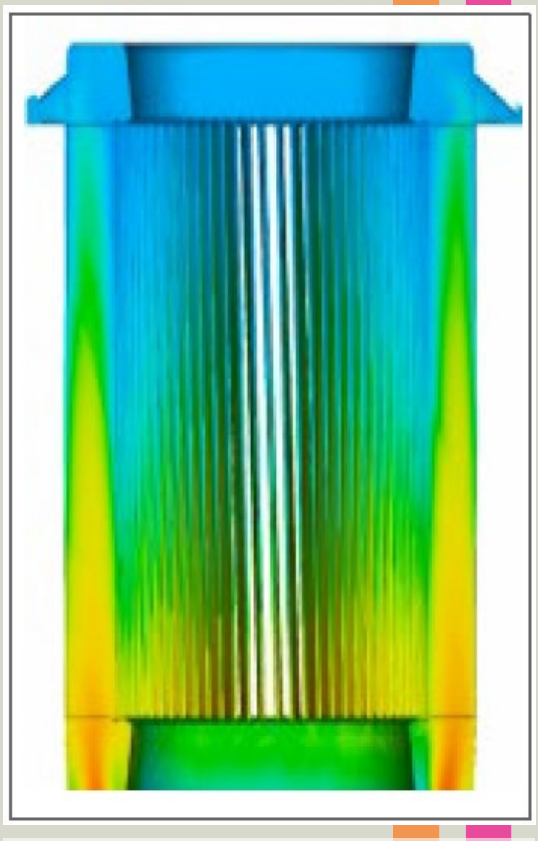
Losses are reduced while keeping the same motor size.

Can lead to weight savings (e-steel and structural steel) compared to other efficiency improvement options.

Manufacturing options: fabricated and die-cast



Fabricated rotor



Die-cast rotor

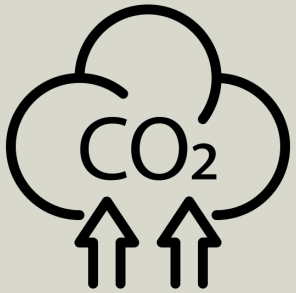
Wieland e-mobility https://www.wieland.com/en/products/e-mobility-components

Energy savings potential

At EU level, the adoption of IE4 in the range 0.75 kW to 75 kW would bring savings of ~2 TWh/year, cumulative over time

Based on annual sales 9.8 M units
Load profiles as per European Commission Impact Assessment SWD(2019) 343 final

Why each kWh saved matters?



2030: -55%

2040: -90%

2050: carbon neutral

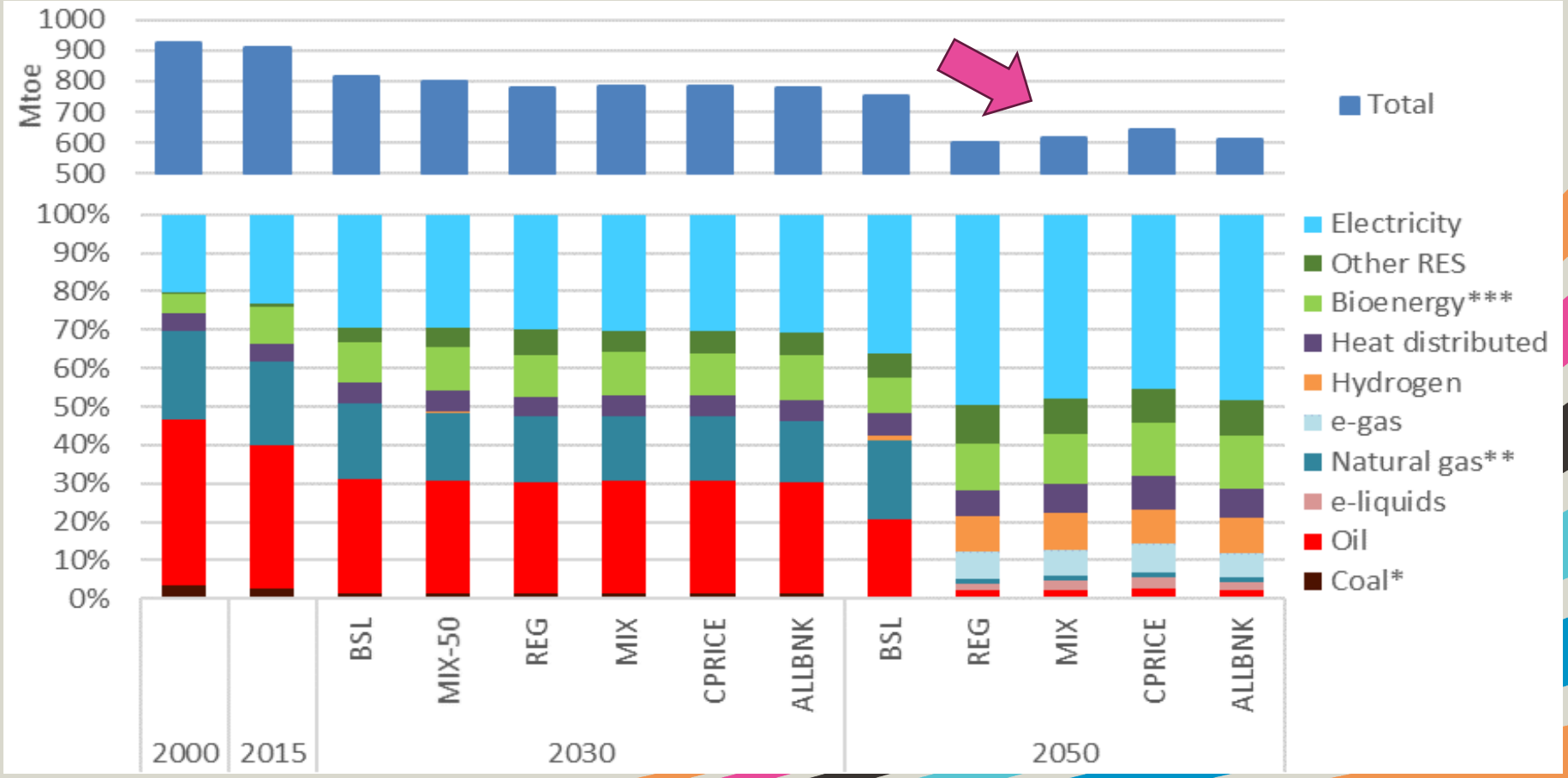
2030 final energy consumption is CAPPED to 763 Mtoe

For reference, final energy consumption was **940 Mtoe in 2022**

→ Needs a reduction equivalent to the whole consumption of Germany, to be implemented in just 8 years

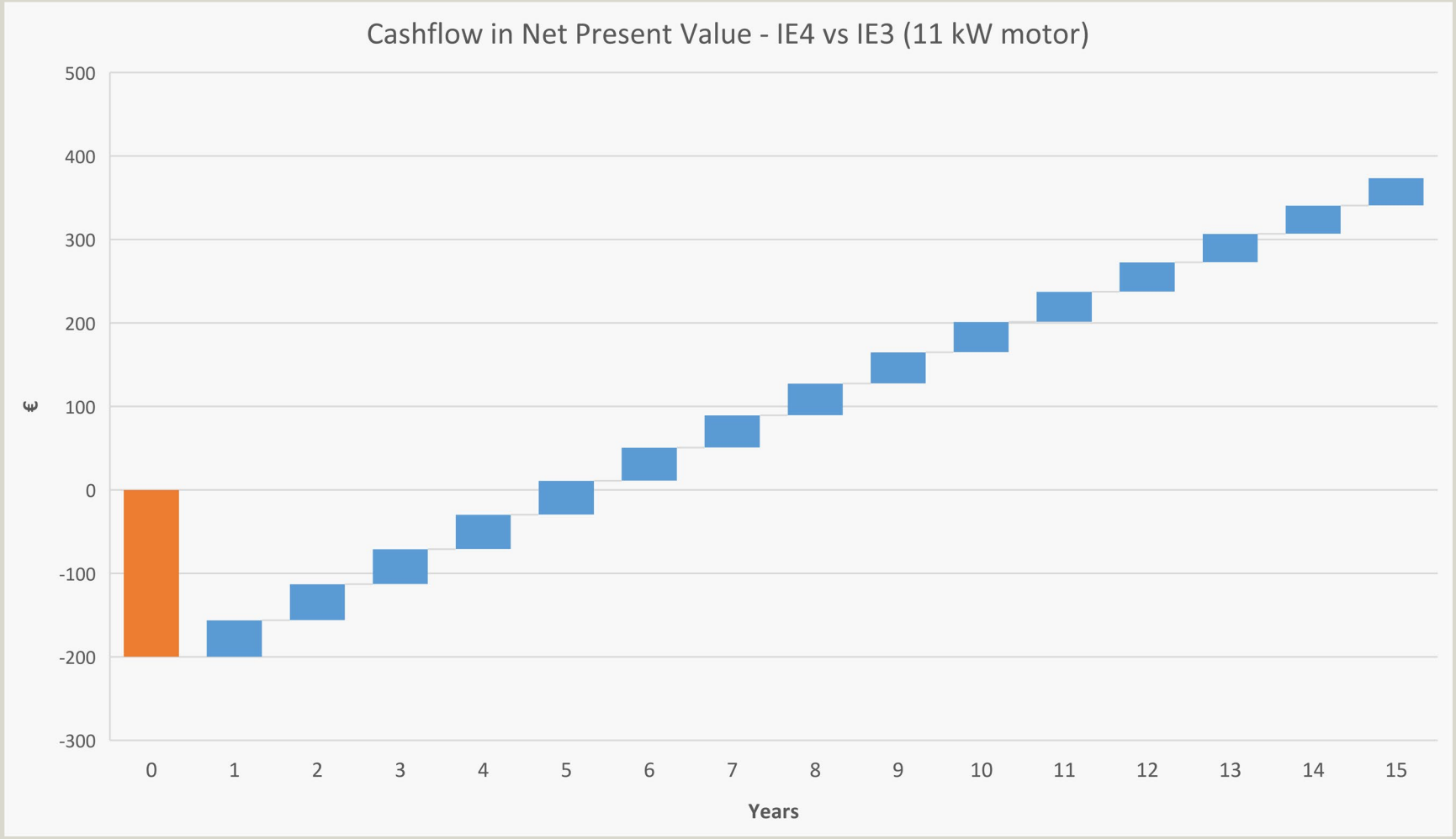
Why each kWh saved matters?

By 2050 the situation is to get even tougher,
with final energy consumption further capped to ~600 Mtoe



Source: Impact Assessment EU Green Deal – Part 2, Figure 37
https://eur-lex.europa.eu/legal-content/EN/TXT/DOC/?uri=CELEX:52020SC0176

Life cycle cost: attractive payback period and net savings

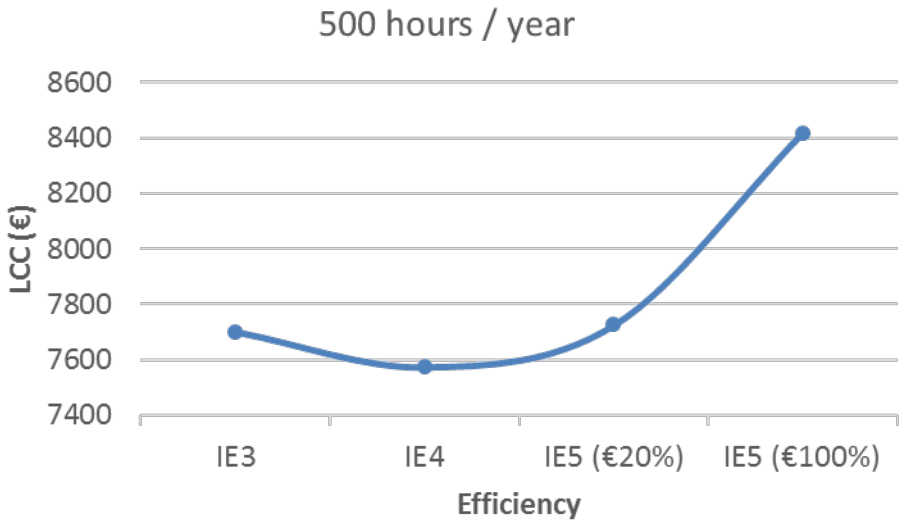


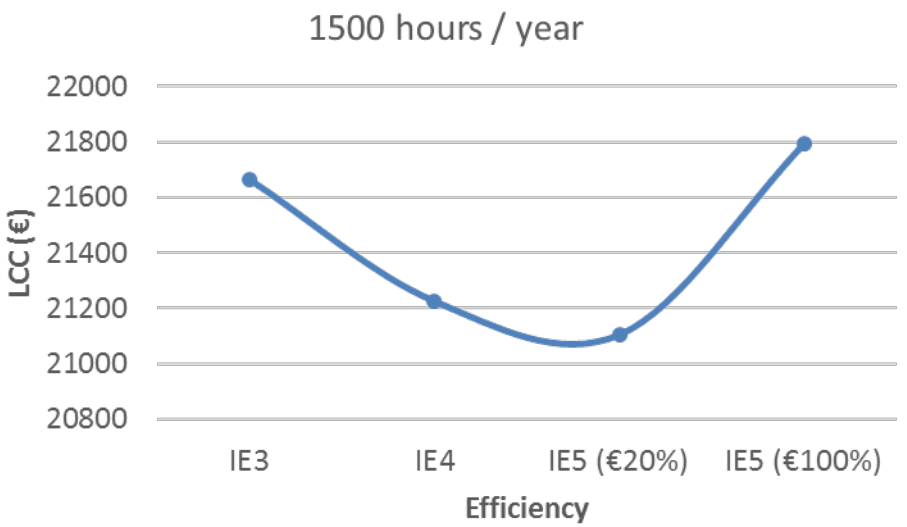
Assumptions:

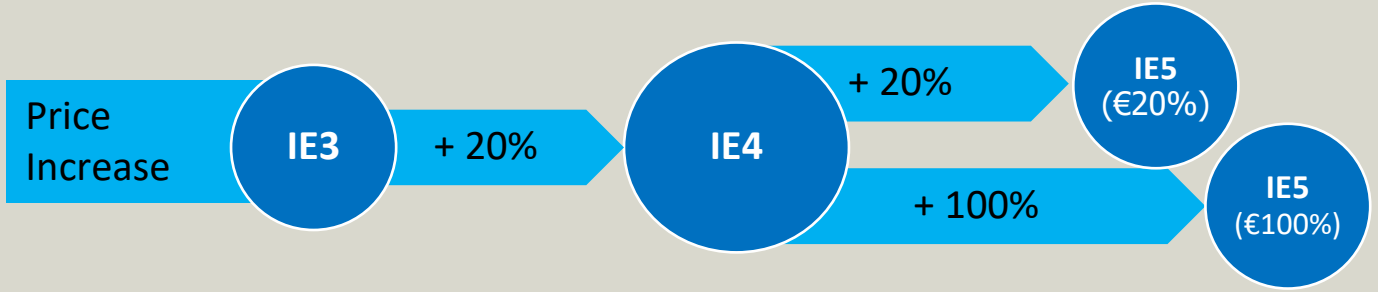
- 11 kW motor
- 1750 h/year full load equivalent
- 0.12 €/kWh electricity cost
- 200 € extra cost of IE4 vs IE3
- 15 years lifetime
- 2% average inflation rate (Net Present Value calculation)

Life cycle cost: attractive payback period and net savings

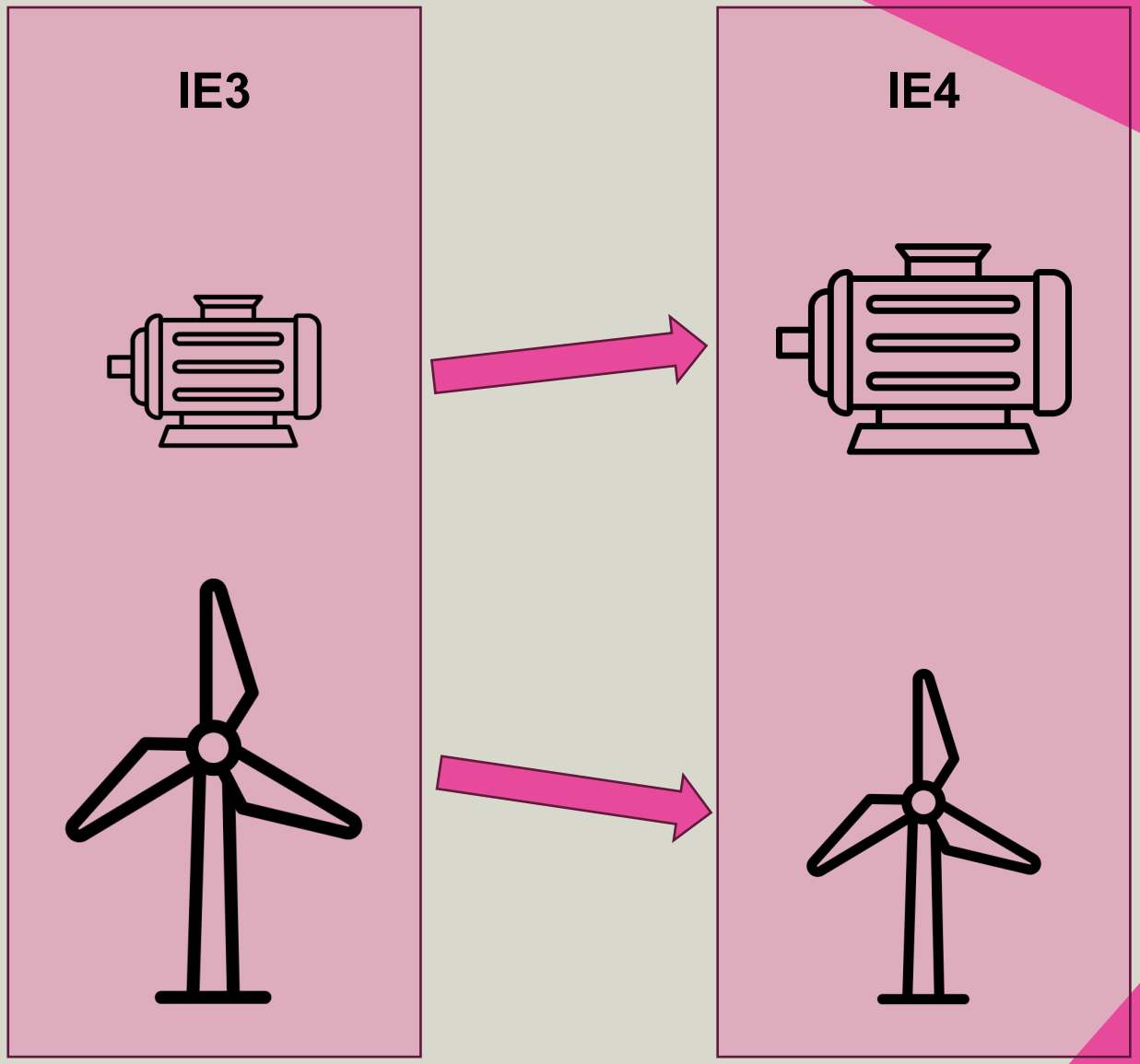
11 kW motor
15 years lifetime
EU average Electricity Price 2015: 0.119 €/kWh



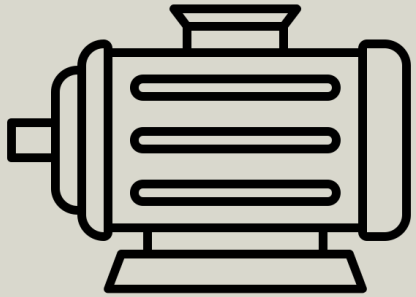




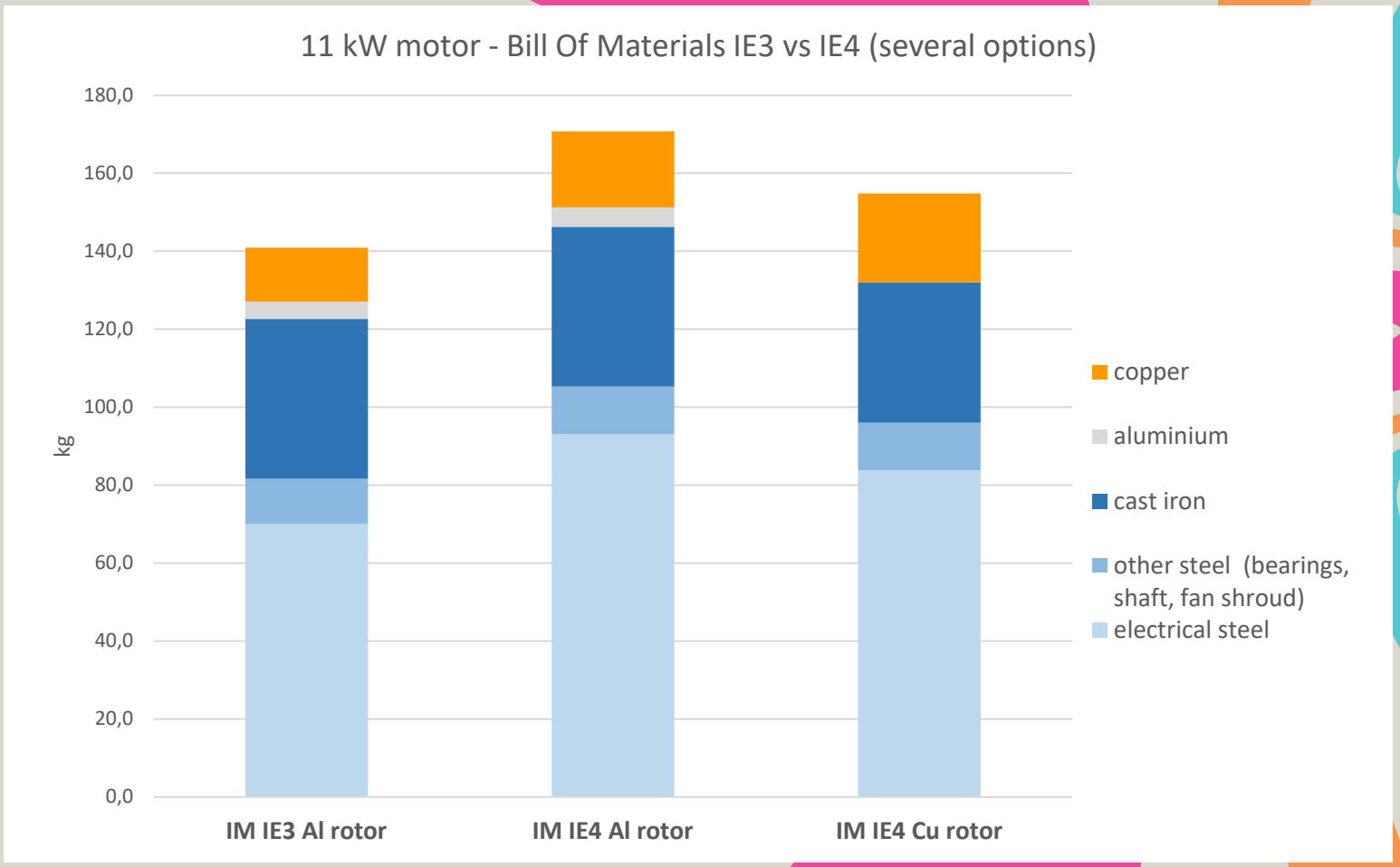
Use of materials



The bigger use of materials at motor level is compensated by a lower need of generation assets (thanks to lower transformer losses)

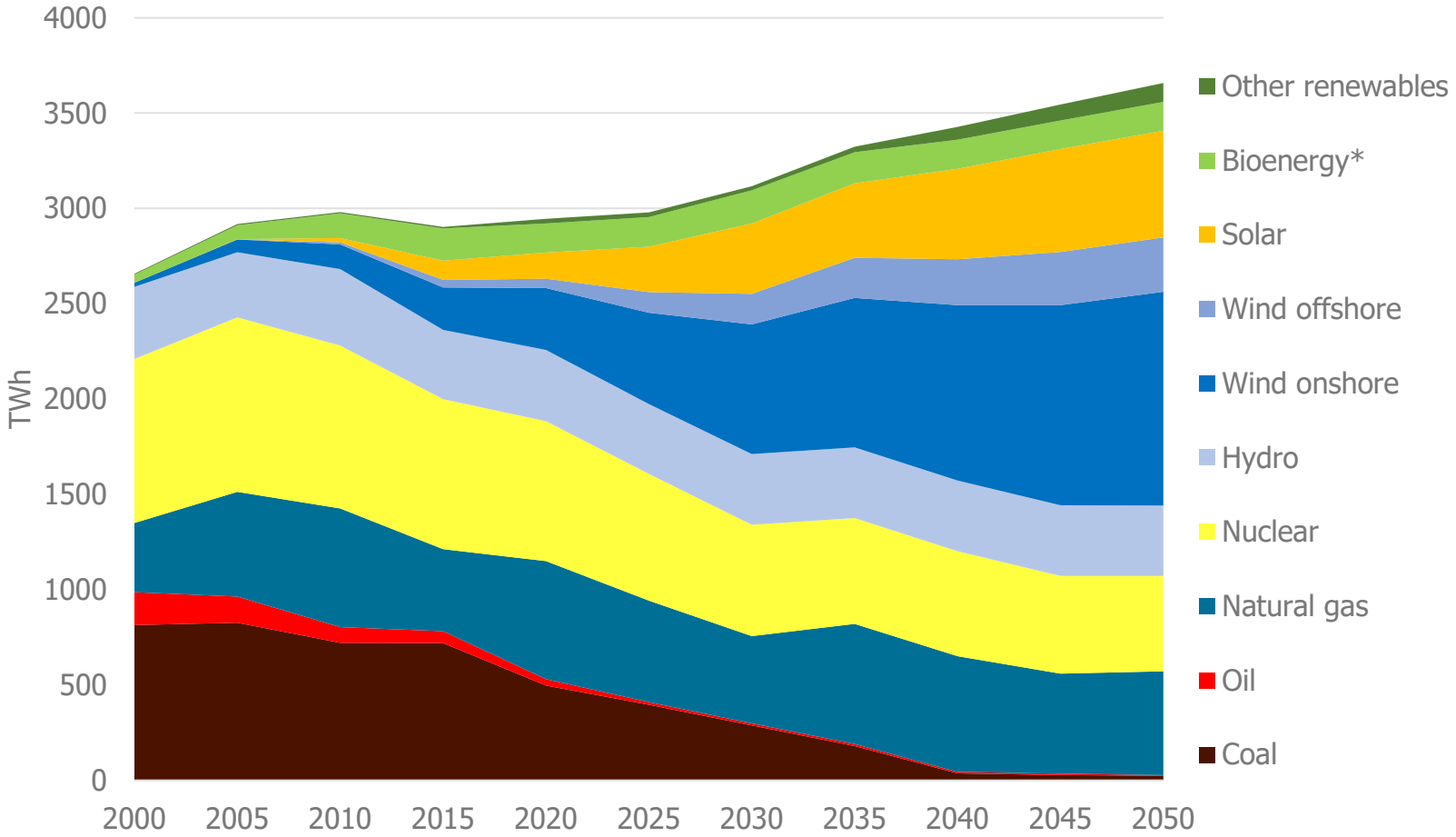


Motor: bill of materials



Bill of materials as per the study of International Copper Association Europe & ISR Coimbra University

EU Electricity generation mix as modelled in the EU Green Deal



New capacity is fully dominated by wind (onshore and offshore) and solar

Electricity mix as modelled in the Green Deal impact assessment
https://climate.ec.europa.eu/document/download/ec1acac9-10fe-4eeb-915f-cad388990e0f_en?filename=2030_climate_target_plan_figures_en.xlsx

How much material is saved when we spare 1 kWh?

Renewable Energy Materials Properties Database: Summary

Aubryn Cooperman, Annika Eberle, Dylan Hettinger, Melinda Marquis, Brittany Smith, Richard F. Tusing, and Julien Walzberg

National Renewable Energy Laboratory

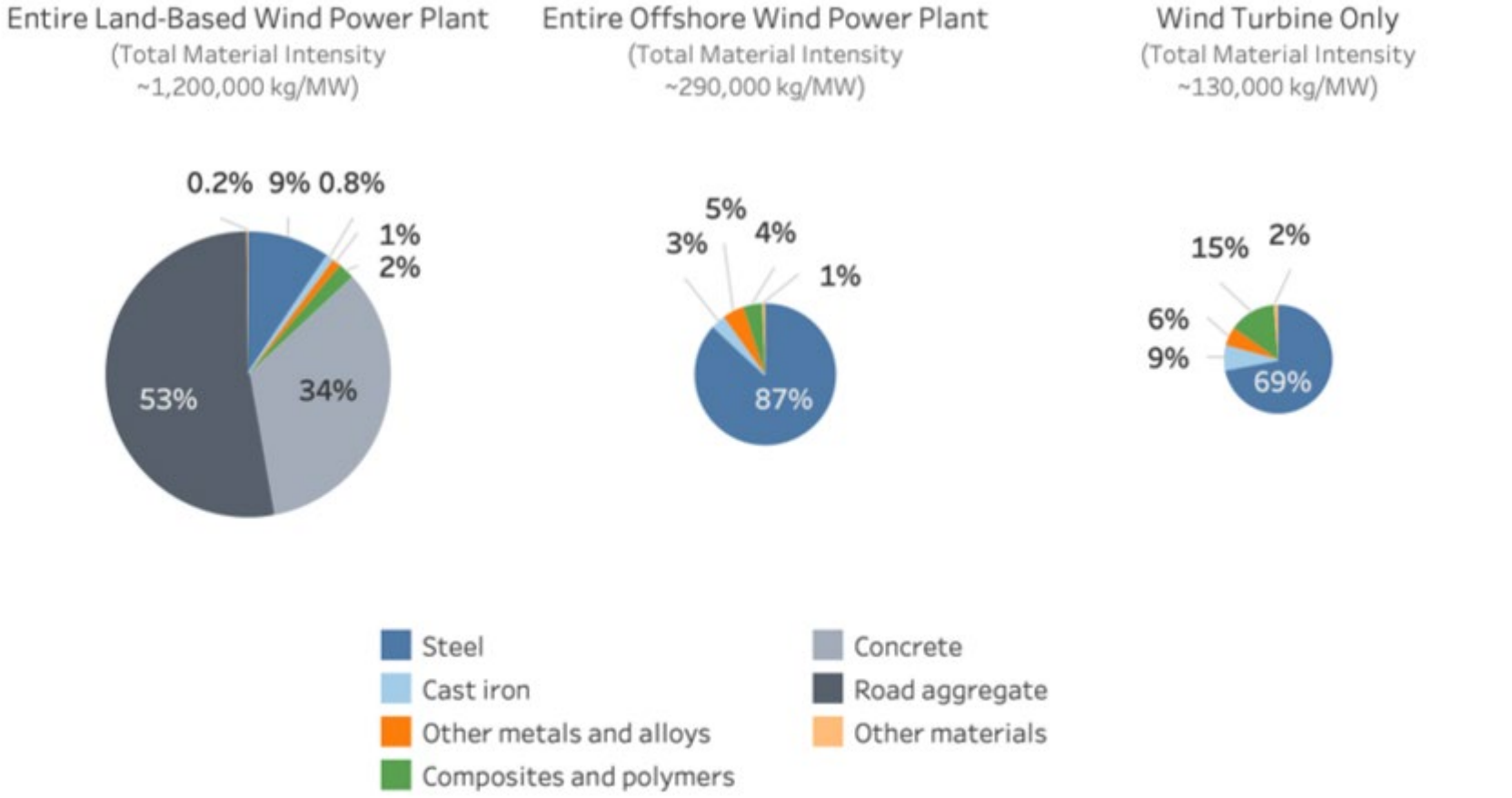


Figure 3. Typical high-level breakdown of wind energy materials by mass as reported in the REMPD

https://www.nrel.gov/wind/materials-database.html

How much material is saved when we spare 1 kWh?

1 kWh/year of electricity losses avoided saves 0.75 kg of materials, of which 0.15 kg of metals

Material Category	Onshore wind (kg/kWh/year)	Offshore wind (kg/kWh/year)	PV (kg/kWh/year)	**EU marginal mix* (kg/kWh/year)**
Concrete	0,389	0,000	0,032	**0,227**
Road aggregate	0,590	0,000	0,000	**0,331**
Steel	0,138	0,137	0,048	**0,112**
Composites and polymers	0,028	0,009	0,015	**0,021**
Cast iron	0,012	0,005	0,016	**0,012**
Other metals and alloys	0,018	0,011	0,035	**0,022**
Other materials	0,003	0,001	0,090	**0,027**
TOTAL	1,178	0,164	0,236	**0,752**

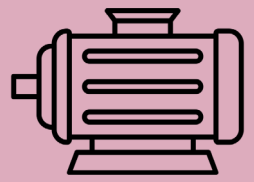
* Marginal electricity generation capacity additions based on the EU Green Deal Impact Assessment: 56% onshore wind, 15% offshore wind, 28% solar

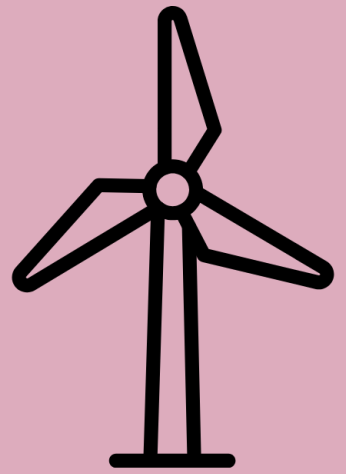
https://www.nrel.gov/wind/materials-database.html

Use of materials: example for a 11 kW induction motor

IE3
Aluminium cage

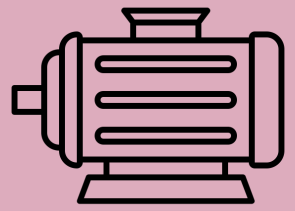
Eff 91.4%



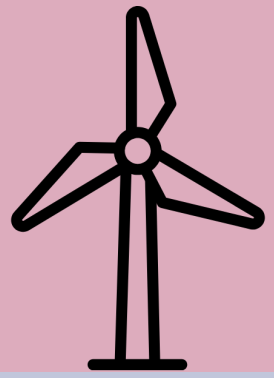


IE4
Copper cage

-366 kWh/year
Eff 93.3%



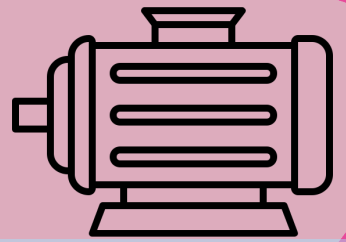
+14 kg metals



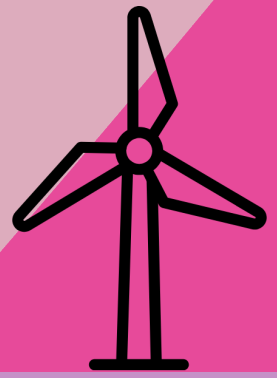
-55 kg metals

IE4
Aluminium cage

-366 kWh/year
Eff 93.3%



+30 kg metals



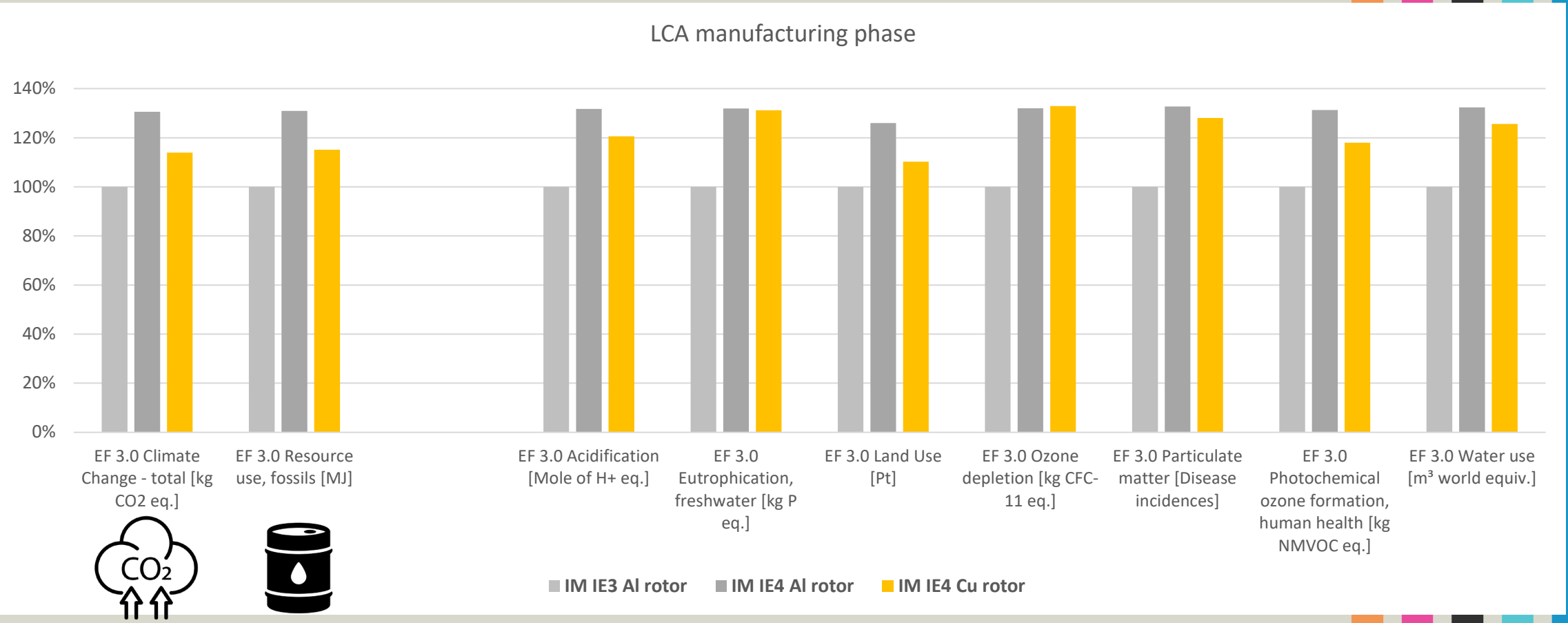
-55 kg metals

Higher efficiency levels save not only ENERGY,

but also MATERIALS at system level.

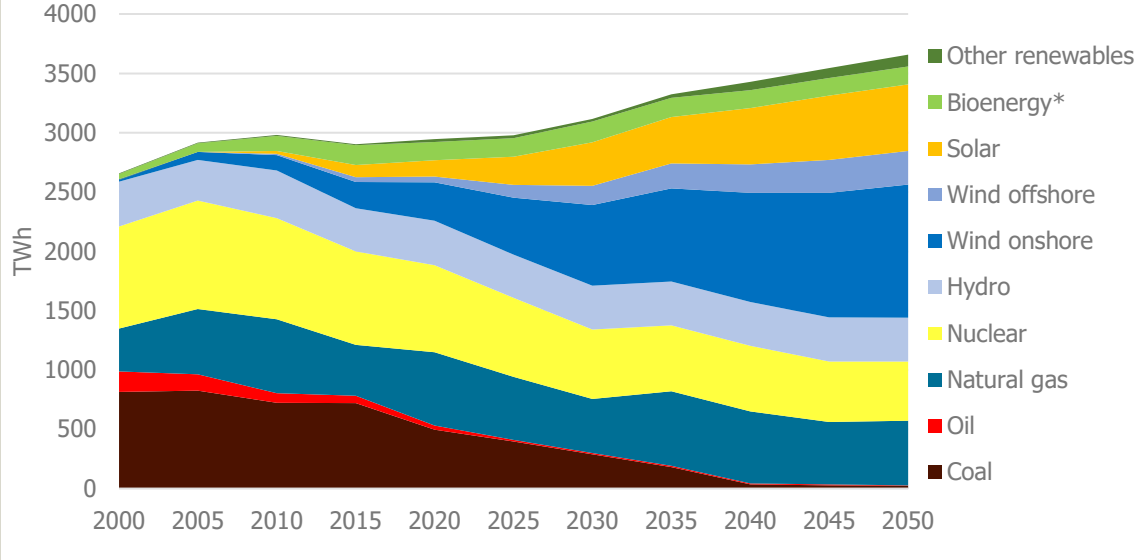
Motor use assumption: 1750 hours/year full load equivalent

Life cycle analysis: manufacturing phase



- Most indicators increase as we move towards IE4, due to an increased use of materials.
- Climate change, energy use and other categories can be mitigated by using copper rotors.

LCA impact of future electricity mix

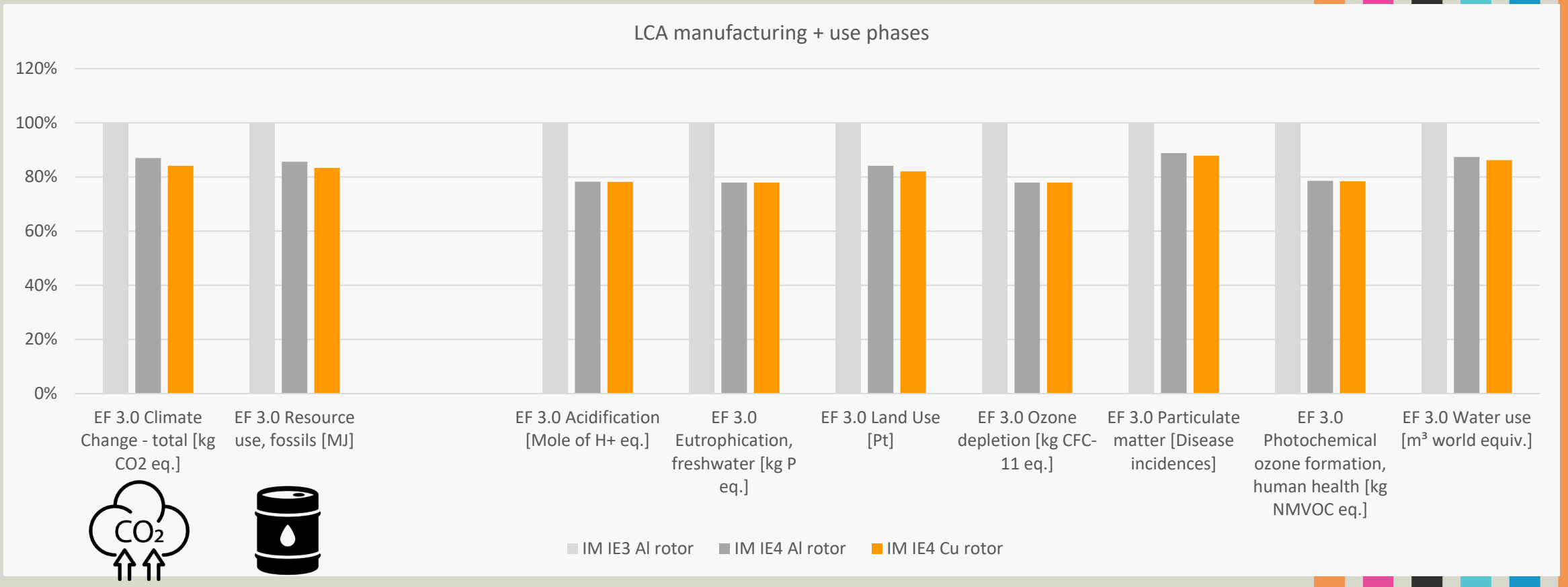


Electricity mix as modelled in the Green Deal impact assessment
https://climate.ec.europa.eu/document/download/ec1acac9-10fe-4eeb-915f-cad388990e0f_en?filename=2030_climate_target_plan_figures_en.xlsx

Impact for 1 kWh electricity produced with		CLIMATE CHANGE TOTAL	FRESHWATER AND TERRESTRIAL ACIDIFICATION	ETC....
		[kg CO2-Eq]	[mol H+-Eq]	
Hard coal	PC, without CCS	1,02E+00	1,73E-03	
Hard coal	IGCC, without CCS	8,49E-01	1,05E-03	
Natural gas	NGCC, without CCS	4,34E-01	3,26E-04	
Hard coal	PC, with CCS	3,69E-01	1,80E-03	
Hard coal	IGCC, with CCS	2,79E-01	1,35E-03	
Natural gas	NGCC, with CCS	1,28E-01	6,07E-04	
Hydro	660 MW	1,47E-01	4,15E-04	
Hydro	360 MW	1,07E-02	4,45E-05	
Nuclear	average	5,29E-03	4,28E-05	
CSP	tower	2,17E-02	9,24E-05	
CSP	trough	4,20E-02	1,51E-04	
PV	poly-Si, ground-mounted	3,67E-02	3,01E-04	
PV	CdTe, roof-mounted	1,46E-02	8,82E-05	
PV	CIGS, ground-mounted	1,14E-02	6,11E-05	
PV	CIGS, roof-mounted	1,41E-02	8,64E-05	
Wind	onshore	1,24E-02	5,28E-05	
Wind	offshore, concrete foundation	1,42E-02	1,00E-04	
Wind	offshore, steel foundation	1,33E-02	9,45E-05	

UNECE: Integrated Life-cycle Assessment of Electricity Sources
https://unece.org/documents/2022/08/integrated-life-cycle-assessment-electricity-sources

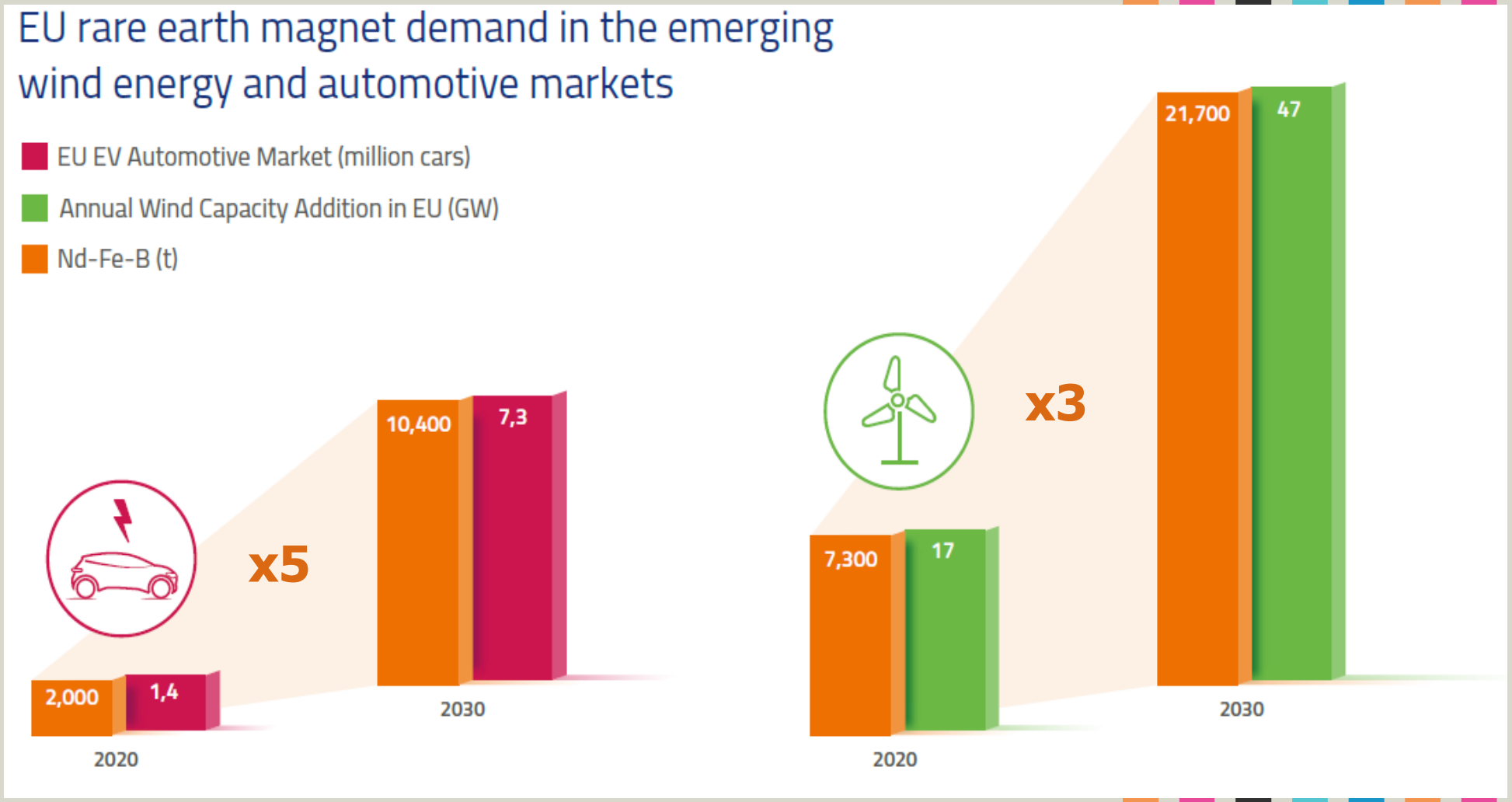
Life cycle analysis: manufacturing + use phase



- The use phase dominates, leading to a better overall picture for IE4 level

Permanent magnets: sourcing considerations

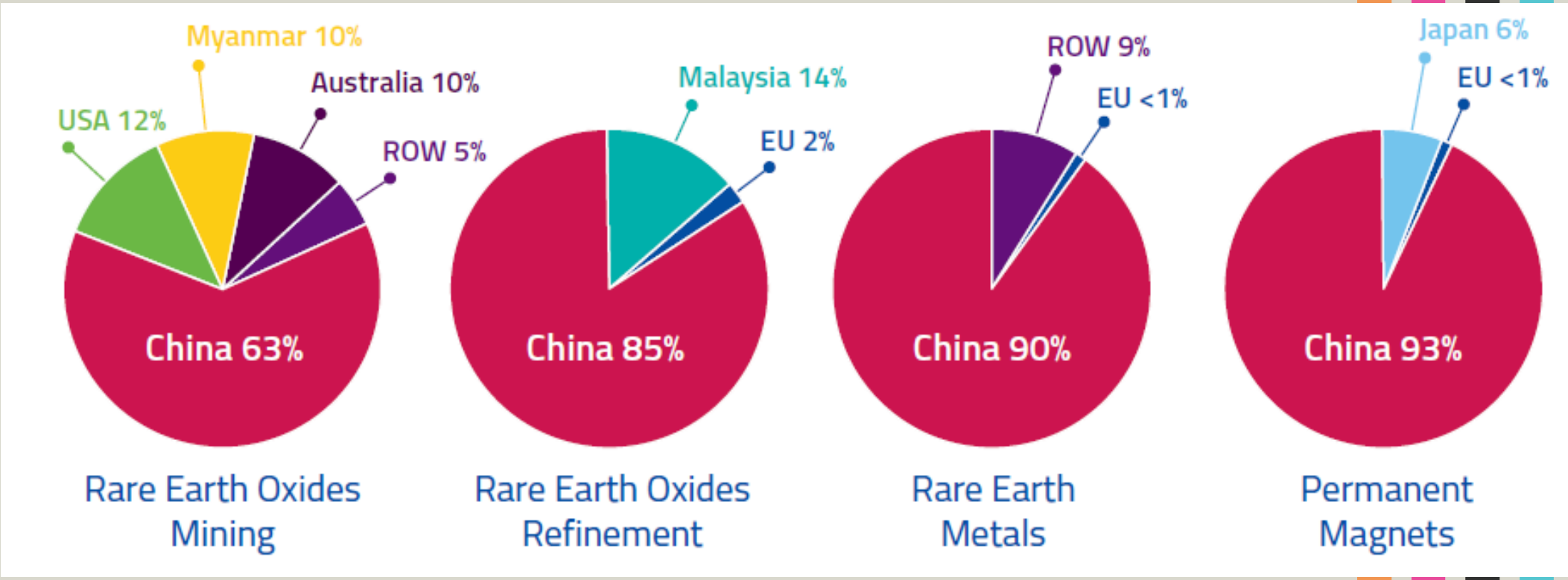
Demand is largely driven by the wind and automotive sectors



https://eit.europa.eu/sites/default/files/2021_09-24_ree_cluster_report2.pdf

Permanent magnets: sourcing considerations

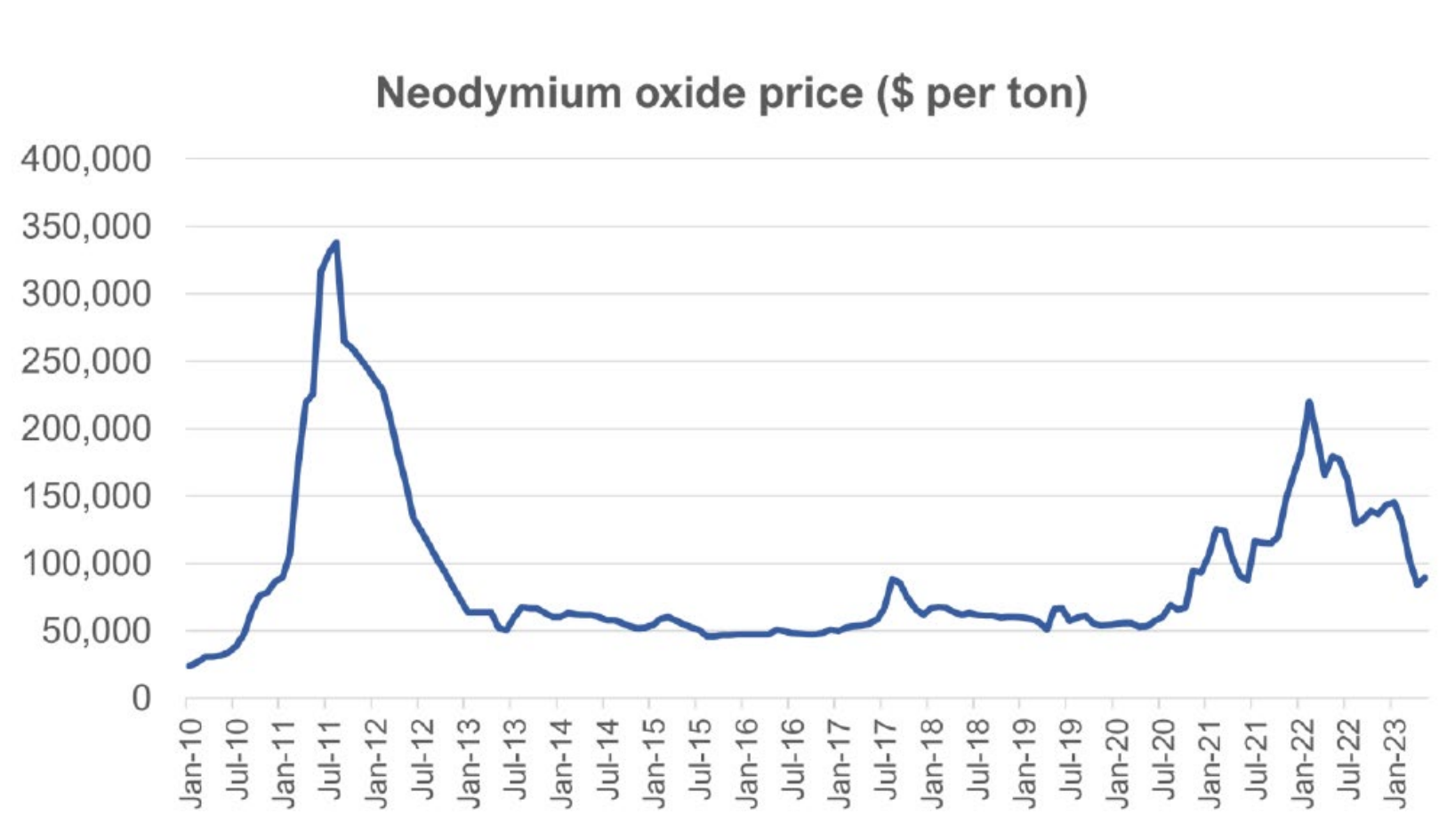
Reliance is very high on a single country



https://eit.europa.eu/sites/default/files/2021_09-24_ree_cluster_report2.pdf

Permanent magnets: sourcing considerations

Prices are volatile



EU: strategic and critical raw materials

Extraction

Processing & Refining

Recycling

Dependency of a single country

European Commission

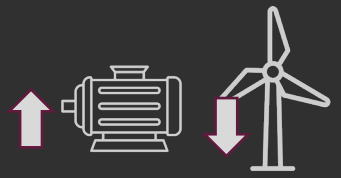
CRM Act 2030 targets	**10%**	**40%**	**15% (25%)**	**<65%**
Copper 2020	**~ 30%**	**~ 80%**	**~ 20%**	**Mining 25% (Chile) Refining 40% (China)**

https://eit.europa.eu/sites/default/files/2021_09-24_ree_cluster_report2.pdf
https://www.energy-transitions.org/publications/material-and-resource-energy-tra

In a nutshell

Electricity savings associated to increased efficiency levels are significant (estimated in the range of TWh/year at EU level).

Total cost of ownership significantly reduced with higher efficiency levels



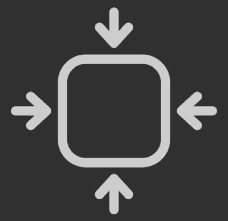
Higher MEPS lead to bigger motors, however, the additional use of materials is compensated by a significant reduction of generation, transmission and distribution assets.

There are technology routes to make more compact designs, such as the use of copper rotors or alternative technologies.

All LCA categories improve with IE4 (compared to IE3).

Recommendations for the Ecodesign regulation

Strengthen Minimum Energy Performance Standards (MEPS)



Take into consideration the material savings produced by higher energy performance units at generation, transmission and distribution level

Introduce Design-for-Recycling requirements. Ensure reutilisation of raw materials with minimum downcycling.

Thank you!

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