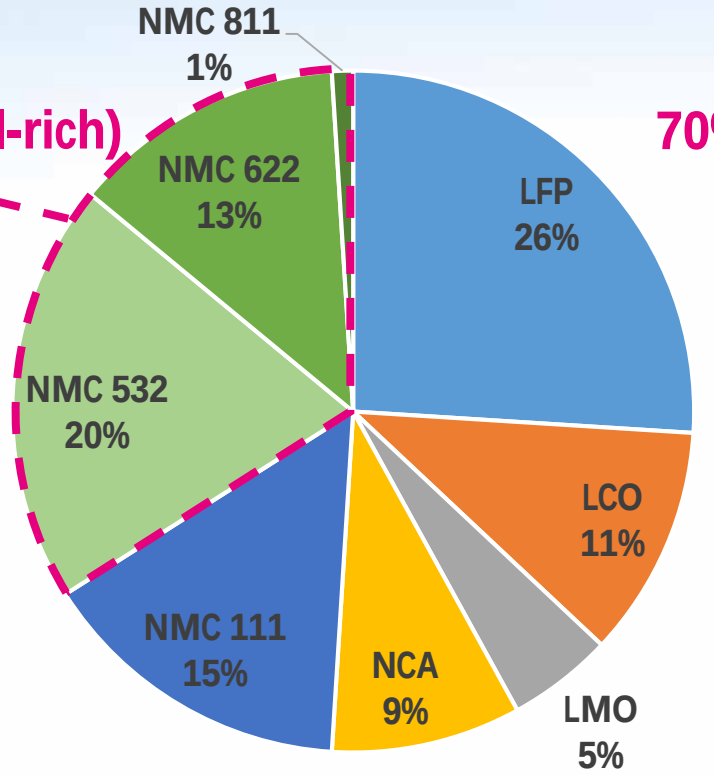
ARMOR

INDUSTRY FOR PEOPLE

A look at battery system cost reduction & extended lifecycle performance

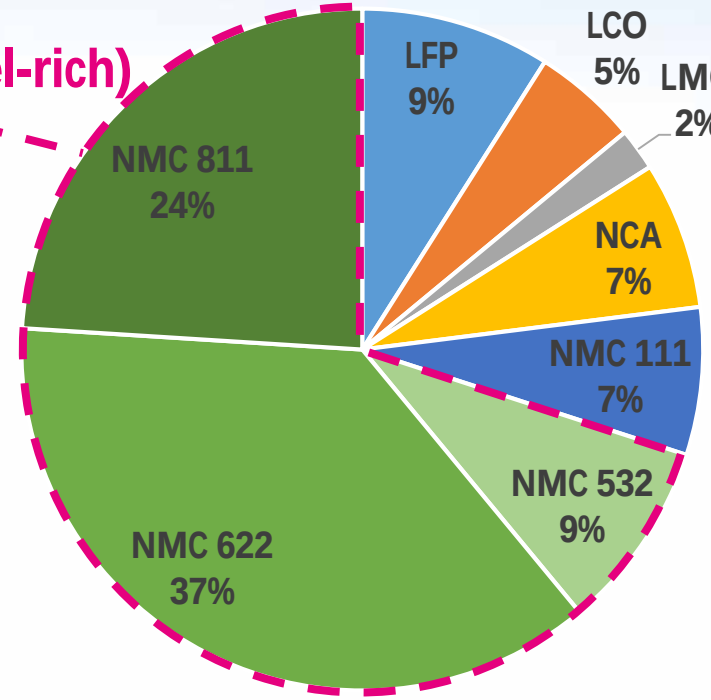
A push for nickel rich NMC
Mainstream market analysis for cathode

34% NMC (Nickel-rich)



2018

70% NMC (Nickel-rich)



2025

Nickel-rich NMC -> main stream market for the next 5 years

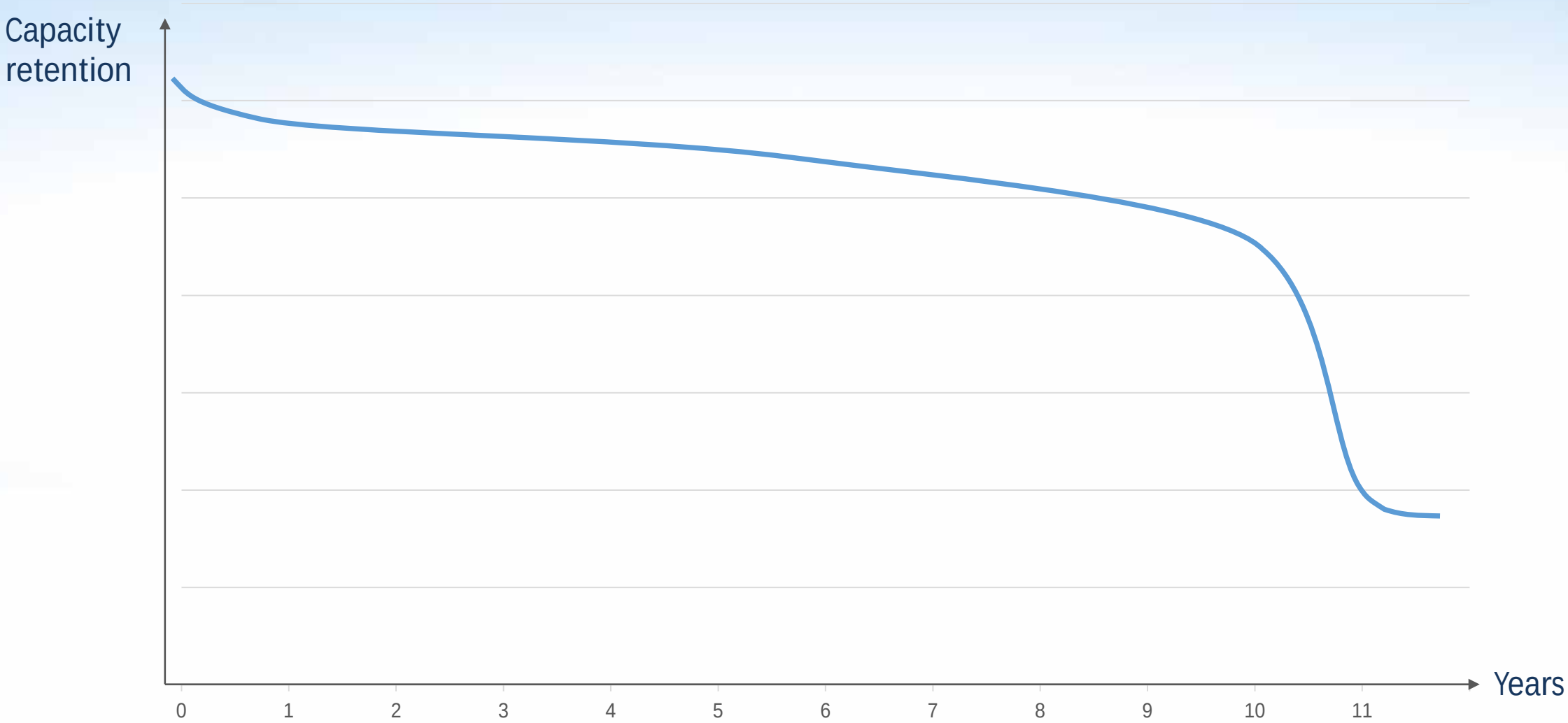
Source: Avicenne, 2019

How important is battery life?
What ARMOR understands as the goal

Combustion vehicles lifetime	Europe	= 11 years
	USA	= 12 years
	Japan	= 13 years

	OEM expectation	Battery manufacturers commitment
Battery for EV	**12 to 15 years lifetime**	**8 to 10 years**
Battery for ESS grid	**15 to 20 years lifetime**	**?**

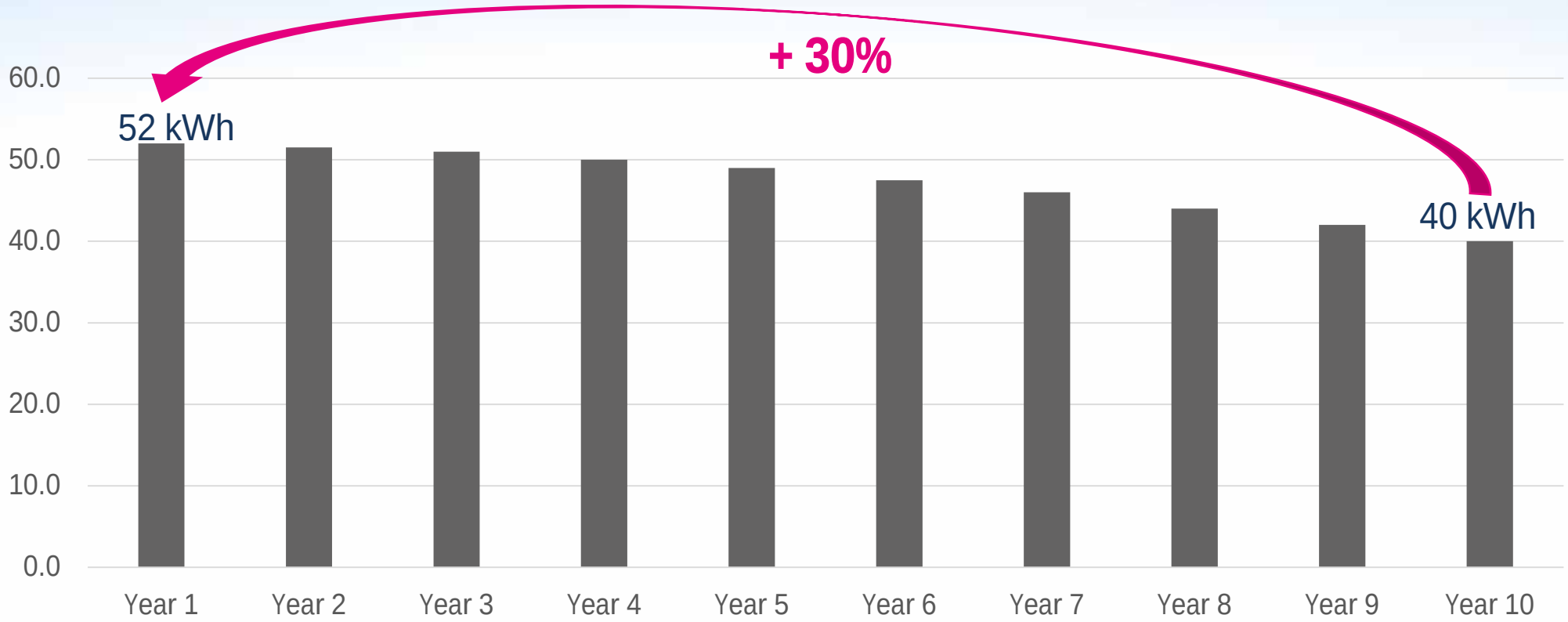
What we know:
NMC Capacity retention decreases over time



Begin with the end in mind

Current solution: increase active materials

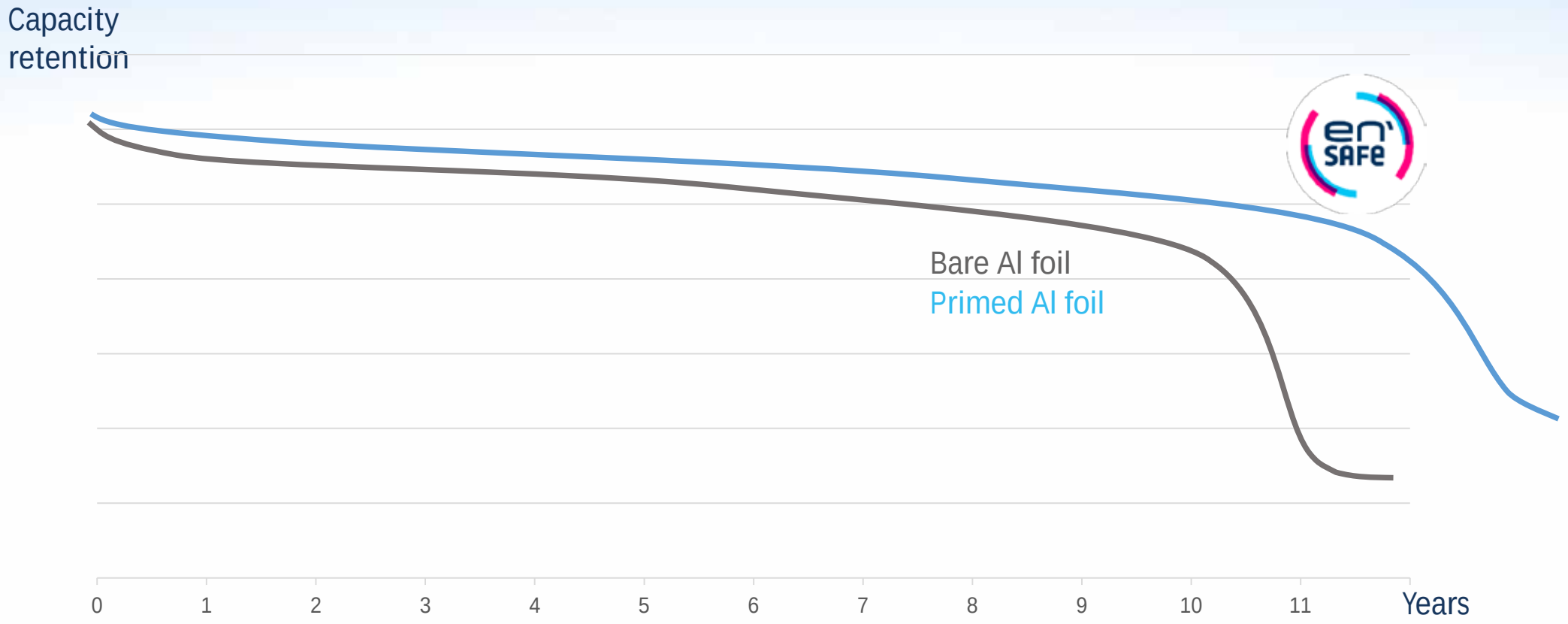
Example: to achieve a 40kWh requirement in year 10, a battery requires 52kWh output in year 1



For 100% capacity at **10 years** lifetime -> over-engineering **130%**

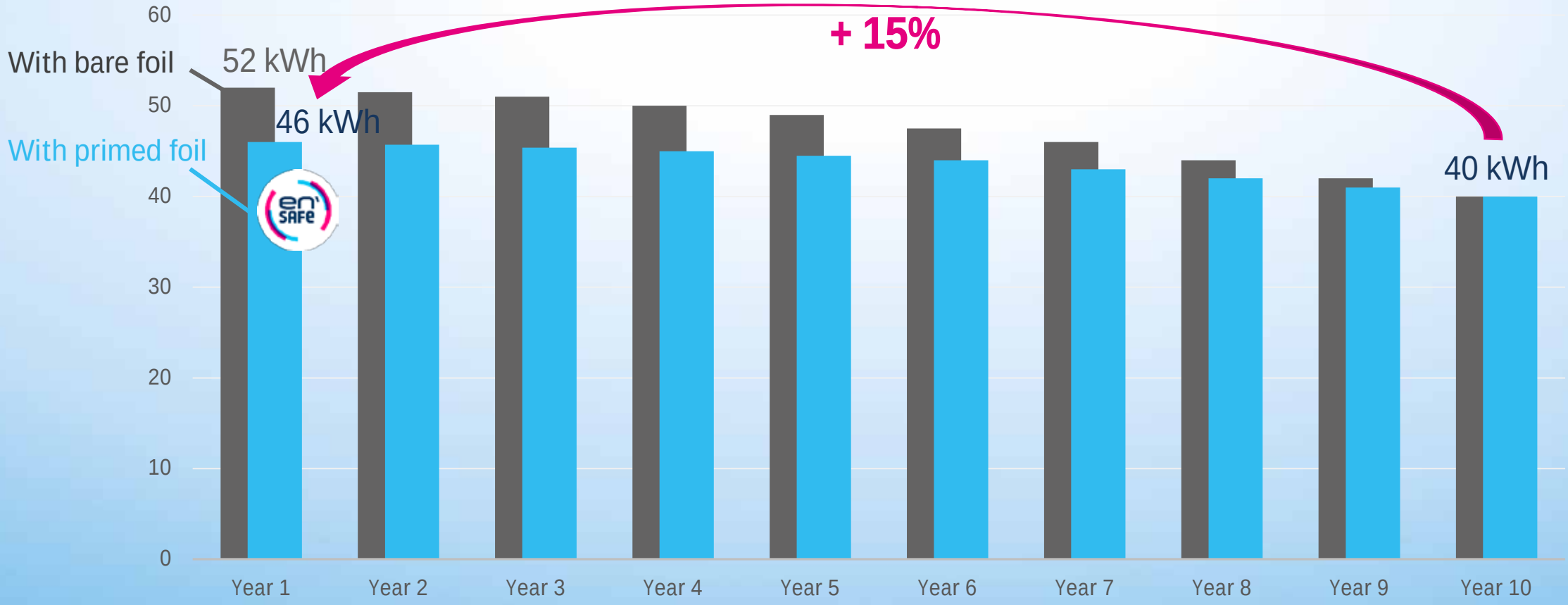
(For 100% capacity at **8 years** lifetime -> over-engineering **120%**)

What is ARMOR's solution?
Extend capacity retention with En' Safe®



Nickel-rich NMC cell

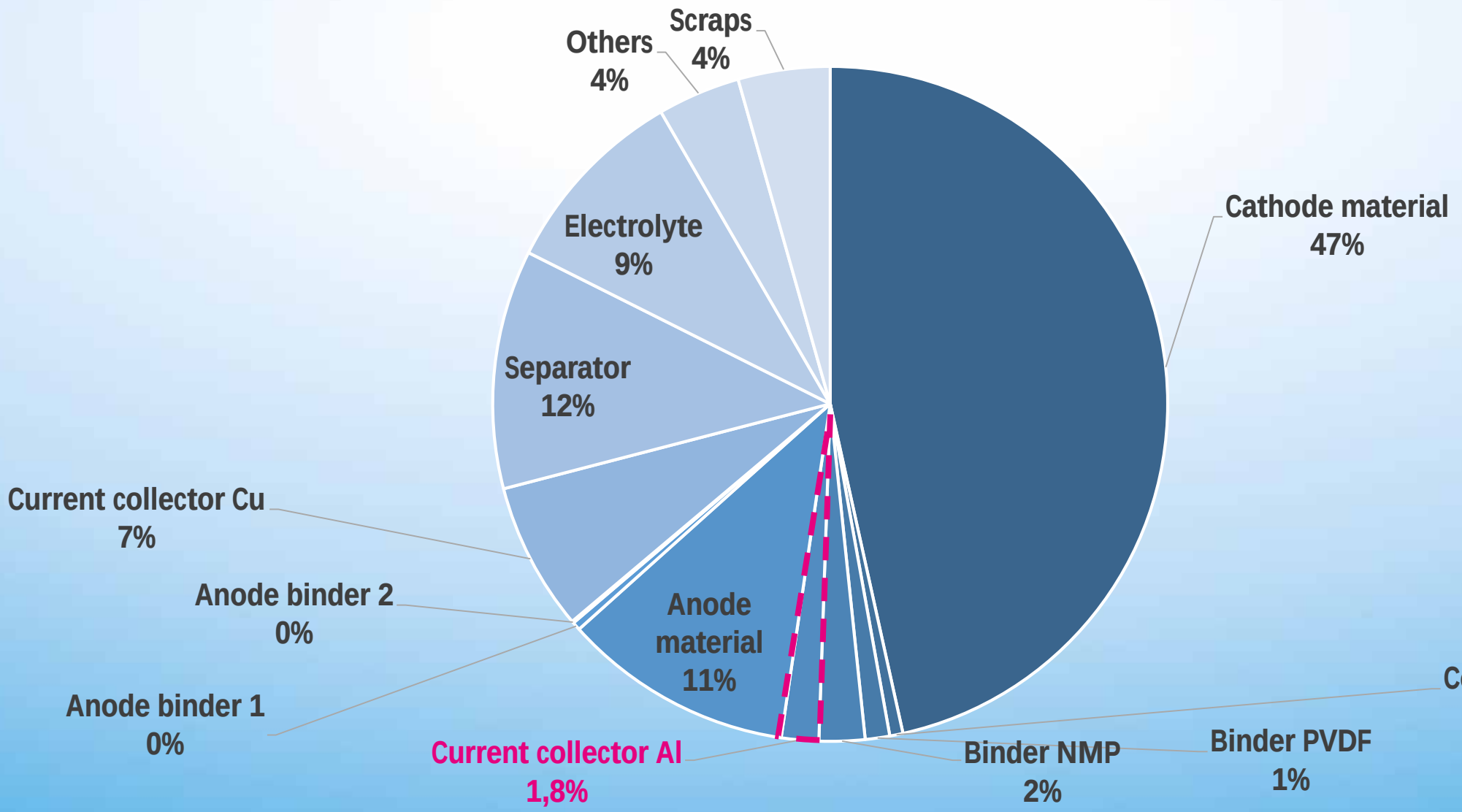
En' Safe® capacity retention compared to bare foil



For 100% capacity at **10 years** lifetime -> over engineering **115%**

How can En' Safe® create a system cost reduction?

Step 1: Evaluate bill of material at cell level



Source: Avicenne, 2018

How can En' Safe® create a system cost reduction?

Step 2: Evaluate bill of material cost to achieve a 40kWh requirement in year 10

		Cell with bare foil	Cell with primed foil	SAVINGS
	$/kWh	52 kWh	46 kWh	
Cathode materials	48,4	2 517	2 227	- 12 %
Current collector Al	1,7 | 5,1	89	236	+ 165 %
Anode materials	11,1	575	507	- 12 %
Current collector Cu	6,8	353	313	- 12 %
Separator	11,0	570	504	- 12 %
Electrolyte	8,9	460	407	- 12 %
Others	3,8	197	174	- 12 %
Scraps	4,2	219	194	- 12 %
TOTAL	**96**	**4 980**	**4 405**	**- 8%**

How can En' Safe® create a system cost reduction?

Step 3: What is most desired:

What have we learned?

By minimizing capacity reduction, En' Safe® can provide 2 options:

8% System cost reduction

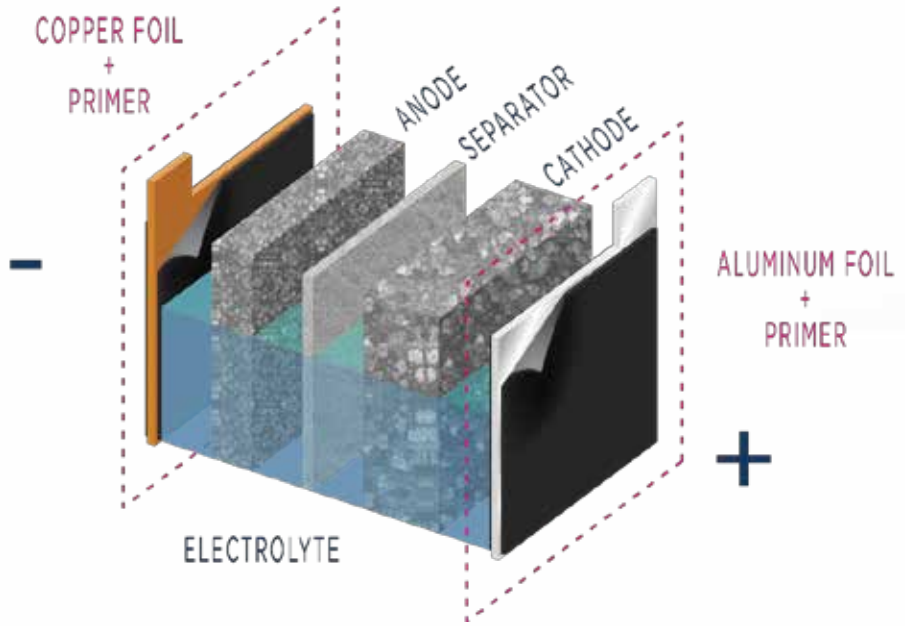
Cycle life extended +2 years

What is En' Safe®?

- Is an Aluminum or Copper foil coated with an ultra-thin conductive and protective primer designed to improve the interface between the anode/cathode and the foil.
- Custom formulation created to maximize performance enhancement for customers specific application/chemistry

Benefits are:

- Longer **calendar & cycle life** thanks to a more cohesive interface
- Higher **power & fast charging** thanks to a lower internal resistance
- Enables **corrosive cathode slurry** thanks to protection of the Aluminum
- Enables **reduction of Carbon Black** content in the cathode slurry
- **Improved adhesion** of Anode & Cathode
- **Great performance @-40°C**



Wide product range required to cope with versatile applications

En' Safe® primed foils

Application examples:

- Cathode: NMC, NCA, LFP, LMFP, LMO/LMNO
- Anodes: silicon-based, LTO
- All-solid-state
- Lithium-Sulfur
- Lithium-ion 4,5 - 5,0V
- EDLC
- Lithium-capacitors
- Sodium-ion
- Etc

Who are we?

Mid-size industrial company

1922 established in Nantes (FRANCE)
265 M€ turnover (2018)
1850 employees

Expert in formulation and high precision coating

1,5 billion sqm of high precision coating produced annually
97 years of expertise in chemical formulation

Global mindset supported by local proximity

80 % turnover from export
26 manufacturing and logistics sites (Europe, Asia, USA)

Thank you for your attention !

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