GREAT DESIGNS IN STEEL

TWENTY YEARS

SUSTAINABLE LIGHTWEIGHT BATTERY ENCLOSURE DESIGN WITH MULTIPLE AHSS STEELS

Sajan George

Cleveland-Cliffs

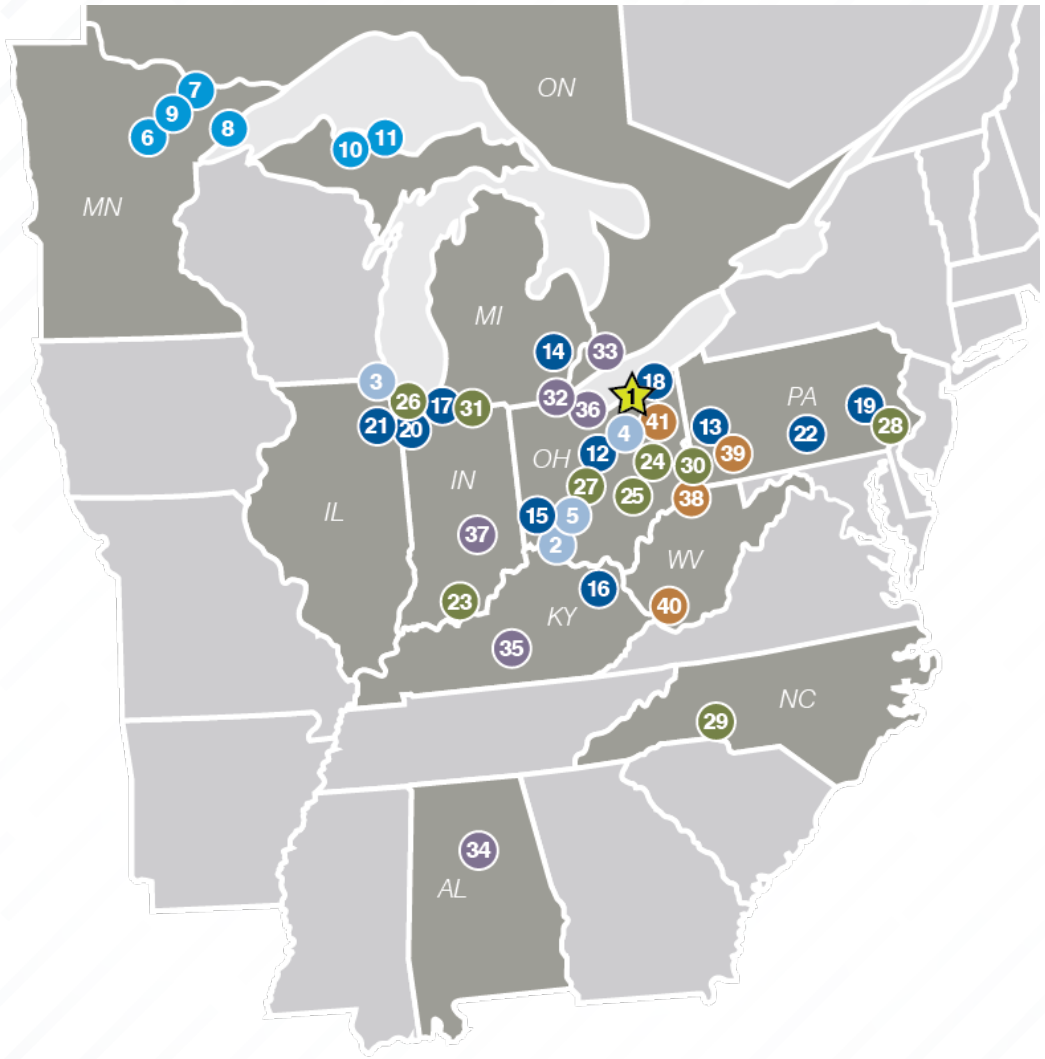
AGENDA

- Introduction of Cleveland-Cliffs Corporation
- BEV growth outlook
- Life cycle assessment – Steel vs. Aluminum
- Challenges in BEV architecture design for safety
- Is lightweighting still relevant ?
- Battery enclosure material – Steel
- AHSS battery pack design
- Summary

CLEVELAND-CLIFFS

- Largest flat-rolled steel producer in North America following 2020 acquisitions of AK Steel and ArcelorMittal USA
- Fully integrated from raw materials to primary steelmaking to downstream stamping, tooling, and tubing
- Steel market leader in automotive industry sales and quality
- Track record of cost synergy achievement, commercial excellence, and disciplined approach to supply
- Full commitment to ESG policies including aggressive GHG emissions reduction and inclusive capitalism

COMPANY OFFICES AND OPERATIONS



Offices
1. Cleveland-Cliffs Headquarters
2. Regional Office – West Chester
3. Regional Office – Chicago
4. Regional Office – Richfield
5. Research & Innovation Center

Mines and Pellet Plants
6. Hibbing Taconite (JV)
7. United Taconite
8. Northshore Mining
9. Minorca Mine
10. Tilden Mine
11. Empire Mine (idled)

Steelmaking
12. Mansfield Works
13. Butler Works
14. Dearborn Works
15. Middletown Works
16. Ashland Works (idled)
17. Burns Harbor
18. Cleveland
19. Coatesville
20. Indiana Harbor
21. Riverdale
22. Steelton

Finishing Facilities
23. Rockport Works
24. Coshocton Works
25. Zanesville Works
26. Burns Harbor Plate and Gary Plate
27. Columbus (idled)
28. Conshohocken
29. Piedmont
30. Weirton
31. I/N Tek and I/N Kote

Value-Added Products
32. Toledo – HBI
33. Windsor/Ontario – Component Stamping
34. Sylacauga – Component Stamping
35. Bowling Green – Component Stamping
36. Walbridge – ERW Tubing
37. Columbus – ERW Tubing

Cokemaking and Coal Mining
38. Mountain State Carbon
39. Monessen (idled)
40. Princeton
41. Warren

A DIFFERENTIATED, FULLY-INTEGRATED BUSINESS MODEL

20 YEARS GDIS

- Vertically integrated in ferrous raw materials

Pellets | **HBI** | **Prime Scrap**



- Annual shipments of 16-17 million tons

Steel Making & Rolling



- Industry leading automotive market share

Finishing & Coating



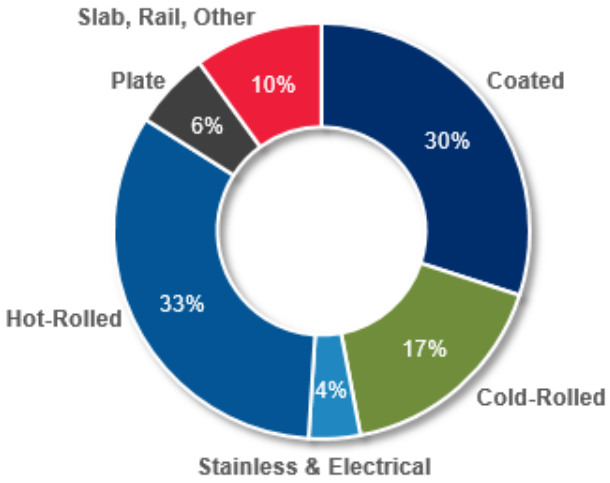
- Innovative and diverse downstream capabilities

Downstream

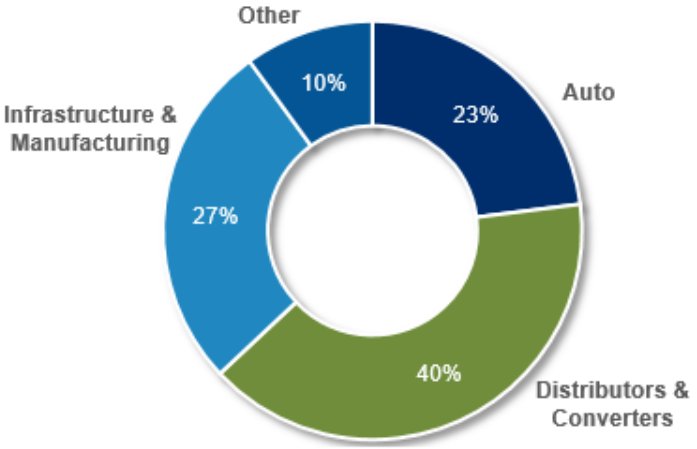


DIVERSIFIED END MARKETS WITH FOCUS ON VALUE ADDED PRODUCTS

Product Mix



End Market Mix



Extensive Product Offering

- ✓ Advanced High-strength Steels
- ✓ Aluminized
- ✓ Automotive Exposed
- ✓ Cold-rolled Coil
- ✓ Electrogalvanized
- ✓ Galvalume
- ✓ Galvanneal
- ✓ Grain Oriented Electrical Steels
- ✓ Hot-dipped Galvanized
- ✓ Hot-rolled Coil
- ✓ Non-oriented Electrical Steels
- ✓ Plate
- ✓ Rail
- ✓ Stainless Steels
- ✓ Stamped Components
- ✓ Tinplate
- ✓ Tool & Die
- ✓ Tubing

CLIFFS NOW HAS INFLUENCE OVER THE ENTIRE STEEL LIFE CYCLE

Cliffs' flat-rolled

The largest original source of prime scrap in the US

Agreement with OEM covers both steel sale and scrap offtake

Equipment Manufacturing

FPT has existing infrastructure inside OEM facilities

Cliffs receives OEM scrap offtake

Cliffs' scrap processing

Internal BOF/EAF use

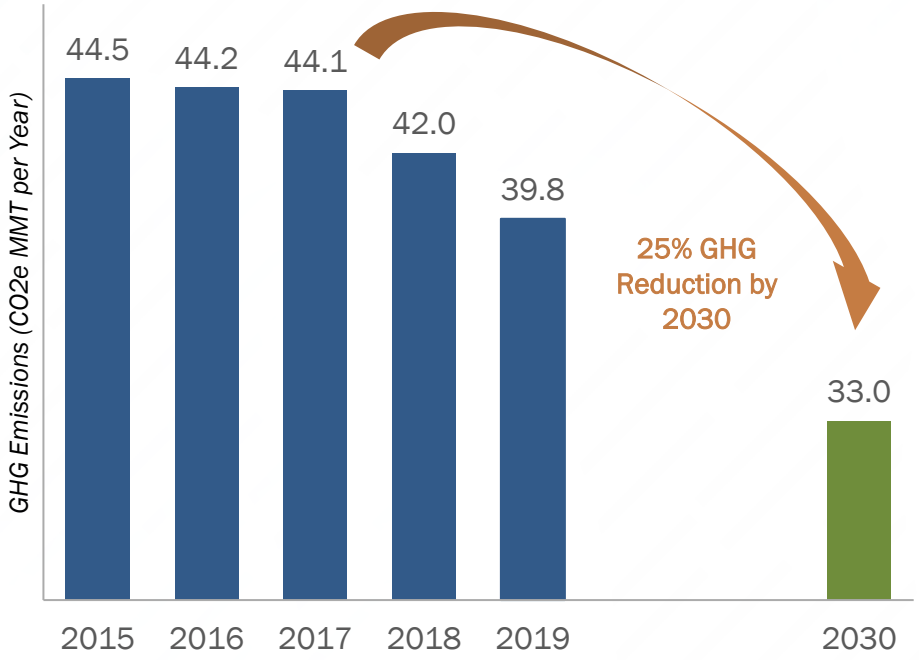
Third party sales

Cliffs' position as the most prominent automotive steel supplier in the US provides the most compelling scrap offtake proposition for the OEM

CLIFFS' COMMITMENT TO GHG REDUCTION

Cliffs' 25% GHG Reduction by 2030

Scope 1 and Scope 2 Emissions



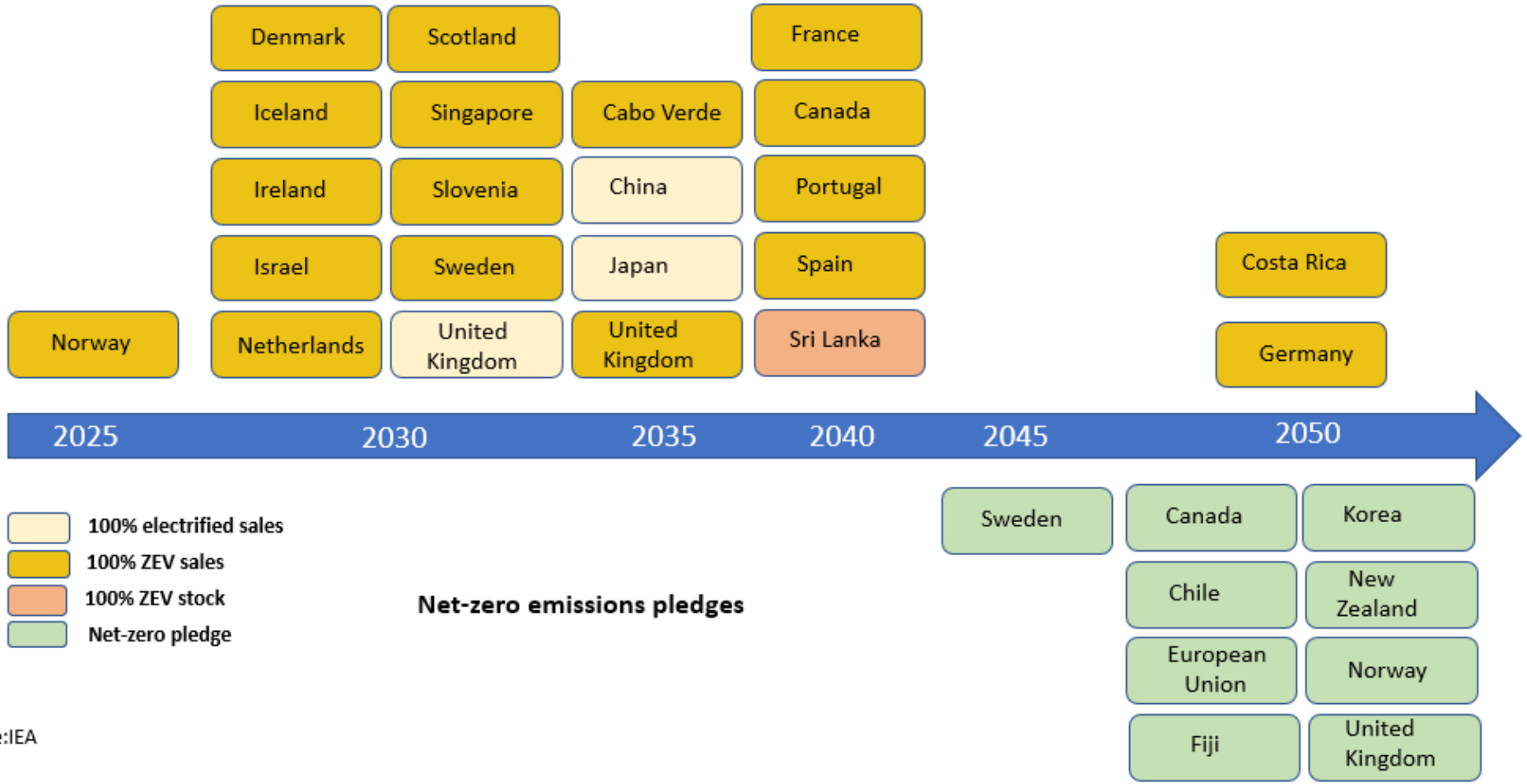
How we will accomplish

- ✓Use of natural gas via direct reduction and blast furnaces
- ✓Clean energy and energy efficiency projects
- ✓Carbon capture

Cleveland-Cliffs' eight operating blast furnaces are among the lower GHG-intensive integrated operations in the world

Pro forma GHG emissions profile of Cleveland-Cliffs' new operating footprint.

ICE PHASE OUT TIME - BEV OUTLOOK



Source:IEA

LIFE CYCLE ASSESSMENT

Outcome	Aluminum (MJ)	AHSS (MJ)
Total Life Cycle Demand Per Vehicle	383,000	347,000
Total Life Cycle Demand for 1 Million	383,000,000,000	347,000,000,000

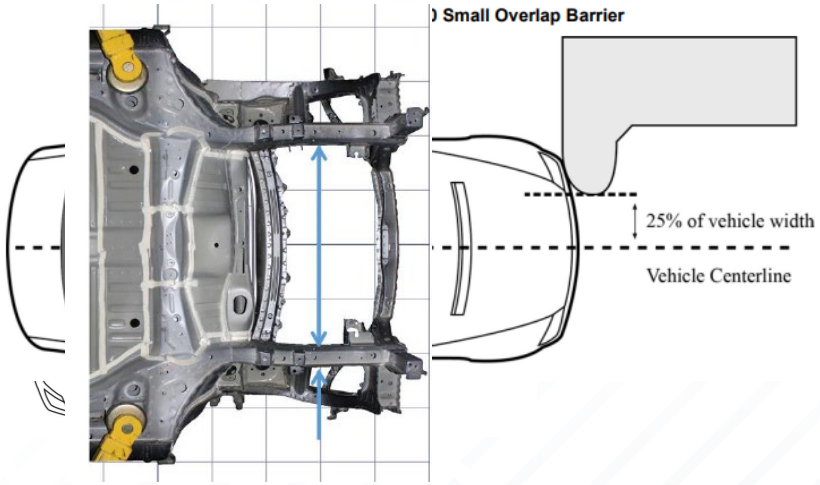
Total Energy Savings with AHSS: 36,000,000,000 MJ (10,000,000 kWh)

This means that, with the energy it would take to produce aluminum-intensive vehicles, you could manufacture, power and recycle AHSS BEVs plus have enough leftover energy to power an additional 170,000 BEVs for their entire useful lives, or supply the total energy demand to 77,000 U.S. households for 12 years (based on publicly available 2015 data)

Source : World Auto Steel

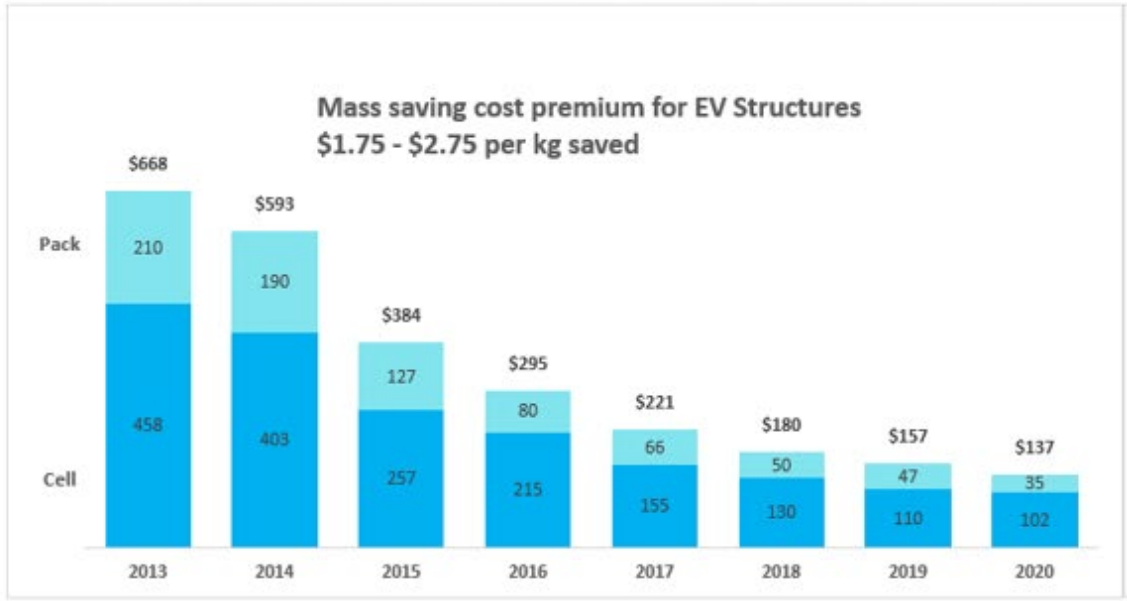
CHALLENGES IN BEV ARCHITECTURE DESIGN FOR SAFETY

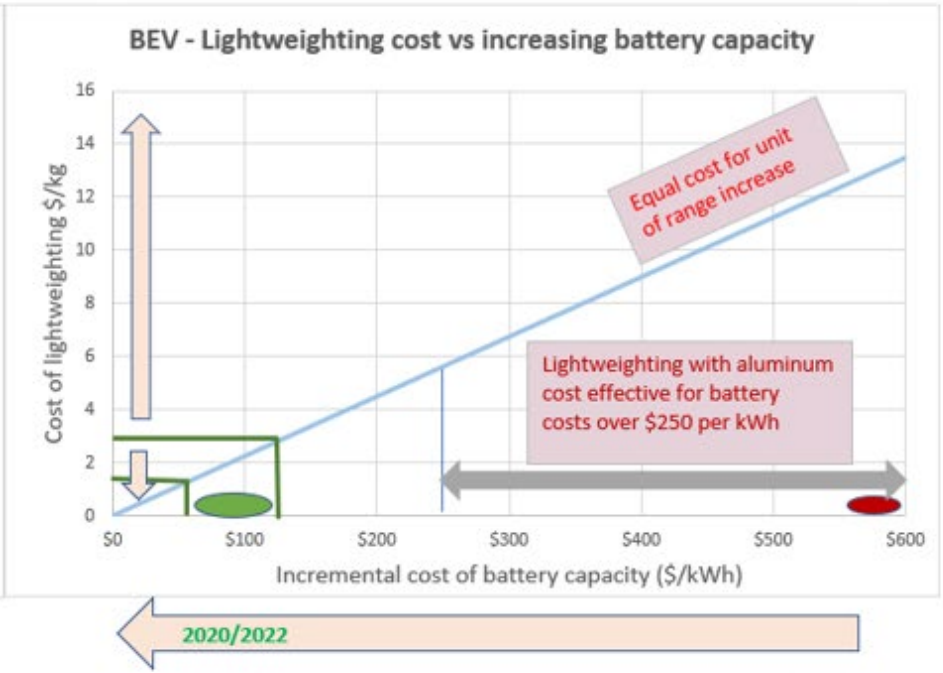
- Unique safety performance like electric safety and cabin deformation
- Mass increase about 50% for the propulsion and 25% of the curb mass compared to ICE
- New layout and structure of the front end to meet the frontal crash requirements
- IIHS SORB adds additional safety requirements
  - Increased role of bumper in high speed impact
- New IIHS side impact protocol introduces 82% more energy
  - Mass increase from 1500 kg to 1900 kg speed increase (50 to 60 kmph)
    - Rocker structures are becoming more complex



DO WE NEED LIGHT WEIGHTING ?

BEV price parity with gas-powered cars by 2024





Source:BloombergNEF

BY JOHN FARREL
https://ilsr.org/report-electric-vehicles

BATTERY WEIGHT COMPARISON

Car Segments	BEV Models (SOP)	Energy Content / Battery Size (kWh)	Battery Range (mi)	Battery Weight (Lbs.)	Battery Housing NetWeight (Lbs.)	Housing Share of Total Battery Weight (%)	Energy Content per Pound of Battery	Energy Efficiency (declared)
A	Volkswagen Up! (2011) (only one A-segmentmodel in NA: JAC Refine S4)	32	160	547	ST: 97 Composite: 21	22%	58.5 Wh/Lbs.	20.3 kWh per 100 mi
B	Chevrolet Bolt (2016)	66	259	960	ST: 190	20%	68.8 Wh/Lbs.	25.5 kWh per 100 mi
C	Nissan LEAF (2017)	62	226	904	ST: 180	20%	68.6 Wh/Lbs	27.4 kWh per 100 mi.
D	Ford Mach-E (2020)	75.7 (70 usable)	230	1069	AL Extrusion: 168 AL Sheet: 45 Composite: 42	25%	70.8 Wh/Lbs.	30.4 kWh per 100 mi
E	Tesla Model S (2012)	85	265	1200	AL: 240 ST: 35	23%	70.8 Wh/Lbs.	32.1 kWh per 100 mi

Source: Ducker

BATTERY ENCLOSURE - STEEL SOLUTION

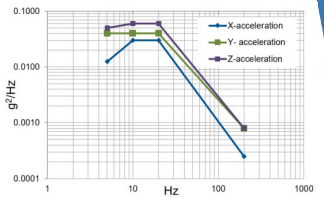
Advantages

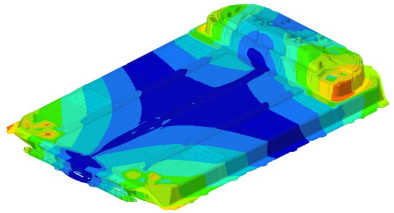
- Manufacturing
- Impact Resistance
- Space Saving
- Fire resistance/Preconditioning
- Lower cost
- Sustainability

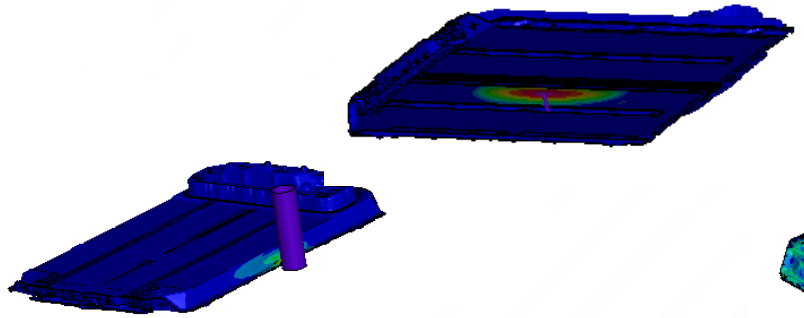
Disadvantages

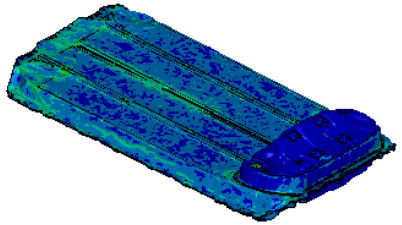
- Corrosion
- Thermal Management
- Limited ability to consolidate parts

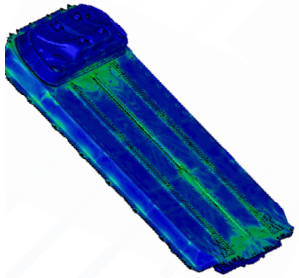
LOAD CASES

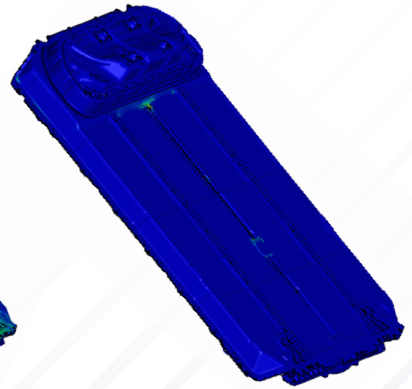
Modal	Crush test	Underfloor Intrusion	Drop Test	Shock Test	Vibrational Fatigue
	EU ECE R100 ChinaGBT31467.3		SAE J2464 China-GBT31467		China –GBT31467
Constraint on BIW attachments	Quasi Static Load Rigid Pole Impactor 150 mm –Dia.	Quasi Static Load Round Shape 20 mm rigid impactor	Drop from 4.9m (Hitting velocity 9.8m/s). Angle with ground 15 degrees.	Proof Shock 2g (x,y)& 4g in Z Abuse Shock (25g)	
Frequency constraint depending on OEM	No contact with Modules before reaching 100 kN	No contact with modules before reaching 35 kN	No failures	Stresses below Yield/Tensile	Stresses below tensile/6



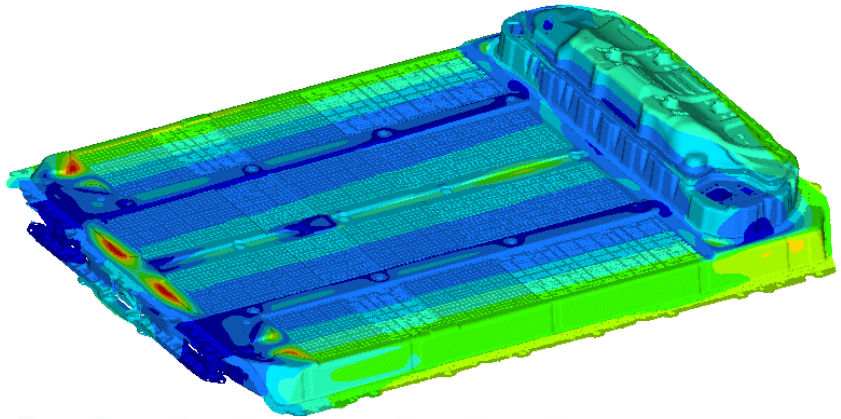


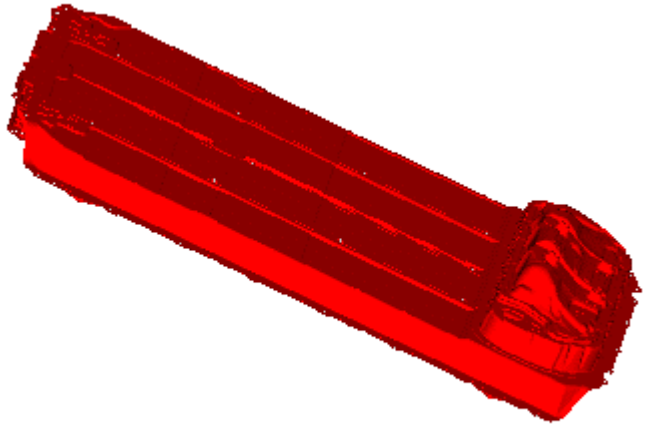




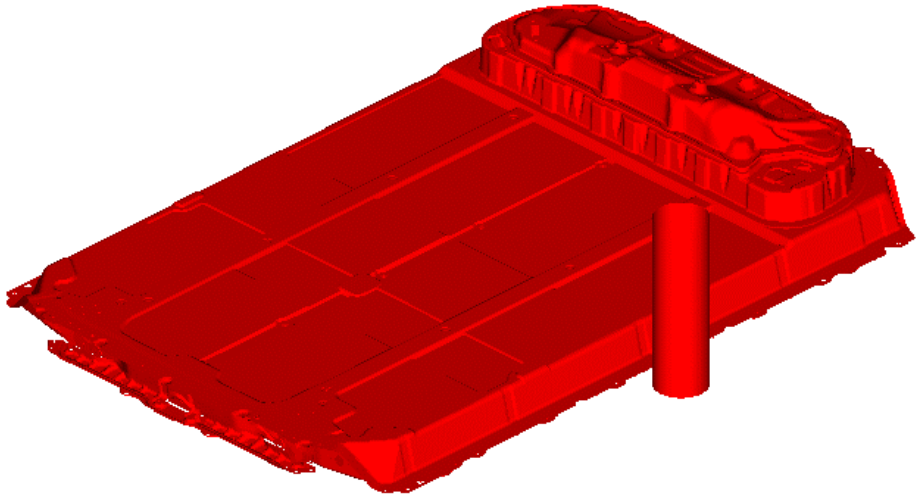


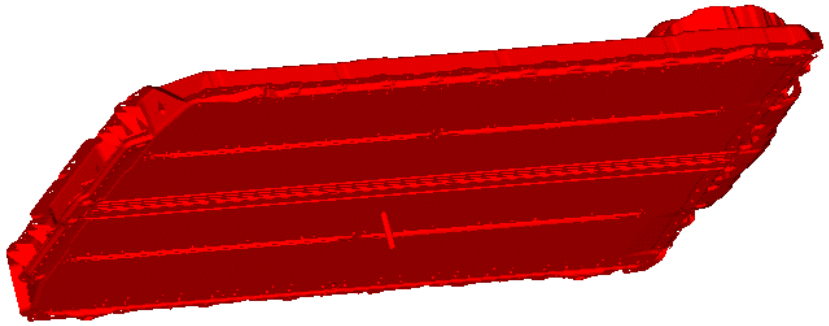
MODAL/DROP TEST





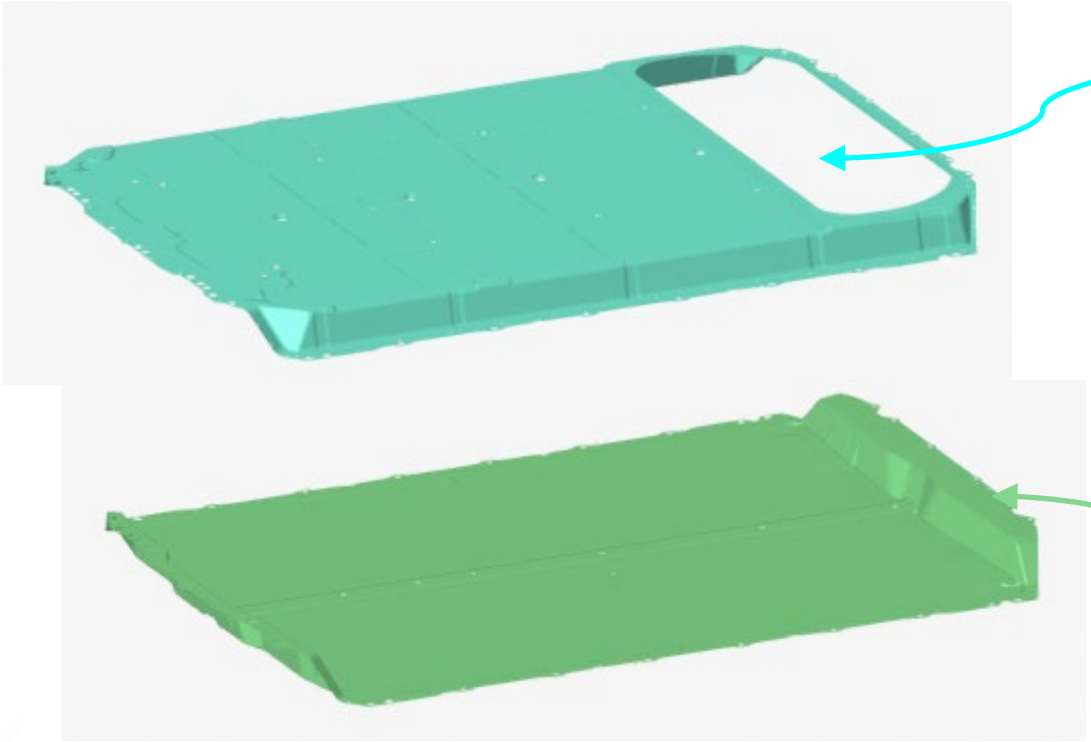
CRUSH & UNDER FLOOR TEST





DIFFERENT BATTERY ENCLOSURE DESIGNS

Top and Bottom Cover

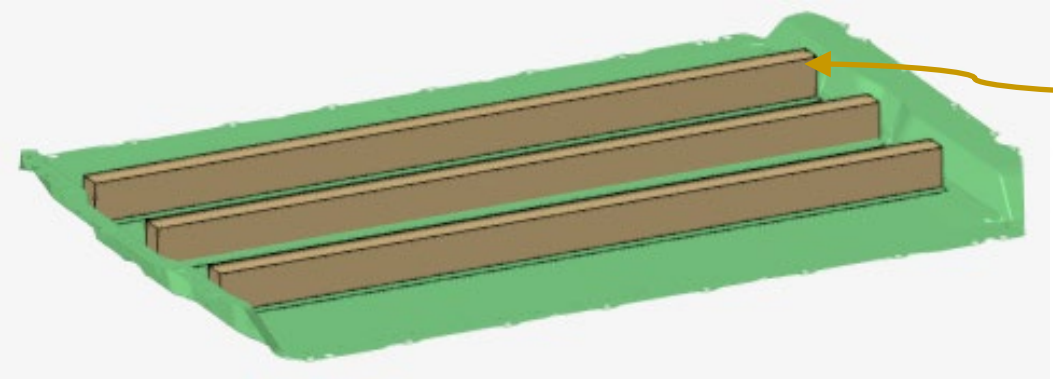


Top Cover
Mild Steel
EDDS/EDDS+

Bottom Cover
DP980/DP1180/NEXMET1200
CP780/CP980/MP780
ULTRALUME® PHS
Stamping

DIFFERENT BATTERY ENCLOSURE DESIGNS

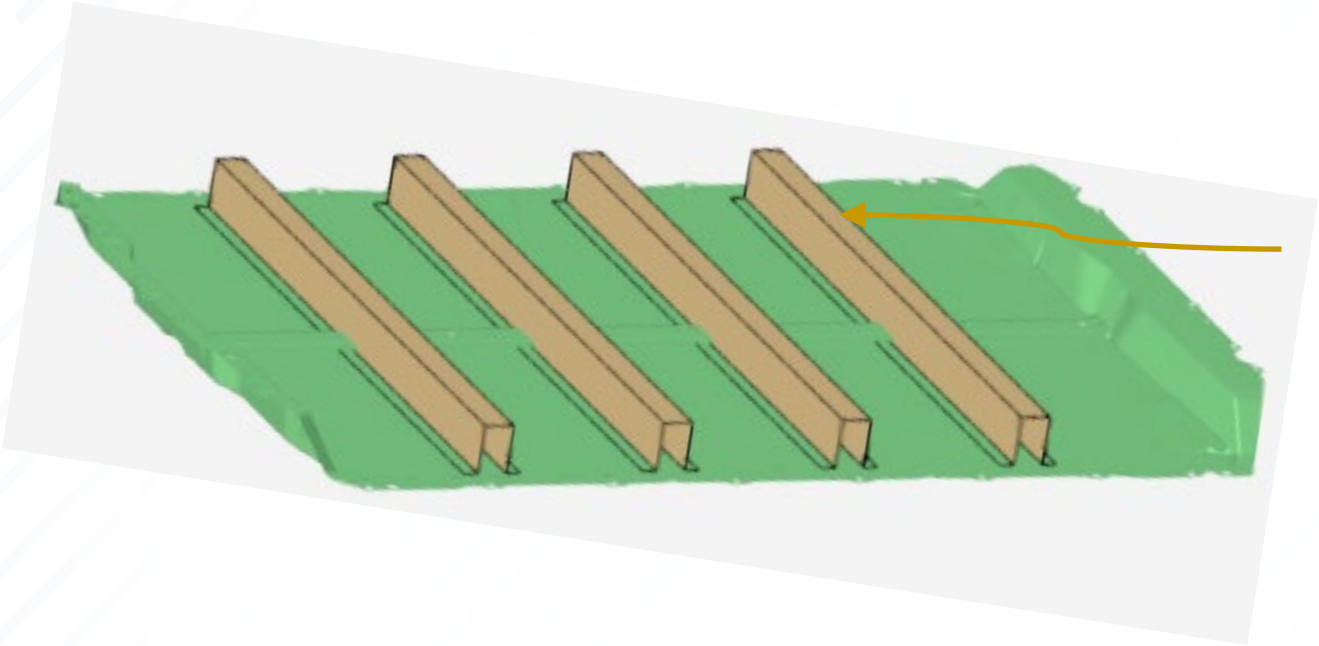
Longitudinal Members



Longitudinal Members
Martensitic M1100/M1300/M1500/M1700
Roll Form

DIFFERENT BATTERY ENCLOSURE DESIGNS

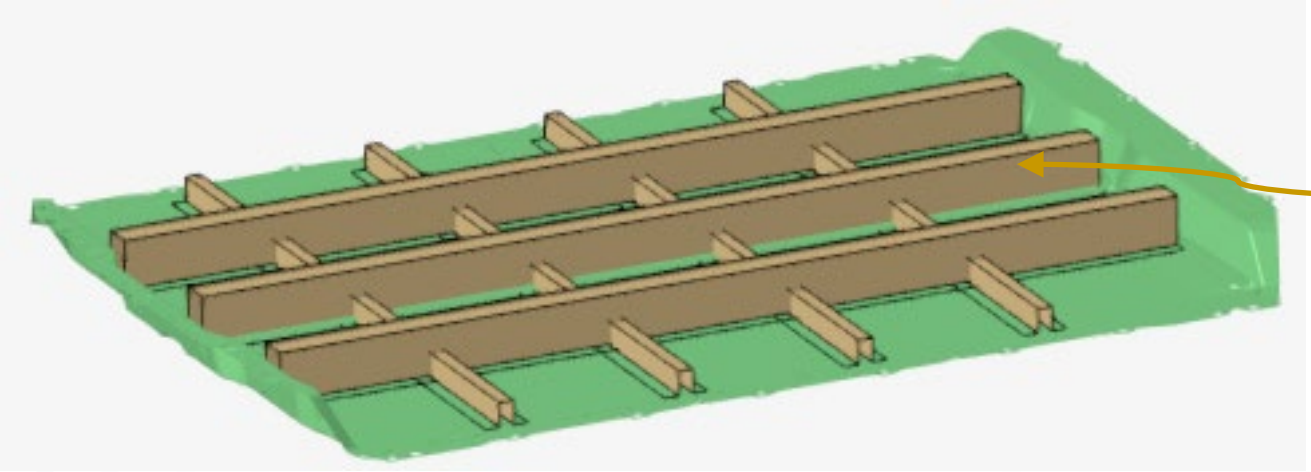
Cross Members



Cross Members
Martensitic M1100/M1300/M1500/M1700
Roll Form

DIFFERENT BATTERY ENCLOSURE DESIGNS

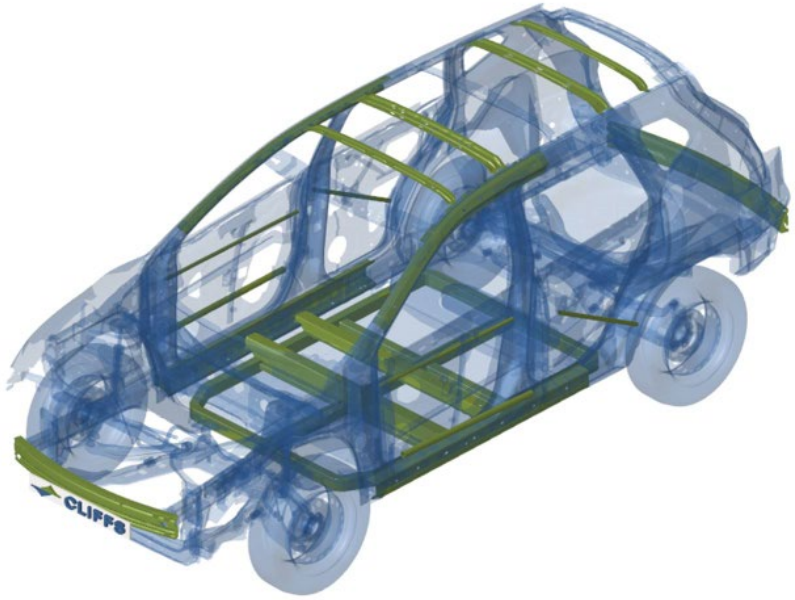
Longitudinal & Cross Members

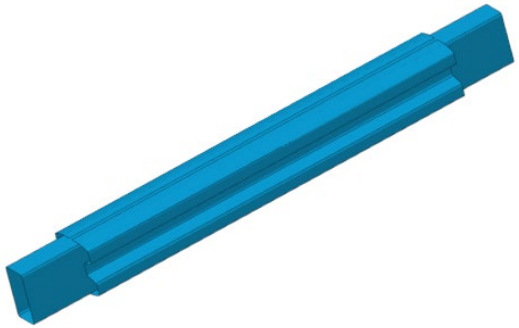


Longitudinal & Cross Members
Martensitic M1100/M1300/M1500/M1700
Roll Form

BEV - INTEGRATED BATTERY/BODY DESIGN

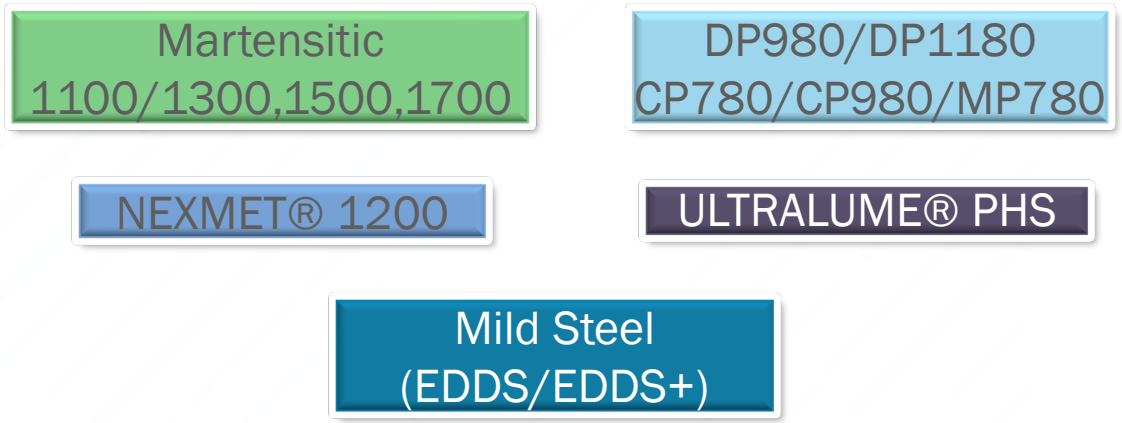
- Industry is heading in this direction
- Integrating battery enclosure to the chassis structure
- Skateboard design
- Steel offers the same advantages as before





SUMMARY

- Steel is clearly the material of choice for the battery enclosure
- Cleveland Cliffs provide a wide portfolio of steel grades for this application



- In addition to the research and innovation center at Middletown, Ohio, Cleveland Cliffs offers a most comprehensive support with our advanced, applications, and customer technical services departments

FOR MORE INFORMATION

Sajan George

Cleveland-Cliffs

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