GREAT DESIGNS IN STEEL

TWENTY YEARS

SUSTAINABILITY ASSESSMENT OF STEEL VS. ALUMINUM BUMPER BEAMS

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SUSTAINABILITY ASSESSMENT OF STEEL VS ALUMINUM BUMPER BEAMS

Agenda

1. Introduction to Sustainability
2. Current Decision Factors in Steel vs. Al Bumper Beams
3. Life Cycle Assessment Model – Automotive Applications
4. Benchmarking Study – Full Size SUV Bumper Beams
5. Case Study – Generic Front Bumper Beam
6. Conclusions

1. Introduction to Sustainability

What is Sustainability?

To create and maintain the conditions under which humans and nature can exist in productive harmony to support present and future generations.

- Environment Protection Agency – US Govt.

Assumptions

- Amount of resources used by humans can be measured
- Resources on earth are finite

Goal

- Use the least amount of resources in order to sustain life for future generations
- Automotive assessments should include all three phases of a vehicle life:
  - Material production and manufacturing phase
  - Use phase (where most decisions are focused currently)
  - End of life phase

2. Current Decision Factors in Steel vs Al Bumper Beams

Current Guidelines for Material Decision on Bumper Beams

- Steel applications for low piece cost.
- Aluminum application for low mass.

Decision Factors for Steel vs. Aluminum

- Piece cost increase per unit of mass saved ($/kg saved).
- Each vehicle has a different $/kg saved based on:
  - Type of vehicle (luxury vs economy).
  - How close the vehicle is to a desired weight class (U.S.)?
  - Other mass savings opportunities on the vehicle.

Result

- Decisions on Steel vs. Al are based on the use phase only of the vehicle life.
  - Ignoring both material production and manufacturing and end of life phases.

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3. Life Cycle Assessment Model – Automotive Applications

- Developed by University of California – Santa Barbara for WorldAutoSteel
- Quantifies the environmental impact of a vehicle over its full life.
- Calculates amount of Green House Gas emissions and Energy consumption for three phases:
  - Material production and manufacturing phase
  - Use phase over the life of the vehicle
  - End of life phase (recycling credits)
- Enables comparison between different vehicle designs.
- Format is Microsoft Excel Worksheet – model is extensive and has many inputs.

Use this tool to assess steel versus aluminum bumper beams

Link: https://www.worldautosteel.org/life-cycle-thinking/ucsb-energy-ghg-model/

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4. Large SUV Benchmarking Study – Front Bumper Beams

0	Year	Model		Vehicle Mass (kg)
1	2021	BMW X7	Lowest	2453
2	2021	Chevrolet Suburban	Highest	2730
3	2018	Ford Expedition		2592
4	2016	Mercedes GL 450		2455
5	2020	Toyota Sequoia		2660
6	2020	Nissan Armada		2615

Average Vehicle mass = 2574 kg






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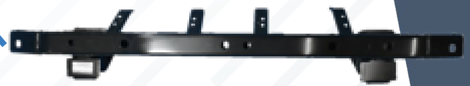
4. Large SUV Benchmarking Study – Front Bumper Beams

	Year	Model	Vehicle Mass (kg)	Material	Frt Beam Mass (kg)
1	2021	BMW X7	2453	Al	5.96
2	2021	Chev Suburban	2730	Steel	6.18
3	2018	Ford Expedition	2592	Steel	Lightest 3.07
4	2016	Mercedes GL 450	2455	Steel	Heaviest 11.2
5	2020	Toyota Sequoia	2660	Al	5.38 w/Brkts
6	2020	Nissan Armada	2615	Steel	8.92



Ave Vehicle Mass = 2574 kg

Front Beam Mass does not correlate to Vehicle Mass

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4. <u>Life Cycle Assessment Case Study – Front Bumper Beam Large SUV</u>

Compare the six benchmarked beams for Green House Gas emissions and energy consumption

- Used University of California – Santa Barbara modeling tool
- Calculations for material production and manufacturing, use, and end of life phases.
- Assumptions to enable comparison:
  - Vehicle mass: 2574 kg (average of 6 vehicles)
  - Vehicle Life: 150,000 miles (242,000 km)
  - Fuel: 10% ethanol made from corn
  - Recycled Content: 3 percentages (0%, 50%, 100%)
  - No analysis on Energy source (Fossil or Green)

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4. Life Cycle Assessment Case Study – Front Bumper Beam Large SUV

Model Outputs

1. Green House Gas – kg CO_2
2. Total Energy – Mega Joules (MJ)
3. Fossil Fuel Requirements – MJ (not considered for this study)

Each Output Includes all three phases of the vehicle life:

1. Material production and manufacturing
2. Use
3. End of Life (recycling credits)

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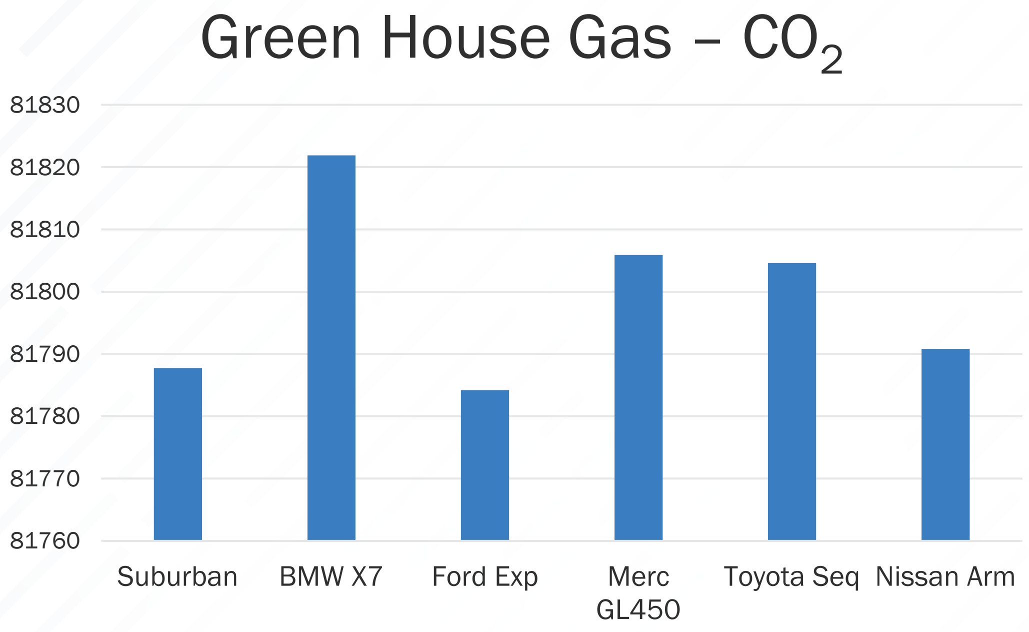
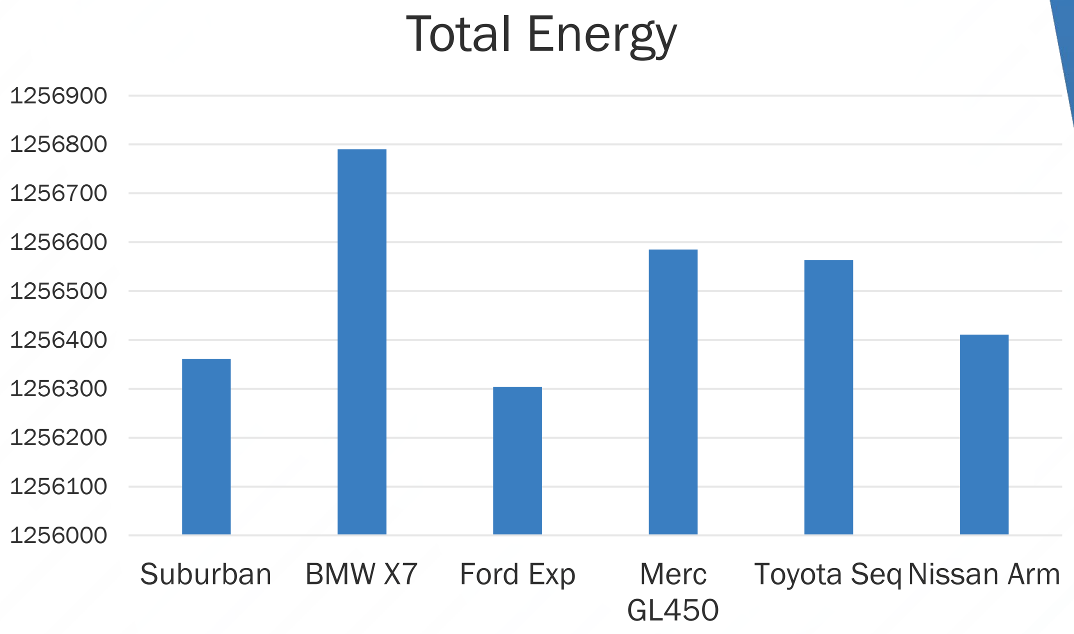
Results





Both GHG emissions and energy consumption values have same relative relationships to each other

Focus → Total Energy

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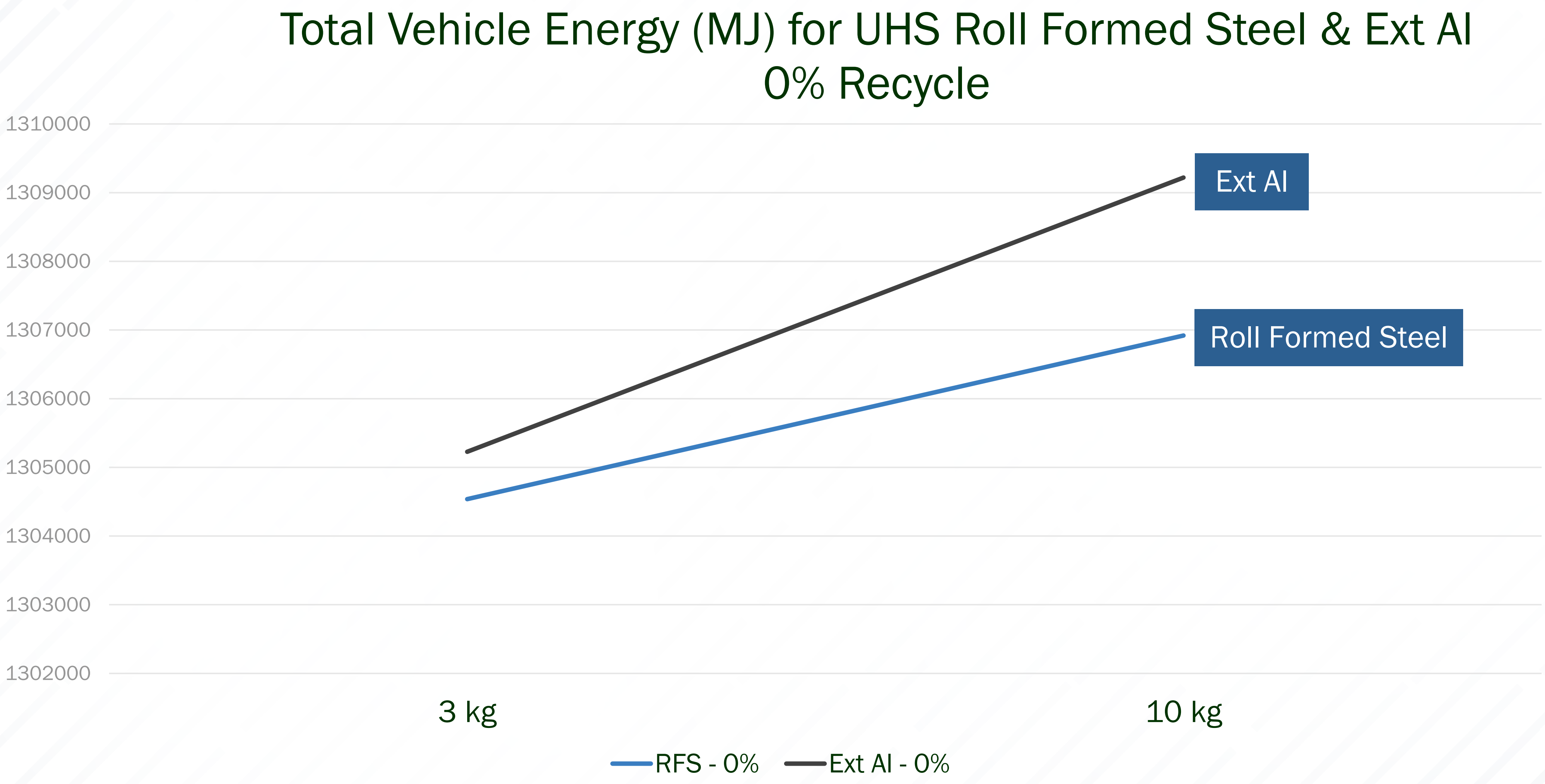

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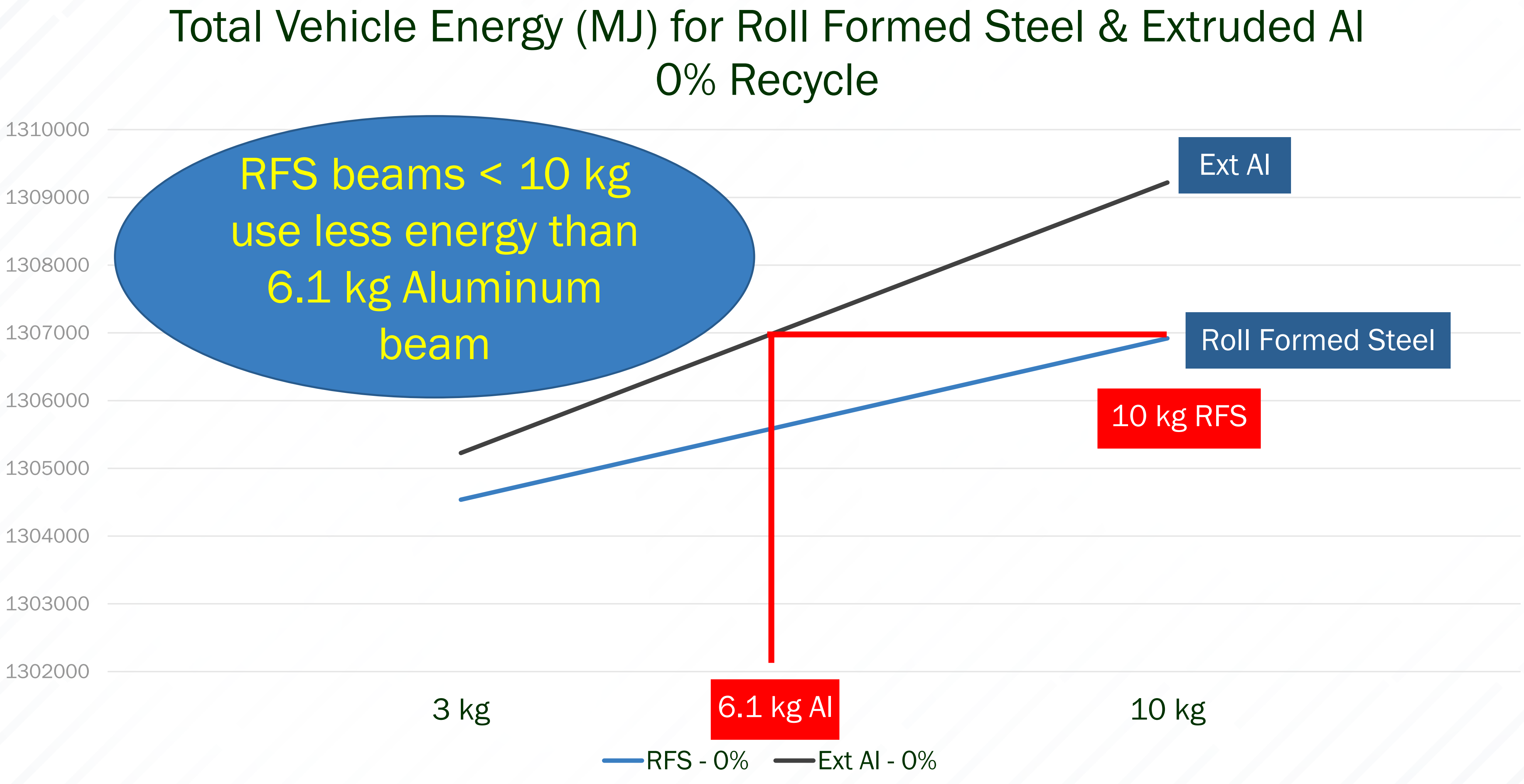


5. Case Study – Generic Front Bumper Beam

Steel Institute data shows:

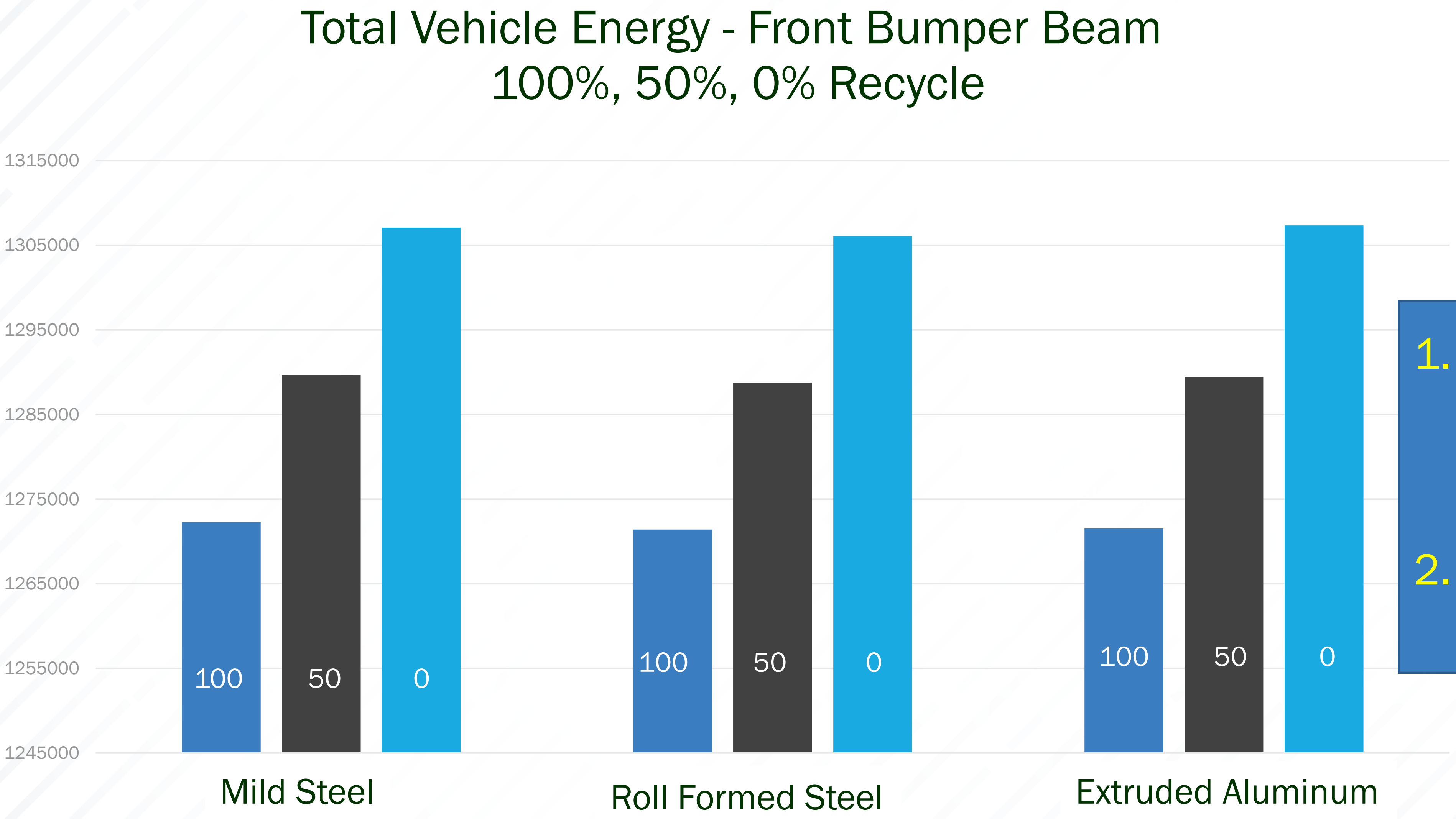
- UHS Steel saves 25% mass over Mild Steel
- Aluminum saves 33% mass over Mild Steel

Assumption

- 10 kg Mild Steel Beam
- 7.5 kg UHS Steel Beam
- 6.7 kg Extruded Aluminum Beam

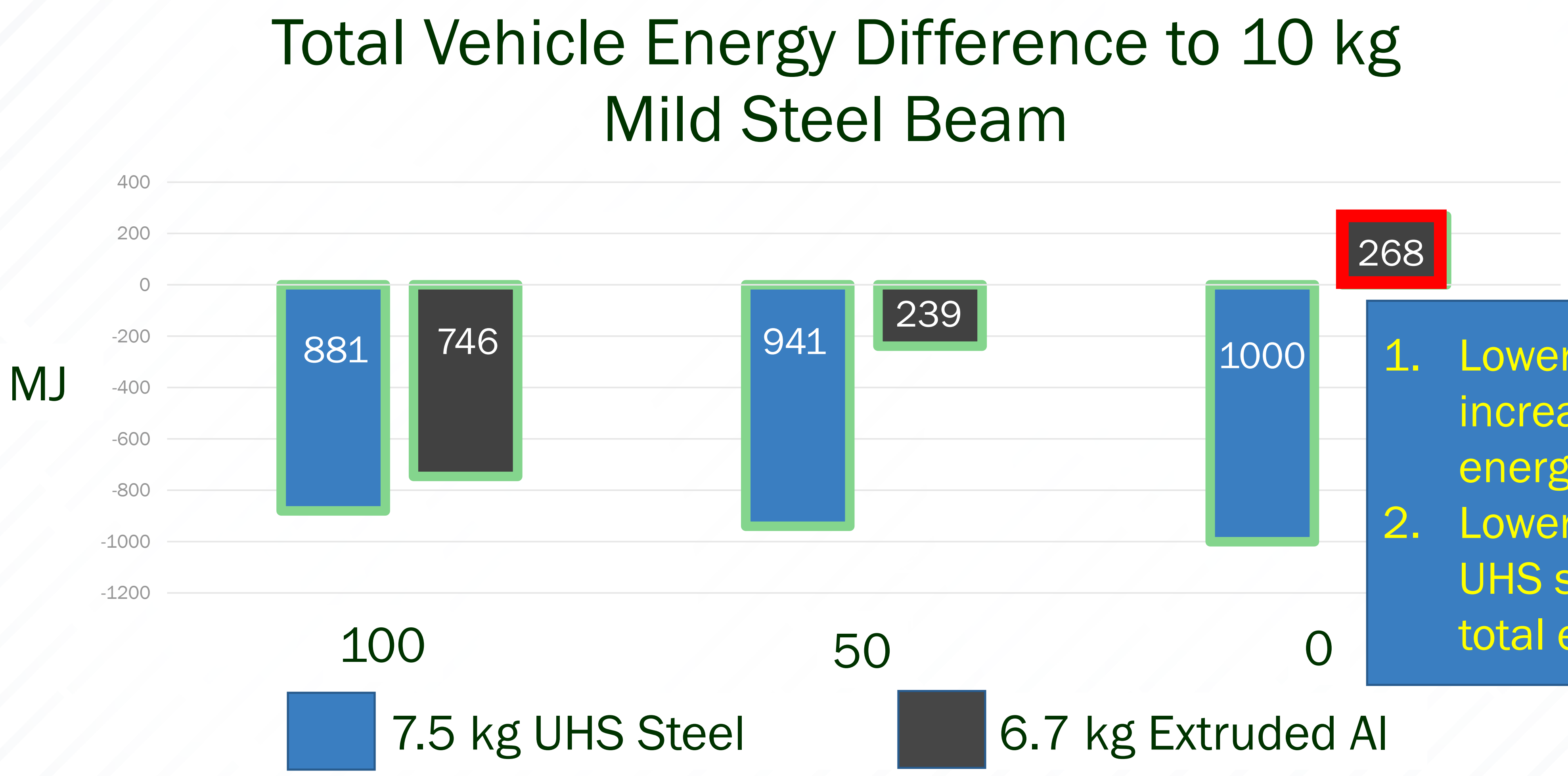
Evaluate Recycling at 100%, 50%, 0%

GENERIC FRONT BUMPER BEAM STUDY



1. Differences between material is small relative to Total Energy.
2. Higher recycling reduces total energy

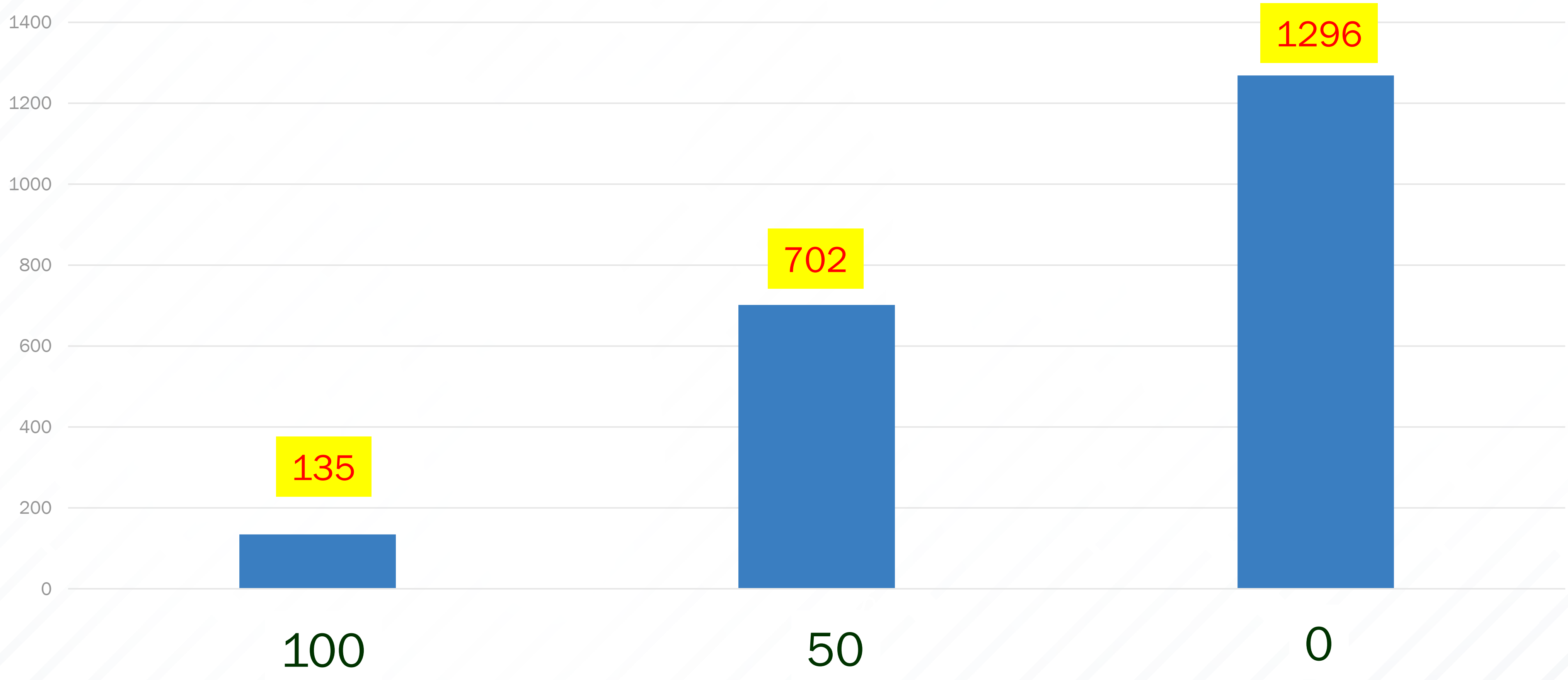
GENERIC FRONT BUMPER BEAM STUDY



1. Lower recycling for Al increases total energy.
2. Lower recycling for UHS steel decreases total energy

GENERIC FRONT BUMPER BEAM STUDY

Total Energy Difference between Roll Formed UHS Steel (7.5 kg) vs Extruded Al (6.7 kg)



5. Generic Case Study Conclusions

- ❑ UHSS Beam at 7.5 kg
- ❑ Extruded Aluminum Beam at 6.7 kg

- UHS Roll Formed Steel takes less Total Energy in Life Cycle Assessment at all recycling levels – 0, 50, 100%
- Total Energy savings of UHS Steel over Aluminum increases as recycling content decreases.
- At 0% Recycling - Total Energy consumption of the Extruded Al beam at 6.7 kg is higher than the Mild Steel beam at 10 kg.

6. Conclusion

- The automotive Industry should use all three phases – material production and manufacturing, use, and end of life – when assessing material usage for bumper beams.

- Focus should be on continuing to develop materials and processes for lighter UHS Steel beams.

FOR MORE INFORMATION

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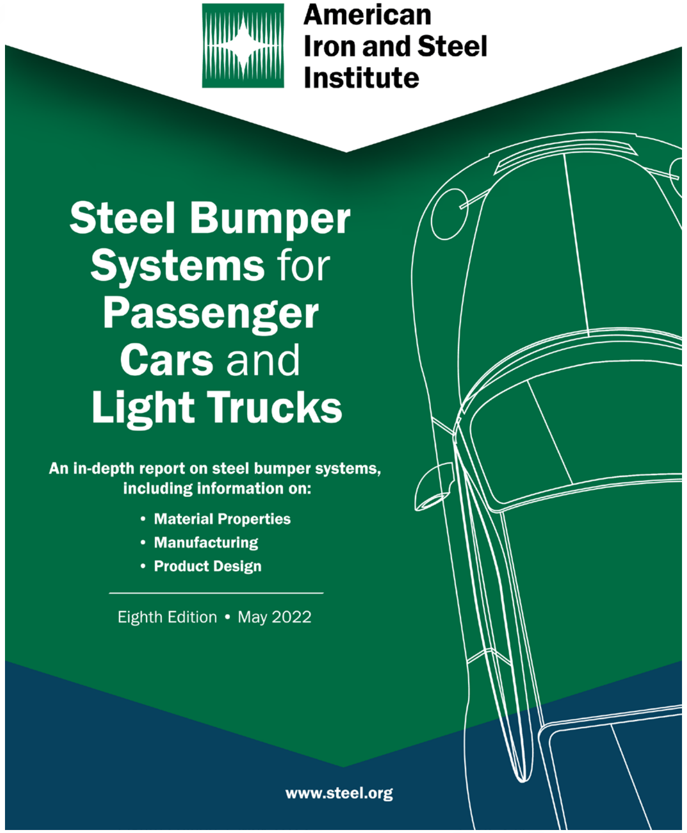
STEEL BUMPER SYSTEM (SBS) VERSION 8



https://www.steel.org/steel-markets/automotive/bumpers/