EXECUTIVE SUMMARY

Introduction

The Mattress Recycling Council (MRC), a non-profit organization which administers mattress recycling programs in states with mattress product stewardship laws, sponsored a life cycle analysis (LCA) of its California mattress recycling operations conducted for calendar year 2021. Since 2016, MRC's California program has collected, transported, and recycled over 8.5 million mattresses and box springs (together called mattresses or units). Scope 3 Consulting conducted the LCA to describe and measure the environmental implications of this mandated statewide recycling program.

The study establishes baseline environmental performance parameters for the mattress recycling industry. In an effort to improve the mattress industry's environmental performance, members of the mattress supply chain are investing in research and pilot facilities to enhance product and materials designs, develop lower carbon footprint materials and explore alternative recycling technologies. MRC expects to use the results of this study as a benchmark for evaluating future technologies.

Key Findings

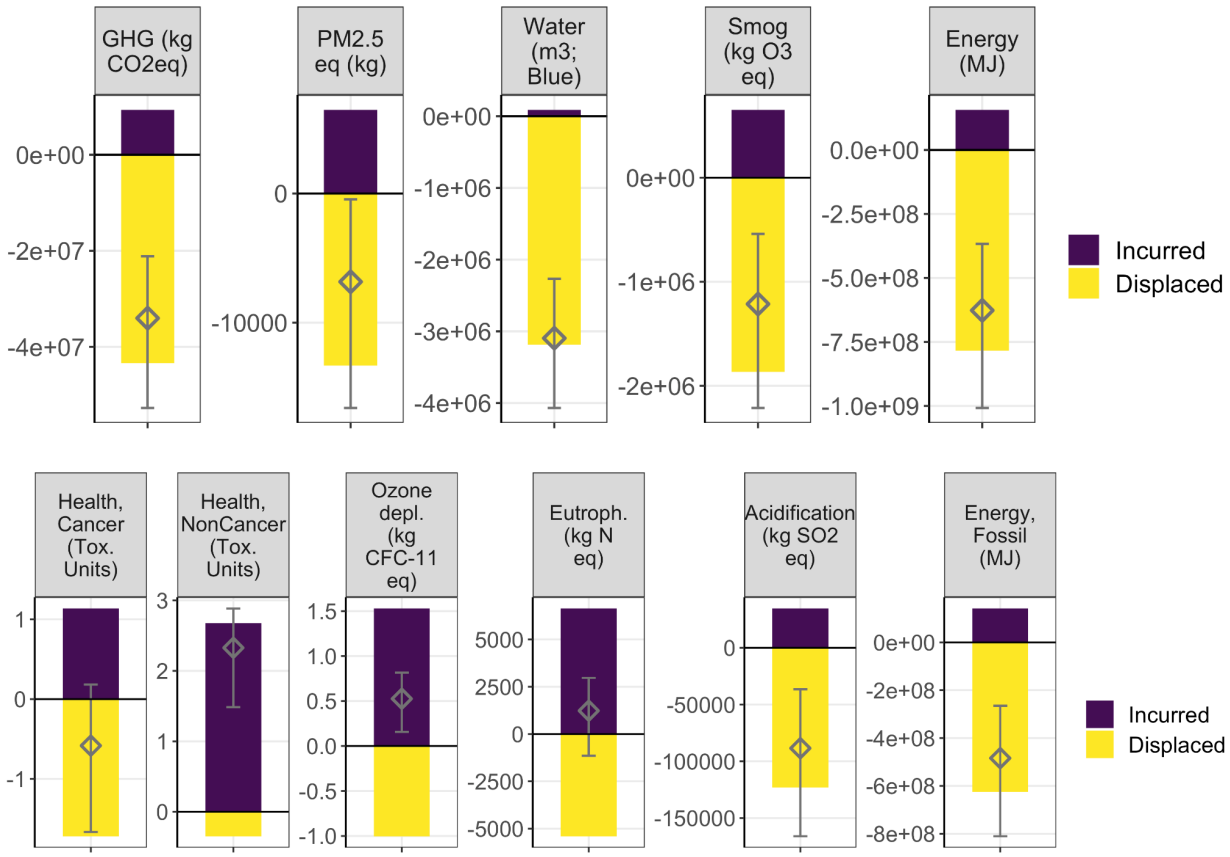
Baseline Performance

In 2021, the California program recycled 1.6 million mattresses. Of the 40.7 thousand metric tons (90 million lbs.) of materials recovered, 31.4 thousand tons (77%) were recycled, and 9.3 thousand tons (23%) were landfilled. The LCA analysis of the 2021 recycling system found that it provides the following significantly favorable environmental benefits:

Greenhouse gas displacement	34,000 metric tons (75 million lbs.) CO_2 equivalents
Energy demand reduction	627 terajoules (174,000 kWh)
Blue water demand reduction	3.1 million m^3 (818 million gallons)
Particulate matter reduction	6.8 metric tons PM2.5e (15 million lbs.)
Smog reduction	1,220 metric tons O_3 equivalents (2.7 million lbs.)

According to the LCA model, the mattress recycling system provided environmental benefits in all 5 of the main study indicators. For supplemental indicators, the overall impact was mixed. Two of the indicators showed consistently better performance (acidification; fossil energy), two had consistently worse performance (non-cancer health; ozone depletion), and two were marginal (cancer; eutrophication). The body of this report defines these indicators and discusses findings in greater detail. Incurred impacts, avoided impacts (displacement) and net results are illustrated in Figure ES.1

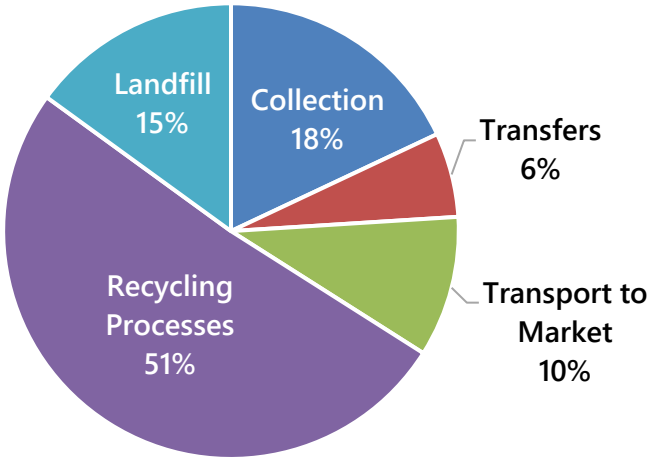
Figure ES.1. Total system impacts for managing 41 thousand tonnes (kt) of used mattresses. Each pane shows the incurred, displaced, and net total impacts of mattress recycling in CA (yr2021). The Diamonds represent the Net total. Top panes show the headline indicators. The Error bars show net total results for a range of assumed displacement rates (see §Displacement rates for explanation, and §Displaced production for ranges). Tabular data in §Appendix.



Incurred Impacts

The environmental impacts incurred includes processes related to used mattress collection, transportation, deconstruction, reclamation, transport of extracted mattress materials to final disposition and re-manufacturing. Figure ES.2 illustrates the major drivers for greenhouse gas emissions resulting from the mattress recycling system. Within the Recycling Processes category, the activity of California recyclers and rebond foam pad production are major drivers. The production of methylene diphenyl diisocyanate (MDI) used in rebond foam pad production is a significant contributor to impacts.

Figure ES2. Incurred Greenhouse Gas Impacts by Process, 7.7 KT/yr.

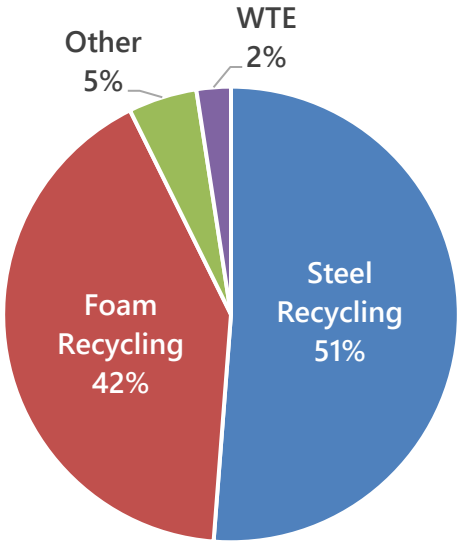


Material, Product and Energy Displacement

In addition, the study reports potentially avoided impacts, which would occur if the supply of recycled materials from mattresses displaces primary (virgin) materials. This relationship between the supply of mattress-derived materials and the displaced production of primary materials is an important uncertainty in this study. For this reason, we model a range of displacement values (depending on the material), and always show incurred impacts (from the mattress recycling system) and potentially avoided impacts (from displaced production), not just a net total.

Figure ES.3 illustrates the major drivers for avoided greenhouse gas impacts were steel recycling and avoided polyurethane foam production.

Figure ES3. Greenhouse Gas Displacement by Material, 34.0 KT/yr.



For climate impact, water use, smog, and energy use, the magnitude of the potentially displaced impacts is consistently larger than the incurred impacts of the recycling system. For the particulate matter indicator, the net benefit is negligible for only the most pessimistic displacement rates.

Alternative Process Assessments

As mentioned previously, global industry research and investments are in progress to develop alternative mattress recycling technologies which aim to create greater circularity and establish new pathways for recycling end-of-life materials. This study made a preliminary assessment of several promising technologies by incorporating published data into the California model.

Initial findings indicate that all established recycling processes, including mechanical recycling, chemical recycling, incineration, and pyrolysis, are more preferable options than landfilling. Chemical recycling may have more favorable environmental impacts particularly with net energy use and water demand than current mechanical recycling processes and market channels. However, it is important to note that an ISO 14040 compliant evaluation of an actual commercial scale facility is necessary to make that firm conclusion.

Improvement Opportunities

The study identified potential short- and long-term opportunities for improving the environmental impacts of mattress recycling.

- **Transportation** of mattresses from collection nodes to recyclers and recovered materials to secondary markets represented approximately 34% of incurred

environmental impacts. The number, size and location of collection nodes and primary and secondary recycling facilities is an important consideration as the mattress recycling industry expands.

- **Automation** to improve recyclers' ability to efficiently separate materials has the potential to increase throughput, reduce landfill rates and reduce the environmental burden and cost per ton of recovered materials.
- **Development of new end markets** for recovered materials remains a key driver for growing and diversifying demand. To maintain and improve current baseline performance, recycling rates for all materials recovered should exceed 75% and must be robust through economic cycles.

Conclusion

The LCA found that the current industry led product stewardship program offers significant environmental benefits. Approximately 34,000 metric tons (75 million pounds) of greenhouse gases were avoided when compared with the production of products from virgin raw materials – the same amount as burning 12.6 million gallons of diesel. The program also saved an estimated 818 million gallons of water and mitigated the production of 636.7 terajoules of electricity.

This LCA report follows ISO 14040 guidelines. Following release of this report, a critical review by an independent panel will be completed in Q1 2023.