Usage and Flow of Aluminum Sheet within the U.S. and Canadian Residential Building Products Industry

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Introduction

A key initiative within the aluminum industry is to support sustainability by promoting and facilitating aluminum recycling efforts. The strategic importance of sustainability is evidenced by the broad support this initiative generally receives from participants throughout the aluminum industry and the visible leadership of high-volume manufacturers, such as Alcoa, Rio Tinto Alcan, Novelis, Aleris International, and industry trade associations, including the Aluminum Association and the Center for a Sustainable Aluminum Industry (CSAI). Aluminum recycling is motivated by several key factors.

Aluminum is infinitely recyclable with only minor material losses and without any degradation in quality. In contrast, other materials, such as paper and plastics, are often downcycled into a product having weaker material properties. Eventually, paper fibers wear out through multiple product life cycles. Alternately, due to the material degradation resulting from mixing that may occur during the recycling process, plastics are "typically good for one downcycling."[1]

Aluminum represents "a key component in the domestic metal supply."[2] From 2001 to 2009, aggregate shipments of aluminum fabricated products have ranged from 17,831-25,967 million lbs.[3] Over the 2000 to 2004 period, Green and Skillingberg (2006) reported that secondary aluminum recovered through recycling ranged from 30.0-32.2% of total aluminum shipments within the U.S.[3]

Aluminum recycling saves 95% of the energy that is otherwise required to convert bauxite ore into aluminum. Concordantly, 95% of the emissions associated with this conversion process are eliminated through recycling.[4]

Aluminum recycling substantively reduces the amount of waste directed to landfills, and consequently, saves landfill space.[4]

Aluminum recycling facilitates the conservation of natural resources. According to Wise Recycling, "every pound of aluminum recycled eliminates the need to mine and process four pounds of bauxite ore."[5]

While the benefits of recycling permeate each market segment of the aluminum industry, little quantitative information is available about the nature of recycling within the building and construction (B&C) segment of the aggregate U.S. and Canadian aluminum industry. In contrast to alternate raw materials, aluminum's physical and mechanical properties—corrosion resistance, light weight, durability, and reflectivity—enable the development of B&C products that withstand the external environment, while not drying, splitting, rotting, curling, or rusting.[6] Further, because aluminum reflects 95% of all sunlight, aluminum B&C products significantly reduce air-conditioning use.[7] According to data published by the Aluminum Association, the B&C market segment ranks third (behind transportation and containers/packaging segments) in CY2008 aluminum consumption, with 2,595 million lbs, representing 11.7% of total annual aluminum consumption. Further, aggregate shipments of aluminum within the B&C industry have ranged from 2,595-3,692 million lbs from 2001 to 2008. Despite the magnitude of the B&C segment of the aluminum industry globally, only a single study—conducted by the Delft University of Technology in Europe—examines the nature of non-residential aluminum building products recycling.

To address this gap in applied research, the CSAI, in collaboration with the University of Kentucky's Gatton College of Business and Economics, conducted a descriptive study of the aggregate U.S. and Canadian residential B&C (i.e., "building products") segment of the aluminum industry to address the following research goals:

- Develop diagrams that depict the flows of residential aluminum building products within the U.S. and Canadian markets.
- Identify each tier of the residential aluminum building products supply chain and characterize the value-adding activities that occur within each tier.
- Report the extent to which recycled materials are used and recycled within each tier of the residential aluminum building products supply chain.

To achieve these research goals, a multi-stage data collection methodology was employed. In the first stage, extant literature that characterizes the aluminum industry was reviewed and knowledgeable leaders within the aluminum industry were consulted. Through unstructured interviews, a rough outline of the residential aluminum building products supply chain was created. In the second stage of the methodology, survey questionnaires were administered to targeted members of each tier of this supply chain. In particular, 45 business units were contacted to participate in this study. After significant follow-up via phone, fax, and email over a three-month period, responses from 17 of the 45 business units were received; as such, the overall response rate for this study is 37.8%. In aggregate, the response frame consists of three producers, four converters and toll processors, five fabricators, two installers, and three recycling centers. Respondents to the survey questionnaires held many positions, including owner, general manager, vice president of sales, director of purchasing, operations manager, and technical manager. As such, the descriptive analyses advanced within this study are based upon survey responses from well-positioned, knowledgeable managers in the aluminum building products industry.

Supply Chain

The aluminum building products supply chain serves two broad sets of customers: residential customers and commercial customers. As reported by the Aluminum Association, these customers are served with a variety of products including doors, windows, canopies, awnings, siding, gutters, and downspouts. In 2008, siding, fascia, and soffits represented the largest single category within the residential aluminum building products segment, with 425 million lbs of aluminum shipped.

The manufacture and installation of residential aluminum building products is accomplished within a multi-tier supply chain. As suggested in Figure 1, this supply

chain consists of five distinct types of firms: producers, converters and toll processors, fabricators, installers, and recycling centers. In the following subsections, how each of these types of firms participates in the manufacture of B&C products is described. Further, the results of the empirical study are presented, describing the nature of recycled residential aluminum flows through each stage of the supply chain.

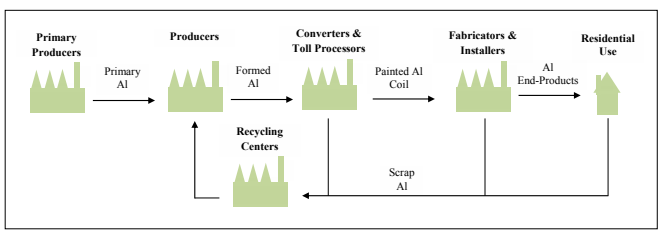
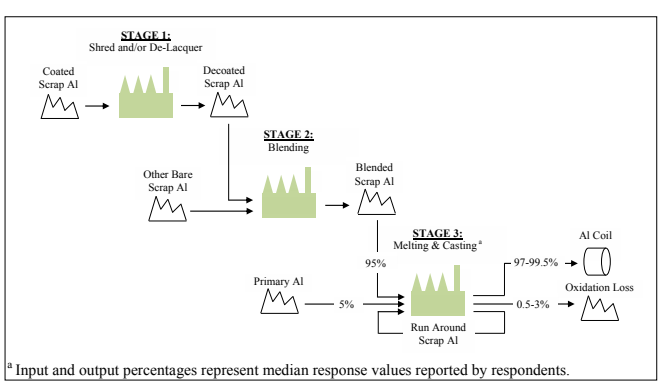


Figure 1. B&C aluminum supply chain.

Producers: As suggested in Figure 2, producers purchase scrap aluminum from recycling centers and other users and employ shredding, delacquering, blending, melting, and casting operations to produce aluminum coil, sheet, and foil stock for the residential building products market segment. In the initial phase of the study, four major producers within the residential aluminum building products market segment were identified; three of these firms participated. The primary business of each of the producers is the production of aluminum for residential products. However, producers also report that they supply aluminum to several other market segments, including automotive, trailer, recreation vehicle, irrigation, signage, license plate, distribution, and other original equipment manufacturer end-products.



[a] Input and output percentages represent median response values reported by respondents.

Figure 2. Producer activity chain.

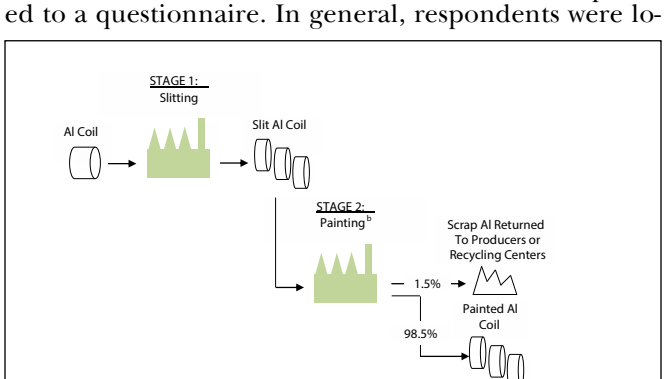
In aggregate, responding producers account for 441,000 tons of 2010 B&C aluminum shipments and 90% of the aluminum used within the U.S. and Canadian residential aluminum building products market segment; these figures include both residential and commercial building products. Annual sales for 2010 ranged from 85,000-206,000 tons of aluminum coil across respondents. Similarly, share of the overall aluminum building products market varied from 10-40% for the producers that participated. Producers manufacture a variety of aluminum alloys; however, for those that participated in this study, the most prevalent alloy is 3105, which accounted for 80-96% of each producer's total output. In addition, each of the producers indicated that they also roll a small percentage (4-15%) of 3004 aluminum alloy. The percentage of coated and/or painted aluminum coil shipped by producers varies from 40-65% across respondents.

Our empirical results provide unconditional support for the central thesis that recycled aluminum serves as the primary input material for the residential, as well as commercial, aluminum building products market segment (raw producer data is not presented in order to protect the anonymity of survey participants). In particular, respondents report that roughly 95% of the aluminum introduced into melting operations is recycled aluminum. Accordingly, very little prime material (i.e., approximately 5%) is introduced into the residential aluminum building products supply chain. In general, producers estimate melt loss—aluminum that is oxidized during the melting process—to be 3%.

Producers report that they purchase scrap aluminum from many scrap yards, dealers, and brokers; more specifically, one respondent reported that they manage roughly 300 suppliers of scrap aluminum and describe 130 of these supplies as "active" and 25 as "very active." For 2010, the number of truckloads of aluminum scrap processed by producers ranged from 8,750-10,400. Further, producers purchased many types of scrap aluminum. In particular, our respondents indicated that painted siding (both old and new) represents the largest category of scrap aluminum that is recycled and cast into new residential aluminum building coil. Old radiators and lithographic printing sheet also represent important scrap materials that are purchased by producers for reprocessing.

Converters and Toll Processors: As indicated in Figure 3, converters and toll processors obtain aluminum coil from producers and add value through the residential aluminum building products supply chain by performing painting, which may include preparation operations, such as cleaning, pre-treatment, and coil coating, as well as slitting. While converters and toll processors perform similar operations, they differ in terms of ownership of raw material stock and the nature of output stock produced. Whereas converters purchase, and subsequently own, the aluminum coil raw materials that they process, toll processors do not. Rather, toll processors generally charge flat fees for processing customers' materials. Further, converters tend to manufacture customized products for specific applications. In contrast, toll processors tend to produce a wide variety of standard outputs, such as 50-100 lbs of aluminum gutter or trim coil. Despite these distinctions inherent within contrasting business models, several firms within this tier of the residential aluminum building products supply chain perform both conversion and tolling processes.

Using referrals from producers and fabricators, ten converters and toll processors with operations throughout the U.S. and Canada were identified; four responded to a questionnaire. In general, respondents were lo-



[a] The order of slitting and painting varies across converters and toll processors and is a function of paint line width. Industry experts suggest that paint lines are generally configured such that narrow aluminum coil output is first slit, then painted. Conversely, wide coil output is painted before it is slit.
[b] Output percentages represent median response values reported by respondents.

Figure 3. Converter and toll processor activity chain.[a]

cated in the Midwest and Southwest U.S. and Eastern Canada. Each respondent confirmed that their primary business involves the conversion of aluminum, with two respondents indicating that aluminum conversion represents 100% of their business. Neither converters nor toll processors distinguish between the residential and commercial segments of the B&C markets; their responses provide the basis for characterizing the movement of recycled residential aluminum through their operations. Further, to varying degrees, each respondent supports aluminum conversion for the B&C market segment by adding value through coating, painting, and slitting operations (Table I).

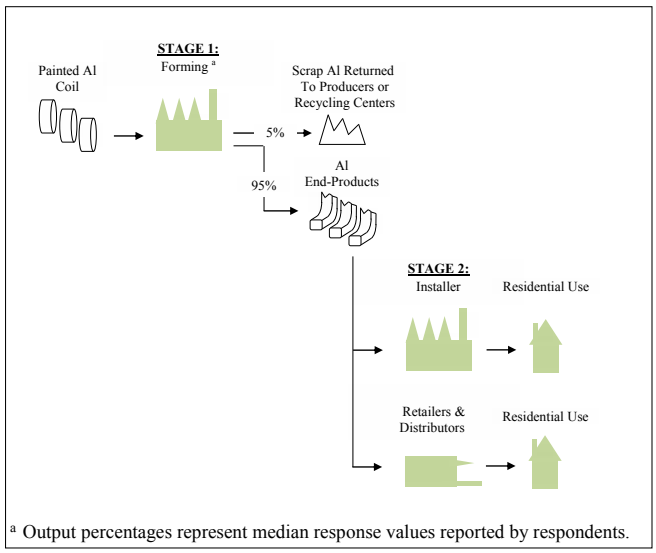
Survey Items	Plant 1	Plant 2	Plant 3	Plant 4
Percent of converting/processing aluminum involved in overall business	100%	100%	67%	5%
Percent of business for B&C market segment	20%	100%	100%	70%
Specific types of aluminum converting and/or tolling processes performed	Coil coating	Conventional coating, painting	Coil coating, slitting	Painting
Extent of				
aluminum purchasing	80%	98%	0%	60%
tolled aluminum	20%	2%	100%	40%
Extent of aluminum				
purchased (tons)	20,000	40,000	0	300
tolled (tons)	5,000	9,000	11,000	200
Percent of the initial metal input that becomes finished product in overall converting and/or tolling process	98%	—	99%	97%
Percent of scrap returned to				
mills	0%	100%	0%	0%
local scrap dealers	100%	0%	100%	100%
Percent of coating/paint per ton of fabricated aluminum building products	3.50%	N/A	3%	N/A
Percent of finished product as				
coil stock	100%	100%	100%	0%
sheet stock	0%	0%	0%	100%
Percent of fabricated aluminum building product output used within				
new construction	50%	5%	—	30%
remodeling	50%	95%	—	70%

Table I. B&C aluminum converter and toll processor material flow characteristics.

As shown in Table I, the extent to which firms process purchased and/or tolled aluminum varies substantively across respondents. In aggregate, the converters and toll processors purchased 60,300 tons and tolled 25,200 tons of aluminum annually. Three of the four converters and toll processors that responded to the questionnaire manufacture residential building products primarily using purchased aluminum stock; for these firms, purchased aluminum represents 60-98% of the aluminum stock processed. In addition, each of the respondents reported that they process tolled aluminum, with one firm exclusively processing tolled aluminum. Across the respondents, the efficiency with which input aluminum stock was converted into finished product ranged from 97-99%. Further, each of the converters and toll processors reported that 100% of the scrap aluminum from internal conversion processes is returned to mills or local scrap dealers for recycling and reuse.

Converters and toll processors participating in this study produce either coil or sheet stock for the residential aluminum building products market segment. Two of the four respondents have coating and/or painting operations within their facilities. For these plants, the coatings and/or paint thickness represent 3.0-3.5% of the aggregate weight of their finished aluminum building products. Empirical findings suggest that converters and toll processors produce coil or sheet stock for both new construction and remodeling applications. For 2010, respondents indicate that the majority of their residential aluminum building finished goods is used within remodeling applications (50-95%).

Fabricators: As suggested in Figure 4, fabricators generally receive painted aluminum coil of specified width from converters and toll processors and manufacture residential aluminum end-products, such as gutters, downspouts, and elbows. In turn, fabricators sell finished products to installers who remove old materials and mount new residential aluminum end-products for residential consumers and/or retailers and distributors who generally resell residential aluminum end-products to homeowners for do-it-yourself applications.



[a] Output percentages represent median response values reported by respondents.

Figure 4. Fabrication and installation activity chain.

Through industry referrals, a sample frame of 21 fabricators were identified to participate in this study. Six of the 21 fabricators responded to a questionnaire; however, one response was excluded from the analysis as it was largely incomplete. Accordingly, the effective response rate for this tier of the residential aluminum building products supply chain was 23.8%. Participating fabricators maintained operations in the Northeast, Midwest, and Southeast U.S. Each of the respondents confirmed that the fabrication of residential and commercial aluminum building products represented a significant portion of their overall business. As noted in Table II, the percent of overall business dedicated to fabricating aluminum building products ranged from 40-100% across the fabricators.

Both large and small fabricators of residential aluminum building products participated in this study. While the largest fabricator purchased 21,000 tons of aluminum building products stock for 2010, annual purchases for the smallest fabricator were limited to 500-1,000 tons. In general, respondents indicate that residential aluminum building products are primarily fabricated using aluminum alloy 3105.

Survey Items	Fabricator 1	Fabricator 2	Fabricator 3	Fabricator 4	Fabricator 5
Percent of business dedicated to fabricating aluminum building products	100%	50-60%	40%	60%	—
Amount of aluminum purchased for building products (tons/year)	21,000	20,000	—	3,600	500-1,000
Percent of metal input that becomes finished product in fabricating process	93-95%	≥ 95%	95%	95%	99%
Percent of aluminum scrap returned to					
mills	100%	0%	0%	0%	0%
local/regional scrap dealers	0%	100%[a]	100%	100%	100%
Percent of painted products	100%	95%	0%	0%	20%
Percent of coating/paint per ton of fabricated aluminum building products	2-3%	2%	N/A	N/A	N/A
Percent of fabricated aluminum building products output used within					
new construction	—	50%	90%	70%	70%
remodeling	—	50%	10%	30%	30%
trending toward	Remodeling	Remodeling	—	—	—
Aluminum alloy used to fabricate building products	3105	—	3105	—	—

[a] All scrap is baled; dealers consolidate it and return it to the mills.

Table II. B&C aluminum fabricator material flow characteristics.

Fabricators report internal efficiencies that range from 93-99%. Our results suggest that fabrication efficiency may be inversely correlated with size. In particular, the yield for the largest fabricator is 93-95%; however, the smallest fabricator reports that it effectively converts 99% of its aluminum raw material into finished product. For each of the respondents, 100% of the scrap that is generated within the fabrication process (i.e., run-around scrap) is returned back to aluminum rolling mills or local or regional scrap dealers for recycling and reuse.

Several of the fabricators that participated in this study indicated that they are backward integrated within the residential aluminum building products supply chain. In particular, two of the five fabricators in this study maintain coating and/or paint lines that involve cleaning, pre-treatment (i.e., adding PVC coating), and painting operations. For these fabricators, paints and coatings add 2-3% to the weight of the finished aluminum building products. Respondents report that their finished goods are used to varying extents within both new construction and remodeling applications. Though the majority of finished goods appear to support new construction, findings suggest that the future trend is strengthening for remodeling applications.

Installers: As suggested in Figure 4, installers generally purchase aluminum building products, such as aluminum siding and soffit, from fabricators to install on residential homes. However, for select residential aluminum building products, installers may also engage in backward integration. In particular, our interviews indicate that installers may purchase coil stock, such as gutter or trim coil stock, from converters and/or fabricators and use portable equipment to manufacture customized finished product on the residential consumers' premises prior to installation.

Relative to upstream tiers of the residential aluminum building products supply chain, the installer tier is highly fragmented. To obtain insights into the nature of aluminum material flows within this tier, five local installers located in the U.S. Midwest were contacted to participate in this study; two installers responded to a survey questionnaire. Both of the responding installers confirmed that they sell and, as indicated in Table III, install residential as well as commercial aluminum building products, which represent 12.5-80% of their overall business. Installers that participated in this study indicated that they return 100% of the aluminum scrap that is removed from (or generated at) a job site to local scrap dealers. Clearly, the value of scrap aluminum, which has ranged from $0.38-0.50 per pound in recent years, offsets the costs associated with the purchase of new residential aluminum building products, which ranged from $1.68-2.70 per pound (prices recorded in 2010). In contrast to aluminum, installers indicate that scrap vinyl and wood have little residual value. As such, installers tend not to recycle these forms of scrap.

Survey Items	Installer 1	Installer 2
Percent of building products that are		
aluminum	80%	12.50%
vinyl	20%	65.00%
hardy plank	0%	12.50%
steel	0%	5.00%
Approximate aluminum building products purchased per year (lbs)	5,000	—
Percent of jobs in which the "removed" aluminum products are recycled (returned for metal scrap value)	100%	100%
Location where "removed" aluminum scrap is returned	Local scrap dealers	Local scrap dealers
Value of recycled aluminum (per lb)	$0.38	$0.50
Cost of new aluminum products (per lb)	$1.68	$2.70
Are any other "removed" building products (such as vinyl, wood, etc.) recycled?	No	No[a]

[a] Vinyl has to be clean or it will not be accepted for return.

Table III. B&C aluminum installer material flow characteristics.

Recycling Centers: The Thomas Registry (Thomas Publishing Company 2011) lists 939 firms that specialize in the recovery of aluminum scrap. Many firms operating in this tier of the aluminum supply chain operate multiple recycling plants and handle both ferrous and non-ferrous material. To gain insights into the recovery of recycled aluminum building products, five of the largest aluminum recycling facilities in the U.S. were contacted; three responded to a survey questionnaire. In general, the recycling centers that participated support residential and industrial aluminum scrap collection and are located in the Midwest and Southwest U.S. As reported in Table IV, recycling centers purchased a substantial amount of scrap aluminum, ranging from 9,000-22,500 tons over the previous five-year period. Scrap aluminum comes from a variety of sources; however, for each respondent, building products ranked amongst the top three sources of procured aluminum scrap. In aggregate, 45-65% of the total aluminum scrap collected by recycling centers is sold to aluminum producers within the B&C segment. Further, for two of the three responding firms, roughly 100% of the aluminum building product scrap is being recycled to aluminum producers in the same market segment; however, for recycling center two, only half of the aluminum sold to B&C aluminum producers is "old removed" building product scrap. Finally, conflicting views of recycling trends for aluminum building product scrap were received, with one respondent suggesting that receipts are slightly growing while another indicates that receipts are slightly contracting. Overall, feedback from recycling center one suggests that 85-95% of all residential and commercial aluminum B&C products are effectively being recycled.

Survey Items	Recycling Center 1	Recycling Center 2	Recycling Center 3
Percent of aluminum in overall procurement	60%	20%[a]	75%
Approximate average procurement of aluminum scrap over the past five years (tons/year)	9,000[b]	—	22,500
Aluminum scrap by end-use segments:			
B&C	35%	18%	50%
Automotive	15%	12%	22%
Cans	50%	22%	20%
Litho sheet	0%	18%	4%
Other	0%	30%	4%
Painted or coated aluminum products segregated?	No[c]	Yes	Yes
Percent of total aluminum scrap sales going to B&C producers	65%	45%	50%
Percent of aluminum scrap sold to B&C aluminum producers from "removed" aluminum building product scrap	98-100%	50%	100%
Percent of aluminum in the B&C industry output being recycled	85-95%	—	—
Status of aluminum building product received (growing, static, or contracting)	—	Growing slightly	Contracting slightly

[a] 45% of nonferrous procurement is aluminum.
[b] 1,500,000 lbs/month—50% cans and 50% building, extrusions, and automotive products.
[c] Not cost justified.

Table IV. Recycling center aluminum material flow characteristics.

Conclusions & Limitations

This study represents an initial effort to characterize the recycle and reuse of aluminum within the residential building products segment of the aluminum industry. Because those organizations involved in the several steps of the whole process do not distinguish between aluminum

recycled metal that has come from or is going into residential, as contrasted to commercial applications, some of the findings related to residential aluminum building products have been deduced from studies where the metal was simply identified as aluminum building products.

Through this study, three salient conclusions are advanced. First, the results of the empirical study suggest that roughly 95% of aluminum building sheet stock produced by rolling mills (i.e., producers) consists of recycled content. More specifically, producers estimate that 75% of the input material used to manufacture sheet stock for building products comes from purchased aluminum scrap—run-around scrap aluminum, which is recycled within a producer's facility, constitutes an additional 20% of the input material (approximately) that is used to form aluminum building products sheet stock.

Second, within all tiers of the residential, as well as commercial, building products supply chain, nearly all scrap aluminum is being recycled. In particular, fabricators, converters, and toll processors unanimously report that all scrap aluminum is either sent back to the mill or sold to local scrap dealers, who, in turn, sell the baled aluminum to rolling mill producers. Further, installers return all removed old aluminum from job sites to local scrap dealers. These findings validate producers' estimation that 85-95% of all residential aluminum building products are recycled. Importantly, this rate of recycling is much greater than the 70% recycling rate that is generally thought to be true for the entire aluminum industry[2] and the 54.2% recycling rate for aluminum UBCs.[7] Further, this realized recycling rate approaches the 98% recycling rate that is believed to be maximally possible for the B&C industry.[8] This high return rate is attributed to: the fact that residential aluminum building product constituent alloys are purposefully designed for recyclability, recycling efforts are largely dependent on industry participants (i.e., installers who remove old aluminum materials) rather than consumers (i.e., residential homeowners), and the economic value of aluminum scrap that motivates downstream returns, offsetting the cost of new material purchases.

Third, our results suggest that, while recycling rates are high, the residential aluminum building products life cycle is not a closed loop. In particular, at least one recycling center sells twice the amount of aluminum scrap to producers than it receives in the form B&C products. Further, producers report that aluminum scrap from building products constitutes a relatively small share (roughly 30%) of aggregate aluminum scrap that is reprocessed. This suggests that other forms of aluminum scrap, such as UBCs and automotive components, may be entering the B&C aluminum life cycle to a greater extent than originally anticipated.

While this study serves to significantly advance understanding of aluminum material flows within the residential aluminum building products market segment, the results of this study must be considered in light of the following limitations.

Respondent Approximation: The survey response data captures respondents' approximations to aluminum material flows within the residential aluminum building products market segment. These responses are based on respondents' best judgments; however, there is little secondary data available to validate survey responses.

Geographic Representation: This study incorporates nearly all of the producers of aluminum within the residential building products market segment. In contrast, our sample frame for fabricators, converters and toll processors, installers, and recycling centers is largely regional and the response rate for firms in these tiers is low. Further, our descriptive analysis includes only one Canadian respondent. While respondents familiar with operations in both the U.S. and Canada suggest that there are no substantive differences in flows across these regions, this perspective cannot be empirically validated.

Market Segment Representation: The extent to which this study captures aluminum material flows associated with do-it-yourself residential building products remains unclear as large retailers and distributors, citing the confidential nature of material flow data, refused to participate in this study.

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