

Theoretical availability of CRMs in Dutch waste streams – methodological report

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1 Introduction

The Netherlands Materials Observatory (NMO) collects, manages, and provides data, information, and knowledge about critical raw materials and supply chains. In doing so, the NMO contributes to a resilient and robust economy and society. The NMO works together with the Dutch national government, companies and research institutions in the Netherlands and abroad. The NMO provides insight into the supply and availability of these critical raw materials in the Netherlands and the European Union (EU). An enhanced understanding enables policymakers and businesses to better respond to risks associated with supply chain disruptions.

The NMO works with partners from the recycling value chain and the research community to analyse how the Netherlands (and neighboring countries) can contribute towards increasing recycling contributions and, by extension, the Critical Raw Material Act (CRMA) benchmarks.

To understand the potential material contributions to the CRMA recycling benchmarks from different waste streams and the role of recycling and circular strategies, it is crucial to identify the current composition of various post-consumer waste streams in the Netherlands focusing on the presence of CRMs in these flows. This work is an important prerequisite to support the decision-making process related to stimulating the recycling of CRM containing waste streams.

This methodological report provides the data and assumptions used to estimate the actual presence (and therefore the theoretical recycling potential) of CRMs in Dutch waste streams. **Note that this report strictly focuses on providing data, assumptions, and sources. A subsequent report “The state of play of the Dutch recycling landscape” presents detailed information for each waste stream, including discussions and policy recommendations.** This is an effort to compile and map the CRM's composition of different waste streams, and thus it is expected to be updated periodically once more detailed information becomes available.

This report strictly focuses on presenting the theoretical availability of CRMs in Dutch waste stream methods. The fate of these elements is not described; it is possible that recycling systems are already in place for some of these waste streams and elements.

2 Methods

2.1 Scope

Under the theme of recycling and circularity, the NMO aims to provide relevant information related to the theoretical availability of CRMs in Dutch waste streams. This is an ongoing effort, and for 2025, the focus has been given to 6 waste stream categories. The selection of these waste streams was based on the CRMs recovery potential waste streams listed by the European Commission, the relevance of the activities related to these waste streams across the Dutch economy, and the availability of data.

The scope of this report is limited to the following waste streams:

- Waste from Electrical and Electronic Equipment (WEEE)
- Vehicles (including batteries)
- Batteries (portable)
- Construction and Demolition Waste (C&DW)
- Steel slags
- Bottom ash

Note that other relevant waste streams, such as industrial batteries or public transport installations, are not covered yet but are expected to be assessed in the near future.

2.2 Approach

To estimate the composition of CRMs for each waste stream, a two-step approach was carried out in which (1) data on the amount (weight) of waste or products coming to the end-of-life for a specific year were gathered with the cooperation of organizations responsible for the management (or generating as byproduct) of such flows in the Netherlands and (2) an extensive literature review was conducted to retrieve CRMs composition data for the different waste streams applicable to the Dutch conditions. For step 2, primary data on composition was preferred if available. Once data on the end-of-life flow and composition were retrieved for each step, it was combined to obtain the actual presence and thus the theoretical availability of CRMs in specific waste streams.

CRMs were mapped to the most up-to-date data available. In addition, results are presented on an element level, following the European Commission methodology;

The assumptions, results of each waste stream and composition were also shared and verified with the organizations responsible for managing (or generating as byproducts) the selected waste streams (for completeness purposes). For that, we want to acknowledge the support and cooperation of Stichting Open, Auto Recycling Nederland (ARN), Rijkswaterstaat, BRBS Recycling and Tata Steel.

All chapters are structured alike to present (1) the organizations related to the management (or byproduct generation) of each waste stream, (2) data on end-of-life flows and (3) material

composition. The final chapter presents the infographic, which compiles the overall results. The assumptions related to each step are present within each section. Note that the scope of this report is limited to CRMs. Therefore, other elements such as lead (Pb) or zinc (Zn) are not included (though data on the presence of these elements is available). The results for this report are also separately presented in the attached “Theoretical Critical Raw Materials availability in Dutch waste streams” infographic.

3 Waste from Electrical and Electronic Equipment (WEEE)

The main organisation responsible for the collection and recycling of waste electrical appliances, lamps, and batteries in the Netherlands is Stichting OPEN (Organisatie Producentenverantwoordelijkheid e-waste Nederland)¹. This organization serves as the executive body responsible for the legal producer's responsibility for e-waste. This means that companies that manufacture or import electronics are financially and organizationally responsible for the collection and recycling of their products at the end of their life cycle. Stichting OPEN provides a collective system for these companies to meet their legal obligations. Once collected, Stichting OPEN ensures that the e-waste is sorted and processed by certified recycling companies. This organization also represents all producers and importers in the Netherlands related to the products mentioned above.

3.1 End-of-life flow

Stichting OPEN provides the amount of materials collected for more than 70 categories related to Waste from Electrical and Electronic Equipment (WEEE). Table 1 provides the amounts of WEEE collected in the Netherlands in 2024, categorized by type (in Dutch). These categories are translated into English in the following section to facilitate matching with material compositions found in literature for various product categories.

Table 1 WEEE collected in the Netherlands for 2024 (Stichting OPEN, 2025b).

Product category (Dutch)	Weight (kton)
E1/01 - Koel- en vriesapparatuur (huishoudelijk)	35,90
E1/02 - Wasdrogers (met warmtepomp)	0,22
E1/03 - Airco-apparatuur (los)	1,15
E1/04 - Airco-apparatuur en warmtepompen (inbouw)	0,09
E1/05 - Koel- en vriesapparatuur (professioneel)	1,43
E1/06 - Automaten (gekoeld)	0,94
E2/0A - TV's en displays (beeldbuis)	0,92
E2/0B - Monitoren (beeldbuis)	0,14
E2/01 - TV's en displays (flatscreen)	7,94

¹ [Stichting OPEN - Stichting OPEN](#)

E2/02 - Monitoren (flatscreen)	2,09
E2/03 - Laptops	0,55
E2/04 - Tablets en navigatiesystemen	0,09
E3/04 - Led-lampen	0,10
E3/05 - Spaar- en gasontladingslampen	0,12
E3/06 - TL-lampen	1,16
E4/01 - Afzuigkappen	0,77
E4/02 - Barbecues, grill- en kookplaten (>50 cm)	0,74
E4/03 - Magnetrons en ovens (>50 cm)	4,34
E4/04 - Fornoizen	2,78
E4/05 - Vaatwassers	10,65
E4/06 - Wasmachines	33,50
E4/07 - Wasdrogers (zonder warmtepomp)	7,19
E4/08 - Huishoud-, keuken- en verzorgingsapparatuur (>50 cm)	0,38
E4/09 - Stofzuigers en vloerreinigers (>50 cm)	0,33
E4/10 - Ketels, boilers en geisers (>50 cm)	0,07
E4/11 - Zonnebanken	0,84
E4/12 - Ventilatie- en recirculatie-apparatuur (>50 cm >150 m ³ /uur inbouw)	0,03
E4/13 - Ventilatie- en recirculatie-apparatuur (>50 cm ≤150 m ³ /uur inbouw)	0,02
E4/14 - Ventilatie-, recirculatie- en verwarmingsapparatuur (>50 cm los)	0,50
E4/15 - Verwarmings- en warmwaterapparatuur (> 50 cm inbouw)	0,41
E4/16 - Grootkeukenapparatuur (ongekoeld)	0,10
E4/17 - Automaten (ongekoeld)	0,26
E4/18 - Textielbewerkingsapparatuur (>50 cm)	0,01
E4/19 - Elektrische muziekinstrumenten (>50 cm)	0,17
E4/20 - Elektrisch speelgoed, ontspannings- en sportapparatuur (>50 cm)	0,35
E4/21 - Medische apparatuur (>50 cm)	0,24
E4/22 - Meet- en regelapparatuur (>50 cm)	0,08
E4/23 - Audio- en video-apparatuur (>50 cm)	1,33
E4/24 - I(C)T- en kantoorapparatuur (>50 cm huishoudelijk)	0,04
E4/25 - I(C)T- en kantoorapparatuur (>50 cm professioneel)	0,05

E4/26 - Armaturen (> 750 gram)	4,85
E4/29 - Elektrisch gereedschap (>50 cm)	1,83
E4/30 - Elektrische fietsen	0,00
E4/31 - Open Scope apparatuur (> 50 cm zonder primaire elektrische functie)	0,00
E4/32 - Zonnepanelen	2,22
E4/33 - Elektrische fietsen	0,01
E4/34 - Open Scope apparatuur (> 50 cm zonder primaire elektrische functie)	0,37
E5/01 - Barbecues, grill- en kookplaten (≤ 50 cm)	0,09
E5/02 - Magnetrons en ovens (≤ 50 cm)	1,59
E5/03 - Huishoud-, keuken- en verzorgingsapparatuur (≤ 50 cm)	9,45
E5/04 - Stofzuigers en vloerreinigers (≤ 50 cm)	5,12
E5/05 - Ketels, boilers en geisers (≤ 50 cm)	0,11
E5/06 - Ventilatie- en recirculatie-apparatuur (≤ 50 cm ≤ 150 m ³ /uur inbouw)	0,02
E5/07 - Ventilatie- en recirculatie-apparatuur (≤ 50 cm > 150 m ³ /uur inbouw)	0,03
E5/08 - Ventilatie-, recirculatie- en verwarmingsapparatuur (≤ 50 cm los)	0,48
E5/09 - Verwarmings- en warmwaterapparatuur (≤ 50 cm inbouw)	0,15
E5/10 - Textielbewerkingsapparatuur (≤ 50 cm)	0,39
E5/11 - Elektrische muziekinstrumenten (≤ 50 cm)	0,01
E5/12 - Spelcomputers	0,07
E5/13 - Elektrisch speelgoed, ontspannings- en sportapparatuur (≤ 50 cm)	0,35
E5/14 - Medische apparatuur (≤ 50 cm)	0,05
E5/15 - Meet- en regelapparatuur, incl. melders, sensoren en schakelaars (≤ 50 cm)	0,90
E5/16 - Audio- en video-apparatuur (≤ 50 cm)	9,08
E5/17 - Armaturen (≤ 750 gram)	0,84
E5/20 - Elektrisch gereedschap (≤ 50 cm)	2,52
E5/21 - Open Scope apparatuur (≤ 50 cm zonder primaire elektrische functie)	0,00
E5/22 - Open Scope apparatuur (≤ 50 cm zonder primaire elektrische functie)	0,00
E6/01 - Mobiele telefoons	0,04
E6/02 - Desktop computers	1,96
E6/03 - Printers en scanners	5,09
E6/04 - I(C)T- en kantoorapparatuur (≤ 50 cm huishoudelijk)	1,96

E6/05 - I(C)T- en kantoorapparatuur (≤ 50 cm professioneel)	0,48
Total	168,08

3.2 Material composition

WEEE composition data was gathered from (Torrubia et al., 2023). This data set provides the material/elemental composition of electrical and electronic equipment according to United Nations University (UNU) categories, known as UNU-Keys. To the best of our understanding, after an extensive literature review, this study publicly reports the most complete composition data on a sub-technological level. The United Nations Institute for Training and Research (UNITAR) contains a more comprehensive material composition database, but it is not yet publicly available.

The UNU-Keys categories were matched to the product categories classification used by Stichting OPEN. In some cases, there was no direct match between dataset categories. For these situations, the matching was done based on the categories from the UNU-Keys that better represented those from Stichting OPEN. To illustrate, category E2/04 - Tablets en navigatiesystemen from Stichting Open has no direct match with the UNU-Keys and thus was matched with category Laptops (including tablets). The matching exercise was carried out with the help of experts at Stichting OPEN. Table 2 provides the matching categories between category classifications. Please note that the composition data is provided at the product category level, not for individual products. Table 3 provides the CRMs composition for the WEEE categories.

Table 2 Stichting Open categories and UNU keys present in (Torrubia et al., 2023).

Product category (Dutch) – Stichting Open	Product category (English) – UNU - Keys	Reference number (R#) for Table 5.3 material composition
E1/01 - Koel- en vriesapparatuur (huishoudelijk)	Fridges (incl. combi-fridges)	#1
E1/02 - Wasdrogers (met warmtepomp)	Dryers (wash dryers, centrifuges)	#2
E1/03 - Airco-apparatuur (los)	Air Conditioners (household installed and portable)	#3
E1/04 - Airco-apparatuur en warmtepompen (inbouw)	Professional Heating & Ventilation (excl. cooling equipment)	#4
E1/05 - Koel- en vriesapparatuur (professioneel)	Freezers	#5
E1/06 - Automaten (gekoeld)	Fridges (incl. combi-fridges)	#6
E2/0A - TV's en displays (beeldbuis)	Cathode Ray Tube TVs	#7
E2/0B - Monitoren (beeldbuis)	Cathode Ray Tube Monitors	#8
E2/01 - TV's en displays (flatscreen)	Flat Display Panel TVs (LCD, LED, Plasma)	#9

E2/02 - Monitoren (flatscreen)	Flat Display Panel Monitors (LCD, LED)	#10
E2/03 - Laptops	Laptops (incl. tablets)	#11
E2/04 - Tablets en navigatiesystemen	Laptops (incl. tablets)	#12
E3/04 - Led-lampen	LED Lamps (incl. retrofit LED lamps)	#13
E3/05 - Spaar- en gasontladingslampen	LED Lamps (incl. retrofit LED lamps)	#14
E3/06 - TL-lampen	Small lighting equipment (excl. LED & incandescent)	#15
E4/01 - Afzuigkappen	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#16
E4/02 - Barbecues, grill- en kookplaten (>50 cm)	Equipment for food preparation (e.g. toaster, grills, food processing, frying pans)	#17
E4/03 - Magnetrons en ovens (>50 cm)	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	#18
E4/04 - Forniuzen	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	#19
E4/05 - Vaatwassers	Dish washers	#20
E4/06 - Wasmachines	Washing Machines (incl. combined dryers)	#21
E4/07 - Wasdrogers (zonder warmtepomp)	Dryers (wash dryers, centrifuges)	#22
E4/08 - Huishoud-, keuken- en verzorgingsapparatuur (>50 cm)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#23
E4/09 - Stofzuigers en vloerreinigers (>50 cm)	Vacuum Cleaners (excl. professional)	#24
E4/10 - Ketels, boilers en geisers (>50 cm)	Central Heating (household installed)	#25
E4/11 - Zonnebanken	Personal Care equipment (e.g. tooth brushes, hair dryers, razors)	#26
E4/12 - Ventilatie- en recirculatie-apparatuur (>50 cm >150 m ³ /uur inbouw)	Professional Heating & Ventilation (excl. cooling equipment)	#27
E4/13 - Ventilatie- en recirculatie-apparatuur (>50 cm ≤150 m ³ /uur inbouw)	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	#28
E4/14 - Ventilatie-, recirculatie- en verwarmingsapparatuur (>50 cm los)	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	#29
E4/15 - Verwarmings- en warmwaterapparatuur (> 50 cm inbouw)	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)	#30
E4/16 - Grootkeukenapparatuur (ongekoeld)	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	#31

E4/17 - Automaten (ongekoeld)	Kitchen equipment (e.g. large furnaces, ovens, cooking equipment)	#32
E4/18 - Textielbewerkingsapparatuur (>50 cm)	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	#33
E4/19 - Elektrische muziekinstrumenten (>50 cm)	Music Instruments, Radio, Hi-Fi (incl. audio sets)	#34
E4/20 - Elektrisch speelgoed, ontspannings- en sportapparatuur (>50 cm)	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	#35
E4/21 - Medische apparatuur (>50 cm)	Household Medical equipment (e.g. thermometers, blood pressure meters)	#36
E4/22 - Meet- en regelapparatuur (>50 cm)	Household Monitoring & Control equipment (alarm, heat, smoke, excl. screens)	#37
E4/23 - Audio- en video-apparatuur (>50 cm)	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	#38
E4/24 - I(C)T- en kantoorapparatuur (>50 cm huishoudelijk)	Small IT equipment (e.g. routers, mice, keyboards, external drives & accessories)	#39
E4/25 - I(C)T- en kantoorapparatuur (>50 cm professioneel)	Professional IT equipment (e.g. servers, routers, data storage, copiers)	#40
E4/26 - Armaturen (> 750 gram)	Household Luminaires (incl. household incandescent fittings & household LED luminaires)	#41
E4/29 - Elektrisch gereedschap (>50 cm)	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	#42
E4/30 - Elektrische fietsen	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	#43
E4/31 - Open Scope apparatuur (> 50 cm zonder primaire elektrische functie)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#44
E4/32 - Zonnepanelen	Photovoltaic Panels (incl. inverters)	#45
E4/33 - Elektrische fietsen	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	#46
E4/34 - Open Scope apparatuur (> 50 cm zonder primaire elektrische functie)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#47
E5/01 - Barbecues, grill- en kookplaten (≤ 50 cm)	Equipment for food preparation (e.g. toaster, grills, food processing, frying pans)	#48
E5/02 - Magnetrons en ovens (≤ 50 cm)	Microwaves (incl. combined, excl. grills)	#49

E5/03 - Huishoud-, keuken- en verzorgingsapparatuur (≤ 50 cm)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#50
E5/04 - Stofzuigers en vloerreinigers (≤ 50 cm)	Vacuum Cleaners (excl. professional)	#51
E5/05 - Ketels, boilers en geisers (≤ 50 cm)	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)	#52
E5/06 - Ventilatie- en recirculatie-apparatuur (≤50 cm ≤ 150 m3/uur inbouw)	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	#53
E5/07 - Ventilatie- en recirculatie-apparatuur (≤50 cm > 150 m3/uur inbouw)	Professional Heating & Ventilation (excl. cooling equipment)	#54
E5/08 - Ventilatie-, recirculatie- en verwarmingsapparatuur (≤50 cm los)	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	#55
E5/09 - Verwarmings- en warmwaterapparatuur (≤50 cm inbouw)	Small household equipment for hot water preparation (e.g. coffee, tea, water cookers)	#56
E5/10 - Textielbewerkingsapparatuur (≤ 50 cm)	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	#57
E5/11 - Elektrische muziekinstrumenten (≤ 50 cm)	Music Instruments, Radio, Hi-Fi (incl. audio sets)	#58
E5/12 - Spelcomputers	Game Consoles	#59
E5/13 - Elektrisch speelgoed, ontspannings- en sportapparatuur (≤ 50 cm)	Toys (e.g. car racing sets, electric trains, music toys, biking computers, drones)	#60
E5/14 - Medische apparatuur (≤ 50 cm)	Household Medical equipment (e.g. thermometers, blood pressure meters)	#61
E5/15 - Meet- en regelapparatuur, incl. melders, sensoren en schakelaars (≤ 50 cm)	Household Monitoring & Control equipment (alarm, heat, smoke, excl. screens)	#62
E5/16 - Audio- en video-apparatuur (≤ 50 cm)	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	#63
E5/17 - Armaturen (≤ 750 gram)	Household Luminaires (incl. household incandescent fittings & household LED luminaires)	#64
E5/20 - Elektrisch gereedschap (≤ 50 cm)	Household Tools (e.g. drills, saws, high pressure cleaners, lawn mowers)	#65
E5/21 - Open Scope apparatuur (≤ 50 cm zonder primaire elektrische functie)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#66
E5/22 - Open Scope apparatuur (≤ 50 cm zonder primaire elektrische functie)	Other small household equipment (e.g. small ventilators, irons, clocks, adapters)	#67

E6/01 - Mobiele telefoons	Mobile Phones (incl. smartphones, pagers)	#68
E6/02 - Desktop computers	Desktop PCs (excl. monitors, accessoires)	#69
E6/03 - Printers en scanners	Printers (e.g. scanners, multi functionals, faxes)	#70
E6/04 - I(C)T- en kantoorapparatuur (≤ 50 cm huishoudelijk)	Small IT equipment (e.g. routers, mice, keyboards, external drives & accessories)	#71
E6/05 - I(C)T- en kantoorapparatuur (≤ 50 cm professioneel)	Professional IT equipment (e.g. servers, routers, data storage, copiers)	#72

Table 3 CRMs composition of WEEE categories in g/kg product category. The column R# corresponds to the categories in Table 2. The reference # is provided for formatting purposes.

R#	Al	Sb	As	Ba	Be	Bi	B	Ce	Co	Cu	Dy	Er	Eu
#1	4,91E+00	2,45E-03	1,24E-06	1,42E-04	1,83E-07			7,52E-06	1,40E-02	1,23E+00	2,04E-06		
#2	1,09E+01	1,09E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,09E+00	1,09E-03	1,79E-07	
#3	2,65E+01									2,03E+01			
#4	2,54E+01									1,94E+01			
#5	4,54E+00	2,27E-03	1,24E-06	1,42E-04	1,83E-07			7,52E-06	1,40E-02	1,14E+00	2,04E-06		
#6	4,91E+00	2,45E-03	1,24E-06	1,42E-04	1,83E-07			7,52E-06	1,40E-02	1,23E+00	2,04E-06		
#7	1,51E+00	3,01E-03	1,79E-02	3,01E+00	6,02E-03	1,18E-02		1,29E-02	3,01E-02	6,02E-01	4,11E-03	4,49E-03	1,36E-04
#8	9,09E+00	2,27E-03	1,79E-02	8,62E+00	4,02E-04	1,18E-02		1,29E-02	1,32E-01	9,09E-01	4,11E-03	4,87E-06	1,36E-04
#9	2,94E+01	9,81E-03	9,81E-03	8,62E+00	4,02E-04	9,81E-03		9,81E-03	1,32E-01	4,90E-01	4,11E-03	4,87E-06	1,36E-04
#10	5,46E+01	9,10E-03	1,79E-02	8,62E+00	4,02E-04	1,18E-02		1,29E-02	1,32E-01	1,82E+00	4,11E-03	4,87E-06	1,36E-04
#11	3,97E+01	3,97E-02	1,79E-02	8,62E+00	4,02E-04	1,18E-02		1,29E-02	1,32E-01	7,94E+00	4,11E-03	4,87E-06	1,36E-04
#12	3,97E+01	3,97E-02	1,79E-02	8,62E+00	4,02E-04	1,18E-02		1,29E-02	1,32E-01	7,94E+00	4,11E-03	4,87E-06	1,36E-04
#13	1,43E+02	6,70E-02		2,88E-01	1,05E-04			1,63E+00	7,14E+00	7,14E+01	3,23E-05	4,15E-05	7,06E-01
#14	1,43E+02	6,70E-02		2,88E-01	1,05E-04			1,63E+00	7,14E+00	7,14E+01	3,23E-05	4,15E-05	7,06E-01
#15	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#16	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#17	6,10E+00	3,05E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	6,10E-01	1,81E-05		
#18	4,19E+00	1,05E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,05E+00	6,29E-03	1,79E-07	
#19	4,19E+00	1,05E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,05E+00	6,29E-03	1,79E-07	
#20	4,63E+00	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,16E+00	2,45E-02	1,79E-07	
#21	2,75E+00	6,89E-04	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	6,89E-01	6,89E-03	1,79E-07	
#22	1,09E+01	1,09E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,09E+00	1,09E-03	1,79E-07	
#23	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#24	8,50E+00	1,70E-04	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	8,50E-01	1,81E-05		
#25	1,62E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	3,25E+00	2,45E-02	1,79E-07	
#26	9,09E+00	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,82E+00	1,81E-05		
#27	2,54E+01									1,94E+01			
#28	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	
#29	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	
#30	2,65E+01	5,29E-04	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,06E+00	1,81E-05		
#31	4,19E+00	1,05E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,05E+00	6,29E-03	1,79E-07	
#32	4,19E+00	1,05E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	1,05E+00	6,29E-03	1,79E-07	
#33	2,01E+01	8,06E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	4,03E+00	1,81E-05		

#34	2,68E+01	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,34E+00	1,81E-05		
#35	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#36	3,89E+01	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,67E+01	1,81E-05		
#37	2,91E+01	4,16E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,25E+01	1,81E-05		
#38	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,17E+01	1,81E-05		
#39	7,50E+01	2,50E-03	2,47E-03	4,35E-01	1,63E-03	5,60E-04	9,51E-06	1,28E-03	2,50E-01	2,50E+00	1,00E-02	1,94E-03	3,56E-05
#40	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	
#41	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#42	2,01E+01	8,06E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	4,03E+00	1,81E-05		
#43	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#44	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#45	9,98E+01	5,81E-03	8,77E-06	1,97E-04	9,36E-06			7,36E-06	1,41E-03	5,66E+01	2,14E-02	1,56E-07	
#46	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#47	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#48	6,10E+00	3,05E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	6,10E-01	1,81E-05		
#49	4,61E+00	2,30E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,38E-01	1,81E-05		
#50	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#51	8,50E+00	1,70E-04	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	8,50E-01	1,81E-05		
#52	2,65E+01	5,29E-04	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,06E+00	1,81E-05		
#53	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	
#54	2,54E+01									1,94E+01			
#55	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	
#56	2,65E+01	5,29E-04	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,06E+00	1,81E-05		
#57	2,01E+01	8,06E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	4,03E+00	1,81E-05		
#58	2,68E+01	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,34E+00	1,81E-05		
#59	1,39E+01	3,46E-02	2,08E-02	6,24E-02	1,63E-03	3,46E-02	9,51E-06	1,28E-03	2,77E+00	1,52E+01	3,92E-02	1,94E-03	3,56E-05
#60	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#61	3,89E+01	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,67E+01	1,81E-05		
#62	2,91E+01	4,16E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,25E+01	1,81E-05		
#63	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,17E+01	1,81E-05		
#64	1,19E+02	2,15E-02	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	2,22E+01	1,81E-05		
#65	2,01E+01	8,06E-03	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	4,03E+00	1,81E-05		
#66	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#67	1,01E-01	1,01E-05	1,98E-05	2,51E-02	2,02E-05			8,97E-05	3,02E-02	1,01E+00	1,81E-05		
#68	3,46E+02	2,77E-01	1,11E-01	4,35E-01	1,63E-03	2,23E-01	9,51E-06	1,28E-03	6,69E+01	7,80E+01	3,92E-02	1,94E-03	3,56E-05
#69	1,14E+01	6,85E-03	2,47E-03	3,43E-02	1,63E-03	5,60E-04	9,51E-06	1,28E-03	2,28E-01	1,49E+00	3,92E-02	1,94E-03	3,56E-05
#70	9,69E+00	4,84E-03	2,47E-03	1,94E-02	1,63E-03	5,60E-04	9,51E-06	1,28E-03	2,91E-01	7,75E-01	3,92E-02	1,94E-03	3,56E-05
#71	7,50E+01	2,50E-03	2,47E-03	4,35E-01	1,63E-03	5,60E-04	9,51E-06	1,28E-03	2,50E-01	2,50E+00	1,00E-02	1,94E-03	3,56E-05
#72	5,23E+01	6,66E-03	1,01E-05	2,26E-04	1,07E-05			8,44E-06	1,62E-03	2,79E+01	2,45E-02	1,79E-07	

Table 4 Continuation of Table 3.

R#	Gd	Ga	Ge	Ho	La	Li	Mg	Mn	Nd	Ni	Nb	Pd	Pt
#1	1,65E-05	8,40E-05	1,84E-07		1,71E-05	1,68E-06	1,23E+00	1,23E+00	2,71E-04	4,91E-01		3,16E-06	
#2	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,09E-01	1,09E+00	4,35E-02	1,09E+00		1,09E-06	2,09E-06
#3													
#4													
#5	1,65E-05	8,40E-05	1,84E-07		1,71E-05	1,68E-06	1,14E+00	1,14E+00	2,71E-04	4,54E-01		3,16E-06	
#6	1,65E-05	8,40E-05	1,84E-07		1,71E-05	1,68E-06	1,23E+00	1,23E+00	2,71E-04	4,91E-01		3,16E-06	
#7	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	3,01E+00	1,51E+00	1,51E-02	4,52E-01	1,28E-04	1,51E-04	2,42E-06
#8	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	4,55E+00	4,55E+00	7,29E-02	4,55E-01	1,28E-04	2,27E-04	2,42E-06
#9	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	2,94E+00	3,92E+00	1,96E-02	4,90E-01	1,28E-04	4,90E-04	2,42E-06
#10	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	9,10E+00	3,64E+00	7,29E-02	9,10E-01	1,28E-04	9,10E-04	2,42E-06
#11	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	1,74E+01	7,66E+00	7,29E-02	1,98E+00	1,28E-04	5,62E-03	2,42E-06
#12	7,16E-04	4,01E-03	1,18E-04	1,06E-04	8,08E-04	3,38E-04	1,74E+01	7,66E+00	7,29E-02	1,98E+00	1,28E-04	5,62E-03	2,42E-06
#13	2,65E-05	3,11E-03	1,23E-04	3,05E-05	2,14E+00	2,16E-03	1,33E+01	2,90E+00	1,88E-03	1,43E+01	2,39E+00	2,18E-03	
#14	2,65E-05	3,11E-03	1,23E-04	3,05E-05	2,14E+00	2,16E-03	1,33E+01	2,90E+00	1,88E-03	1,43E+01	2,39E+00	2,18E-03	
#15	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#16	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#17	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	3,05E-01	3,05E-01	2,59E-04	6,10E-01	8,27E-05	2,25E-04	5,62E-06
#18	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	1,05E+00	3,56E-01	1,05E-01		3,01E-05	2,09E-06
#19	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	1,05E+00	3,56E-01	1,05E-01		3,01E-05	2,09E-06
#20	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	2,31E+00	1,16E-01	1,16E+00		3,01E-05	2,09E-06
#21	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,38E-01	1,38E+00	6,89E-02	6,89E-01		6,89E-06	2,09E-06
#22	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,09E-01	1,09E+00	4,35E-02	1,09E+00		1,09E-06	2,09E-06
#23	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#24	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	6,80E-01	6,80E-01	2,59E-04	8,50E-01	8,27E-05	1,70E-08	5,62E-06
#25	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	3,25E+00	1,62E-01	1,62E+00		3,01E-05	2,09E-06
#26	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	1,82E-07	5,62E-06
#27												0,00E+00	
#28	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06
#29	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06
#30	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	5,29E+00	2,59E-04	1,06E+00	8,27E-05	5,29E-08	5,62E-06
#31	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	1,05E+00	3,56E-01	1,05E-01		3,01E-05	2,09E-06
#32	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	1,05E+00	3,56E-01	1,05E-01		3,01E-05	2,09E-06
#33	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	8,06E-01	8,27E-05	2,25E-04	5,62E-06
#34	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	2,68E+00	2,59E-04	1,34E+00	8,27E-05	2,25E-04	5,62E-06
#35	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06

#36	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#37	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	2,08E+00	8,27E-05	2,25E-04	5,62E-06
#38	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#39	3,43E-04	4,34E-03	4,32E-04	3,45E-05	1,07E-03	1,45E-03	1,07E+00	2,50E+00	2,50E-03	1,25E+00	3,13E-04	7,50E-04	2,06E-04
#40	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06
#41	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#42	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	8,06E-01	8,27E-05	2,25E-04	5,62E-06
#43	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#44	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#45	2,78E-06	4,32E-04	6,99E-07	1,08E-07	4,91E-06	9,32E-06	1,15E+00	7,95E+00	3,10E-01			2,62E-05	1,82E-06
#46	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#47	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#48	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	3,05E-01	3,05E-01	2,59E-04	6,10E-01	8,27E-05	2,25E-04	5,62E-06
#49	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	1,84E+00	1,38E+00	2,59E-04	3,22E-01	8,27E-05	4,61E-07	5,62E-06
#50	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#51	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	6,80E-01	6,80E-01	2,59E-04	8,50E-01	8,27E-05	1,70E-08	5,62E-06
#52	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	5,29E+00	2,59E-04	1,06E+00	8,27E-05	5,29E-08	5,62E-06
#53	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06
#54												0,00E+00	
#55	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06
#56	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	5,29E+00	2,59E-04	1,06E+00	8,27E-05	5,29E-08	5,62E-06
#57	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	8,06E-01	8,27E-05	2,25E-04	5,62E-06
#58	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	2,68E+00	2,59E-04	1,34E+00	8,27E-05	2,25E-04	5,62E-06
#59	3,43E-04	1,39E-02	4,32E-04	3,45E-05	1,07E-03	1,39E-02	6,93E-01	2,08E+00	3,90E-01	1,39E+00	3,13E-04	1,39E-03	2,06E-04
#60	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#61	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#62	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	2,08E+00	8,27E-05	2,25E-04	5,62E-06
#63	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#64	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	5,71E+00	8,27E-05	2,25E-04	5,62E-06
#65	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	8,06E-01	8,27E-05	2,25E-04	5,62E-06
#66	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#67	1,42E-05	2,33E-04	3,20E-05		1,43E-04	1,39E-05	2,76E+00	7,79E+00	2,59E-04	1,01E-01	8,27E-05	2,25E-04	5,62E-06
#68	3,43E-04	1,11E-01	4,32E-04	3,45E-05	1,07E-03	9,70E+00	7,36E+00	3,23E+00	3,90E-01	3,01E+01	3,13E-04	5,97E-03	2,06E-04
#69	3,43E-04	4,34E-03	4,32E-04	3,45E-05	1,07E-03	1,45E-03	4,57E-01	4,57E-01	5,71E-02	6,85E-01	3,13E-04	3,43E-04	2,06E-04
#70	3,43E-04	4,34E-03	4,32E-04	3,45E-05	1,07E-03	1,45E-03	7,75E-01	1,94E-01	9,69E-02	3,87E-01	3,13E-04	9,69E-05	1,45E-04
#71	3,43E-04	4,34E-03	4,32E-04	3,45E-05	1,07E-03	1,45E-03	1,07E+00	2,50E+00	2,50E-03	1,25E+00	3,13E-04	7,50E-04	2,06E-04
#72	3,19E-06	4,96E-04	8,01E-07	1,24E-07	5,63E-06	1,07E-05	1,32E+00	9,12E+00	3,56E-01	1,24E+01		3,01E-05	2,09E-06

Table 5 Continuation of Table 3

R#	Pr	Rh	Ru	Sm	Sc	Si	Sr	Ta	Tb	Ti	W	V	Y
#1	4,89E-05				5,38E-07		3,09E-01	3,07E-05		1,55E-03	4,91E-02	1,77E-04	2,21E-07
#2	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	2,17E-02	1,94E-04	1,43E-06
#3													
#4													
#5	4,89E-05				5,38E-07		3,09E-01	3,07E-05		1,55E-03	1,09E-01	1,77E-04	2,21E-07
#6	4,89E-05				5,38E-07		3,09E-01	3,07E-05		1,55E-03	4,91E-02	1,77E-04	2,21E-07
#7	1,20E-02		1,09E-05	4,87E-06	9,09E-05		3,01E-04	3,01E-04	1,37E-04	9,04E-01	2,94E-02	1,55E-03	5,72E-02
#8	1,20E-02		1,09E-05	4,87E-06	9,09E-05		9,74E+00	2,27E-02	1,37E-04	1,90E+00	2,94E-02	1,55E-03	1,51E-03
#9	9,81E-03		1,09E-05	4,87E-06	9,09E-05		9,74E+00	9,81E-03	1,37E-04	1,90E+00	9,81E-03	1,55E-03	1,51E-03
#10	1,20E-02		1,09E-05	4,87E-06	9,09E-05		9,74E+00	4,44E-02	1,37E-04	1,90E+00	2,94E-02	1,55E-03	1,51E-03
#11	1,20E-02		1,09E-05	4,87E-06	9,09E-05		9,74E+00	4,44E-02	1,37E-04	1,90E+00	2,94E-02	1,55E-03	1,51E-03
#12	1,20E-02		1,09E-05	4,87E-06	9,09E-05		9,74E+00	4,44E-02	1,37E-04	1,90E+00	2,94E-02	1,55E-03	1,51E-03
#13	2,48E-04			2,78E-05	1,46E-04		8,39E-03	4,29E-03	2,86E-01	8,21E-02	9,47E+00	7,09E-04	1,01E+01
#14	2,48E-04			2,78E-05	1,46E-04		8,39E-03	4,29E-03	2,86E-01	8,21E-02	9,47E+00	7,09E-04	1,01E+01
#15	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#16	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#17	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,53E-01	6,37E-04	1,13E-05
#18	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#19	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#20	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#21	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	2,75E-02	1,94E-04	1,43E-06
#22	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	2,17E-02	1,94E-04	1,43E-06
#23	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#24	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	3,40E-01	6,37E-04	1,13E-05
#25	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#26	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,82E-01	6,37E-04	1,13E-05
#27													
#28	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#29	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#30	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	2,65E-01	6,37E-04	1,13E-05
#31	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#32	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#33	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	4,03E-01	6,37E-04	1,13E-05
#34	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	5,36E-01	6,37E-04	1,13E-05
#35	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#36	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#37	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#38	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05

#39	7,91E-02	1,25E-05	4,09E-06	2,16E-02	5,94E-04		2,51E-01	2,55E-02	2,81E-03	3,18E-01	1,14E-01	1,40E-03	4,60E-04
#40	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#41	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#42	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	4,03E-01	6,37E-04	1,13E-05
#43	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#44	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#45	6,88E-06				4,65E-06	4,46E-02	2,03E-02	1,41E-04		7,00E-03	1,53E-01	1,69E-04	1,25E-06
#46	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#47	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#48	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,53E-01	6,37E-04	1,13E-05
#49	6,47E-05	8,55E-06	1,11E-05		3,14E-06		4,61E-01	4,42E-04	8,01E-07	2,19E-02	2,30E-01	6,37E-04	1,13E-05
#50	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#51	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	3,40E-01	6,37E-04	1,13E-05
#52	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	2,65E-01	6,37E-04	1,13E-05
#53	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#54													
#55	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06
#56	6,47E-05		1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	2,65E-01	6,37E-04	1,13E-05
#57	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	4,03E-01	6,37E-04	1,13E-05
#58	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	5,36E-01	6,37E-04	1,13E-05
#59	7,91E-02	2,41E-04	4,09E-06	2,16E-02	5,94E-04		6,93E-02	2,55E-02	2,81E-03	3,18E-01	1,14E-01	1,40E-03	4,60E-04
#60	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#61	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#62	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#63	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#64	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,40E+00	6,37E-04	1,13E-05
#65	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	4,03E-01	6,37E-04	1,13E-05
#66	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#67	6,47E-05	8,55E-06	1,11E-05		3,14E-06		9,83E-01	4,42E-04	8,01E-07	2,19E-02	1,01E-01	6,37E-04	1,13E-05
#68	7,91E-02	2,41E-04	4,09E-06	2,16E-02	5,94E-04		2,51E-01	2,23E-01	2,81E-03	3,34E+00	2,23E-01	4,46E-01	4,60E-04
#69	7,91E-02	1,14E-05	4,09E-06	2,16E-02	5,94E-04		2,28E-02	2,55E-02	2,81E-03	3,18E-01	1,14E-01	1,03E-02	4,60E-04
#70	4,84E-03	2,91E-05	4,09E-06	2,16E-02	5,94E-04		2,91E-02	2,55E-02	2,81E-03	4,84E-02	1,14E-01	1,40E-03	4,60E-04
#71	7,91E-02	1,25E-05	4,09E-06	2,16E-02	5,94E-04		2,51E-01	2,55E-02	2,81E-03	3,18E-01	1,14E-01	1,40E-03	4,60E-04
#72	7,89E-06				5,33E-06		2,33E-02	1,61E-04		8,03E-03	1,76E-01	1,94E-04	1,43E-06

4 Vehicles (including batteries)

Auto Recycling Nederland (ARN)² is the main organization in the Netherlands responsible for the management of vehicles at their end-of-life. ARN ensures that car manufacturers and importers fulfill their legal obligations for the responsible processing of discarded vehicles. The ARN coordinates the collection of end-of-life vehicles and batteries, enabling affiliated car-dismantling companies to dismantle and recycle them. ARN is composed of more than 200 companies, including dismantling, shredding, and post-shredding companies. ARN recycling rates (% of car recovered, weight basis) are above 98%³.

4.1 End-of-life flow

According to the ARN, the average age at which a car is scrapped in the Netherlands was 19 years and 7 months at the end of 2023 (ARN, 2023). Therefore, given that 2023 is the most recent data point, it is assumed that vehicles coming to the end of their life in 2023 are those that were placed on the market between 2003 and 2008. However, note that the passenger car fleet in the Netherlands comprises different car types, including petrol, diesel, and electric. To account for the differences in car types (and materials) for the Netherlands, the Centraal Bureau voor de Statistiek (CBS) fleet of passenger cars in the Netherlands over time dataset was applied, as shown in Table 6. The CBS data set was used to estimate, on average, the share of vehicle types that were present in the Dutch car fleet between 2003 and 2008 (see Table 7). This process was carried out, as ARN provides the total number of vehicles reaching end-of-life in a specific year, without disregarding vehicle type (see Table 8). Note that the scope of this (waste) flow is limited to passenger cars. The vehicle shares reaching the end-of-life by vehicle type were applied to estimate the number of vehicles by type reaching the end of life in the Netherlands for the most recent years, as shown in Table 9.

Table 6 Number of passenger vehicles fleet in the Netherlands over time (CBS, 2022).

Year	Petrol	Diesel	LPG	Electric	CNG	Other/Unknown
2000	5 214 684	797 592	330 797	40	51	0
2001	5 345 589	870 862	322 485	58	46	0
2002	5 468 017	929 839	312 252	436	51	0
2003	5 586 341	978 763	289 277	518	48	0
2004	5 624 642	1 022 087	261 609	518	33	1
2005	5 683 229	1 068 593	238 445	1 669	38	0

² [ARN](#)

³ [What happens to an end-to-life vehicle? - ARN](#)

2006	5 740 891	1 117 019	229 685	4 612	85	1
2007	5 810 798	1 184 300	227 291	7 680	107	2
2008	5 905 281	1 251 082	224 066	11 295	178	1
2009	6 011 945	1 277 128	229 554	23 387	316	1
2010	6 070 432	1 289 544	222 137	39 585	542	113
2011	6 170 127	1 297 113	211 455	55 826	912	114
2012	6 253 639	1 326 853	203 851	70 140	1 942	2 287
2013	6 276 990	1 339 935	202 322	90 703	3 125	2 538
2014	6 289 890	1 320 088	186 366	129 673	3 681	2 592
2015	6 331 816	1 313 752	168 234	155 938	6 706	2 637
2016	6 401 864	1 323 320	154 842	210 609	7 452	2 777
2017	6 509 025	1 314 225	143 542	245 427	7 901	2 854
2018	6 649 496	1 306 960	132 989	271 785	9 001	3 013
2019	6 804 125	1 275 081	123 669	314 563	9 890	3 256
2020	6 954 271	1 193 136	115 039	402 205	9 799	3 461
2021	7 059 978	1 084 072	109 926	526 540	9 456	3 620
2022	7 108 139	989 894	105 138	725 610	8 961	3 714

Table 7 Average shares (%) of passenger vehicle types in the Dutch fleet between 2003 and 2008.

Petrol	Diesel	LPG	Electricity	CNG	Other/Unknown
80,88	15,59	3,46	0,06	0,001	0,00001

Table 8 Number of vehicles reaching an end-of-life in the Netherlands based on ARN and the Online Registratie Auto's in Demontage ORAD (ARN, 2023).

Year	# of vehicles ORAD	# of vehicles ARN	t/vehicle
2010	249008	215975	0,999
2011	249607	206150	1,016
2012	237207	196763	1,022
2013	232720	192433	1,031
2014	226103	188279	1,041
2015	213639	185110	1,038
2016	216281	185740	1,035

2017	234595	196252	1,035
2018	247663	207239	1,043
2019	234348	197650	1,052
2020	225804	186300	1,07
2021	220926	178136	1,067
2022	176887	143036	1,072
2023	159262	133224	1,083

Table 9 Number of vehicles reaching the end of life in the Netherlands per vehicle type based on ORAD.

Year	Petrol	Diesel	LPG	Electricity	CNG	Other/Unknown
2020	182637	35207	7818	140	3	0
2021	178692	35207	7818	140	3	0
2022	143072	27580	6124	110	2	0
2023	128816	24832	5514	99	2	0

Note that for electric vehicles, the number of them reaching the end of their life is limited, given their relatively recent introduction to the market.

The end-of-life data considered for vehicles corresponds to 2023 for the petrol, diesel, and electric categories, given the availability of data on material composition. See the next section for more information.

4.2 Material composition

Material composition data is only presented for internal combustion engines (petrol and diesel) and electric vehicles. No data with a high degree of specificity was available for LPG and CNG cars; thus, the results on the theoretical CRM composition for vehicles represent only petrol, diesel, and electric vehicles. The material composition data for internal combustion engines were derived from (Iglesias-Émbil et al., 2025) and for electric vehicles from (Iglesias-Émbil et al., 2020).

4.2.1 Internal combustion engines

For internal combustion engines Iglesias-Émbil et al., (2025) considers the following:

“This study considers three generations of the C-segment SEAT Leon model (Generations II, III and IV). The main reason for selecting the SEAT Leon is that this model is the only one in the brand with more than two generations documented in the available material database. For each generation, two trims are considered, namely, reference (basic) and FR (high), and there are two combustion versions, gasoline and diesel. Thus, 12 configurations are assessed, covering ten years of production and 2 million units sold. Furthermore, several Volkswagen (VW) Group models (VW Golf, Audi A3, and Skôda Octavia) share the same platform on which

SEAT Leon is based. Moreover, it corresponds to the medium segment, the second most important segment in sales worldwide (Statista, 2024). Taking into account these considerations, the car model shown here is a good example of the current situation in the European automotive market”.

Therefore, data from the generation II models was applied as they were placed on the market in 2005 and are representative of vehicles from 2003 to 2008. The reference model metal compositions for petrol and diesel cars were applied. Table 10 provides the CRM's composition of petrol and diesel vehicles.

Table 10 CRMs composition of reference generation II petrol and diesel I (Iglesias-Émbil et al., 2025).

Element	Reference generation II petrol vehicles (g/vehicle)	Reference generation II diesel vehicles (g/vehicle)
Al	75397,87	72136,84
As	2,97	0,36
Ba	1651,07	1660,23
Be	0,03	0,03
Bi	12,09	9,83
Ce	50,55	1,83
Co	9,45	14,62
Cu	17085,97	17677,06
Dy	0,15	0,42
Ga	0,22	0,22
Hf	0,01	-
Ir	0,05	-
La	5,89	0,91
Li	1,02	1,02
Mg	2596,08	2209,42
Mn	4411,98	4786,13
Nb	168,10	131,17
Nd	13,81	13,99
Ni	2812,39	2171,28
Pd	2,53	5
Pt	0,18	8,69
Rh	0,09	-
Ru	0,01	0,01

Sb	52,79	19,39
Sm	0,56	-
Sr	352,70	351.86
Ta	4,91	5.77
Ti	599,75	626.29
V	113,60	113.22
W	7,28	9.14

4.2.2 Electric vehicles

For electric vehicles Iglesias-Émbil et al., (2020) considers the following:

“...the data corresponds to the medium segment, the second in importance in terms of worldwide sales (Statista, 2020). Additionally, the Volkswagen Group (to which SEAT brand belongs) is the world's largest car manufacturer by sales since 2016 (12% of market share) (Volkswagen, 2020).”

“...the preferred chemistry is lithium nickel manganese cobalt oxide (NMC), which is the Li-ion battery type considered in this study. In the considered BEV here, the metal composition of the cells corresponds to a proportion of 6:2:2 of nickel, cobalt and manganese (generation 2b of Li-ion battery). This battery type represents better the first BEV models”.

Therefore, the material composition data applied in this study for electric vehicles corresponds to medium segment electric vehicles with a 6:2:2 of nickel, cobalt and manganese generation 2b of Li-ion battery (Table 11).

Table 11 CRMs composition of medium segment electric vehicles with a 6:2:2 of nickel, cobalt and manganese generation 2b of Li-ion battery (Iglesias-Émbil et al., 2020).

Element	g/vehicle
Al	161464,68
As	0,88
B	57,24
Ba	1634,15
Be	0,05
Bi	34,50
Ce	0,14
Co	12324,36

Cu	59517,26
Dy	59,73
Ga	0,50
Gd	0,002
Ge	0,01
La	3,67
Li	7211,57
Mg	2339,42
Mn	17959,34
Nb	198,23
Nd	972,90
Ni	37600,61
Pd	0,42
Pr	9,29
Pt	0,06
Rh	0,001
Ru	0,04
Sb	129,99
Sr	326,28
Ta	11,51
Tb	2,24
Ti	1359,72
V	146,42
W	5,24
Y	0,10

5 Batteries (portable)

The main organisation responsible for the collection and recycling of waste electrical appliances, lamps, and batteries in the Netherlands is Stichting OPEN (Organisatie Producentenverantwoordelijkheid e-waste Nederland)⁴. This organization serves as the executive body responsible for the legal producer's responsibility for e-waste. This means that companies that manufacture or import electronics are financially and organizationally responsible for the collection and recycling of their products at the end of their life cycle. Stichting OPEN provides a collective system for these companies to meet their legal obligations. Once collected, Stichting OPEN ensures that the e-waste is sorted and processed by certified recycling companies. This organization also represents all producers and importers in the Netherlands related to the products mentioned above.

5.1 End-of-life-flow

Stichting OPEN provides the collection rates for different types of portable batteries on a group level. Table 12 provides the amounts of batteries collected in 2024 for the Netherlands.

Table 12 Portable batteries collected in the Netherlands for 2024 (Stichting OPEN, 2025a).

Batteries category (Dutch)	English translations	Weight (ton)
Big Blocks	Big Blocks (metal of unknown)	85,09
Cartridges uit sortering	Cartridges out of sorting (plastic)	2,14
Fietsbatterijen NiMh	NiMH Bicycle Batteries	-
Knoopcellen (los) Gesorteerd - Lithium	Loose Button Cells (Assorted) - Lithium	101,19
Knoopcellen (los) Gesorteerd - Overig	Loose Button Cells (Assorted) - Other	15,42
Knoopcellen (los) Ongesorteerd	Loose Button Cells (Unsorted)	87,70
Knoopcellen en Blisters mix	Mixed Button Cells and Blisters	3,78
Lithium	Lithium	5,68
Lithium primary	Lithium Primary	50,22
Lithium TCL	Lithium TCL	55,30
Lithium-ion (high C)	Lithium-ion (high C)	221,20
Lithium-ion (low C)	Lithium-ion (low C)	555,04
Loodcellen	Lead Cells	68,24
Mix alkaline zinkkoolstof batterijen	Mixed Alkaline Zinc-Carbon Batteries	3002,61
Nicd Packs	NiCd Packs	135,34

⁴ [Stichting OPEN - Stichting OPEN](#)

Nicd Rondcellen	NiCd Round Cells	202,13
Niet Sorteerbaar	Unsortable	4,40
Nimh Rondcel/Packs	NiMH Round Cell/Packs	181,18
Ongesorteerde Industriële batterijen	Unsorted Industrial Batteries	16,72
Vermiculiet	Processing material – no battery	117,82
Vuil	Dirt	6,89
Total		4918,1

Note that categories “dirt” and “processing material – no battery” are part of the end-of-life flow and displayed as such but not considered in the calculations.

5.2 Material composition

The theoretical availability of CRM in portable batteries is estimated for all categories mentioned in Table 12, with the exception of the “Big Blocks” and “Unsorted Industrial Batteries” types, given the lack of specificity in these categories to match with the literature data.

5.2.1 Button cells

The material composition of button cells was retrieved from (Moreno-Merino et al., 2015). This study reports the chemical composition of more than 60 samples for the most common button cells types: alkaline, zinc air, silver oxide and lithium. Table 13 provides the CRMs composition of button cells. The composition of lithium button cells is used to obtain the CRMs potential contribution for the “Loose Button Cells (Assorted) – Lithium category”. The composition of alkaline, zinc air and solid oxide is used to obtain the CRMs contribution for the “Loose Button Cells (Assorted) – Other” with a share of 60% silver oxide, 25% alkaline and 15% zinc air. The shares of button cell type within the “Loose Button Cells (Assorted) – Other” is provided by Stichting OPEN. There is no level of specificity for the categories “Loose Button Cells (Unsorted)” and “Mixed Button Cells and Blisters”. Therefore, for these two categories, the CRM's potential contribution was obtained by applying the average composition considering all button cell types.

Table 13 CRMs composition of button cells in mg/g button cell weight (Moreno-Merino et al., 2015). Average, maximum and minimum values of each cell type samples. Maximum and minimum values are provided for comparison purposes.

Element	Average	Max	Min
Alkaline			
Al	3,80	4,37	3,17
As	0,0015	0,0034	0,00075
Ba	0,00094	0,0012	0,00056
Cu	9,57	30	1,70

Li	0	0	0
Mn	147,25	171	125
Ni	12,75	28,30	5,50
Sb	0,000238	0,00031	0,00019
Zinc air			
Al	0,072	0,079	0,065
As	0,0087	0,022	0,002
Ba	0,0047	0,0066	0,0022
Cu	15,15	17	11,7
Li	0,000045	0,00007	0,00001
Mn	2,68	4,09	1,99
Ni	48,70	50,90	46,30
Sb	0,0012	0,0028	0,00016
Silver oxide			
Al	0,18	0,22	0,15
As	0,009	0,010	0,0079
Ba	0,0027	0,0055	0,00043
Cu	20,73	28,70	12,50
Li	0,00084	0,003	0,00005
Mn	78,50	111	53
Ni	30,50	37,80	24,10
Sb	0,0022	0,0026	0,0019
Lithium			
Al	2,52	3,26	1,17
As	0,0063	0,0084	0,0017
Ba	0,00265	0,0031	0,0019
Cu	0,097	0,14	0,065
Li	19,65	22,90	15,20
Mn	149,50	201	61
Ni	5,30	9,50	3,30
Sb	0,0013	0,0019	0,00026

5.2.2 Lithium batteries from portable electronic devices

The material composition of lithium batteries from portable electronic devices was obtained from (Morita et al., 2021). This study analyzes the elemental composition of 26 different lithium battery types for portable equipment, including laptops, digital cameras, music players, and video players, with various cathode chemistry types. An average CRM composition was established based on the data from (Morita et al., 2021) and applied to obtain the CRM's potential contribution for the “Lithium”, “Lithium Primary”, “Lithium TCL”, “Lithium-ion (high C)”, and “Lithium-ion (low C)” categories. This assumption was made given that such categories encompass lithium batteries from portable electronic devices, and there was no higher level of specificity within these categories to distinguish the composition of battery types for specific devices. Table 14 provides the CRMs composition of lithium batteries for portable devices. Note that the applied composition corresponds to the elements present only in the battery cell.

Table 14 CRMs composition of lithium batteries for portable devices in g/ battery cell (Morita et al., 2021) . Average, maximum and minimum values for the whole sample.

Element	Average	Max	Min
Al	1,76	7,85	0,53
Co	5,36	14,91	0,41
Cu	3,51	11,77	1,13
Li	1,19	3,92	0,42
Mg	0,01	0,06	0
Mn	2,02	42,61	0
Ni	2,62	12,78	0
P	0,12	0,53	0,010

5.2.3 Ni-Cd batteries

The material composition of Ni-Cd batteries was retrieved from (Blumbergs et al., 2021). This review provides an estimate of the metal content in commercial batteries, expressed as a weight percentage in relation to the total weight of the batteries. The average CRMs composition of Ni-Cd batteries was used to obtain the CRMs' potential contribution to the “NiCd Packs” and “NiCd Round Cells” categories. Table 15 provides the CRMs composition of Ni-Cd batteries.

Table 15 CRMs composition of Ni-Cd batteries as % ratio of element content in relation to battery weight (Blumbergs et al., 2021). Note that the values are in total less than 100%, given that non-CRMs are not accounted for.

Element	Average	Max	Min
Al	0,019	0,019	0,019

Ce	2,97	5,50	0,43
Co	0,60	0,60	0,60
Mn	0,083	0,083	0,083
Ni	17,50	20	15

5.2.4 NiMH batteries

The material composition of NiMH batteries was retrieved from (Müller & Friedrich, 2006). This study provides the average chemical composition of NiMH cylindrical and prismatic cells, as shown in Table 16. Since there is no specificity regarding the battery type within the “NiMH Round Cell/Packs” (as provided by Stichting OPEN), an average composition was estimated between NiMH cylindrical and prismatic types and applied to estimate the CRM potential contribution of the categories mentioned above. Müller & Friedrich, (2006) provided a compiled composition for La, Ce, Nd and Pr. The same share was assumed for each element from the compiled composition for La, Ce, Nd and Pr.

Table 16 CRM's composition of NiMH Cylindrical and Prismatic batteries, mass% of battery (Müller & Friedrich, 2006). Note that the values are in total less than 100% given that non-CRMs are not accounted for.

Element	Average	Max	Min
NiMH Cylindrical			
C	1	1	1
Ce	2,25	2,50	2
Co	3,50	4	3
La	2,25	2,50	2
Nd	2,25	2,50	2
Ni	39	42	36
Pr	2,25	2,50	2
NiMH Prismatic			
C	1	1	1
Ce	1,88	2	1,75
Co	2,50	3	2
La	1,88	2	1,75
Nd	1,88	2	1,75
Ni	39	40	38
Pr	1,88	2	1,75

5.2.5 Mixed alkaline zinc-carbon batteries

The material composition of “Mixed Alkaline Zinc-Carbon batteries” category was retrieved from (Sayilgan et al., 2009). This review study provides the elemental composition, expressed as a weight percentage in relation to the total weight of the alkaline, zinc, and mixed carbon battery powder from different samples. An average was estimated across the presented data and is presented in Table 17. Given that there is no specificity on the battery types within the category of “Mixed Alkaline Zinc-Carbon batteries”, an 80% alkaline and 20% zinc-manganese mix was applied to the end-of-life flows for this category. This assumption was made given that there are considerably higher shares of alkaline batteries in the market.

Table 17 CRMs' composition of alkaline and zinc-carbon batteries, %mass of battery powder (Sayilgan et al., 2009). Note that the values are in total less than 100% given that non-CRMs are not accounted for.

Element	Average	Max	Min
Alkaline battery powder			
Ni	0,010	0,010	0,010
Mn	35,53	45	31,10
Zinc-Manganese battery powder			
Mn	26,30	-	-
Powder mix			
Al	0,36	-	-
Mn	33,59	-	-
Si	0,49	-	-
Ti	0,27	-	-

6 Construction and demolition waste (C&DW)

Construction and Demolition Waste (C&DW) is a broad category of waste generated from the construction, renovation, and demolition of buildings and infrastructure. It encompasses a diverse range of materials. The stony fraction, often referred to as mixed rubble or construction and demolition rubble, is the most significant portion of C&DW by weight. It primarily consists of mineral-based materials (Dijkstra et al., 2019). In the Netherlands, BRBS Recycling⁵ is the leading trade association for companies involved in the recycling of C&DW. The acronym of BRBS stands for Belangenvereniging Recycling Bouw- en Sloopafval, which translates to the Association for the Interests of Recycling Construction and Demolition Waste.

6.1 End-of-life-flow

Data for C&DW was provided by Rijkswaterstaat in the “Euralwastecodes through LMA from Construction and Demolition in NL 2012-2022 report” (Rijkswaterstaat, 2024). Data on C&DW stony fraction is presented in Table 18 for 2022 (the most updated value).

Table 18 C&DW in the Netherlands for 2022 (Rijkswaterstaat, 2024).

C&DW waste (stony fraction)	Weight (kton)
2022	24104,55

6.2 Material composition

The elemental composition of C&DW was retrieved from (Dijkstra et al., 2019). This paper presents the elemental composition of C&DW from Denmark and Norway and uses it as proxy for the Netherlands, as data for Dutch conditions are currently unavailable. Therefore, these values were used as proxy indicators for this assessment and presented in Table 19. For comparison purposes, the (measured) range of minimum and maximum values from other studies is presented.

Table 19 CRMs composition of C&DW waste in g/kg (Dijkstra et al., 2019).

Element	Typical	Max	Min
Al	52	63	25
Si	267	320	240
Mg	7	13	1.8

⁵ brbs.nl

7 Steel slags

Tata Steel⁶ is the only producer of steel in the Netherlands and, therefore, the only ‘source’ of steel slags. Steel slag is a byproduct generated during the steelmaking process. As molten steel is separated from its impurities in furnaces, a substance primarily composed of silicates and oxides solidifies to form slag. Steel slags are formed during different steps of the iron and steel manufacturing process. Blast Furnace Slag (BFS) originates from the iron-making process, where iron ore, coke, and limestone are heated to extremely high temperatures. Basic Oxygen Furnace Slag (BOFS – also known as Linz-Donawitz slag) originates at a later stage, when molten iron is introduced into the basic oxygen furnace to reduce carbon content and refine the iron into steel. For this report, the theoretical viability of CRMs in steel slags is represented by the BFS and the BOFS.

7.1 End-of-life flow

Tata Steel has estimated the expected volumes of steel slag generation in the report “Detailed study of secondary flows and waste” (Royal HaskoningDHV, 2025). Tata Steel estimated three scenarios (best-case, middle-case and worst-case) for each slag flow. The scenarios are based on the expected amount of slag per ton of steel produced and the possible variation, given the ore quality. The volumes of BFS and BOFS present in Table 20 correspond to the middle case.

Table 20 Production volumes of steel slags for Tata Steel in the Netherlands (Royal HaskoningDHV, 2025).

Steel slag	Weight (kton)
Blast Furnace Slag - BFS	1300
Basic Oxygen Furnace Slag - BOFS	900

7.2 Material composition

The elemental composition of BFS was retrieved from (Jonczy et al., 2022). This study analyses the chemical composition of different BFS samples of Polish metallurgical plants operating on the basis of the blast furnace process. This study was used to address the (1) lack of primary data from Tata BFS, (2) the similarity in blast furnace processes, and (3) data completeness. Note that this composition was corroborated for completeness purposes with Tata Steel. Data was processed from an oxide level to an element level and presented in Table 21. The material composition of the BOFS was based on primary data provided by Tata Steel (Tata Steel, 2025). An average composition of BOFS data between 2025 and 2020 is presented in Table 22. Data was processed from an oxide level to an element level.

⁶ [Homepage | Tata Steel](#)

Table 21 CRM's composition of BFS, % mass basis (Jonczy et al., 2022). Note that values are in total less than 100% given that non-CRMs are not accounted for.

Element	Typical value
Al	3,89
As	0,00020
Ce	0,0010
Co	0,00010
Mg	3,30
Mn	0,093
Nb	0,014
Ni	0,0010
P	0,0044
Si	17,91
Ti	0,16
V	0,072
W	0,0070
Y	0,0010

Table 22 CRM's composition of BOFS, % mass basis (Tata Steel, 2025). Note that values are in total less than 100% given that non-CRMs are not accounted for.

Element	Average	Min	Max
Al	0,91	0,75	1,07
Mg	4,91	4,47	5,26
Mn	3,53	3,24	3,95
P	0,61	0,55	0,69
Si	6,21	5,84	6,62
Ti	0,82	0,74	0,95
V	0,66	0,56	0,79

8 Bottom ash

Municipal waste incineration bottom ash is the primary solid residue that remains after the combustion of household and similar commercial waste in a waste-to-energy facility. This material represents the incombustible components of the waste stream and accounts for approximately 80-90% of the total ash produced during incineration (Meskers et al., 2023). Note that bottom ash in the Netherlands undergoes a mandatory treatment process that includes metal recovery, screening, sizing, and washing.

8.1 End-of-life flow

For the Netherlands, Rijkswaterstaat reports the amount of municipal waste raw bottom ash from combustion. These volumes are reported annually in the “Waste processing in the Netherlands” and correspond to an overview provided by the waste management agency. The most updated value is for the year 2022 (Rijkswaterstaat, 2024), as shown in Table 23.

Table 23 Raw bottom ash from combustion in the Netherlands (Rijkswaterstaat, 2024).

Year	Volume (kton)
2022	1678
2021	1899
2020	1895
2019	1880

8.2 Material composition

The typical elemental composition of municipal waste incineration was retrieved from (Dijkstra et al., 2019) and presented in

Table 24. This paper provides an overview of the elemental composition of bottom ash according to Dutch conditions. For comparison purposes, the (measured) range of minimum and maximum values from other countries in Europe is given. This range is based on measurements in Belgium, Denmark, France, Ireland, Italy, Sweden and the UK. Note that in the Netherlands, there are several waste-to-energy facilities, and the composition of bottom ash between facilities can vary to some extent. Currently, the NMO is testing the elemental composition of Dutch bottom ash, and the results will be updated with primary data at the beginning of 2026.

Table 24 CRMs composition of municipal waste bottom ash in g/kg (Dijkstra et al., 2019).

Element	Typical Dutch value	Bottom ash in Europe min value	Bottom ash in Europe max value
Al	40	31	75
Cu	3	1	18
Mg	13	6	34
Mn	1	1	2
P	3	3	13
Si	216	61	96
Ti	6	3	7
V	0,5	0,5	0,5

9 Results

Figure 1 displays the results for the 6 waste stream with the theoretical amount of CRMs present for each waste stream.

		Batteries (portable)	Bottom ash	C&D	Steel slags	Vehicles	WEEE
Al		5	9	11	9	12	8
As		2			6	7	4
B					5		
Ba		1			7	10	6
Be					5	3	
Bi					8	4	
C		5					
Co		7			5	8	6
Cu		6	8	9		11	7
Ga						2	4
Ge						1	2
He							
Hf						5	
Li		6				7	4
Mg		4	9	10	9	10	7
Mn		8	8		9	10	7
Nb					7	9	4
Ni		7			5	10	7
P		5	8		8		
Sb		1				8	4
Sc							2
Si			10	11	10		3
Sr						9	7
Ta						7	4
Ti			9		8	9	5
V			7		8	9	4
W					6	8	6
Dy	HREE					6	4
Er							3
Eu							4
Gd						1	3
Ho							2
Lu							
Tb						4	3
Tm							
Y					5	5	5
Yb							
Ce	LREE	3			4	8	4
La		5				7	4
Nd		5				8	5
Pr		6				6	4
Sm						6	4
Ir	PMGs					3	
Os							
Pd						7	3
Pt						7	2
Rh						6	1
Ru						5	1

kton	Category	kton
0,1 kg >=	1	< 1 kg
1 kg >=	2	< 10 kg
10 kg >=	3	< 100 kg
100 kg >=	4	< 1000 kg
1 ton >=	5	< 10 ton
10 ton >=	6	< 100 ton
100 ton >=	7	< 1000 ton
1 kton >=	8	< 10 kton
10 kton >=	9	< 100 kton
100 kton >=	10	< 1000 kton
1000 kton >=	11	< 10000 kton
10000 kton >=	12	< 15000 kton

Figure 1 CRMs theoretical availability for the 6 Dutch waste streams in scope.

10 References

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