



**TOBACCO
TRANSFORMATION
INDEX**

RRP Supply Chain Landscape Study

Phase 1: Raw Materials

April 2023

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1. Introduction

This report is part one of five in the Reduced-Risk Product (RRP) Supply Chain Landscape Study (“Study”). The purpose of the Study is to provide a comprehensive review of the manufacturing and distribution of RRP, including particular attention to environmental impacts across all parts of the supply chain. The Study is structured in five phases, to be published during the course of 2023:

- 1) Phase 1: Raw Materials
- 2) Phase 2: Manufacturers
- 3) Phase 3: Distribution
- 4) Phase 4: Consumers
- 5) Phase 5: Waste

This report focuses on the raw materials used in the manufacturing of RRP. The structure of the research was leveraged by first identifying top brand owners¹ across RRP categories, based on Euromonitor International’s Passport data, and by researching outsourced manufacturing and supply chains on a global level. Research was conducted on information available as of March 2023 and covered company reporting up to and including full-year 2022. Information was collected via a mixed methodology approach, including Euromonitor International’s Passport database, a thorough review of secondary sources, and a range of expert consultations.

The purpose of this report is to offer an overview across several topics:

- 1) Key raw materials used for RRP manufacturing, e.g., consumable ingredients, plastic for vapes, electronic parts, and packaging such as tins for snus and e-liquid bottles.
- 2) Key manufacturers of ready-to-use raw materials, e.g., premixed liquid, special tins, electronic parts, etc.
- 3) Extraction or manufacturing impact of certain raw materials with presumed high environmental impact, such as nicotine or certain metals, e.g., lithium.

The report scope covers RRP products as described in detail in the Appendix section. While the report covers all RRP categories, particular attention is paid to vaping products (closed and open system), and heated tobacco, due to:

- 1) Relatively high value share within the total RRP landscape: Combined share 4.9% of Global Nicotine Ecosystem Retail Value Sales, 2020;²
- 2) Initial assumption of high environmental impact, notably because these include disposable and or rechargeable electronic devices.

Another product category of particular attention is non-tobacco nicotine pouches. While the category had a relatively low share estimated at 0.1% of Global Nicotine Ecosystem Retail Value Sales, 2020,³ it was marked by the highest retail value and volume change for 2020 vs 2019.

The upcoming phases of the Study aim to cover further aspects of the supply chain, researching the key players in the manufacturing and distribution of RRP, assessing consumer perception, and evaluating environmental impact across the various stages of the supply chain through post-consumption waste.

All definitions and acronyms used in this report can be found in the Appendix.

¹ For the list of brand owners, please see the Appendix

² Foundation for A Smoke-Free World. Global Trends in Nicotine Report, December 2021, from https://www.smokefreeworld.org/wp-content/uploads/2021/12/Global-Trends-in-Nicotine-Report_3.21.22.pdf

³ Ibid

2. Executive summary

Diverse product categories require a wide-reaching supply chain

The RRP manufacturers offer an increasingly diverse range of products, which require a similarly varied scope of raw materials encompassing agricultural products, metals, minerals, chemicals, plastics, and electronics. A broad distinction can be made between the ingredients and raw materials required across the consumable elements of RRPs; and those associated with delivery systems, notably devices and pouches. Crossover occurs between the components, with fossil fuels being the base elements for chemicals and plastics.

For the consumable element of RRPs, nicotine is the common ingredient. Synthetic nicotine usage is growing, but it is relatively small compared to naturally sourced nicotine. Therefore, most products remain dependent on tobacco, which is sourced through millions of independent farmers globally. For smokeless tobacco and heated tobacco sticks, tobacco not only provides the nicotine but also acts as the bulk ingredient.

RRP specialist suppliers have developed, but the category is also dependent on multi-industry suppliers

Extracted nicotine used in e-liquids and nicotine replacement therapy (NRT) products is sourced through RRP-focused companies. Some of the producers, such as Contraf-Nicotex-Tobacco (CNT)⁴ and BGP⁵, have been in operation for decades, having been established to support the production of NRT products. The companies are increasingly focused on vaping products, while other companies such as Chemnovatic are also entering the market.

For e-liquids, the bulk ingredients are vegetable glycerin and propylene glycol, which carry the flavors and impact the density of the vapor produced. Both products are widely used across food and personal care product categories and are manufactured on an industrial scale. The same can be said for other ingredients, such as flavoring, preservatives, PH balancing, and moisturizing and lubricating agents. These ingredients are commonly sourced from multi-industry chemical and ingredients companies, such as Cargill Inc, The Eastman Chemical Company, and Ingredion Inc.

Tobacco companies generally manufacture the consumable element and outsource the devices

Global tobacco companies such as Altria Group Inc (Altria), British American Tobacco Plc (BAT), Imperial Brands Plc (Imperial Brands), Japan Tobacco Group (JT), Philip Morris International Inc (PMI), and Swedish Match AB (Swedish Match)⁶, which are leading players in RRPs, have differentiated strategies when it comes to the production of RRPs and raw materials. For devices, the companies have outsourced production of raw materials and final products to third parties. In our view, this is because the companies have limited experience in the production of electronic devices. Regarding tobacco products, the companies take on a more proactive role. For example, the process of assembling heated tobacco sticks is similar to that of making cigarettes and often the same factory is used for both products. Regardless of the involvement in production, the tobacco companies remain reliant on raw materials from tobacco farmers, paper mills, and chemical manufacturers.

Similar to electronic devices, tobacco companies have limited experience in the manufacture of e-liquids, and the component is predominantly outsourced. However, as the e-liquid is a key point of brand differentiation, companies have taken greater ownership of the process with, for example, Imperial Brands purchasing Nerudia, a UK-based company that produces the e-liquids for Blu.

⁴ CNT Group. Corporate Website, Accessed March 2023, from <https://cntgroup.de/our-business/#leaf-tobacco>

⁵ BGP Group. Corporate Website, Accessed March 2023, from <https://www.bgpgroup.biz/history/>

⁶ This research was conducted on information available as of March 2023 and covered company reporting up to and including full-year 2022. For this reason, despite PMI's acquisition of Swedish Match, they both are analyzed as two separate entities in this report.

Chinese players dominate the supply of electronic devices

RRP expert consultation indicated that 90-95% of RRP devices are made in Shenzhen China. A number of leading brands originate there: Joyetech (Shenzhen Joye Technology Co Ltd); SMOK (Shenzhen IVPS Technology Co Ltd); Kanger (Shenzhen Kanger Technology Co Ltd); Innokin (Shenzhen Innokin Technology Co Ltd); and Vaporesso (Shenzhen Smoore Technology Co Ltd). While the sales of the brands are significant, more so are the sales of brands the companies produce under license. For example, Shenzhen Smoore Technology Co Ltd produces for Logic (JT), RELX, and Vuse (BAT).

The Chinese companies that perform Original Design Manufacturer (ODM) and Original Equipment Manufacturer (OEM) functions are significant electronic raw materials suppliers for the RRP. These companies also, however, source from other third-party suppliers, who focus on specialist areas such as batteries, Printed Circuit Board Assembly (PCBAs), and atomizers. For many of the specialist companies, such as Huachengda in atomizers, RRP are the key focus. Others, such as BYD in PCBAs, operate widely in other industries like automotives.

Chinese companies likewise have a significant role in the manufacture of electronic components for RRP. International companies, such as Nolato, have also set up divisions in China to supply RRP. Other international companies contribute to the electronic supply of RRP as well, even though their focus on the sector is limited. Samsung in batteries is one such example. The condition also applies to the supply of metals and plastics for devices, which are key raw materials. US-based Eastman, for example, is the most significant plastic provider for RRP.

Additional elements and processing necessary for RRP add to their environmental impact

The environmental impact of the extraction and manufacture of raw materials in RRP varies by category. PMI, for example, states that on a per unit basis the environmental impact of its RRP is higher than its High-Risk Products (HRP).⁷ The situation reflects the number of raw materials and processes involved and, significantly, the incorporation of electronic devices. Research on the direct environmental impact of RRP is currently limited and presents a research gap, which this report series aims to address. For Phase 1, inputs such as tobacco farming, fossil fuel extraction, mining, paper sourcing, and chemical reactions are considered.

⁷ PMI. Integrated Report 2021, P.109, from https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

3. Manufacturers of raw materials

3.1 Supply chain

The RRP manufacturing process is diverse and uses a wide range of raw materials requiring agricultural products, metals, minerals, chemicals, and electronics. The raw materials move through several processes and are combined with other elements to create work-in-process materials at different stages of production. For this reason, each RRP requires multiple manufacturers. If raw materials were traced back to source materials through curing, refining, and smelting, each fully functioning RRP device including the consumable element is likely to be sourced from hundreds, if not thousands, of suppliers.

In simplified terms, the production of RRP has five stages:

- 1) **Extraction of source materials**
- 2) **Source material processing**
- 3) **Component/Raw material production**
- 4) **Product assembly**
- 5) **Final product**



Within the five stages is added complexity, as it is common for raw materials to move through multiple companies, even within a specific stage. In this context, the role of brand owner varies. Outsourcing the production of final products and raw materials to third parties is common practice. In some instances, brand owners do not produce any raw materials.

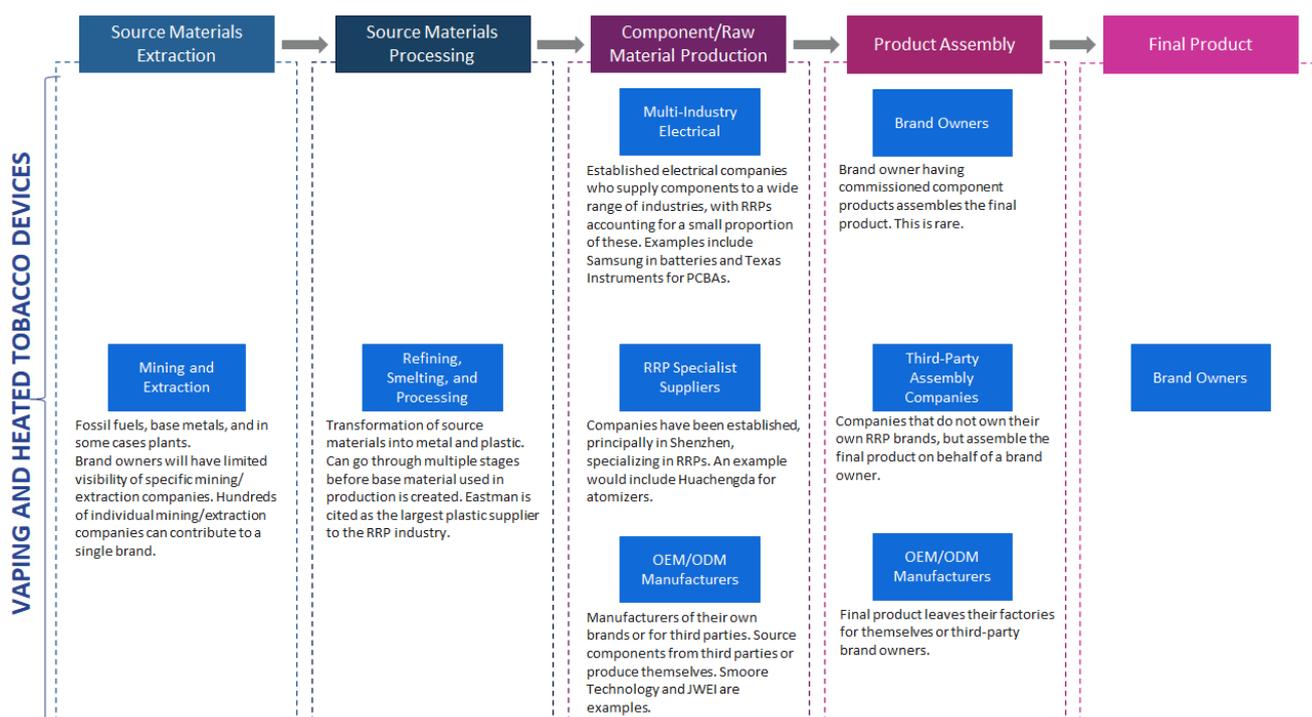
Leading international tobacco companies such as BAT, Imperial Brands, JT, and PMI commonly outsource the manufacture of devices and are not significant raw material manufacturers. Despite this fact, the tobacco companies curate certain components for different products, often being responsible for the final stage of mixing e-liquids or producing heated tobacco sticks.

There are common raw materials used across all RRP categories, and some raw material manufacturers operate across multiple categories. However, significant differences exist among the categories. To analyze the key raw material manufacturers, four supply chain groupings can be defined:

- 1) **Vaping and heated tobacco devices**
- 2) **E-liquids, nicotine pouches, and NRT products**
- 3) **Tobacco products (includes chewing tobacco, snus, and the tobacco used in heated tobacco sticks)**
- 4) **Pouches and heated tobacco stick components (non-consumables)**

Vaping and heated tobacco devices produce different vapors from different source materials, but share many of the same components, with similarities in supply chains.

3.2 Vaping and heated tobacco devices



Source materials extraction and processing

The key source materials for devices are fossil fuels and metals. Fossil fuels are utilized for a number of components, most notably plastics, which are used throughout device production including caps and the outer casings. Polycyclohexylenedimethylene terephthalate glycol-modified (PCTG) is the most commonly used plastic, given its stability and anti-corrosion properties.⁸ PCTG is recyclable, but at present only limited quantities are recycled in vaping. A wide variety of metals are used, both for external and internal functions. Aluminum is often used for the outer casings; while lithium, copper, nickel, and stainless steel are common for working parts.

Brand owners and final raw material producers typically are several steps in the supply chain away from the sourcing of base materials. This is highlighted, for example, by PMI's conflict minerals report, in which its suppliers have provided the list of over 200 companies from which the 3TGs (tin, tantalum, and tungsten) used in their components are sourced.⁹ While RRP brand owners do not purchase minerals and metals directly, the traded prices of these commodities can have a significant impact on their profits. For this reason, the brand owners track prices closely and build in costing caveats with their suppliers on how changes in commodity prices are absorbed.

Cross-industry players in metals, plastics, and chemicals process and supply source materials to RRP raw material manufacturers. For example, Eastman Chemical Company, which manufactures additives and functional products, as well as chemical intermediates and fibers for industries as diverse as construction, agriculture, and consumer durables, produces PCTG for RELX cartridges.¹⁰ Eastman had an annual turnover of USD10.5 billion in 2022, employed 14,000¹¹, and its TX1501 is cited as the most used and competitively priced plastic for RRP devices¹².

⁸ Industry Consultation, March 2023

⁹ PMI. CONFLICT MINERALS REPORT OF PHILIP MORRIS INTERNATIONAL INC. FOR THE YEAR ENDED DECEMBER 31, 2021. Appendix B, from https://www.pmi.com/resources/docs/default-source/pmi-our-company/2022-05-17-conflict-minerals-report.pdf?sfvrsn=251561b6_2&tags=operationspage

¹⁰ RELX. Brand Website. RELX Classic - *What is the material of device and pod?* Accessed March 2023, from https://relxnow.com/blogs/product-information/relx-classic-what-is-the-material-of-device-and-pod?_pos=1&_sid=fee21c875&_ss=r

¹¹ Eastman. Corporate Website, Accessed March 2023, from <https://investors.eastman.com/overview/default.aspx>

¹² Industry consultations, March 2023.

Component/Raw material production

As electronic goods, vaping, and heated tobacco devices compete with other sectors for supply from multi-industry electronic parts suppliers, such as Texas Instruments in PCBA (Printed Circuit Board Assembly) and Samsung in batteries.¹³ This situation was particularly true in the early stages of category development, where the brand owners went to the market looking for producers to supply their new designs. In many instances, such as batteries, the brand owners sourced off-the-shelf products.

Multi-industry electronic parts suppliers remain important for the RRP ecosystem, but increasingly supply is fulfilled by specialist RRP electronic companies who are often located in Shenzhen, China. Hundreds of companies have gravitated to the sector as it has grown and the barriers to entry are regarded as relatively low, given the similarities in the manufacturing processes to those used for other electronic goods. Players include Dongguan Yihi Electronic in microchips and Huachengda in atomizers, which through its four factories have a capacity of two billion atomizers per year.¹⁴ Specialist RRP electronic companies can supply both vaping and heated tobacco devices, with Huachengda producing heating blades which it markets as Fever Sheet.¹⁵ Manufacturing in China is seen as attractive to brand owners because of the low cost. Companies, such as US Thermal Circuits, which were leaders in the early stages of the sectors development, have become less prevalent.¹⁶ A number of international electronic companies, such as Sweden's Nolato and Finland's Scanfil, have set up factories in China, to remain competitive on price, although these companies are still regarded as premium suppliers.¹⁷

Chinese OEM/ODM manufacturers who produce their own brands and those of third parties, have become key players in RRP manufacturing. Based on industry consultations, research estimates that 90-95% of vaping device supply is derived from China.¹⁸ The OEM/ODM manufacturers produce some of their own raw materials, but also source from specialist suppliers.

Shenzhen Smoore Technology Co Ltd is cited as the leading OEM/ODM manufacturer¹⁹ producing its own brands, such as Vapresso and FEELM. Smoore also manufactures for other brands, including Vuse (BAT), NJOY, Logic (JT), and RELX.²⁰ For some brand owners, Smoore produces the whole device, while for others it produces components. The majority of Smoore's business is focused on vaping devices, but since 2017 it has also manufactured components in heated tobacco for Japan Tobacco. In 2019, Smoore's sales to Japan were CNY605 million (USD88 million) and 99% related to heated tobacco, given the 2010 ban on vaping products containing nicotine in Japan.²¹ Smoore also produces and sells separate components such as coils to retail clients. Smoore sources most of its raw materials in China. In 2019, its largest supplier Eve Energy, the battery manufacturer, accounted for 6.7% of its purchase costs. Smoore's top five suppliers accounted for 25.5% of purchase costs. Smoore's total raw material costs in 2019 were CNY3,049 million (USD443 million). Of the raw material cost, 30% was on electronic materials, 27% metal components, 22% plastic materials, 12% packaging materials, and 8% classified as "other".²²

Other significant OEM/ODM manufacturers based in Shenzhen include JWEI (Shenzhen Joye Technology), Shenzhen IVPS Technology Co Ltd (Smork), and Tian Chang Group. Tian Chang Group, among others, supplies the Blu device (Imperial Brands). As well as finished consumer products, Tian Chang Group produces battery rods, liquid pods, atomizers, and clearomizers (i.e., see-through tanks which hold premade atomizers²³).

¹³ Ibid

¹⁴ Huachengda. Corporate Website, Accessed March 2023, from <https://www.hcdjm.com/en/2022/06/30/hcd-company-profile/>

¹⁵ Ibid

¹⁶ Industry consultations, March 2023.

¹⁷ Ibid

¹⁸ Ibid

¹⁹ Ibid

²⁰ Smoore International Holdings Ltd. Global Offering, June 29, 2020, P.1

²¹ Ibid, P.200

²² Smoore International Holdings Ltd. Global Offering, June 29, 2020, P.1. P16

²³ Vapresso. Brand website, Accessed March 2023, from <https://www.vapresso.com/blog/difference-between-an-atomizer-cartomizer-and-clearomizer>

Product assembly

Leading international tobacco companies, such as BAT, Imperial Brands, and JT, who are brand owners in vaping devices, design the physical specifications of products and own the intellectual property of their brands. Production, however, is done by third parties such as Smoore Technology and JWEI, who deliver the final product to the brand owner, having manufactured and/or sourced electronic components. This scenario is the case for BAT's Vuse brand, which is produced by Smoore. The e-liquid is sourced by BAT and shipped to Smoore, which fills the Vuse device to deliver the final product. There are variations on how the brand owners work with third parties. BAT, for example, takes a different approach in heated tobacco with its glo brand relative to Vuse. For glo, BAT commissions the separate manufacture of individual components and employs another third party to assemble the final product. glo utilizes two companies, BYD and Nolato, to assemble and deliver its final product. BYD and Nolato produce certain components and perform finishing processes, for example, molding the outer casing from the raw plastic. Other components are sourced and supplied by BAT, for example, through a contract with Samsung for batteries.²⁴ In part, BAT appears to have created separate supply chains for its heated tobacco and vape brands.

PMI, the market leader in heated tobacco, accounting for over 70% of global volume sales in 2021, designed its supply chain from scratch.²⁵ PMI initially focused production of IQOS in Malaysia, although it has since incorporated Chinese manufacturers in its supply chain.²⁶ In 2021, PMI spent approximately USD1 billion on direct supplies for electronic devices.²⁷ Through Veev, PMI also has a relatively small presence in vaping devices and e-liquids. PMI sources electronic devices for its heated tobacco and vaping devices from four suppliers. Companies that have produced IQOS include Venture Corporation (Malaysia) and Flex Manufacturing (Zhuhai) Company (China).²⁸

The contracts between brand owners and third-party manufacturers vary. Some brand owners use a variety of suppliers to produce raw materials, in part mitigating against supply chain issues or shortages. For example, JUUL has used Pegatron and Feixu Electronics to produce its devices.²⁹ A similar principle is employed by brand owners even when the final device is produced by a single manufacturer.

Third-party manufacturers often directly source components, but they can be contractually obliged by the global brand owner to deal with a selection of suppliers at pre-defined prices. Brand owners stipulate sourcing for supply security and buying power. The rationale is relevant for international tobacco companies, who have a range of products across product categories which use the same components. BAT has, for example, established agreements with Scanfil (Suzhou) Co Ltd and BYD to buy PCBAs.³⁰

In the wider context of the electronic goods market, vaping devices are relatively small consumers of components such as printed circuit boards compared to the automotive and smartphone industries. In the US, for example, the FDA estimates that approximately 22 million e-cigarettes are sold a year, therefore requiring 22 million printed circuit boards.³¹ By comparison, it is estimated that approximately 120 million smart phones are sold a year in the US,³² while approximately 14 million new automobiles were registered in the US in 2022.³³ On average an automobile uses 100

²⁴ Industry consultations, March 2023.

²⁵ Euromonitor International's Passport, Tobacco database, updated May 2022.

²⁶ Industry Consultations, March 2023

²⁷ PMI. Corporate Website, Accessed March 2023, from <https://www.pmi.com/sustainability/fundamentals/manage-our-supply-chain-sustainably>

²⁸ Singapore Business Review. Accessed March 2023, from <https://sbr.com.sg/manufacturing/news/should-venture-worry-about-third-iqos-manufacturer-philip-morris>

²⁹ VapeHK, September 3, 2019, from <https://vape.hk/excel-5000>

³⁰ Industry Consultations, March 2023.

³¹ Tobacco Free Kids. New Study Shows Continuing Popularity of Juul and Other Flavored E-Cigarettes Among Youth – Underscores Why FDA and Other Policymakers Must Eliminate All Flavored E-Cigarettes, June 7, 2021, from https://www.tobaccofreekids.org/press-releases/2021_06_07_jama-network-open-study

³² Canalys. US Smartphone market Q2 2020, Accessed April 2023, from <https://www.canalys.com/newsroom/canalys-us-smartphones-shipments-Q2-2020>

³³ Autoleap. Accessed April 2023, from

printed circuit boards, meaning in the US the automobile sector consumes approximately 1,400 million per year.³⁴ Therefore, in contrast to the automobile and smart phone sectors, vaping manufacturers have relatively low buying power.

Brand owners sourcing components and assembling final products is less common. Kaival Brands Innovations Group Inc (Kaival Brands), through its Bidi brand, takes this approach by using a number of raw material suppliers: Huachengda for heating coil, cotton, and ceramic; Timeyaa as PCBA supplier; Jee Precision as hardware supplier; and Shouju Group Jo Ltd as plastic mold supplier.³⁵

Table 1: Vaping and heated tobacco devices raw material manufacturers*

| Type of Company | Company | Headquarters | Raw Materials |
|---|----------------------------------|--------------|-------------------------|
| Multi-Industry Electronic Companies | BYD Company Ltd | China | Device Assembly & PCBAs |
| | DLG Electronic Technology Co Ltd | China | Batteries |
| | Eastman | USA | Plastics |
| | Eve Energy | China | Batteries |
| | Feixu Electronics | China | Devices |
| | Flex Manufacturing (Zhuhai) | China | Device Assembly |
| | ITM | China | Batteries |
| | KUK Group | Switzerland | Coils |
| | Nolato AB | Sweden | Device Assembly |
| | Pegatron Technologies | Taiwan | Devices |
| | Samsung | South Korea | Batteries |
| | Scanfil Oy | Finland | PCBAs |
| | Venture Corp | Malaysia | Device Assembly |
| RRP Specialist Suppliers | Dongguan Yihi Electronic | China | Microchips |
| | Timeyaa | China | PCBAs |
| | Huachengda | China | Atomizers |
| OEM/ODM Manufacturers (also Brand Owners) | First Union | China | Devices and Parts |
| | Shenzhen IVPS Technology Co Ltd | China | Devices and Parts |
| | JWEI Group (Joyetech) | China | Devices and Parts |
| | Kanger Technology Co Ltd | China | Devices and Parts |
| | Smoore Technology Co Ltd | China | Devices and Parts |
| | Tian Chang Group | China | Devices and Parts |

Note: *This table is not comprehensive, but indicative of leading raw materials manufacturers.

<https://autoleap.com/blog/how-many-cars-are-sold-in-the-us-each-year/#:~:text=Just%20over%20three%20million%20cars,include%20light%20truck%20sales.>)

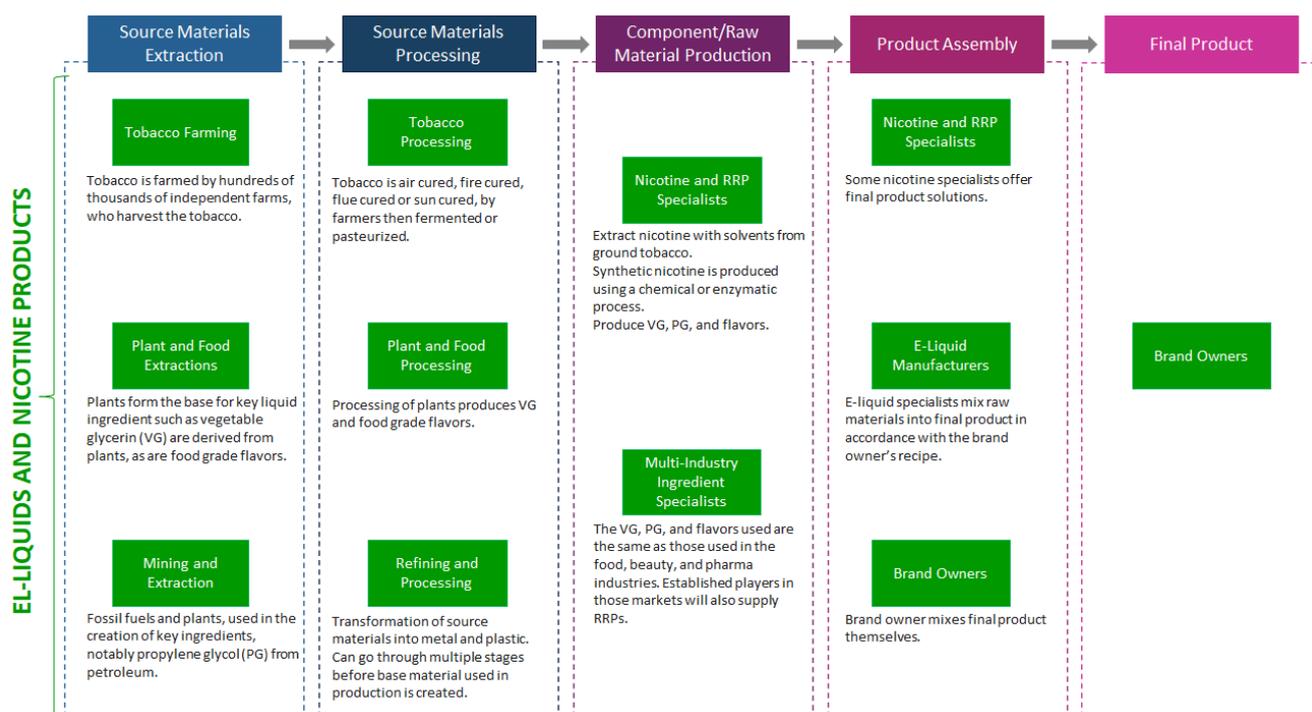
³⁴ Moko Technology. Accessed April 2023, from

<https://www.mokotechnology.com/automotive-pcb-guide/>

³⁵ Bidi Vapor. Integrated Sustainability Strategy Report 2020-2021, from:

<https://wholesale.bidivapor.com/integrated-sustainability-strategy-report-2020-2021/> P.34

3.3 E-liquids, nicotine pouches, and NRT products



Source material extraction and processing

Farmers produce and cure tobacco, the core direct ingredient for heated tobacco and smokeless tobacco consumable products. Tobacco is the base source for the production of nicotine used in RRP's, except where synthetic nicotine is used. Synthetic nicotine is currently a niche product, although Contraf-Nicotex-Tobacco GmbH (CNT) has cited the potential of the category. Torsten Siemann, managing director of CNT, stated in 2019, "Synthetic nicotine can become important in supplying markets such as China, India and Russia where you've got many nicotine users who still have to carry out the switch to next-generation products. We see enormous demand there, and the capacity for synthesis of chemicals is unlimited... Presently, synthetic nicotine clearly is a negligible product for us in terms of volume."³⁶

Raw material manufacturers and brand owners typically source tobacco from a number of producers and countries, and process tobacco into the final consumable product. Crops support the production of e-liquids ingredients, notably vegetable glycerin, as well as flavorings. The extraction of fossil fuels remains important in the production of e-liquids, as the majority of propylene glycol used is derived from petroleum. Additional plant crops, such as corn for ethanol, and fossil fuels can be used in the extraction of nicotine from tobacco. Depending on the process, applied solvents and acids may be used, which can be plant or fossil fuel based.

Synthetic nicotine is a relatively new process and companies have patented different methodologies, although ethyl nicotinate, which is a natural product found in plants *Areca catechu* and *Averrhoa carambola*, is a common starting point.^{37,38}

³⁶ The Tobacco Reporter. *Synthetic Nicotine Is Gaining Acceptance*, Accessed March 2023, from <https://tobaccoreporter.com/2019/12/01/mirror-image/>

³⁷ Labstat. *The Difference Between Synthetic Nicotine And Natural Nicotine*, Accessed March 2023, from <https://labstat.com/understanding-synthetic-nicotine-and-how-it-is-regulated-in-canada/#:~:text=Synthetic%20nicotine%20refers%20to%20nicotine,therefore%20not%20a%20tobacco%20product.>

³⁸ Pubchem. *Compound Summary*, Accessed March 2023, from <https://pubchem.ncbi.nlm.nih.gov/compound/Ethyl-nicotinate>

Raw material production

Vegetable glycerin and propylene glycol, which make up the bulk ingredients of e-liquids, are significant and long-standing ingredients used in a range of consumer products, notably in foods and personal care. As such, the major manufacturers are large-scale ingredients companies, such as Cargill Inc, for which e-liquid supply is a relatively small proportion of their portfolio. In context, Cargill's annual revenues in 2022 were USD165 bn³⁹ compared to the total global retail value sales of the e-liquids market being USD5.9 bn in 2021.⁴⁰

E-liquid flavors are often the same as those which are used in foods. In 2020, the country with the largest value exports for glycerin was Indonesia, followed by Malaysia, the Netherlands, and Brazil. In 2020, the countries with the largest value exports for propylene glycol were Germany, followed by China, the USA, South Korea, and Thailand.⁴¹

Nicotine production, in contrast to vegetable glycerin and propylene glycol, directly relates to the manufacturing of RRP. The growth of the RRP category has spurred the development of a number of nicotine manufacturers. Specialist companies that focus on nicotine commonly provide mixtures combining nicotine with vegetable glycerin and propylene glycol, while some also produce the final e-liquid product. While vaping has increasingly become a focus area, many nicotine suppliers were established to serve NRT products and still do. CNT is one such company having formed in 1982.

CNT claims to be the world's largest supplier of U.S. Pharmacopeia/European Pharmacopeia grade nicotine (USP/PhEur). CNT's starting material (tobacco) is sourced from its processing facility in India. The final processing of CNT's nicotine USP/PhEur takes place in Switzerland through its exclusive contract manufacturer Siegfried AG under full pharmaceutical Current Good Manufacturing Practice (cGMP).⁴² In addition, CNT has leaf operations in Argentina, Germany, Zambia, Zimbabwe, Brazil, and the US. CNT provides pure nicotine and e-liquids base solutions mixed with vegetable glycerin and propylene glycol.⁴³

Alchem International claims to be the world's leading supplier of nicotine specifically to the vaping sector.⁴⁴ Alchem supplies pure nicotine, nicotine bases, nicotine salts, nicotine powder, nicotine pouch mixtures, pharmaceutical nicotine, and its absolute tobacco - e-liquid tobacco flavor. Alchem operates three manufacturing plants in India. In addition, Alchem has an EU plant for blending and mixing of nicotine dilutions and processing of nicotine salts. Alchem states it is able to "assure quality and full batch to batch traceability from leaf through to deliver to our customers."⁴⁵

BGP Group is an India-based company, which began extracting nicotine in 1976 and employs 500 people.⁴⁶ BGP Group produces: nicotine sulphate 40%; nicotine alkaloid 95%; nicotine base USP/ PhEur; nicotine bitartrate dihydrate; nicotine polacrilex/ resinate USP/ PhEur; and potassium nitrite.⁴⁷

The growth of vaping has led to the establishment of a number of nicotine companies focused on the category, such as Nicotine River in the USA and Chemnovatic in Poland. Nicotine River claims to be one of the world's largest suppliers of

³⁹ Cargill. Annual Report 2022, P.3, Accessed April 2023, from <https://www.cargill.com/doc/1432215917376/2022-cargill-annual-report.pdf>

⁴⁰ Euromonitor International's Passport, Tobacco database, updated May 2022.

⁴¹ OEC. Website, Accessed March 2023, from <https://oec.world/en/profile/hs/propylene-glycol-propane-12-diol?redirect=true>

⁴² CNT Group. Corporate Website, Accessed March 2023, from <https://cntgroup.de/our-business/#nicotine>

⁴³ CNT Group. Subsidiary Website, Accessed March 2023, from <https://nicotineusp.com/>

⁴⁴ Alchem. Subsidiary Website, Accessed March 2023, from <https://www.nicselect.com/gb/why-alchem/>

⁴⁵ Alchem. Subsidiary Website, Accessed March 2023, from <https://www.nicselect.com/gb/supply/>

⁴⁶ BGP Group. Corporate Website, Accessed March 2023, from <https://www.bgpgroup.biz/history/>

⁴⁷ BGP Group. Corporate Website, Accessed March 2023, from https://www.bgpgroup.biz/wp-content/themes/avada/pdf/DataSheet-Nicotine_Free_Base.pdf

USP grade nicotine and The Flavor and Extract Manufacturers Association (US)/generally recognized as safe (FEMA/GRAS) flavors.⁴⁸ Nicotine River produces both natural and synthetic nicotine in California, as well as supplying vegetable glycerin and propylene glycol. Nicotine River's vegetable glycerin is made from palm. Chemnovatic was formed in 2013 and produces pure nicotine, nicotine salts, nicotine salt bases, natural nicotine, vegetable glycerin, propylene glycol, and concentrate flavors. Chemnovatic sells over 10,000 tonnes of raw materials per annum, over 10 tonnes of nicotine per annum, and it operates a factory with over 60,000 sqft at capacity of over 500,000 bottles per week.⁴⁹

Synthetic nicotine is currently a relatively small category but growing quickly. One of the drawbacks of synthetic nicotine is that it is approximately four times more expensive to produce than naturally sourced nicotine. However the ratio is set to fall as volumes increase and economies of scale are realized.⁵⁰ Next Generation Labs has been the pioneer in the market for synthetic nicotine, and it announced in 2019 that it would be doubling its production capacity.⁵¹ Contraf-Nicotex-Tobacco (CNT) launched synthetic nicotine in 2018, which was indicative of the potential seen in the category.⁵² In April 2022, in the US, a federal law came into effect extending the FDA's authority to regulate synthetic nicotine. Previously FDA authority had been restricted to products derived from tobacco.⁵³

Product assembly

A number of nicotine manufacturers also produce the final products for brand owners. Chemnovatic, for example, offers private label services. Nicotine River, through its Midnight Manufacturing affiliate, produces white label e-liquids for third parties.⁵⁴ Alchem, through its subsidiary NicSelect, advertises its New NicSelect Pouch White Label, which it describes as a full white label service.⁵⁵

There are a large number of e-liquid producers in Shenzhen, China, with Zinwi Biotechnology Co Ltd and Shenzhen Yupeng Technology Co Ltd, as leading examples. International brand owners, such as BAT, Imperial Brands, and JUUL, who have their devices manufactured in China, state that their e-liquids are sourced from North America or Europe. The rationale is brand differentiation. Producing in domestic markets is thought to have an additional cachet with consumers, where safety is a high concern. JUUL, for example, stipulates it fills its pods in the USA. JUUL does not produce its own e-liquid but uses Phillips-Medisize as its third-party manufacturer.⁵⁶

BAT's Vuse makes a similar claim stating all "Vuse liquids are manufactured in the USA". BAT highlights that it has one factory making vapor liquids.⁵⁷ BAT also use third parties, namely GoodCat Laboratories. The fact that BAT has its own factory is indicative of brand owners taking ownership of e-liquid production.⁵⁸

⁴⁸ Nicotine River. Corporate Website, Accessed March 2023, from <https://nicotineriver.com/>

⁴⁹ Chemnovatic. Corporate Website, Accessed March 2023 from <https://chemnovatic.com/>

⁵⁰ Labstat. The Difference Between Synthetic Nicotine And Natural Nicotine, Accessed March 2023, from <https://labstat.com/understanding-synthetic-nicotine-and-how-it-is-regulated-in-canada/#:~:text=Synthetic%20nicotine%20refers%20to%20nicotine,therefore%20not%20a%20tobacco%20product.>

⁵¹ Market Insider. *Next Generation Labs Expands Tobacco-Free Nicotine Production, August 26, 2019*, from <https://markets.businessinsider.com/news/stocks/next-generation-labs-expands-tobacco-free-nicotine-production-1028474603>

⁵² Tobacco Reporter. *Synthetic Nicotine is Gaining Acceptance*, December 1, 2019, from <https://tobaccoreporter.com/2019/12/01/mirror-image/>

⁵³ FDA. FDA Updates Regulatory Documents to Include "Non-Tobacco Nicotine" Products, Accessed March 2023, from <https://www.fda.gov/tobacco-products/ctp-newsroom/fda-updates-regulatory-documents-include-non-tobacco-nicotine-products>

⁵⁴ Nicotine River. Corporate Website, Accessed March 2023, from <https://nicotineriver.com/>

⁵⁵ Nicselect. Brand Website, Accessed March 2023, from <https://www.nicselect.com/gb/products/applications/>

⁵⁶ Exposed by CMD. *Koch Subsidiary Supplier of JUUL Vaping Products Announces Layoffs*, September 2, 2022, from <https://www.exposedbycmd.org/2022/09/02/koch-subsidiary-supplier-of-juul-vaping-products-announces-layoffs/>

⁵⁷ BAT. Corporate Website, Accessed March 2023, from https://www.bat.com/group/sites/UK__9D9KCY.nsf/vwPagesWebLive/DO52AEAY

⁵⁸ Industry Consultation, March 2023

All of Blu's (Imperial Brands) e-liquids are produced by Nerudia, a UK-based company Imperial Brands acquired in 2017.⁵⁹ While Nerudia produces Blu's final liquid in the United Kingdom, the nicotine is sourced from a specialist company based in Switzerland, which extracts nicotine from tobacco grown in India.⁶⁰

The e-liquid market that serves open devices is fragmented. A number of significant producers have emerged. Pure Labs has a 110,000 sqft facility in Florida, USA, where it manufactures white label products for third parties and its own brand Halo. With regard to Halo, Pure Labs states "Other e-cigarette suppliers sometimes rely on foreign manufacturers to produce e-liquid in countries where quality standards fall far below those of the US.... By handling Halo e-juice production domestically, we can source premium ingredients like U.S. Pharmacopeia-grade nicotine, propylene glycol and vegetable glycerin."⁶¹ eLiquitech is another e-liquid manufacturer based in the USA, which exclusively manufactures for third parties through its 22,000 sqft facility in Maryland.⁶²

For nicotine pouches, the brand owners are responsible for assembling the final product. Swedish Match⁶³ is the largest company in nicotine pouches, with its Zyn brand having a 48% global share in 2021.⁶⁴ Swedish Match has a long-established tradition of manufacturing snus, and it has been able to adapt these processes to nicotine pouches. The other leading players are Altria, BAT, and JT, each of which have acquired a nicotine pouch brand and taken on the existing manufacturing facilities.

NRT products were established by the pharmaceutical industry, and many of the ingredients used in NRT products are used in other medicines. As such, the pharma companies have global agreements with the largest producers of the specific commodities, including companies such as The Dow Chemical Company and Lotte Fine Chemical, which are significant hypromellose producers.⁶⁵ Ingredients suppliers such as Du Pont, Roquette Frères S.A., Cargill Inc, and Ingredion Inc are also significant suppliers of flavors and ingredients such as xylitol and sorbitol.⁶⁶ Similarly, from a packaging perspective, aluminum blister packs are widespread in pharmaceutical and OTC products, with large suppliers being Amcor and Eurofoil.

The brand owners do not produce the nicotine, which is sourced from the same specialists that supply e-liquids and non-tobacco nicotine pouches. CNT is a significant supplier, having been established to meet NRT needs. CNT supplies Fertin Pharma, which in turn works with companies such as Novartis and GlaxoSmithKline.⁶⁷

Tobacco companies have entered the NRT space and through acquisition have inherited manufacturing facilities. PMI, for example, acquired Fertin Pharma in 2021. Nicovom, the manufacturer of Zonnic, was purchased by Reynolds in 2009, which was in turn acquired by BAT in 2017.

⁵⁹ Imperial Brands. Corporate Website, Accessed March 2023, from <https://imperialbrandsscience.com/about-us/>

⁶⁰ Imperial Brands. Brand Website, Accessed March 2023, from <https://www.blu.com/en-GB/blog/how-to-and-guides/how-are-e-liquid-made>

⁶¹ Halo. Brand Website, Accessed March 2023, from <https://www.halocigs.com/pages/american-made-e-liquid/>

⁶² Eliquitech. Corporate Website, Accessed March 2023, from <https://www.eliquitech.com/#about>

⁶³ This research was conducted on information available as of March 2023 and covered company reporting up to and including full-year 2022. For this reason, despite PMI's acquisition of Swedish Match, they both are analyzed as two separate entities in this report.

⁶⁴ Euromonitor International's Passport, Tobacco database, updated May 2022.

⁶⁵ Pharma Offer. Accessed March 2023, from <https://pharmaoffer.com/api-exciipient-supplier/hypromellose>

⁶⁶ Expert Market Research. Accessed March 2023, from <https://www.expertmarketresearch.com/articles/top-xylitol-manufactures-suppliers>

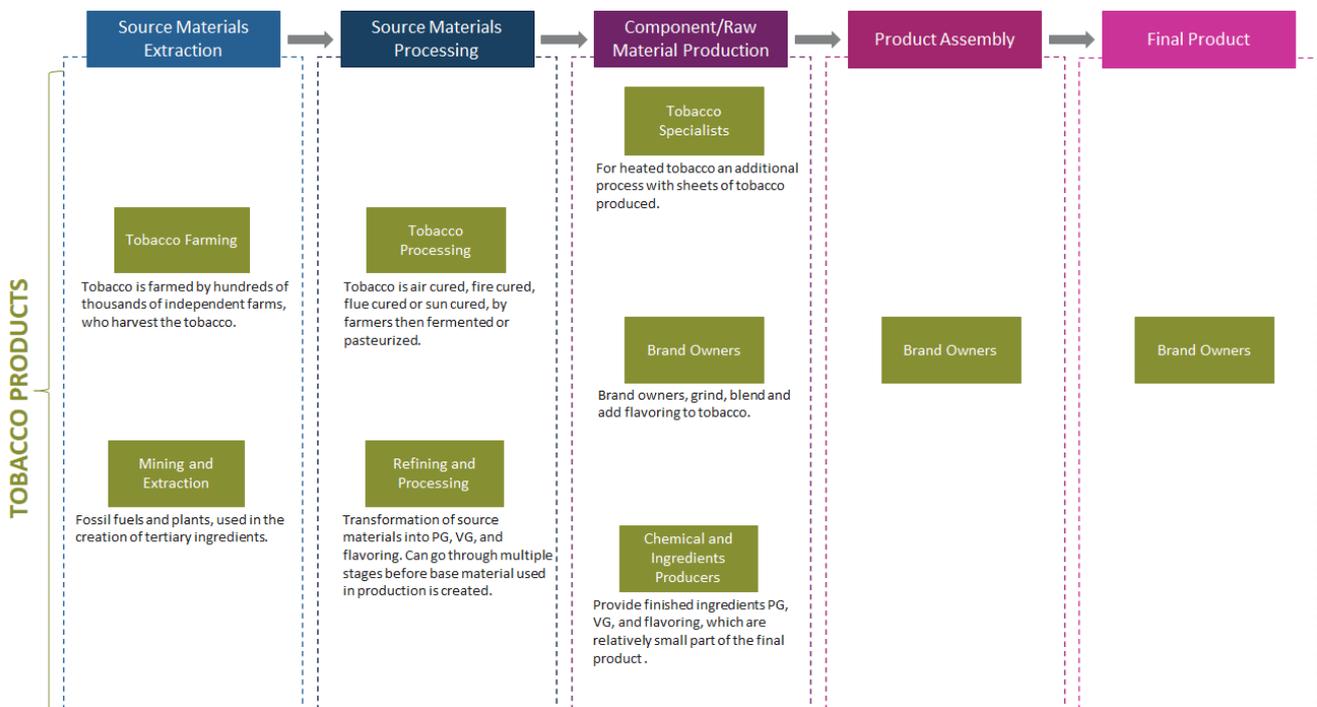
⁶⁷ Manufacturingdigital.com. Fertin Pharma Company Report, Accessed March 2023, from <https://manufacturingdigital.com/company-reports/fertin-pharma>

Table 2: Manufacturers of e-liquids, nicotine pouches, and NRT products*

| Type of Company | Company | Headquarters | Raw Materials |
|--------------------------------------|------------------------------------|--------------|---------------|
| Multi-Industry Ingredient Specialist | Cargill Inc | USA | Ingredients |
| | Eastman Chemical Company | USA | Ingredients |
| | Flavourart | UK | Flavors |
| | Hertz Flavors | Germany | Flavors |
| | Ingredion Inc | USA | Ingredients |
| | Phillips-Medisize | USA | E-Liquids |
| | The Dow Chemical Company | USA | Ingredients |
| Nicotine and RRP Specialists | Alchem | India | Nicotine |
| | BGP Healthcare | India | Nicotine |
| | Chemnovatic | Poland | Nicotine |
| | CNT Group | Germany | Nicotine |
| | IPURE | China | Nicotine |
| | Next Generation Labs | USA | Nicotine |
| | Nicotine River | USA | Nicotine |
| E-Liquid Manufacturers | GoodCat LLC | USA | E-liquid |
| | Cut Ice Ltd | UK | E-liquid |
| | eLiquitech | USA | E-liquid |
| | Pure Labs | USA | E-Liquids |
| | Zinwi Biotechnology Co Ltd | China | E-Liquids |
| | Shenzhen Yupeng Technology Co. Ltd | China | E-Liquids |
| | Brand Owners | BAT | UK |
| Imperial Brands | | UK | E-Liquids |

Note: *This table is not comprehensive, but indicative of leading raw materials manufacturers.

3.4 Tobacco products (includes chewing tobacco, snus, and the tobacco used in heated tobacco sticks)



Source material extraction and processing

Similar extraction processes and suppliers are used for tobacco products as for those present in e-liquids and nicotine products, but tobacco products utilize a larger proportion of the base material. Fossil fuels are relevant, as propylene glycol is used in heated tobacco sticks, although the physical content is relatively small. Similarly, flavors sourced from crops can be used across tobacco products in small volumes.

Component/ Raw material production and assembly

Once cured, the degree to which tobacco is processed varies across product categories and in most cases, it is carried out by brand owners. There are, however, tobacco specialists who take on the first stage of grinding the tobacco and reconstituting it into sheets which are delivered to the brand owners. SWM is an example of a company that produces tobacco sheets, which are most commonly used in heated tobacco sticks.

In 2021, Altria, BAT, DS Group, and Swedish Match were the world's leading smokeless tobacco companies and all process their own smokeless tobacco.⁶⁸ Brand owners are therefore the key raw material manufacturers. Depending on the product, brand owners may grind and steam the tobacco, while adding preservatives, pH balance, moisturizing, and flavor elements. These elements are provided by multi-industry chemical and ingredients companies.

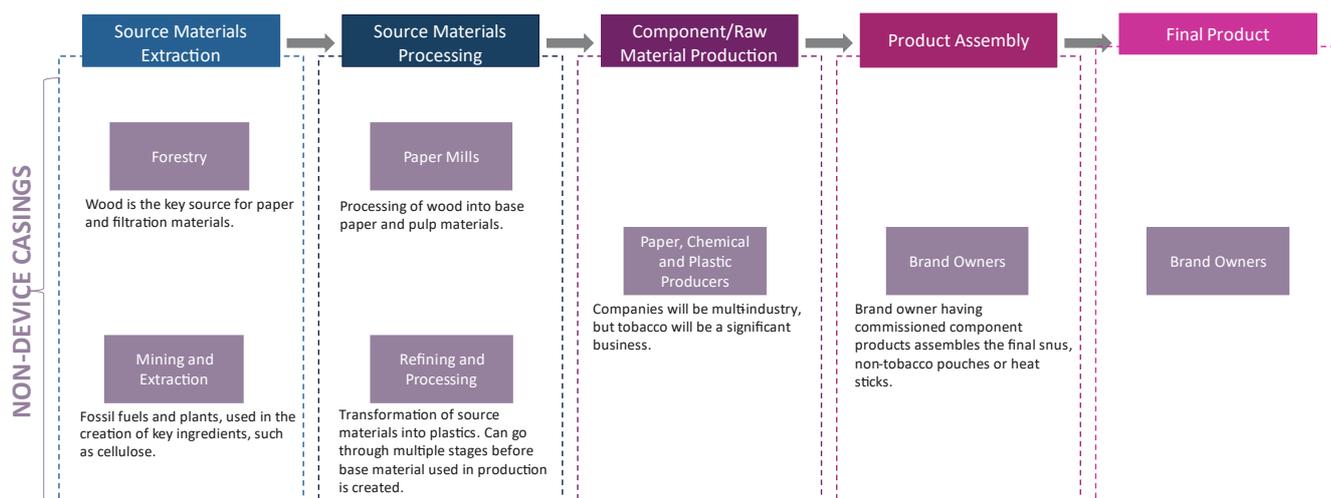
Table 3: Tobacco products (includes chewing tobacco, snus, and the tobacco used in heated tobacco sticks) manufacturers*

| Type of Company | Company | Headquarters | Raw Materials |
|------------------------------------|--------------------------|--------------|--|
| Chemical and Ingredients Producers | Cargill Inc | USA | Ingredients |
| | Eastman Chemical Company | USA | Ingredients |
| | Flavourart | UK | Flavors |
| | Hertz Flavors | Germany | Flavors |
| | Ingredion Inc | USA | Ingredients |
| | The Dow Chemical Company | USA | Ingredients |
| Tobacco Specialists | SWM | USA | Tobacco and Paper |
| Brand Owners | Altria | USA | Tobacco |
| | BAT | UK | Tobacco and Heated Tobacco Sticks |
| | DS Group | India | Tobacco |
| | Imperial Brands | UK | Tobacco |
| | JT | Japan | Tobacco and Heat Heated Tobacco Sticks |
| | PMI | Switzerland | Tobacco and Heat Heated Tobacco Sticks |
| | Swedish Match | Sweden | Tobacco |

Note: *This table is not comprehensive, but indicative of leading raw materials manufacturers.

⁶⁸ Euromonitor International's Passport, Tobacco database, updated May 2022

3.5 Non-device casings (pouch wrappers and non-consumable tobacco stick components)



Heated tobacco sticks (excluding tobacco)

Wood is the primary base material used in the production of the non-tobacco part of heated tobacco sticks. Cellulose acetate, a plastic derived from wood, is the basis of the filtration, while paper is utilized as the outer coating. Adhesives are the other component used in heated tobacco sticks. Paper, chemical, and plastic companies, therefore, are the suppliers of raw materials for the non-tobacco part of heated tobacco sticks. Brand owners PMI, BAT, and JT assemble heated tobacco sticks given the similarities in the process to assembling cigarettes.

Pouches

Pouches, which hold nicotine pouches and snus, are made of plastics, which can be either organically or synthetically produced. Extraction sources are therefore either plant or fossil fuel-based, and the raw material providers are chemical or plastic companies. Tyvek, owned by DuPont, is cited as a material often used. The snus and nicotine pouch brand owners, such as Altria, BAT, Imperial Brands, JT, and Swedish Match, take the pouch material and assemble it around the snus or nicotine products.

Table 4: Pouches and heated tobacco stick components (non-consumable) manufacturers*

| Type of Company | Company | Headquarters | Raw Materials |
|------------------------------------|-----------------|--------------|-----------------------|
| Chemical and Ingredients Producers | Celanese Corp | USA | Cellulose Acetate Tow |
| | Cerdia GmbH | Germany | Cellulose Acetate Tow |
| | Daicel Corp | Japan | Cellulose Acetate Tow |
| | Eastman | USA | Cellulose Acetate Tow |
| | HB Fuller | USA | Adhesives |
| | Henkel | Germany | Adhesives |
| Paper Companies | Stora Enso Oyj | Finland | Paper |
| | SWM | USA | Paper |
| | UPM | Germany | Paper |
| Brand Owners | Altria | USA | Assembly |
| | BAT | UK | Assembly |
| | Imperial Brands | UK | Assembly |
| | JT | Japan | Assembly |
| | PMI | Switzerland | Assembly |
| | Swedish Match | Sweden | Assembly |

Note: *This table is not comprehensive, but indicative of leading raw materials manufacturers.

3.6 Packaging

Packaging takes place at the point of assembly. In most cases, brand owners outsource the production of packaging materials, although there are exceptions. Swedish Match, for example, produces its own cardboard cans which it uses for loose snus. However, the company outsources the manufacture of plastic cans which it uses for portioned snus. Swedish Match uses plastic for portioned snus because of better durability.⁶⁹

The companies which produce packaging materials, when it is outsourced, are commonly located close to where the products are assembled, which for the devices means China. The rationale is shipping costs within the supply chain. The packaging suppliers based in China may not be Chinese-owned companies, with global packaging companies setting up divisions there, which serve the RRP sector. For example, BAT has used the Chinese division of the Swedish company, Stora Enso, as well as China-based ZRP Printing Co Ltd.⁷⁰

Paper and plastic packaging solutions for devices, smokeless tobacco, and NRT products are for the most part sourced from multi-industry players. In e-liquids, however, distinct players have developed particular styles and shapes for the market. Chubby Gorilla claims to be the world leader and industry standard for bottle manufacturing in the e-liquids market. Chubby Gorilla's products are designed and engineered in California, USA, but its major manufacturing facility is in China. In August 2020, it announced the opening of a 400,000 sqft facility in Hangzhou, China.^{71,72}

4. Key raw materials

4.1 Vaping device raw materials

The five essential components across all vaping devices are mouthpiece, liquid container (tank/pod), atomizer, PCBA, and battery. The other components listed in the table below are common, but not essential. In an evolving sector, new features are continuously being introduced. Individual brands also have pieces which connect different components together, such as seal pads for mouthpieces, fiberglass tubes for insulation, and controller cases, which for the most part are made of metals or plastics.

Table 5: Key vaping device components

| Component | Description |
|------------|---|
| Mouthpiece | Mouthpieces can be separate components or molded into the external casing, or be part of a disposable pod. Mouthpieces are made of plastic or metal. |
| Tank/Pod | The tank/pod is the container in which the e-liquid is held. In single-use and open systems it is fixed in the device, while it is the disposable cartridge/pod in rechargeable systems. The tank/pod is usually constructed of polycarbonate plastic, but can also be made of glass, which is more common in open systems. |
| Atomizer | The atomizer is the central component of a vaping device as it turns liquid into vapor. It can be a separate component or sit within the tank/pod. Atomizers typically contain a wick and a coil. The coil is wire, commonly made from a metal such as nickel-chromium, which is wrapped in a cotton or ceramic wick. |
| Batteries | Lithium-ion batteries are used starting from 350 milliampere hour (mAh) in single-use devices going up to 3,000 mAh in open system devices. |
| PCBA | Allow customizable features such as controlling temperature. |

⁶⁹ Swedish Match. Corporate Website, Accessed March 2023, from <https://www.swedishmatch.com/Our-business/smokefree/Snus-production/>

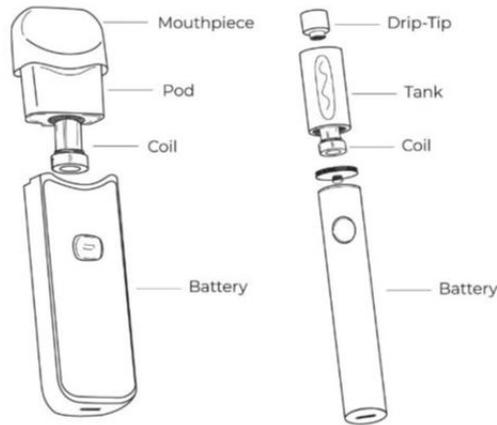
⁷⁰ Industry Consultation, March 2023.

⁷¹ Chubby Gorilla. Corporate Website, Accessed March 2023, from <https://www.chubbygorilla.com/us/en/press/chubby-gorilla-expands-yet-again-to-a-larger-manufacturing-facility/#>

⁷² Zhejiang Xinmeng Plastic Co. Ltd. Corporate Website, Accessed March 2023, from <https://www.yhxinmengplastic.com/e-liquid-bottle/gorilla-bottle/>

| | |
|----------------------|---|
| Activation Button | Activation (control) button releases the vapor. Not essential, as similar action can be achieved by drawing breath. |
| LCD Screen | Displays what functionality a specific brand offers and allows the users to engage with the functionality. |
| Airflow Control Ring | Airflow control ring allows users to adjust the amount of vape inhalation. |

Figure 1: Positioning of the Coil



Source: decadentvapours.com⁷³

Traditionally, the coil has been housed in the device, but for cartridge/ pod systems it is part of the disposable cartridge/ pod system.

Each device brand has its own specific components, although there are similarities within the core vaping device types of single-use closed systems, rechargeable closed system devices, and open system devices.

Single-use closed system devices

The disposable nature of the single-use closed system device means that as a category it tends to have more basic features. Some brands have added more sophisticated features as the category becomes more competitive. The Vapen Macro 2000, for example, has an adjustable bottom airflow, so the user can regulate the hit.⁷⁴ The GeekBar X5000, despite being disposable, has adjusted its product to include a charge port, as well as a transparent liquid container, to show how much e-liquid is left.⁷⁵ In 2022, FEELM Max was the first brand to introduce a ceramic wick to the single-use category.⁷⁶ The advantage of ceramic over cotton is that it can withstand higher temperatures, thereby reducing the chance of damage and metal oxidation.⁷⁷

The outer casings of single-use devices are commonly made from molded polycarbonate plastic, as per GeekBar, or aluminum, as per Bidi.⁷⁸ Recycling single-use devices is an emerging problem and research has been undertaken into using more biodegradable materials. For example, Smoore has created the FEELM Future concept, which replaces some plastic with paper and uses post-consumer recycled (PCR) or bio-based materials, the net effect being that it will use

⁷³ Decadent Vapors. A Quick Guide to Vaping for Beginners [UPDATED 2023], Accessed March 2023, from <https://decadentvapours.com/blog/tutorial/new-to-vaping/>

⁷⁴ Vapen Labs Retail Website. Accessed March 2023, from <https://www.vapenlabs.com/2021/03/the-development-history-and-internal-organization-of-disposable-vapes/>

⁷⁵ *The GeekBar X5000 - Does it get any Better?* Accessed March 2023, from <https://www.youtube.com/watch?v=vwzbfBuhuE>

⁷⁶ FEELM. Brand Website, *Winning Again! FEELM Max Awarded the Golden Leaf Award for "Most Promising Innovation"*, October 24, 2022, from <https://www.feelmttech.com/OfficialReports/54.html>

⁷⁷ RELX. Brand Website, *Ceramic Coils for Vaping: Pros and Cons*, August 30, 2022, from <https://ca.relnow.com/blogs/vape-knowledge/ceramic-coils-for-vaping>

⁷⁸ Bidi. Corporate Website, *Integrated Sustainability Report 2020-2021*, Accessed March 2023, from <https://wholesale.bidivapor.com/integrated-sustainability-strategy-report-2020-2021/>

60% less plastic than its existing brands.⁷⁹ ALD Group showcased prototypes using post-consumer recycled materials, which they claim can reduce plastic use by 75% and carbon emissions by 46%. ALD Group has also demonstrated it can use bio-based polylactic acid (PLA) materials for the outer shell of disposable products, which can be 100% degraded into the soil by plants.⁸⁰

Subsequent phases of this Study will aim to further delve into recycling.

Rechargeable closed system devices

Rechargeable closed system devices often have a greater number of sophisticated components, given they are built for greater longevity than single-use devices. The fundamental functionality of rechargeable and single-use devices is similar, with the key differences being that rechargeables have replaceable pods, in which the atomizer sits, and a charge port.

JUUL, in terms of value sales in 2021, was the world's leading cartridge brand for rechargeable closed system devices.⁸¹ JUUL's outer shell is made aluminum extracted from raw bauxite ore, and its pod outer case is made from food grade plastic. Internally, JUUL's pods circuit board is made from fiberglass epoxy resin bound on foil, and the coil is made of an alloy of nickel and chromium. JUUL uses a lithium-ion battery and has a USB magnet to help keep the product connected to the charging doc.⁸² Other leading pod systems are manufactured in similar ways, although variations exist by brand. Ceramic wicks, for example, are increasingly being adopted, with the RELX Pod Pro using such technology.⁸³ Although some premium single-use brands have ceramic wicks, ceramic wicks are more advantageous for rechargeable devices, as the higher resilience to heat aids longevity.

Rechargeable closed system devices produce less waste, as the replaceable pod component is disposed of on a regular basis and the battery has a longer life span. The pod, which is regularly disposed of, can contain electronic elements, magnets, metals, and plastics, which can cause environmental damage. Measures taken to reduce the environmental impact include Vuse removing silicon caps from its e-pen pods.⁸⁴

Open system devices

Open vaping devices contain tanks in which the user can refill the e-liquid of choice. The devices are built for long-term use, and components including batteries, tanks, and coils are often replaceable. The components tend to be larger as they are expected to be handled by consumers rather than being micro-engineered and sealed. The core operating principles for the key components of the atomizer, battery, and PCBA, remain the same as compared to other device types.

There are a wide range of open vaping devices, with Joye, for example, producing a number of varieties. At one end of the spectrum, is the large eVic Primo Fit with EXCEED Air Plus which has a 3ml e-liquid capacity and a built-in 2,800 mAh battery. In addition, the device has an LCD display, which quantifies key performance metrics and includes non-performance-related features such as a clock.⁸⁵ Joytech's eGo One, by comparison, is a smaller product, with fewer add-on features, although it comes with different options. Its batteries are either 1,100 or 2,200 mAh and with the product offers metal mouthpieces or organic glass mouthpieces.⁸⁶ Plastic and metal remain the dominant raw materials within open system devices, although increasingly brands use glass tanks and mouthpieces which are easier to recycle.

⁷⁹ Vaping Post. *FEELM named its new sustainable product as Future*, November 28, 2022, from <https://www.vapingpost.com/2022/12/02/feelm-named-its-new-sustainable-product-series-as-future/>

⁸⁰ Vaping HK. *ALD Leads Trend of Eco-friendly Vaping*, December 14, 2022, from <https://vape.hk/ald-leads-trend-of-eco-friendly-vaping/>

⁸¹ Euromonitor International's Passport, Tobacco database, updated May 2022.

⁸² Design Life-Cycle. *JUUL Life Cycle*. Accessed March 2023, from <http://www.designlife-cycle.com/juul>

⁸³ RELX. *Brand Website, Understanding Atomizers: Cotton vs Ceramic*, September 4, 2022, from <https://relxnow.com/blogs/product-information-review/understanding-atomizers-cotton-vs-ceramic>

⁸⁴ Vuse. *Brand website*, Accessed March 2023, from <https://www.vuse.com/gb/en/sustainability-carbon-neutral>

⁸⁵ Joyetech. *Brand Website*, Accessed March 2023, from <https://www.joyetech.com/product/evic-primo-fit-with-exceed-air-plus/>

⁸⁶ Joyetech. *Brand Website*, Accessed March 2023, from <https://www.joyetech.com/ego-one/>

4.2 E-liquids

Vaping liquids commonly share four core ingredients: vegetable glycerin, propylene glycol, flavoring, and nicotine. Brands vary and other ingredients are also present, but broadly speaking, vegetable glycerin and propylene glycol account for approximately 80% of an e-liquid’s volume.⁸⁷ The proportion of the remaining 20%, accounted for by flavorings and nicotine, varies depending on the product’s nicotine strength and flavor combinations. The leading closed vaping system brands, such as Vuse and JUUL, also use benzoic acid, which when combined with nicotine creates nicotine salts.⁸⁸ Use of nicotine salts is also becoming more frequent in e-liquids, but freebase nicotine, which does not require benzoic acid, is still the common option.

Table 6: Key ingredients in e-liquids

| Ingredient | Description |
|--------------------|---|
| Vegetable Glycerin | A clear, odorless liquid with a slightly sweet flavor. Its viscosity is responsible for the thickness of the vapor produced. E-liquids with a higher vegetable glycerin content create a thicker vapor cloud and stimulate a smoother throat sensation. Vegetable glycerin is sourced primarily from soybeans, palm hearts or coconut oil and is a commonly used ingredient across personal care and food products. |
| Propylene Glycol | A clear, odorless liquid with a slightly sweet flavor. It is syrupy in texture, but less viscous than vegetable glycerin. In vaping, propylene glycol’s primary function is to carry flavor. The higher the proportion of propylene glycol in a vape, the sharper its flavor. It also can generate a stronger throat sensation, to mimic the experience of cigarette smoking. Propylene glycol is derived from petroleum, although some manufacturers have started substituting propylene glycol for 1,3-propanediol, an organic plant extract. ⁸⁹ At present the latter is a niche trend and has a limited impact on the global supply of RRP raw materials. Other than in the manufacture of RRP, propylene glycol is commonly used in cosmetic products and as a food additive. |
| Extracted Nicotine | Nicotine can be sourced through solvent extraction, dry extraction, or supercritical extraction. To facilitate these processes, water, acids, alcohols, or mineral oils can be used as solvents. For supercritical extraction, CO2 is used, while in dry extraction, heating is required to create a steam/smoke which is dissolved in water. |
| Freebase Nicotine | Sourced from pure nicotine in tobacco, to which ammonia is added in order to increase its ability to move across organic membranes. This in turn heightens nicotine’s effect when used. The process of adding ammonia to create freebase nicotine has been used in cigarettes since the 1960s. ⁹⁰ The vaping sector was originally created with freebase nicotine, and it continues to be the most common form of nicotine used in e-liquids. |
| Nicotine Salts | Derived from pure nicotine in tobacco, but rather than having ammonia added to it, benzoic acid is added. The addition of benzoic acid creates a chemical reaction allowing nicotine to be more readily absorbed. Benzoic acid also lowers nicotine’s pH levels, which creates a smoother throat sensation. Nicotine salts are a relatively new innovation but are used by the world’s three largest e-vapor brands by value sales: JUUL; Vuse; and RELX. |
| Synthetic Nicotine | Not derived from tobacco, but from chemical substances, such as ethanol, niacin, and sulphuric acid. Synthetic nicotine is in its relatively early stages of development, but |

⁸⁷ Ruthless Vapor. Brand Website, Accessed March 2023, from <https://www.ruthlessvapor.com/blogs/ruthless-e-liquid/whats-in-vape-juice>

⁸⁸ Vuse. Brand Website, Accessed March 2023, from <https://www.vuse.com/gb/en/know-your-vape/nicotine-salts-what-are-nic-salts>

⁸⁹ NATURACIG. Brand Website, Accessed March 2023, from <https://naturacig.com/blogs/e-liquides/le-propanediol-dans-les-e-liquides>

⁹⁰ Ruthless Vapor. Brand Website, Accessed March 2023, from <https://www.ruthlessvapor.com/blogs/ruthless-e-liquid/nicotine-salt-vs-freebase-why-nicotine-salt-is-the-new-craze>

| Ingredient | Description |
|-------------------|---|
| | has been adopted by Puff Bar, ⁹¹ the world's leading single-use vaping brand by value sales in 2021. ⁹² |
| Flavors | Usage varies by brand. RELX, for example, states that between 1% and 10% of its liquid is flavoring. Ingredients vary by specific brand and can be natural or synthetic. Natural flavors are extracted from natural materials and often contain many flavor components. For this reason, they may be less precise in their application. Synthetic flavors are produced through chemical reactions and the specific flavors are created individually with the quantity specified. |
| Other Ingredients | There are additional ingredients which have received negative publicity. These include acrylamide and formaldehyde, which are reported as carcinogens, diacetyl, which is associated with bronchiolitis, acetoin, which is suspected of causing lung disease, and acetylpropionyl, which is an irritant that can be absorbed into the bloodstream. Certain claims are disputed; however, it is noticeable the major manufacturers have distanced themselves from specific ingredients. BAT's Vuse website, for example, says, " <i>To put it simply, we do not add any of the following harmful ingredients to our vaping products: Acetoin; Diacetyl; Methyl Eugenol; Oils containing THC or Vitamin E Acetate; or 2,3-Pentadione.</i> " ⁹³ |

4.3 Heated tobacco

The internal workings of heated tobacco devices have similarities to vaping devices in that they have a battery and PCBA. They also have a heating element but not the uniformity of a coil as for vaping devices. Heating technology was introduced with blades, which have direct contact with the tobacco. Heating blades remains the most common component used by heated tobacco devices. However, IQOS Iluma, for example, has introduced bladeless technology, whereby a coil transfers heat through magnetic induction. An advantage of this process is that residue does not occur on the blade, which can reduce heating performance and impact taste.

Separate heated tobacco sticks are inserted into heated tobacco devices, replacing the function of the mouthpiece in vaping devices. Heated tobacco sticks raw materials can broadly be broken down into two categories - those that are inhaled, and those that support the delivery system. PMI has a 70% retail volume share of the heated tobacco, and its market leading brand is IQOS.⁹⁴ Regarding ingredients that are consumed, tobacco is the most significant, accounting for approximately 65%.⁹⁵ The tobacco used in heated tobacco sticks is ground to dust and then reconstituted into sheets, from which the brand owners create the plugs that are used in the stick. The other inhaled ingredients are glycerol (~16%), water (~12%), cellulose (~3%), guar gum (<1%), flavorings (<1%), and propylene glycol (<1%). The core non-inhaled components are a hollow acetate tube, polymer-film filter, cellulose-acetate mouthpiece filter, and outer and mouth-end papers. The breakdown of raw materials is filtration materials (~70%), paper and wrappers (~20%), tipping papers (~5%), and adhesives (~2%).⁹⁶

The process of manufacturing heated tobacco sticks is similar to that of cigarettes and often both products are made at the same facility. A key difference in the tobacco used is that the moisture level in heated tobacco sticks is lower at approximately 9%. This is because with heated tobacco sticks, steam can form in the user's mouth, which is referred to as "hot puff". Conversely there is less filter resistance in heated tobacco sticks compared to those in cigarette filters, enabling an easier inhalation of vapor compared to smoke from cigarettes.⁹⁷

⁹¹ Puff Bar. Brand Website, Accessed March 2023, from <https://uk.puffbar.com/blogs/puff-blogs/are-puff-bars-banned?shpxid=eee343a6-695d-44db-8fc8-474c4ef0364b>

⁹² Euromonitor International's Passport, Tobacco database, updated May 2022.

⁹³ Vuse. Brand Website, Accessed March 2023, from <https://www.vuse.com/za/en/know-your-vape/about-our-eliq-ingredients>

⁹⁴ Euromonitor International's Passport, Tobacco database, updated May 2022.

⁹⁵ Euromonitor International's Passport, Tobacco database, updated May 2022.

⁹⁶ PMI. Corporate Website, Accessed March 2023, from <https://www.pmi.com/investor-relations/overview/making-heated-tobacco-products#:~:text=HEETS%20are%20made%20up%20of,outer%20and%20mouth%20Dend%20papers.>

⁹⁷ Industry consultations, March 2023.

4.4 Smokeless tobacco

While outsourcing manufacturing is prevalent in vaping products, it is less so for snus, snuff, and chewing tobacco. DS Group, Swedish Match, Altria, BAT, and Imperial Brands produce brands, and the ingredients listings where available are similar.

Tobacco is the primary ingredient in snus, snuff, and chewing tobacco with other ingredients principally being used to balance pH value, maintain moisture levels, or add flavor. Common ingredients are highlighted in the table below:

Table 7: Key ingredients in smokeless tobacco⁹⁸

| Ingredient | Function | Description |
|------------------------|--------------------------------|---|
| Potassium Carbonate | pH balance | Makes the tobacco more alkaline and eases the absorption of nicotine. |
| Sodium Carbonate | pH balance | Reduces acidity. It is a natural compound but can also be manufactured artificially. |
| Calcium Chloride | pH balance | As well as adjusting pH it promotes sweetness. Calcium chloride can be derived from limestone or through the purification of brine. |
| Magnesium Carbonate | pH balance | Magnesium carbonate is usually obtained by mining the mineral magnesite, and 70% of the world's supply originates in China. |
| Propylene Glycol | Moisture and product integrity | Propylene glycol helps keep the product stable and prevent bacteria growth. In Sweden, it must not exceed 4% of the final product's weight. |
| Sodium Chloride (Salt) | Flavor | As well as adding flavor, salt can act as a preservative. |
| Xylitol | Flavor | A natural sweetener added to some snus products. |

Other ingredients cited by specific brands include ethyl alcohol, ammonium carbonate, and sodium saccharin. DS Group, the world's leading chewing tobacco brand owner, by volume in 2021⁹⁹ uses a range of natural flavors including silver and saffron.¹⁰⁰

Swedish Match is the world's largest snus manufacturer accounting for almost 50% of global volume sales in 2021.¹⁰¹ Swedish Match's production is based in Sweden and Denmark. Raw tobacco is sourced from various countries across South America, Africa, and Asia. The raw tobacco is ground into a coarse, intermediate and fine meal at Swedish Match's factories. By contrast Altria's tobacco for smokeless tobacco is locally sourced in the USA and shipped to its manufacturing operations in Nashville, Tennessee and Hopkinsville, Kentucky.¹⁰²

Swedish Match's portioned snus is wrapped in cellulose fiber tubes, which are then sealed crosswise and cut apart into pellets. Portioned snus is packed in a polypropylene plastic can, which is used to stop the snus drying out. Loose snus is packed in paraffin-coated cardboard tins, which have a polypropylene lid.¹⁰³ Swedish Match produces the cardboard cans itself while it outsources the plastic cans.

⁹⁸ Swedish Match and Altria smokeless tobacco websites
<https://www.swedishmatch.ch/en/what-is-snus/snus-production/ingredients/>
<https://www.ussmokeless.com/products/making-our-smokeless-products>

⁹⁹ Euromonitor International's Passport, Tobacco database, updated May 2022.

¹⁰⁰ DS Group. Corporate Website, Accessed March 2023, from
<https://www.dsgroup.com/our-businesses/tobacco#baba>

¹⁰¹ Euromonitor. Passport, Tobacco System, 2022

¹⁰² Altria Group Inc. Subsidiary Website, Accessed March 2023, from
<https://www.ussmokeless.com/products/making-our-smokeless-products>

¹⁰³ Swedish Match. Corporate Website, Accessed March 2023, from
<https://www.swedishmatch.com/Our-business/smokefree/Snus-production/#content1>

4.5 Non-tobacco nicotine pouches

For non-tobacco nicotine pouches, in comparison to snus, the core ingredient of tobacco is replaced with manufactured nicotine. Zyn (Swedish Match), the world's leading non-tobacco nicotine brand by volume sales in 2021,¹⁰⁴ is made using a pharmaceutical-grade version of the same nicotine salt found naturally in tobacco leaves.¹⁰⁵

Velo (BAT), the world's second highest selling brand in volume terms,¹⁰⁶ uses pharmaceutical-grade nicotine polymer that contains no tobacco. Other than manufactured nicotine, the other ingredients found in non-tobacco nicotine pouches, are similar to snus, with flavors used varying by brand. Table 8 below illustrates Zyn's ingredient list as an example.¹⁰⁷

Table 8: Key ingredients in non-tobacco nicotine pouches

| Ingredient | Function | Description |
|---|------------|--|
| Nicotine Salt (Nicotine Bitartrate Dihydrate) | Nicotine | Derived from pure nicotine in tobacco, with the addition of benzoic acid. |
| Hydroxypropyl Cellulose | Stabilizer | A plant-based food additive used to maintain pouch consistency. |
| Micro crystalline Cellulose | Fillers | Ingredients used to add bulk to each pouch. Commonly found in chewing gum. |
| Maltitol | Fillers | Ingredients used to add bulk to each pouch. Commonly found in chewing gum. |
| Gum Arabic | Fillers | Ingredients used to add bulk to each pouch. Commonly found in chewing gum. |
| Sodium Carbonate | pH balance | Reduces acidity. It is a natural compound but can also be manufactured artificially. |
| Sodium Bicarbonate | pH balance | Minerals used in baked goods to help adjust pH levels. |
| Acesulfame K | Flavor | Sugar substitute often used in beverages and confectionery as a flavor enhancer. |
| Food-Grade Flavorings | Flavor | Natural additives used to enhance the taste of each pouch. |

4.6 NRT products

NRT products consist of four main categories - gums, lozenges, patches, and inhalators - but continued innovation has seen the launch of additional products including sprays, microtabs, and capsules. NRT products represent the origins of the RRP sector and remain significant with retail value sales of over USD10 billion per annum. That said, NRT product sales have been overtaken by newer RRP categories, with vapor products generating retail value sales of USD23 billion in 2021.¹⁰⁸

NRT gum is medicated chewing gum produced from a gum base, nicotine, and a buffering agent, with other ingredients varying by brand.¹⁰⁹ The gum base can be from natural bases such as balata, or synthetic, consisting of elastomers and plasticizers, while the buffering agents are usually metal carbonates and glycinates. To the gum and buffering agents, a number of different agents such as fillers, lubricant, flavors, and preservatives can be added.

¹⁰⁴ Euromonitor International's Passport, Tobacco database, updated May 2022.

¹⁰⁵ Zyn. Brand website, Accessed March 2023, from <https://us.zyn.com/questions/>

¹⁰⁶ Euromonitor International's Passport, Tobacco database, updated May 2022.

¹⁰⁷ Zyn. Brand Website, Accessed March 2023, from <https://us.zyn.com/questions/>

¹⁰⁸ Euromonitor International's Passport, Tobacco database, updated May 2022.

¹⁰⁹ European Patent Specification. Process for manufacture of nicotine comprising chewing gum, April 4, 2018, from <https://patentimages.storage.googleapis.com/f1/a1/40/a1585cde2f674e/EP2480221B1.pdf>

NRT lozenges, similar to gums, can have a wide range of ingredients. Fillers, such as calcium sulphate or calcium carbonate, and binders such as acacia and corn syrup, are combined with lubricants such as magnesium stearate.

NRT patches place nicotine in a permeable membrane, which is attached to the skin with an adhesive. The rate at which the nicotine is then absorbed by the user is controlled by an element such as ethylene vinyl acetate copolymer.

NRT microtabs are manufactured by compressing nicotine with other ingredients such as sodium bicarbonate into a tablet and wrapping it with a film by adding a hydroxypropyl methylcellulose and plasticizer to purified water.

NRT inhalators and sprays use devices to deliver the nicotine solution. The inhalators use a plastic cylindrical cartridge, with a porous plug, made from plastic fibers. NRT sprays mix nicotine with a pharmaceutical solvent such as phosphate buffered saline, which is delivered by a plastic pump.

The variety of products means that the category has a wide array of ingredient inputs. An indicative summary of key active ingredients is supplied in Table 9, however there are several substitutional ingredients, and in addition there are numerous flavor options and packaging solutions involved in the supply chain. Packaging materials have similarities with those used by other RRP categories, with the exception of aluminum blister packs common to gum, lozenges, and microtabs.

Table 9: Key ingredients in NRT products

| Ingredient | Product format | Description |
|----------------------------|-------------------------|---|
| Nicotine | All | Nicotine can be extracted from tobacco, or from chemical substances, such as ethanol, niacin, and sulphuric acid. |
| Acrylic Adhesive Solution | NRT Patches | The adhesive is used to mount the patch on the skin. Acrylic adhesive solution has a low level of allergenicity and is water resistant. |
| Anhydrous Ethanol | NRT Mouthspray | Ethanol is widely used as solvent in mouthwashes. |
| Beta-Cyclodextrin | NRT Microtabs | Beta-cyclodextrin, also known as Betadex, is used as an excipient to solubilize water-insoluble drugs, enhance drug stability, improve efficacy or lower dosage of drugs, moderate and control drug release, and to diminish the toxicity and side effects of drugs. |
| Butylated Hydroxytoluene | NRT Gum, NRT Mouthspray | As a part of chewing gum base, butylated hydroxytoluene (BHT) is an additive used as an antioxidant and preservative. It is produced by reacting 4-methylphenol with isobutylene with a catalyst. |
| Carnauba Wax | NRT Gum | Carnauba wax is a natural vegetable wax that comes from the leaves of the Brazilian carnauba tree. It is often used as a release agent and coating material in the food industry, particularly in chewing gum. |
| Citric Acid | NRT Nasal Spray | Citric acid is used for pH level stabilization and acidity regulation. It is manufactured commercially by starch hydrolyzate using mold cultures. Naturally it can be found in many fruits, particularly citrus. |
| Colloidal Anhydrous Silica | NRT Microtabs | Colloidal silica is an inorganic substance widely used as an excipient in pharmaceutical preparation. In tablets, capsules, and granules, colloidal silicon dioxide is popularly used as a glidant and anti-adherent, where it allows powder formulations to efficiently flow on high-speed tablet presses. |
| Disodium Edetate | NRT Nasal Spray | Disodium edetate, also known as EDTA, is a chelating agent that sequesters a variety of polyvalent cations such as calcium. It is used in pharmaceutical manufacturing to disrupt biofilm which are harboring bacteria and fungi in the nasal passages. |

| Ingredient | Product format | Description |
|---------------------------------------|-----------------------------|--|
| Disodium Phosphate Dodecahydrate | NRT Nasal Spray | Disodium phosphate dodecahydrate is an acidity regulator. |
| Ethylene Vinyl Acetate Copolymer | NRT Patches | Ethylene vinyl acetate (EVA) is used to control the rate at which NRTs are delivered through patches. |
| Hypromellose | NRT Gum | Hypromellose is a polymer used in medicated chewing gum. It is one of the components of chewing gum's sub-coating. It provides the release of a drug in a controlled manner, effectively increasing the duration of release of a drug to prolong its therapeutic effect. |
| Magnesium Oxide | NRT Gum | Magnesium oxide is added to chewing gum as an element of the core gum to neutralize the acidity of the mouth. |
| Magnesium Stearate | NRT Microtabs, NRT Lozenges | Magnesium stearate is the magnesium salt of the fatty acid, stearic acid. It is used as an emulsifier, binder, and thickener. |
| Medium Chain Triglycerides | NRT Patches | Medium-chain triglycerides (MCTs) contain a mixture of fatty acids of 6-12 carbon saturated fatty acids. They serve for better transdermal penetration of the active ingredient in NRT patches. |
| Poloxamer 407 | NRT Mouthspray | Poloxamer 407 is used as an emulsifying agent and solubilizing agent. |
| Polysorbate 80 | NRT Gum, NRT Nasal Spray | Polysorbate 80, also known as Tween 80, is a non-ionic surfactant and emulsifier. It is manufactured by the reaction between sorbitol, a fatty acid, and ethylene oxide. |
| Sodium Carbonate Anhydrous | NRT Gum, NRT Lozenges | Also known as soda ash or calcined soda, sodium carbonate is used as a food additive, acidity regulator, and stabilizer. It constitutes a part of core gum. It is produced from limestone or trona ore. |
| Sodium Chloride | NRT Nasal Spray | Sodium chloride, also known as table salt, is added to nasal spray for moisturizing properties. |
| Sodium Dihydrogen Phosphate Dihydrate | NRT Nasal Spray | Sodium dihydrogen phosphate dihydrate is a reagent with high buffering capacity. |
| Sodium Hydrogen Carbonate | NRT Gum | Also known as baking soda, or bicarbonate of soda, sodium hydrogen carbonate is used as an acidity regulator and stabilizer. Adding bicarbonate as a part of core gum is beneficial for oral health. |
| Talc | NRT Gum | Talc acts as a filler and texturizing and anti-sticking agent in the manufacture of chewing gum. Talc is a hydrated magnesium silicate. |

5. Extraction impact

The negative environmental impact of the production of high-risk tobacco products (HRPs) is well documented. Tobacco farming is associated with deforestation, soil degradation, and water use, while tobacco processing requires high energy use and high CO2 emissions. In addition, paper and plastics are heavily used in the production of cigarettes and packaging. However, PMI, for example, highlights that “In general, our smoke-free products have a higher carbon footprint than combustible cigarettes. This is primarily due to the inclusion of an electronic device, which involves new components and requires electricity to charge. Additionally, the process used to manufacture consumables such as HTUs (heated tobacco units) is more energy intensive than for cigarettes due to the production of cast leaf tobacco.”¹¹⁰

In essence, RRP require more components and manufacturing processing than HRP. While this means RRP have a greater environmental footprint, it also means there are multiple points to potentially reduce such impact. This report highlights the potential environmental impact of the key RRP components. Meanwhile, the environmental impact of the final product and its disposal will be assessed in detail in a later report in this same series.

¹¹⁰ PMI. Integrated Report 2021, P.109, from https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

Tobacco cultivation

Tobacco cultivation has a significant environmental impact and the majority of RRP are sourced from tobacco, either by using it directly or by extracting nicotine from it. In total impact terms, RRP have a relatively small contribution in comparison to cigarettes. In 2021, 120,000 tonnes of smokeless tobacco were sold.¹¹¹ In comparison 5,200 billion cigarettes were sold. With the average cigarette containing 0.7g of tobacco this equates to over four million tonnes of tobacco.¹¹² While the scale of cigarette usage and the quantities of tobacco used have a more significant impact, RRP consumption is growing at a faster rate and addressing environmental concerns is becoming an increasing focus.

At an aggregate level, the World Health Organization (WHO) estimates that global tobacco cultivation utilizes 5.3 million hectares of agricultural land and accounts for 6,500 hectares of deforestation per year. It is estimated that the sector's annual climate change impact at 84 tonnes of CO₂ equivalent (MTCO₂e) accounts for 0.2% of the global total. Water depletion caused by tobacco is estimated to be 22.2 billion cu m per year.¹¹³

Tobacco brand owners do not commonly grow tobacco, but source it from third-party farmers. Tobacco is a traded commodity, but brand owners have established ongoing relationships with growers, and a number have set up schemes to reduce the environmental impact. PMI, for example, estimates that its contract farmers use 100 million cu m of water for irrigation each year. It is introducing schemes to reduce this figure to 10 million cu m per year by 2030.¹¹⁴ JT has set a target to reduce water withdrawal from its business by 15% and has introduced initiatives with its contract farmers to reduce deforestation.¹¹⁵ These include encouraging the building of “live barns” where trees form the main structure of curing barns, while it pledges to replace all wood from natural forests used in the tobacco curing process of its directly contracted growers with renewable fuel sources.¹¹⁶

China, Brazil, and India are the world's largest tobacco producers, together accounting for approximately 60% of global supply. Tobacco, however, is a global crop and a number of smaller countries are heavily dependent on it for income generation. For example, tobacco accounts for 8.5% of Malawi's GDP, 3.5% of Zimbabwe's and 2% of Mozambique's. RRP companies commonly source tobacco from a wide variety of countries. Swedish Match sources tobacco from South America, Africa, and Asia. PMI sources tobacco from 30 countries including Argentina, Brazil, China, Greece, Italy, Malawi, Mozambique, Spain, Tanzania, Turkey, and the USA. Altria sources the majority of its tobacco from the USA, exclusively so when it comes to smokeless tobacco. BAT illustrates the diversity of tobacco supply, by stating that it has contracts with over 75,000 farmers, and then through third-party contracts is supplied by a further 250,000.¹¹⁷ A number of companies that produce nicotine to be used in RRP have facilities in India and source tobacco directly from there. Contraf-Nicotex-Tobacco GmbH (CNT) has a processing facility in India, Alchem operates three manufacturing plants in India, and BGP is an India-based company.

The extraction of nicotine from tobacco to produce RRP that do not directly use tobacco is adding another level of processing to the farming and curing of tobacco, as too is reconstituting it into tobacco sheets for heated tobacco. As a minimum this adds another layer of fuel and energy environmental costs, from a factory and logistics perspective. For nicotine extraction, there is also the environmental cost of sourcing whatever element is used for processing. The elements used vary including water, ammonia, acid, and CO₂. Similar elements are used in the creation of synthetic nicotine, but without the associated cost of tobacco farming. The process of creating synthetic nicotine is still niche and

¹¹¹ Euromonitor International's Passport, Tobacco database, updated May 2022.

¹¹² Malson, J., Sims, K., Murty, R. & Pickworth, W. (2001). Comparison of the nicotine content of tobacco used in bidis and conventional cigarettes. *Tobacco Control*. 2001 June. Volume 10 (2): 181-183. doi: 10.1136/tc.10.2.181

¹¹³ WHO FCTC, Imperial College London. Cigarette Smoking - An assessment of tobacco's global environmental footprint across its entire supply chain, and policy strategies to reduce it.

¹¹⁴ PMI. Integrated Report 2021, P.180, from

https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

¹¹⁵ JT. Corporate Website, Accessed March 2023, from

<https://www.jt.com/sustainability/environment/index.html>

¹¹⁶ JT. Integrated Report 2021, P. 77

¹¹⁷ BAT. Corporate Website, Supply Chain Management, Accessed March 2023, from

https://www.bat.com/group/sites/UK__9D9KCY.nsf/vwPagesWebLive/DOC88FUS

there are different methodologies used. Lack of reliance on raw tobacco, however, means it avoids the impact of farming.

Propylene glycol

Propylene glycol, a key ingredient in e-liquids, is traditionally formed using propylene monomers, which is dependent on fossil fuels, and therefore it has an inherent environmental impact. Techniques have developed to produce propylene glycol from bio-feedstock, namely glycerin, thus reducing its environmental output.¹¹⁸

Vegetable glycerin

Vegetable glycerin, being plant based, is biodegradable, meaning it will break down naturally in the environment. It is not toxic to aquatic life, so it poses no threat to fish or other organisms living in water. While it may not be toxic, there are extraction consequences. Palm is the major source for vegetable glycerin, as it is for a large proportion of foods and beauty products. If not managed, the scale of the demand poses a significant risk to deforestation.

Paper

Deforestation is a threat from tobacco farming, but also from the usage of pulp and paper and cellulose acetate. Cigarettes and packaging are the biggest contributors to this in the tobacco industry, but heated tobacco sticks also contribute. Heated tobacco brand owners do not source pulp and paper directly, but they have set targets to reduce the impact of deforestation from supply chains. BAT, for example, has set the target of “Net Zero deforestation by 2025 of managed natural forests in our tobacco, paper and pulp supply chains.” In relation to this in 2022, 94% of the paper and pulp volumes it uses are certified as sourced sustainably.¹¹⁹ PMI publishes a document called “PMI Zero Deforestation Manifesto and Commitments”, in which it targets: “Zero gross deforestation of primary and protected forest associated with PMI’s paper and pulp-based materials supply chain by 2025; and zero net deforestation of managed natural forest in the paper and pulp-based products PMI’s supply chain and no conversion of natural ecosystems by 2030.”¹²⁰

In RRP, to date most environmental activities have been focused on reducing packaging usage. PMI, for example, for its heated tobacco sticks packaging, has worked with its suppliers to provide board that is 10% lighter.¹²¹

Plastics

Plastics are an integral part of RRP devices. The outer casing is often made of plastic, as seen with GeekBar X5000. Plastic is also used for internal parts, including e-liquid tanks, caps, and heated tobacco sticks. Packaging also often consists of plastic, and this also applies to smokeless tobacco, although cardboard packaging is also prevalent.

Specific plastics used vary, but the majority are made from fossil fuels - oil, gas, or coal. Usage therefore has an inherent environmental impact. Altria acknowledges that and states: “Today, all the plastics used in our products and packaging are fossil fuel derived.” Altria also states that it is looking into biodegradable, bioderived, and recycled content plastics, but that currently recycled and bioderived plastics are not commercially available in quantities needed.¹²²

Brands such as FEELM and ALD have experimented with using post-consumer recycled (PCR), which reduces the impact of plastic. Plastic derived from polylactic acid (PLA), as used by ALD, is another innovation. PLA is derived from renewable resources, such as corn starch or sugar cane. PMI also uses PLA in the manufacture of its HEETS heated

¹¹⁸ S&P Global. *Propylene Glycol from Glycerin*, Accessed March 2023, from <https://www.spglobal.com/commodityinsights/en/ci/products/chemical-technology-pep-propylene-glycol-from-glycerin-2007.html>

¹¹⁹ BAT. Annual Report, 2022. P.6.

¹²⁰ PMI. PMI Zero Deforestation Manifesto and Commitments V.20/04.02.2021

¹²¹ PMI. Integrated Report 2021, P.109, from

https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

¹²² Altria. Protect the Environment 2020-2021 Corporate Responsibility Progress, P.24, from

<https://www.altria.com/-/media/Project/Altria/Altria/responsibility/corporate-responsibility-reports/protect-the-environment-2020-2021.pdf>

tobacco sticks.¹²³ PLA polymers are considered biodegradable and compostable. According to research, the carbon emissions associated with PLA production are 80% lower than that of traditional plastic.¹²⁴

Cellulose fibers are commonly used in the outer wrappings of snus and non-tobacco nicotine pouches. While these will eventually degrade it can take a long time.¹²⁵ As the category expands though new techniques are being developed to improve sustainability. Nonwovenn, for example, uses Lyocell, a regenerated cellulose, which can be manufactured with non-toxic solvents and water, which are both then fully recycled.¹²⁶

Reducing raw material use will inevitably reduce environmental impact. Initiatives include BAT removing the polypropylene device overwrap and replacing plastic trays with pulp-based alternatives for its glo devices and starter kits.¹²⁷ glo also reduced the number of components it produces by removing the separate AC adapter in its starter sets. PMI, for Iluma, launched in 2021, removed plastic shrink film and plastic windows, which led to a 9-ton reduction in plastic. Additionally new technology in plastics is 40% lighter and 20% smaller representing a 43-ton fiber-based packaging reduction.¹²⁸ The absolute weight of the plastic used in PMI's TERA heated tobacco stick has reduced by 45% in comparison to HEETS.¹²⁹

While companies are experimenting with alternatives, the vast majority of plastics used in the RRP sector remain fossil fuel based.

Metals

Aluminum is used in electronic components and in the outer casing of vaping devices, such as Bidi. 95% of global aluminum is produced from refining bauxite into alumina, which in turn is smelted into aluminum metal.¹³⁰ The process of smelting alumina into aluminum metal is electricity intensive. Bauxite is sourced from open pit mines, with the largest world producers being Australia, China, and Guinea.¹³¹ The major environmental impact of its extraction is water pollution and land degradation. Re-vegetation schemes are one way in which this can be mitigated, although at present adoption of these is limited.

Nickel is a component used within batteries and is also smelted with chromium. Nickel-chromium is the most prominent material used in coils. Indonesia, the Philippines, and Russia are the world's biggest nickel producers, while South Africa, Turkey, and Kazakhstan are the biggest chromium manufacturers.¹³² The mining process uses fossil fuels and can lead to land and water degradation. For nickel there is also an issue with mining waste, as only a small proportion of what is extracted can be used. In Indonesia, companies are increasingly using deep sea disposal for waste.¹³³

¹²³ IQOS Brand Website Greece. Accessed March 2023, from <https://gr.iqos.com/en/myiqos/get-support/faq-list/sup-directive#:~:text=They%20are%20biodegradable%20but%20they,all%20of%20which%20are%20compostable>

¹²⁴ BioPak. Australian Website, *What is PLA?* Accessed March 2023, from <https://www.biopak.com/au/resources/what-is-pla>

¹²⁵ Swedish Match. Corporate Website. Put the pouch in the garbage, Accessed March 2023, from <https://www.swedishmatch.com/Media/Pressreleases-and-news/News/put-the-used-pouch-in-the-garbage/>

¹²⁶ Nonwovenn. Corporate Website. Lyocell: A staple fibre suited to the future of modern oral products, Accessed March 2023, from <https://nonwovenn.com/pouchtech/pouchtech-innovations/lyocell-based-fabrics/>

¹²⁷ BAT. ESG Report 2021, P.47, from [https://www.bat.com/group/sites/UK__9D9KCY.nsf/vwPagesWebLive/DOAWWEKR/\\$file/BAT_ESG_Report_2021.pdf?open&v=1](https://www.bat.com/group/sites/UK__9D9KCY.nsf/vwPagesWebLive/DOAWWEKR/$file/BAT_ESG_Report_2021.pdf?open&v=1)

¹²⁸ PMI. Integrated Report 2021, P.115, from https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

¹²⁹ PMI. Integrated Report 2021, P.109, from https://pmidotcom3-prd.s3.amazonaws.com/docs/default-source/pmi-sustainability/pmi-integrated-report-2021.pdf?sfvrsn=646e6ab6_4

¹³⁰ Geoscience Australia, *Aluminium*, Accessed March 2023, from <https://www.ga.gov.au/education/classroom-resources/minerals-energy/australian-mineral-facts/aluminium>

¹³¹ NS Energy. *Profiling the top five bauxite producing countries in the world*, January 14, 2021, from <https://www.nsenerybusiness.com/news/profiling-the-top-five-bauxite-producing-countries-in-the-world/>

¹³² Investing News. *Top 9 Nickel-producing Countries (Updated 2023)*, February 23, 2023, from <https://investingnews.com/daily/resource-investing/base-metals-investing/nickel-investing/top-nickel-producing-countries/#toggle-gdpr>

¹³³ Mining.com. *As demand for nickel grows, so do environmental concerns* - report, October 11, 2020, from <https://www.mining.com/as-demand-for-nickel-grows-so-do-environmental-concerns-report/>

Batteries

Lithium-ion batteries are the dominant energy source used in both single-use and rechargeable devices. Since commercialization in the 1990s, lithium-ion batteries have become ubiquitous in electronic devices, principally because of their high energy density, allowing more time between charges. They are also low maintenance and the higher voltage produced per cell (approximately 3.6 volts) means that fewer cells are required, simplifying the power management of electronic devices.¹³⁴In 2021, 106,000 tonnes of lithium was extracted, of which it is estimated 74% was used in the production of batteries, equating to approximately 80,000 tonnes.¹³⁵ Given the breadth of use across electronic devices, vaping and heated tobacco devices account for a very small proportion of this. It is estimated that each vaping device uses approximately 0.15g of lithium.¹³⁶

Lithium-ion batteries have environmental advantages over other battery varieties as their raw materials are viewed as less harmful than substances such as cadmium, lead, and mercury. However, while lower, the main raw materials of lithium-ion batteries - lithium, carbon, manganese, nickel, and cobalt - do have an environmental impact, and concerns have been raised over the sourcing of these materials.

The lithium extraction process involves drilling holes in salt flats and pumping a mineral-rich brine to the surface. From this, lithium salts are extracted after several months of evaporation. It is estimated that 500,000 gallons of water are used in the extraction of one tonne of lithium.¹³⁷ Taking this water out of the ecosystem, combined with open pit mines and waste, cause disruption to vegetation and can create toxic soils.

According to the World Economic Forum, Australia is the world's largest producer of lithium, extracting 55,000 tonnes in 2021, equating to 52% of global supply. 90% of its output was exported to China. Chile was the second largest producer, accounting for 25% of global supply. It is estimated that in Chile's Salar de Atacama, mining activities consumed 65% of the region's water. China is the third largest producer of lithium, accounting for 13% of supply, while it accounts for 60% of global refining capacity for lithium batteries.¹³⁸

It is argued that a benefit of lithium-ion batteries is that certain components are recyclable and that this can reduce the environmental impact of further extraction. Bidi (Kaival Brands), for example, specifies the proportion and components of its battery that can be recycled - graphite, copper (17%), electrolyte solution (15%), separator plastics (3%), carbon and black binder (4%), aluminum (8%), and active cathode material (31%) including lithium cobalt oxide, lithium oxide, lithium nickel, and cobalt aluminum oxide.¹³⁹Bidi has begun a recycling program, as have other RRP manufacturers. It is not, however, entirely clear how devices are recycled. Vuse, for example, states in relation to its disposable device that once returned "We will try and find more sustainable ways to dispose of them to prevent them from ending up in landfill or being fully incinerated."¹⁴⁰ Regardless of the efforts of companies, the majority of lithium-ion batteries are thrown away. In Australia, it is estimated that only 2% of total lithium-ion waste, not limited to RRPs, is recycled.¹⁴¹

¹³⁴ Electronics Notes. Lithium-Ion Battery Advantages & Disadvantages, Accessed March 2023, from https://www.electronics-notes.com/articles/electronic_components/battery-technology/li-ion-lithium-ion-advantages-disadvantages.php

¹³⁵ World Economic Forum, *Lithium Production by Country*, Accessed March 2023, from <https://www.weforum.org/agenda/2023/01/chart-countries-produce-lithium-world/#:~:text=The%20three%20largest%20producers%20of,3%20million%20tonnes%20by%202030.>

¹³⁶ Material Focus. *One million single use vapes thrown away every week contributing to the growing e-waste challenge in the UK*, Accessed March 2023, from <https://www.materialfocus.org.uk/press-releases/one-million-single-use-vapes-thrown-away-every-week-contributing-to-the-growing-e-waste-challenge-in-the-uk/>

¹³⁷ Institute for Energy Research. *The Environmental Impact of Lithium Batteries*, November 12, 2020, from <https://www.instituteforenergyresearch.org/renewable/the-environmental-impact-of-lithium-batteries/>

¹³⁸ World Economic Forum, *Lithium Production by Country*, Accessed March 2023, from <https://www.weforum.org/agenda/2023/01/chart-countries-produce-lithium-world/#:~:text=The%20three%20largest%20producers%20of,3%20million%20tonnes%20by%202030.>

¹³⁹ Kaival Brands Innovations Group Inc. *Integrated Sustainability Strategy Report 2020-2021*, P.11

¹⁴⁰ BAT. Vuse website, Accessed March 2023, from <https://www.vuse.com/gb/en/takeback>

¹⁴¹ Wired. *The spiralling environmental cost of our lithium battery addiction*, Accessed March 2023, from <https://www.wired.co.uk/article/lithium-batteries-environment-impact>

Other ingredients/raw materials

As highlighted in section 4, there are many ingredients that can contribute to RRP. While in percentage terms the majority make up a very small proportion of an RRP offering, their impact still needs to be considered, as formulations and production methods continue to develop. All chemical reactions, mining, farming, and processing activities have an impact. For example, the synthetic production of sodium carbonate is considered highly environmentally burdensome given CO₂ emissions and waste suspension.¹⁴² The production of sorbitol from glucose, which is used as a sweetener across various RRP products, is also shown to produce significant CO₂ levels at 3.551kg CO₂eq/kg sorbitol.¹⁴³ The mining of talc, which is used in NRT gum, is highlighted as destroying natural habitats, which can be applied to any mining activities. This is accentuated for talc, which is usually in close proximity to asbestos, and the disruption of this can have a knock-on effect on the wider environment.

While any extraction and processing can have an environmental impact, the counter argument is that favoring certain raw materials can make a positive sustainability contribution. Gum arabic, for example, as used in nicotine pouches among others, is sourced from acacia trees which nourish soils with nitrogen and restore fertility, even in dry desert conditions. Countries such as Senegal and Eritrea have seen the economic benefit of gum arabic, and as such farmers have been encouraged to plant the tree leading to a positive environmental impact.¹⁴⁴

¹⁴² Cichosz, Kielkowska et al. *Changes in Synthetic Soda Ash Production and Its Consequences for the Environment*, July 11, 2022, from <https://www.mdpi.com/1996-1944/15/14/4828>

¹⁴³ Akmanila. R. *Environmental Impacts Evaluation of Sorbitol Production from Glucose*, 2019, from <http://jurnal.upnyk.ac.id/index.php/eksergi/article/view/2695>

¹⁴⁴ PR Newswire. *Acacia Gum: An Important Social, Economic and Environmental Role for the Southern Sahel Countries*, Accessed March 2023, from <https://www.prnewswire.com/in/news-releases/acacia-gum-an-important-social-economic-and-environmental-role-for-the-southern-sahel-countries-616100243.html>

6. Appendix

6.1 Definitions

Foundation for a Smoke-Free World - an independent, non-profit organization created in 2017 with the mission of ending smoking within this generation.

High-Risk Products (HRPs) - combustible or other high-risk nicotine products, including cigarettes, cigars, cigarillos, smoking tobacco, moist snuff, and bidis, as well as traditional smokeless tobacco, such as gutkha.

Reduced-Risk Products (RRPs) - nicotine products that are considered less harmful than combustible cigarettes and/or other traditional products. Products that are reduced-risk include vapor products (including open and closed vaping systems and their consumables, and heated tobacco), snus, NRT products, and non-tobacco nicotine pouches.

6.2 Acronyms

BAT - British American Tobacco Plc

cGMP - Current Good Manufacturing Practice

CNT - Contraf-Nicotex-Tobacco GmbH

ESG - Environmental, Social and Governance

FCTC - Framework Convention on Tobacco Control

FDA - U.S. Food and Drug Administration

FEMA/GRAS - Flavor and Extract Manufacturers Association (USA)/generally recognized as safe

HRP - High-Risk Product

JT - Japan Tobacco Group

mAh – milliampere hour. A milliampere hour (mAh) is 1000th of an ampere hour (Ah). Both measures are commonly used to describe the energy charge that a battery will hold and how long a device will run before the battery needs recharging.¹⁴⁵

NRT - Nicotine Replacement Therapy

ODM - Original Design Manufacturer

OEM - Original Equipment Manufacturer

PCBA - Printed Circuit Board Assembly

PCR - Post-Consumer Recycled

PCTG - Polycyclohexylenedimethylene Terephthalate Glycol-Modified

PG - propylene glycol

PhEUR - European Pharmacopeia

PLA - polylactic acid

PMI - Philip Morris International Inc

RRP - Reduced-Risk Product

UK - United Kingdom

USA - United States of America

USP - U.S. Pharmacopeia

VG - vegetable glycerin

WHO - World Health Organization

¹⁴⁵ Tech Target. Accessed April 2023, from [https://www.techtarget.com/whatis/definition/milliampere-hour-mAh#:~:text=A%20milliampere%20hour%20\(mAh\)%20is,before%20the%20battery%20needs%20recharging.](https://www.techtarget.com/whatis/definition/milliampere-hour-mAh#:~:text=A%20milliampere%20hour%20(mAh)%20is,before%20the%20battery%20needs%20recharging.)

6.3 Product scope¹⁴⁶

| Product type | Product category | Definition |
|-----------------------------|-------------------------------|---|
| Smokeless Tobacco | Chewing Tobacco | Chewing tobacco consists primarily of two types of products: Asian-style and US-style available in those specific geographic areas; and other chewing tobacco available in all other markets. For the purposes of the Index, chewing tobacco consists primarily of US-style chewing tobacco. Leading brands of US-style chewing tobacco include America's Best Chew (previously Red Man), Stoker's, and Levi Garrett. |
| | Moist Snuff | Moist snuff is either loose or pre-portioned in miniature-sized "teabag" pouches that are placed on the gum and sucked on. American snuff is sometimes referred to as "dip". Moist snuff is distinguished from snus by its processing. Moist snuff is fermented, compared to snus which is pasteurized (heat-treated). Leading brands of moist snuff in the USA include Copenhagen, Grizzly, and Skoal. |
| | Snus | Snus is either loose or pre-portioned in miniature-sized "teabag" pouches that are placed on the gum and sucked on. Snus is distinguished from moist snuff by its processing. Snus is pasteurized (heat-treated), compared to moist snuff which is fermented. Leading brands of snus in Sweden include General, Knox, and Göteborgs Rapé. |
| Non-Tobacco Products | Non-Tobacco Nicotine Pouches | Non-tobacco nicotine pouches are manufactured in a similar way to snus using ingredients such as filler, flavors, stabilizers, and nicotine but do not contain tobacco. |
| | NRT Products | Nicotine-based products such as gum, lozenges, patches, and inhalators used to aid smoking cessation. It also includes nicotine-based products sold as capsules, micro-tabs, or sprays. |
| Vapor Products | Closed System Vaping Products | This product category consists entirely of the sales of pre-filled pods or capsules for use with a non-cig-a-like closed system device, as well as single-use (disposable) cig-a-like products. Currently, these are universally proprietary in nature (pods are useable exclusively with a single specific hardware device). |
| | Open System Vaping Products | Charging and vaporizing devices includes sales of any product related to the powering of tank systems, e.g., batteries and modified batteries or the charging of such products, e.g., cables (where sold specifically for this purpose), and any product forming part of the heating and inhalation mechanism, e.g., clearomizers, tank units, atomizers, and drip tips. Broadly put this category covers the technology and hardware of tank system use. |
| | E-Liquids | E-liquids includes nicotine and non-nicotine bottled e-liquids which are decanted by the consumer into a tank for heating and inhalation. E-liquids can have different nicotine levels and flavors. |
| | Heated Tobacco | Heat-not-burn devices include products, generally manufactured by major tobacco companies, which allow the consumer to heat rather than combust a tobacco product. Heated tobacco is the consumable element of heat-not-burn devices, which comes in the form of pods or in specially designated cigarette sticks. |

¹⁴⁶ Based on Euromonitor International Passport's Tobacco and Consumer Health databases, and the National Cancer Institute's Dictionary of Cancer Terms.

6.4 Brand owners¹⁴⁷

| # | Brand Owner Name |
|----|-------------------------------------|
| 1 | Altria Group Inc |
| 2 | British American Tobacco Plc |
| 3 | DS Group |
| 4 | Evo Brands LLC |
| 5 | Imperial Brands Plc |
| 6 | Japan Tobacco Inc |
| 7 | JUUL Labs Inc |
| 8 | Kaival Brands Innovations Group Inc |
| 9 | Philip Morris International Inc |
| 10 | RELX Technology Co Ltd |
| 11 | Shenzhen IVPS Technology Co Ltd |
| 12 | Shenzhen Joye Technology Co Ltd |
| 13 | Shenzhen Kanger Technology Co Ltd |
| 14 | Shenzhen Smoore Technology Co Ltd |
| 15 | Swedish Match AB |

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6.6 Expert consultations

As part of the research process for the Study, industry expert consultations across manufacturers, brand owners, and consultants were conducted to collect additional insights and details across topics covered in this report. The targeting of relevant experts was based on their past or present experience working for or with global brand owners listed in the Appendix of this report.