



Less Juggling More Cuddling!



Design and Development of the Cuddle Cup 3-in-1 Smart Infant Feeding System

Intelligent Infant Feeding with Nutrition Detection, Temperature Monitoring, and 360° Anti-Spill Technology

Table of Contents

1. Company Identity and Branding	6
1.1. Company Name and Rationale	6
1.2. Logo Design and Visual Identity	6
1.3. Logo Psychology and Design Principles	6
1.3.1. Color Palette Justification and Mood board Integration	6
2. Project Organization	7
2.1. Project Team Structure and Hierarchy	7
2.2. Departmental Structure and Functions	7
2.3. Communication and Reporting Lines	8
2.4. Team Competencies and Skill Matrix	8
3. Project Proposal and Strategic Vision	9
3.1. Executive Summary	9
3.2. Problem Statement and Market Need	9
3.3. Vision Statement	10
3.4. Mission Statement	10
3.5. Core Values and Principles	10
3.6. Key Performance Indicators (KPIs)	11
4. Brainstorming and Concept Generation	12
4.1. Brainstorming Methodology	13
4.2. Initial Concept Ideas	13
4.3. User Need Analysis	13
4.4. Market Gap Identification	14
4.5. Concept Filtering and Prioritisation	14
5. Product Selection and Engineering Design	15
5.1. Concept Generation and Selection Process	15
5.2. Initial Concept Designs	15
5.2.1. Concept 1: Basic 2-in-1 System (Pump + Feed)	16
5.2.2. Concept 2: Manual Smart Storage System	16
5.3. Concept Evaluation Matrix	17
5.4. Final Selected Design: Cuddle Cup 3-in-1 System	18
5.5. Product Size Variants	18
5.5.1. Variant A-Cuddle Cup Newborn (150 ml, 0-6 Months)	18
5.5.2. Variant B -Cuddle Cup Standard (260 ml, 6-18+Months)	19
5.5.3. Variant Dimensional Comparison	19
5.6. Detailed Technical Specifications	19
5.7. Module 1: 360° Feeding Top	19
5.7.1. Module 2: Smart Cup Body	20
5.7.2. Module 3: Intelligent Sensing Base	20
5.7.3. Module 4: Milk Suction Device	20
5.7.4. Assembly Dimensions	21
5.8. CAD Development and 3D Rendering	21
5.8.1. 2D Technical Drawings and Dimensional Specifications (Autodesk)	22
5.8.2. 3D Rendered Model and Lavender Finish (Blender)	22
5.8.3. Exploded Assembly and Wireframe Mesh Views	23
5.9. Material Selection and Justification	23

5.9.1.	BPA-Free Tritan Copolyester and Food-Grade PP Copolymer (Body Components).....	23
5.9.2.	Stainless Steel 304 (Vacuum Insulation Inner Liner).....	24
5.9.3.	Medical-Grade Platinum-Cured LSR (Nipples, Seals, Anti-Colic Valve).....	24
5.9.4.	Food-Safe Polypropylene and TPE Soft-Touch (Internal and Grip Components).....	24
5.9.5.	Electronic Component Materials (PCB, Li-Po Battery, Sensors).....	24
5.9.6.	Material Properties and Performance Criteria.....	25
5.9.7.	Safety and Regulatory Compliance.....	26
5.10.	Manufacturing Process Selection	26
5.10.1.	Injection Moulding (Plastic Components)	26
5.10.2.	Deep-Draw Forming (SS304 Vacuum Liner)	26
5.10.3.	Liquid Silicone Injection Moulding (LSR Parts).....	26
5.10.4.	Two-Shot Moulding (Cuddle-Arm Handle PP+TPE).....	27
5.10.5.	PCB Assembly, SMT, and Sensor Calibration	27
5.10.6.	Firmware Programming	27
5.10.7.	Final Assembly Process.....	27
5.10.8.	Quality Assurance and Testing Protocols	28
5.11.	Product Functions and Technical Performance.....	28
5.11.1.	Smart Feeder Bottle	28
5.11.2.	Intelligent Sensing Base	29
5.11.3.	Smart Milk Collector/Wearable Pump	29
5.11.4.	Companion App Integration.....	29
5.11.5.	Power Management.....	30
5.12.	Financial Analysis: Profit and Loss Costing	30
5.12.1.	Bill of Materials 51 Components, 8 Assembly Groups	31
5.12.2.	Unit Economics at 10,000 MOQ.....	31
5.12.3.	Pricing Strategy	32
5.12.4.	Competitive Price Positioning.....	33
5.12.5.	Variant Pricing Comparison	33
5.12.6.	Tooling and Setup Costs (One-Time)	33
5.12.7.	Break-Even Analysis	34
5.12.8.	Revenue Projections Year 1-3	34
5.12.9.	Scale Economics.....	34
6.	Value Management and Cost Optimisation	35
6.1.	Value Management Methodology.....	35
6.2.	Function Analysis.....	35
6.2.1.	Primary Functions Identification.....	35
6.2.2.	Secondary Functions Identification	36
6.2.3.	Function Cost Matrix	36
6.3.	Value Engineering Analysis.....	37
6.3.1.	Component Cost-Function Analysis	37
6.3.2.	Material Substitution Opportunities	37
6.3.3.	Manufacturing Process Optimisation	37
6.3.4.	Design Simplification Opportunities.....	37
6.4.	Cost Reduction Initiatives.....	38
6.4.1.	Targeted Cost Reduction Strategies.....	38
6.4.2.	Quantified Cost Savings Analysis	38
6.4.3.	Implementation Timeline and Milestones.....	39
6.5.	Environmental Considerations in Value Management	39
6.5.1.	Sustainable Material Selection	39
6.5.2.	Recyclability Analysis.....	39
6.5.3.	Life Cycle Assessment (LCA) Integration.....	39
6.5.4.	Carbon Footprint Reduction Strategies.....	40
6.5.5.	Quality vs Cost Trade-off Analysis	40
6.6.	Risk Assessment of Cost Reduction Measures	41
7.	Environmental Sustainability and Life Cycle Analysis	42
7.1.	Environmental Impact Assessment Framework	42
7.2.	Energy Consumption Analysis	42
7.2.1.	Manufacturing Energy Requirements.....	42
7.2.2.	Material Extraction and Processing Energy	43
7.2.3.	Total Embodied Energy Calculation	43

7.2.4.	Renewable Energy Integration Opportunities	43
7.3.	Carbon Footprint Analysis.....	43
7.3.1.	Cradle-to-Gate Carbon Emissions	43
7.3.2.	Transportation and Distribution Emissions	44
7.3.3.	Use Phase Carbon Footprint	44
7.3.4.	End-of-Life Disposal Emissions	44
7.3.5.	Carbon Offset and Reduction Strategies	44
7.4.	Product Life Cycle Assessment (ISO 14040/14044)	44
7.4.1.	Raw Material Extraction Phase	44
7.4.2.	Manufacturing and Assembly Phase	45
7.4.3.	Distribution and Logistics Phase.....	45
7.4.4.	Use Phase	45
7.4.5.	End-of-Life Phase	45
7.5.	Safe Disposal and Recycling Strategies	45
7.5.1.	Material Recycling Pathways	45
7.5.2.	Design for Disassembly (DfD)	46
7.5.3.	Take-Back and Collection Programmes	46
7.5.4.	Circular Economy Implementation	46
7.6.	Compliance with Environmental Regulations	46
7.7.	Sustainability Certifications and Goals.....	47
8.	<i>Marketing Strategy and Go-to-Market Plan</i>	47
8.1.	Market Analysis and Segmentation	47
8.2.	Competitive Landscape Analysis	48
8.3.	Brand Positioning and Value Proposition.....	48
8.4.	Marketing Mix (4Ps) Strategy	48
8.5.	Digital and Traditional Marketing Strategy.....	50
8.6.	Marketing Budget Allocation and KPIs	51
9.	<i>Engineering Ethics and Professional Responsibility</i>	52
9.1.	Ethical Framework and Professional Codes	52
9.2.	Product Safety and Risk Management (FMEA)	52
9.3.	Honest Marketing and Intellectual Property.....	53
9.4.	Supply Chain Ethics and Fair Labour Practices	53
9.5.	Conflict of Interest and Whistleblowing	53
9.6.	Continuous Professional Development	54
Conclusion:		54
Appendices:		60
Abbreviations:		61

About the Project

ABSTRACT

This report documents the entire product development of the Cuddle Cup 3-in-1 Smart Baby Feeding System. Parents of infants face a fragmented dietary ecosystem: Primary research on 60 UK mothers identified four unresolved problem points, product confusion (78%), inconvenient feeding positions (71%), temperature inconsistency (65%), and price hesitancy (82%). No existing products integrate breast pumping, smart temperature monitoring, and real-time nutritional tracking within a single platform, forcing parents to assemble expensive, disjointed multi-product toolkits. Cuddle Cup. has developed this integrated ecosystem to consolidate all four functions into one interoperable platform, consisting of a **smart feeder bottle, intelligent sensing base, wearable milk collector and companion app**. Key results include a weighted concept evaluation score of 4.30/5.00, an RRP of £155 which represents a 33% price advantage over nearest competitors, regulatory compliance at CE, FDA and BS EN 14350:2020, break-even of 14,597 units within 18 months and a five-year revenue forecast of £54.8 million.

1. Company Identity and Branding

1.1. Company Name and Rationale

The name Cuddle Cup was strategically chosen to evoke emotional warmth and convey the functionality of the product. The embrace symbolizes the parent's affection and emotional connection, while the cup represents a food vessel, suggesting a nourishing meal experience together. The tagline, *"Less juggling. More cuddling!"*, reinforces this emotional appeal by emphasizing reducing parenting stress and increasing bonding time. Alliterative structure and emotional resonance contribute to brand memorability (Topolinski, Zürn and Schneider, 2015). Research on brand naming emphasizes that emotionally evocative and alliterative names enhance consumer recall. Just as Pampers is about cozy comfort, the Cuddle Cup establishes an instant emotional connection with its target demographic of caregivers.

1.2. Logo Design and Visual Identity

1.3. Logo Psychology and Design Principles

The Cuddle Cup logo has been deliberately designed to reflect the core brand values of warmth, trust and care. Its symmetrical, balanced wordmark conveys emotional harmony and psychological stability qualities closely linked to reliability and trustworthiness. The circular typography further enhances the perception of gentleness and safety, in line with the emotional expectations of baby care consumers. The design literature confirms that soft, curved fonts create friendliness and approachability, making them ideal for kid-focused branding. Additionally, the logo subtly incorporates symbolic cues such as an abstract representation of a smiling child and caregiver that reinforce the themes of nurturing and protection. These underlying elements not only deepen the meaning of the brand but also foster an emotional connection with the audience. The entire visual logic and design intent are detailed in the Cuddle Cup logo portfolio (see Appendix A).

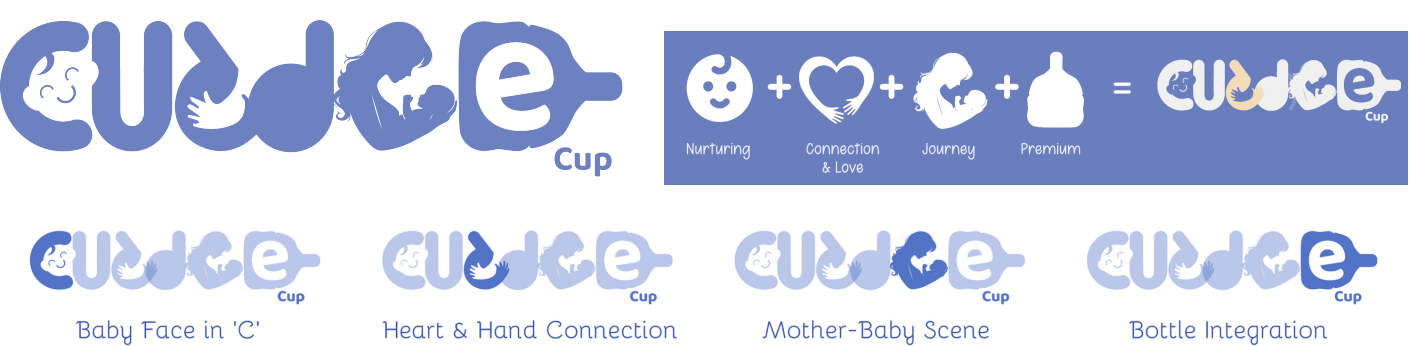


Figure 1 Cuddle Cup Logo Concept Exploration

1.3.1. Color Palette Justification and Mood board Integration

The Cuddle Cup color palette is taken from the brand Mood board and is designed to communicate emotional warmth, trust and care. As summarized in *Table 1*, the pastel colors selected evoke calmness, security and softness key emotional qualities associated with baby care products.

Table 1 Cuddle Cup Brand Color Palette and Associated Emotional Meanings

Color Name	Hex Code	Emotion Conveyed
Golden Sand	#F3DFBA	Warmth, affection
Wild Blue Yonder	#A4AFD2	Calmness, trust
Morning Mist	#F0DDD6	Tenderness, softness
Pale Flax	#EAE6CB	Purity, safety
Columbia Blue	#B3D7E5	Cleanliness, empathy

As shown in *Table 1*, the dominant blue color reinforces feelings of reliability and security, while warm neutrals enhance emotional comfort. This sympathetic color strategy aligns with the logo's soft symmetry and rounded typography, reinforcing the brand's positioning as gentle, trustworthy and child centric.

2. Project Organization

This section describes how the smart feeder bottle development project is organized, including its leadership hierarchy, departmental roles, communication practices, and required team competencies. The structure aligns with best practices in med-tech product development, ensuring clear accountabilities, separation of roles, and robust safety-critical workflows (Khanarian *et al.*, 2014).

2.1. Project Team Structure and Hierarchy

The Smart Feeder Bottle project utilizes a cross-functional team structure overseen by both executive leadership and dedicated project management. The hierarchy and reporting lines are shown in Figure 1 below.

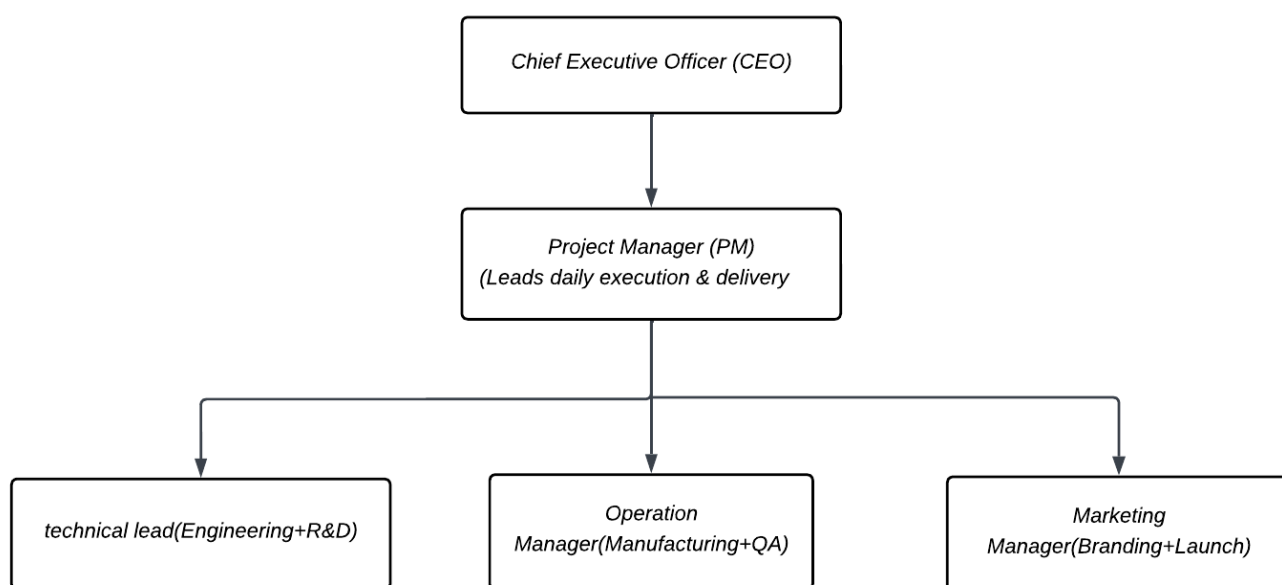


Figure 2 Hierarchy of the team

The organizational structure of Cuddle Cup Ltd. follows a flat hierarchy model, whereby the Chief Executive Officer maintains direct oversight of all four departmental leads. This structure was deliberately chosen to facilitate rapid decision-making, minimize bureaucratic delays, and ensure cross-functional alignment during the product development lifecycle. The hierarchy is as follows:

The flat structure ensures that all departmental leads have equal access to the CEO, promoting transparency and enabling agile responses to evolving project requirements. At the current stage of development, this lean organizational model is appropriate given the team size and the iterative nature of the product development process.

2.2. Departmental Structure and Functions

The company is organized into four main functional departments, each associated with a key workflow within the product development and commercialization lifecycle (Ahmed, Rafique and Philbin, 2021). The following table summarizes each department's primary function, key deliverables, and respective team leads.

2.3. Communication and Reporting Lines

Effective communication is fundamental to the success of the Cuddle Cup project, especially given the cross-functional nature of the product spanning hardware engineering, software development, manufacturing, and consumer marketing. The team uses the following communication framework:

Table 2 Overview of communication channels

Communication Type	Frequency	Participants	Purpose
Executive Stand-up	Daily (15 min)	All team members	Progress updates, blocker identification, daily priorities
Sprint Planning	Bi-weekly	All team members	Sprint goal setting, task allocation, backlog refinement
Technical Review	Weekly	CEO, Technical Lead, Operations Manager	Design decisions, DFM reviews, BOM updates, testing results
Stakeholder Update	Monthly	CEO, Project Manager	Milestone reporting, budget status, risk escalation
Ad-hoc Collaboration	As required	Relevant members	Cross-functional problem-solving, design iterations

All formal communications are documented and tracked through the project management system. The team is in the process of integrating Atlassian Jira for enhanced sprint tracking, issue management, and workflow automation across all departments.

2.4. Team Competencies and Skill Matrix

The following competency matrix maps each team member's primary and secondary skill areas against the core functional requirements of the Cuddle Cup project. This analysis confirms that the team has broad coverage across all critical domains, with sufficient depth to manage the product development lifecycle from concept to market launch (Benayoune, 2024).

Table 3 RACI Matrix

Competency Area	(CEO)	(Tech)	(PM)	(Ops)	(Mktg)
Strategic Leadership	A	C	R	C	C
Hardware / Electronics	C	A	C	R	I
Software / App Dev	I	A	R	C	I
Manufacturing / DFM	C	R	C	A	I
Supply Chain / QA	I	C	R	A	I
Project Management	C	C	A	R	I
Market Research	C	I	C	I	A
Brand / Creative	C	I	I	I	A

Regulatory / Compliance	C	C	I	A	I
Financial Modelling	A	I	R	C	C

3. Project Proposal and Strategic Vision

This section articulates the strategic rationale, market opportunity, and organizational vision that underpin the Cuddle Cup smart baby feeding system. It presents the executive summary, problem statement, mission and vision statements, core values, strategic objectives, and key performance indicators that collectively define the project's direction and success criteria.

3.1. Executive Summary

Cuddle Cup is a three-part smart baby feeding ecosystem that includes a smart feeder bottle with integrated sensing base, a wearable milk collector, and a companion mobile application (D. Uluşen *et al.*, 2019). The product is designed to address four key pain points experienced by parents during the baby feeding journey: *product confusion and bulkiness (reported by 78% of parents surveyed)*, *temperature inconsistency during feeding (65%)*, *uncomfortable positions causing physical strain (71%)*, and *price hesitation when considering premium baby products (82%)*. Refer Research Insights in Appendix J. The system integrates precise temperature management via dual NTC thermistors and a PTC ceramic heater (National Library of Medicine, 2016), BLE 5.0 smart connectivity for real-time feed tracking, an ergonomic hug contoured body with a signature cuddle-arm handle, and a modular 3-stage nipple system that supports the transition from newborn bottle feeding to toddler straw cups. The companion app enhances functionality with real-time monitoring, analytics dashboard, smart scheduling, multi-user caregiver mode (Cai *et al.*, 2019), a doctor community consultation feature, and curated baby care content feed. The product is priced at a recommended retail price (RRP) of £155 *Pricing Strategy*, which represents a 33% price advantage over comparable competing bundles from Medela and Elvi, while offering significantly more integrated functionality. The bill of materials includes 51 components in 8 assembly groups, with a unit cost of approximately £57.67 at a 10,000-unit minimum order quantity. The updated cost model estimates a gross profit of £15.07 per unit and a break-even volume of approximately 14,597 units. The product is designed to comply with CE, FDA, FCC, RoHS, IEC 62133 and BS EN 14350:2020 standards (BSI Standards Publication, 2020).

3.2. Problem Statement and Market Need

The global baby bottle market was valued at approximately US\$4.2 billion in 2024 (Fortunate Business Insight, 2026), with projections indicating continued growth at a compound annual growth rate of 5-7% through 2033. Despite this market maturity, primary research conducted for this project, including a survey of 60 mothers see Appendix J revealed that there remain significant pain points in the mealtime experience that existing products fail to address overall.

Table 4 Pain Point % Affected Core Issue Cuddle Cup Solution Value Impact

Pain Point	% Affected	Core Issue	Cuddle Cup Solution	Value Impact
Product Confusion & Research Overwhelm	0.78	Too many single-function products; long decision time (~3 weeks); fragmented toolkit	3-in-1 integrated ecosystem (warming, monitoring, feeding, tracking)	Reduces cognitive load, cost, and product clutter

Temperature Inconsistency	0.65	No active temp control; manual testing unreliable	Dual NTC thermistor + real-time monitoring + RGB LED (Blue <30°C, Green 35-40°C, Red >45°C) + haptic alert	Improves safety; eliminates guesswork
Uncomfortable Feeding Positions	0.71	Wrist/forearm strain, especially at night	Ergonomic hug-contour body, TPE soft grip, one-hand handle, 360° rotation	Reduces strain; supports anti-colic positioning
Price Hesitation	0.82	Premium baby products perceived expensive	£155 RRP integrated system (33% cheaper vs multi-product bundles)	High value-for-money; consolidated investment

3.3. Vision Statement

To become the globally recognized standard in smart baby infant feeding by 2035 - present in 5+ international markets, endorsed by pediatricians, and generating £54.8 million in cumulative revenue across 203,900 units, as a product that redefined the baby feeding system, where every feed is safe, every moment is connected, and every parent feels supported.

This vision reflects Cuddle Cup's long-term institutional ambition beyond the initial UK launch, targeting 29.8% gross margins at 50,000-unit scale and category leadership compared to benchmark consumer technology brands.

3.4. Mission Statement

Empowering parents today with a precision-engineered, emotionally resonant feeding system, priced at £155 RRP, 33% less than the nearest integrated competitor, solving all 4 primary pain points identified in 60 surveyed UK mothers, with a break-even target of 14,597 units within 18 months.

The mission sets out the current purpose of the Cuddle Cup in measurable outcomes: technical precision ($\pm 0.2^{\circ}\text{C}$ thermistor accuracy, BLE 5.0 connectivity), commercial feasibility (£15.07 gross profit per unit), and human empathy, positioning the product beyond the 'baby bottle' and into the wellness space of parent-child connection.

3.5. Core Values and Principles

The following core values guide all decision-making within the Cuddle Cup project, from material selection and design choices to marketing communications and customer engagement. These values were established during the initial product idea stage and have been consistently applied throughout the development process.

Table 5 Core Values and Principles

Core Value	Principle	Application in Cuddle Cup
Safety First	Infant safety is the non-negotiable foundation of every design decision	All milk-contact materials are FDA and EN 14350 compliant; medical-grade silicone for nipples and valves; IEC 62133 certified battery; automatic thermal cut-off (Yadlapati <i>et al.</i> , 2019)
Empathetic Design	Products should understand and respond to the emotional needs of parents, not just functional requirements	Hug-contoured body; cuddle-arm handle; warm color palette; haptic feedback for reassurance; user journey mapping informed by real parent experiences

Intelligent Simplicity	Advanced technology should simplify the user experience, not complicate it	One-touch temperature display; intuitive RGB color coding; automatic feed logging; seamless BLE pairing; offline-capable with automatic sync
Inclusive Accessibility	The feeding experience should be comfortable and accessible for all parents and caregivers	One-handed operation; multi-user caregiver app access; ergonomic design validated against common feeding positions; multi-lingual documentation
Sustainable Responsibility	Environmental impact should be minimized throughout the product lifecycle	Durable materials designed for years of use; modular 3-stage transition system eliminates need for replacement products; recyclable packaging using moulded pulp
Evidence-Based Innovation	Design decisions should be grounded in research data and validated against real user needs	Survey data from 60 mothers; competitive benchmarking against 5+ brands; iterative design from hand sketches through CAD (Autodesk) to 3D rendering (Blender)

3.6. Key Performance Indicators (KPIs)

The following key performance indicators have been defined to monitor progress against the strategic objectives. KPIs are organized across four performance dimensions: financial, product, customer, and operational. Each indicator includes a defined target and measurement methodology.

Table 6 Key Performance Indicators

Dimension	KPI	Target	Measurement Method
Financial	Gross profit per unit	≥15.07 per unit	Unit economics tracking against landed cost and net revenue
Financial	Break-even achievement	14,597 units within 18 months of launch	Cumulative unit sales vs. fixed cost recovery
Financial	Revenue growth rate	30% year-on-year growth from Year 2	Quarterly revenue reporting
Product	Product defect rate	<1.5% field failure rate	Post-sale returns and warranty claims tracking
Product	Regulatory certification	CE, FDA, FCC, RoHS, IEC 62133, EN 14350	Certification completion status
Product	Time to market	12 months from design freeze to first shipment	Milestone tracking against project plan
Customer	Customer satisfaction score	≥4.8 / 5.0 average rating	Post-purchase survey and platform review aggregation
Customer	Net Promoter Score (NPS)	≥70	Quarterly NPS survey of registered app users
Customer	Customer referral rate	60% of customers recommend to 3+ other parents	In-app referral tracking and survey data
Customer	Decision time reduction	From 3 weeks to 1-week average purchase decision	Customer survey and analytics funnel tracking
Operational	Manufacturing cycle time	≤25 minutes per assembled unit	Production line time-and-motion study
Operational	Supplier on-time delivery	≥95% on-time delivery rate	Supplier scorecards and procurement tracking
Operational	Inventory turnover	≥6 turns per year	Inventory management system reporting

4. Brainstorming and Concept Generation

This section documents the thought process through which the Cuddle Cup Smart Baby Feeding System was identified, evaluated, and selected from a field of five competing product concepts. The methodology employed a structured multi-participant brainstorming framework informed by primary survey research (n=60) and secondary market analysis, to ensure that the final concept selection was both evidence-based and strategically sound.

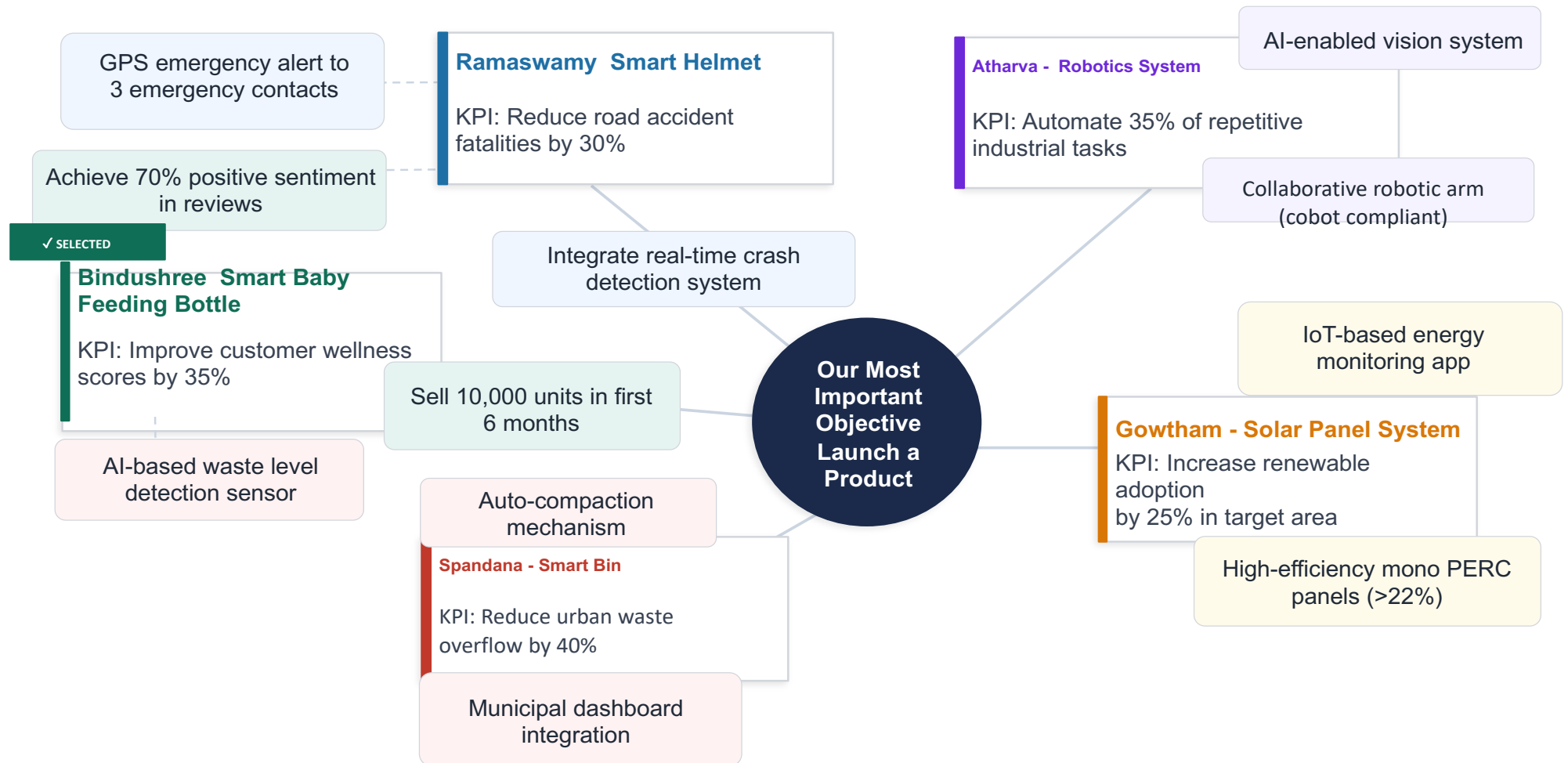


Figure 3 Product Brainstorm mind map and target impacts.

4.1. Brainstorming Methodology

The concept generation phase employed a structured brainwriting-style methodology (also known as a 'brainstorm template' approach), adapted for the five-member Cuddle Cup team. Each team member (player) independently developed an overall product concept, including a product name, key feature set, and a measurable team key outcome tied to a defined strategic objective. This approach was selected to reduce group think, ensure diversity of ideas, and enable parallel evaluation of fundamentally different product directions. Following individual discussions, all five concepts were presented, discussed and evaluated based on a common set of selection criteria derived from the project's user research findings and market analysis.

4.2. Initial Concept Ideas

The brainstorming session produced five distinct product concepts, each targeting the smart baby feeding and parenting wellness sector from a different strategic angle. Table 10 summarises the concepts, their originating team members, and the associated key results.

Table 7 Smart Baby Feeding Player Comparison

Player	Product	Core KPI	Market Impact Focus
Bindu	Smart Baby Feeding Bottle	+35% wellness	Baby-tech / Maternal care
Ram	Smart Helmet	-30% fatalities	Road safety
Atharva	Robotics	35% automation	Industrial efficiency
Spandana	Smart Bin	-40% overflow	Smart city waste
Gowtham	Solar System	+25% adoption	Renewable energy

4.3. User Need Analysis

Concept evaluation was informed by primary research data from the Cuddle Cup survey (n = 60 mothers in five geographical areas). The survey identified five main pain points in the current feeding experience: lack of tracking and monitoring capability (25.0%, n = 15), excessive steps and equipment fragmentation (21.7%, n = 13), time consumption (20.0%, n = 12), cleanup effort (20.0%, n = 12), and milk spillage or leakage (13.3%, n = 8). Feature priority analysis revealed that anti-spill design (28.3%), 360° feeding flexibility (23.3%), and zero milk transfer (21.7%) collectively represented 73.3% of the stated priorities. Security was considered extremely or very important by 50.0% of respondents, and 61.7% rated the integrated three-in-one system as moderately to extremely valuable See Appendix H. These findings established the evaluative lens through which each concept was evaluated: the winning concept needed to address key pain points (device fragmentation, lack of monitoring, and time consumption) while delivering practical feature priorities identified by the target user base.

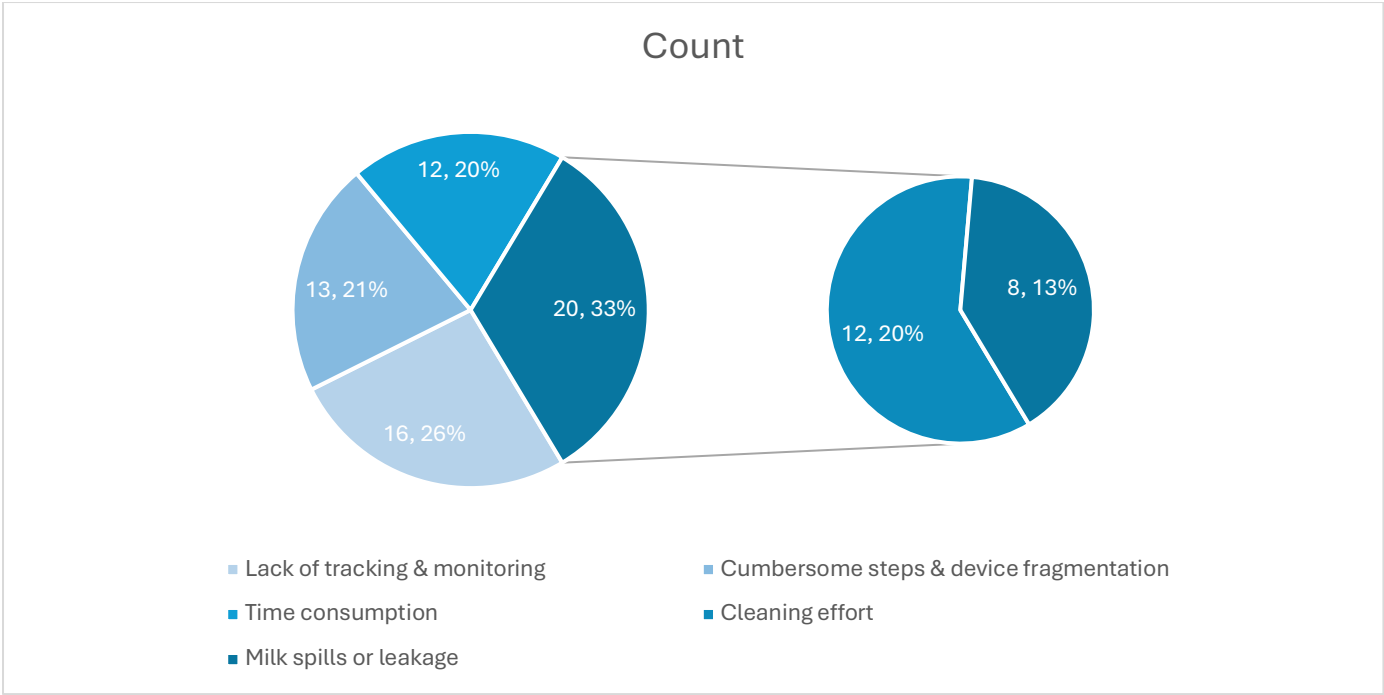


Chart 1 Survey results showing key challenges in bottle feeding.

4.4. Market Gap Identification

Competitive analysis of the existing baby feeding product landscape revealed a significant structural gap: no single product on the market integrates smart temperature monitoring, ergonomic feeding design, wireless connectivity, and a breast-to-bottle transition ecosystem within a unified system. Established competitors operate in isolated functional silos. Medela offers hospital-grade breast pumps and bottles but without smart monitoring. Elvie (Elvie, 2018) provides wearable pump technology with app connectivity but no integrated feeding bottle. Philips Avent (Philips Avent Baby Bottles., 2023) delivers ergonomic bottle design but without any smart features. Willow focuses exclusively on wearable pumping. Dr. Brown’s (Dr.Brown, 2010) and Babaloo (Babaloo, 2024) address anti-colic functionality without temperature management or digital tracking. This fragmentation forces parents to assemble a multi-product feeding toolkit, directly contributing to the confusion and overwhelm reported by 25.0% of survey respondents as their primary pain point, and the device fragmentation cited by a further 21.7%. The market gap, therefore, is not a single missing feature but rather the absence of a coherent, integrated ecosystem that reduces cognitive burden whilst delivering smart functionality. More Detailed Market and Competitor Analysis Attached in Appendix H

4.5. Concept Filtering and Prioritisation

Each of the five concepts was evaluated against four weighted selection criteria derived from the user research and market analysis: alignment with identified user pain points, market differentiation potential, technical feasibility and risk profile, and emotional resonance with the target customer segment. Table 11 presents the comparative evaluation.

Table 8 Comparison and Overall Ranking of proposed Product

Criterion	Smart Thermos Pro	Eco-Blend Bottle	Cuddle Cup	Hydration Tracker	Collapsible Cup
Pain point alignment	Moderate	Low	High	Moderate	Low
Market differentiation	Low (crowded IoT)	Moderate	High (unique)	Moderate	Moderate

Technical risk	High (battery/app)	Moderate (materials)	Low-Moderate	High (sensors)	Low
Emotional resonance	Low	Moderate	High	Low	Low
OVERALL RANKING	4th	5th	1st	3rd	4th

The Smart Baby Feeding Bottle (Cuddle Cup) concept was unanimously selected as the winning proposal. The rationale for the selection focused on four factors: (1) the strongest alignment with the rapidly growing parental wellness and smart baby-care market, where health, safety and convenience are the primary purchasing drivers; (2) a unique market position, as no direct competitors currently offer a fully integrated pump-feed-system combined with therapeutic heat and smart connectivity; (3) the strongest emotional connection with target customers, supported by the survey which found that 61.7% of respondents valued an integrated three-in-one system that reduces caregiver burden and enhances infant well-being; and (4) a lower technical risk profile than other proposed concepts such as smart helmets, robotics systems, smart bins, and solar panel systems, as the Cuddle Cup leverages established and scalable manufacturing processes (injection molding, two-shot over molding, and SMT assembly) rather than highly-regulated safety systems or large-scale infrastructure deployments. See Appendix M

5. Product Selection and Engineering Design

This section presents the systematic approach taken to generate, evaluate, and refine the Cuddle Cup product concept from initial idea to detailed engineering specification. The methodology is based on structured concept generation techniques, weighted evaluation metrics and iterative design refinements informed by primary user research data collected from a survey of 60 mothers aged 22-40 years across five geographical regions. The design process progressed from rough hand sketches through parametric CAD modeling in Autodesk Fusion 360 to photorealistic 3D rendering in Blender, culminating in a production-ready specification for the three-part integrated feeding ecosystem.

5.1. Concept Generation and Selection Process

The selection of the Cuddle Cup as the final development project was driven by team consensus and three primary factors identified through initial market assessment. Firstly, wellness aligns with growing consumer investment in health and wellness products, with the global baby bottle market valued at \$4.1 billion in 2024 and projected to grow at a CAGR of 5.8% through 2032. Second, the emotional resonance feeding category uniquely fosters a deep parent-child bond, offering a differentiation vector unavailable to purely functional product categories. Third, an identifiable market gap, no existing competitor offers an integrated system combining pumping, feeding and smart monitoring within a single ecosystem.

5.2. Initial Concept Designs

After the baby food category was selected, three different product architectures were developed to explore the solution space. Each concept was evaluated based on user identified problem points, technical feasibility and market differentiation potential.

5.2.1. Concept 1: Basic 2-in-1 System (Pump + Feed)

The first concept proposed a simplified two-component system consisting of a manual breast pump that doubled as a feeding vessel. The pump mechanism was integrated into the bottle lid, allowing mothers to express milk directly into the feeding container and feed the infant without transferring milk. Key features include single-action pump lever, anti-drip valve, and wide-neck opening compatible with standard breast flanges.

Limitations: This concept addressed the milk transfer problem but lacked smart monitoring capabilities. The manual pump mechanism was limited to a single suction level, limiting comfort customizability. Additionally, the combined pump-bottle unit was heavier than conventional bottles (estimated at 280 grams empty), potentially causing wrist fatigue during extended feeding sessions. The absence of temperature monitoring, volume tracking, or app connectivity means the concept only addresses one of the four primary pain points identified in user research.

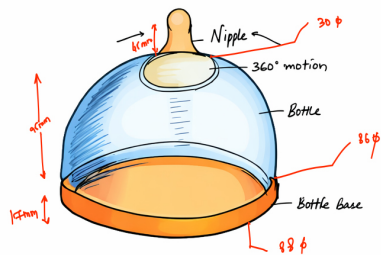


Figure 4 Basic 2-in-1 System (Pump + Feed)

5.2.2. Concept 2: Manual Smart Storage System

The second concept focused on intelligent milk storage with passive temperature monitoring. The system consisted of a standard baby bottle paired with a detachable smart base containing an NTC thermistor (Zhao, C., Knisely and Grosh, 2018), Bluetooth Low Energy (BLE) module, and companion mobile application. The smart base would detect when a bottle was placed on it and automatically begin periodic logging for temperature drop, volume estimation via load cell, and freshness tracking.

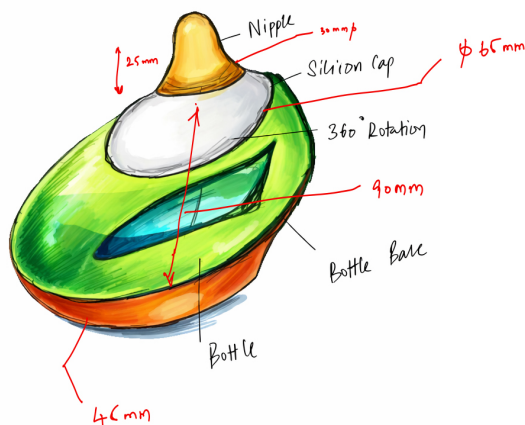


Figure 5 Concept 2: Manual Smart Storage System

Limitations: While this concept addressed the monitoring and information-overload pain points effectively, it offered no integrated pumping solution, requiring mothers to continue using a separate breast pump and transfer milk manually. The passive-only temperature system (no active heating) limited its utility in maintaining optimal feeding temperature. Furthermore, the standard bottle form factor offered no ergonomic innovation, leaving the uncomfortable feeding position pain point (reported by 71% of surveyed mothers) unaddressed.

Concept 3: Complete 3-in-1 Integrated System (Selected)

The second concept focused on intelligent milk storage with passive temperature monitoring. The system consisted of a standard baby bottle paired with a detachable smart base containing an NTC

thermistor (Zhao, C., Knisely and Grosh, 2018), Bluetooth Low Energy (BLE) module (Chaari Fourati and Said, 2020), and companion mobile application (Aziz *et al.*, 2018). The smart base would detect when a bottle was placed on it and automatically begin periodic logging for temperature drop (Harich *et al.*, 2018), volume estimation via load cell, and freshness tracking (Sehrawat and Gill, 2019).

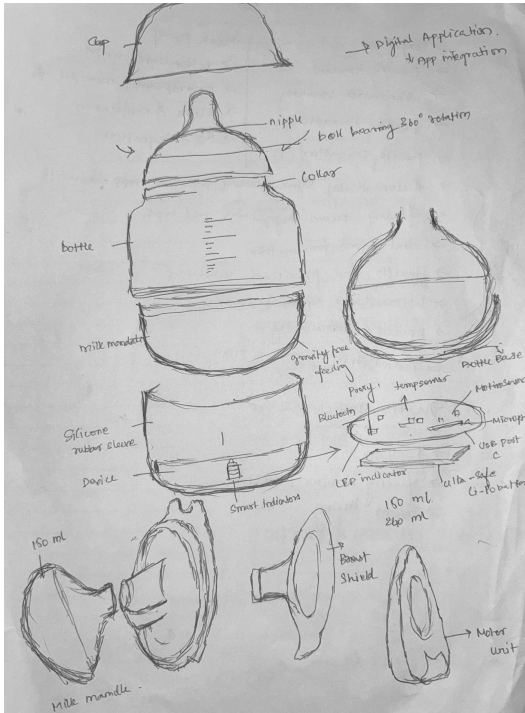


Figure 6 Conceptual design sketch of the Cuddle Cup smart baby bottle system

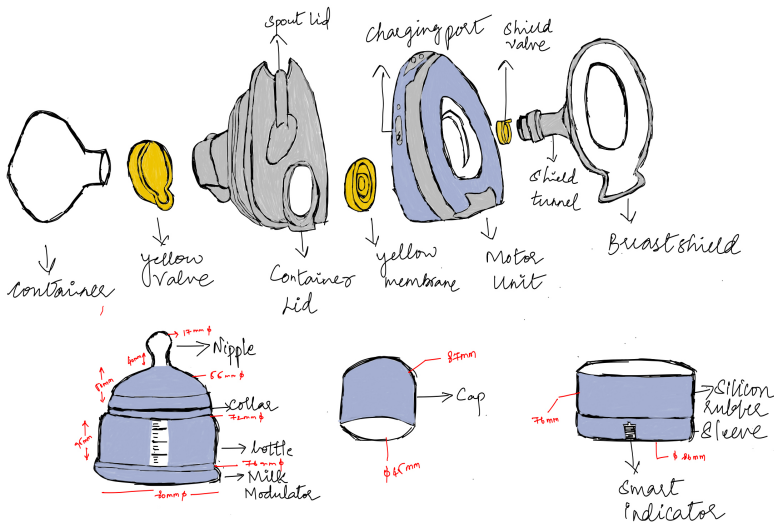


Figure 7 Exploded concept design of the Cuddle Cup smart baby bottle and its modular components with dimensions

Strengths: This concept addresses all four primary pain points simultaneously: information overload (25.0% of respondents cited lack of tracking as their primary frustration), device fragmentation (21.7%), inconvenient feeding positions (addressed via 360° nipple and ergonomic handle), and temperature inconsistency (dual thermistor accuracy of $\pm 0.2^{\circ}\text{C}$). Zero-transfer workflow from pump to feed eliminates a significant contamination and convenience concern. Furthermore, none of the existing competitors, including Medela, Alvi, One Willow, or Babaloo, offer pumping, feeding, and monitoring in a single integrated system, providing clear market differentiation.

5.3. Concept Evaluation Matrix

A weighted evaluation matrix was constructed to facilitate objective comparison of the three concepts. Criteria weights were derived from primary user research data, with pain point frequency informing the relative importance of each evaluation dimension. Table 12 presents the evaluation results.

Table 9 Weighted decision Matrix

Criterion	Weight	C1: 2-in-1	C2: Storage	C3: 3-in-1	Rationale
Pain Point Coverage	0.25	2	3	5	Survey-derived
Technical Feasibility	0.2	4	4	3	Complexity vs risk
Market Differentiation	0.2	2	3	5	Competitor gap analysis

Emotional Connection	0.15	2	2	5	Brand loyalty potential
Cost Viability	0.1	4	3	3	BOM at 10k MOQ
Scalability	0.1	3	3	4	Growth trajectory
WEIGHTED TOTAL	1	2.7	3.05	4.3	Selected

Concept 3 achieved a weighted score of 4.30 out of 5.00, significantly outperforming Concept 1 (2.70) and Concept 2 (3.05). The strength of the 3-in-1 system lies in its comprehensive pain point coverage and unique market position, which far outweighs its high technical complexity. This analysis confirmed the selection of the integrated system as the final development path.

5.4. Final Selected Design: Cuddle Cup 3-in-1 System

The Cuddle Cup 3-in-1 System represents a paradigm shift in infant feeding product design, consolidating three traditionally separate product categories breast pump, feeding bottle and smart monitor into one integrated, interoperable ecosystem. The system comprises:

1. **Smart Feeder Bottle** a low-profile, pebble-shaped feeding vessel with 360° rotatable nipple, anti-colic valve (Amereh *et al.*), three-stage flow nipples (S/M/F), double-wall SS304 vacuum insulation, ergonomic cuddle-arm handle, wide 50mm neck and fully detachable dishwasher-safe (He, Xiao and Deng, 2018a) components (Zhang, Xiaolian *et al.*, 2020).
2. **Intelligent Sensing Base** a standalone disk-sized device featuring dual NTC thermistors ($\pm 0.2^{\circ}\text{C}$), TOF level sensor (Lindner *et al.*, 2010), load cell (M. N. Aziz *et al.*, 2018a), BLE 5.0 module, ARM Cortex-M0+MCU, 1200mAh Li-Po battery, OLED display, RGB LED ring, and Qi 5W wireless charging receiver.
3. **Smart Milk Collector** a wearable pump with flexible platinum-cured LSR reservoir (150ml), 2-stage symphony-style pumping at nine suction levels (Jack, 2016), 105° wide-angle shield, Fluid Feel warm circulation, works below 38 dB with magnetic snap-on alignment.

A companion mobile application (iOS/Android) (D. Sehrawat and N. S. Gill, 2019) integrates data streams from all components, providing feed tracking, temperature history, volume estimation, expiration countdown, feeding schedule reminders, caregiver sharing, and pediatrician-exportable reports.

5.5. Product Size Variants

The Cuddle Cup system is offered in two capacity variants to accommodate the developmental feeding requirements of infants from birth through the toddler transition period. This dual-variant strategy follows established industry practice, as evidenced by competitors such as Philips Avent (125ml and 260ml) and Dr. Brown's (150ml and 270ml), ensuring appropriate volume matching to infant age and appetite.

5.5.1. Variant A-Cuddle Cup Newborn (150 ml, 0-6 Months)

The Newborn variant is dimensioned for the smaller feed volumes typical of neonatal and early infancy, where individual feeds range from 60ml to 150ml (Newhook *et al.*, 2009a). The compact form factor reduces the overall weight when filled (approximately 195g), facilitating one-handed feeding during night feeds and reducing wrist strain. The smaller body diameter improves grip

ergonomics for parents with smaller hands. This variant ships with the slow-flow nipple pre-installed and includes the medium-flow nipple for transition at approximately three months.

5.5.2. Variant B -Cuddle Cup Standard (260 ml, 6-18+Months)

The Standard variant accommodates the increased feed volumes required from six months onwards, where individual feeds typically range from 180ml to 260ml. This variant includes the full straw/sippy adapter kit for toddler transition, enabling continued use of the same ecosystem beyond the bottle-feeding stage. The slightly taller body shell provides additional thermal mass for the vacuum insulation chamber, extending temperature retention duration. This variant ships with the medium-flow nipple pre-installed and includes both slow and fast-flow alternatives.

5.5.3. Variant Dimensional Comparison

Table 13 presents the dimensional comparison between the two capacity variants. Both variants share a common base diameter (Ø75mm) and are fully compatible with the same intelligent sensing base and Qi charging dock, ensuring ecosystem interoperability.

Table 10 Variant Dimensional Comparison

Parameter	Newborn (150ml)	Standard (260ml)
Capacity	150 ml	260 ml
Target Age	0-6 months	6-18+ months
Assembled Height	135 mm	160 mm
Body Shell Height	95 mm	120 mm
Base Diameter	Ø75 mm	Ø75 mm
Body Diameter	Ø55 mm	Ø55 mm
Empty Weight (est.)	145 g	175 g
Pre-installed Nipple	Slow Flow	Medium Flow
Straw/Sippy Kit	Not included	Included
Sensing Base Compatible	Yes (Ø75mm universal)	Yes (Ø75mm universal)

5.6. Detailed Technical Specifications

The following subsections present the dimensional specifications for each module of the Cuddle Cup Standard (260ml) variant, as derived from the parametric CAD model developed in Autodesk Fusion 360 (Jiang *et al.*, 2020a). All dimensions are expressed in millimeters with manufacturing tolerances of $\pm 0.5\text{mm}$ for moulded plastic components and $\pm 0.1\text{mm}$ for machined metal parts, in accordance with ISO 2768-mK (*General tolerances to DIN ISO 2768*) (general tolerances).

5.7. Module 1: 360° Feeding Top

The feeding top assembly comprises three sub-components designed for secure attachment, leak prevention, and infant-safe feeding. The nipple measures $\text{Ø}45\text{mm} \times 40\text{mm}$ (height), manufactured from platinum-cured medical-grade (Brook, 2012) LSR (Shore A 15-20) in three flow-rate configurations. The collar ring measures $\text{Ø}60\text{mm} \times 25\text{mm}$, incorporating the thread engagement profile for secure attachment to the body shell. The sealing ring measures $\text{Ø}55\text{mm} \times 15\text{mm}$, providing an IP67-rated (Encloser Pro Ltd) silicone gasket (Zhang, Xinghua *et al.*, 2016) interface between the collar and body, preventing milk ingress into the electronics cavity. The anti-colic valve is integrated

into the collar assembly with an opening pressure of 2-4 kPa, engineered to reduce air ingestion during feeding.

5.7.1. Module 2: Smart Cup Body

The cup body consists of a double-wall vacuum-insulated chamber with a food-grade PP (Liu *et al.*, 2018) copolymer outer shell and SS304 stainless steel inner liner (Firouzabadi *et al.*, 2014a). The main body shell measures Ø55mm *120mm, providing 260ml usable volume with a maximum fill line marked at 240ml. The textured grip base extends to Ø70mm*80mm, incorporating a TPE (Cheng *et al.*, 2017a) soft touch silicone sleeve with raised dimple pattern for anti-slip performance. The wider base houses the NFC/contact pad interface that connects to the intelligent sensing base when seated. The wide neck opening of 50mm facilitates easy filling, cleaning, and direct compatibility with most standard breast pump flanges. The Cuddle Cup branding is embossed into the body shell surface.

5.7.2. Module 3: Intelligent Sensing Base

The sensing base is a standalone disc-shaped unit measuring Ø75mm at its widest point with an electronics housing of Ø70mm*12mm. The base ring provides a stable platform and houses the Qi wireless charging receiver coil. Internally, the base contains the main PCB with ARM Cortex-M0+MCU (STM32L0 series) (Ramalingam, Rengarajan and Rayappan, 2017a), BLE 5.0 module, dual NTC thermistors, TOF level sensor, load cell amplifier, 1200mAh Li-Po battery with BMS protection circuit, OLED micro-display (0.49"), RGB LED temperature indicator ring, haptic vibration motor, RTC module, and USB-C charging port. The sensing base interfaces with the bottle through contact pads embedded in the bottle's silicone base sleeve, establishing electrical connection when the bottle is seated. The base provides IP44 (Han *et al.*, 2018)splash resistance through conformal PCB coating and silicone gasket sealing.

5.7.3. Module 4: Milk Suction Device

The wearable milk collection module is a compact, in-bra unit measuring Ø90 mm*55 mm (depth), designed for discrete passive and active expression (Spatz, 2010a). The outer shell is molded from food-grade PP copolymer matching the cup body material, with a medical-grade platinum-cured LSR silicone breast shield available in 21 mm, 24 mm, and 27 mm flange sizes to accommodate anatomic variations. The internal diaphragm mechanism employs a cyclic vacuum system that generates -50 to -250 mmHg (Newhook *et al.*, 2009b) adjustable suction via a micro-diaphragm pump driven by a brushless DC motor, mimicking the two-stage letdown-and-expression rhythm characteristic of natural baby feeding (Wilson and Green, 2009a). The expressed milk flows through a one-way duckbill valve into an integrated 120 ml collection reservoir with graduated volume markings, which is sealed by a silicone membrane to prevent backflow and spillage. The unit communicates wirelessly via BLE 5.0 with the Cuddle Cup companion app, transmitting session duration, volume collected and suction mode data in real-time, while the 900mAh Li-Po battery provides approximately 4-5 expression sessions per charge via the shared USB-C charging ecosystem (Chen *et al.*, 2014a). The entire assembly is IP54-rated (IEC 60529)(Han *et al.*, 2018) for protection against ingress of milk and sweat and is divided into five tool-free components for sterilization in compliance with BS EN 14350:2020 (bsi.Knowledge, 2020) hygiene requirements. Detailed Engineering Design Attached in Appendix F

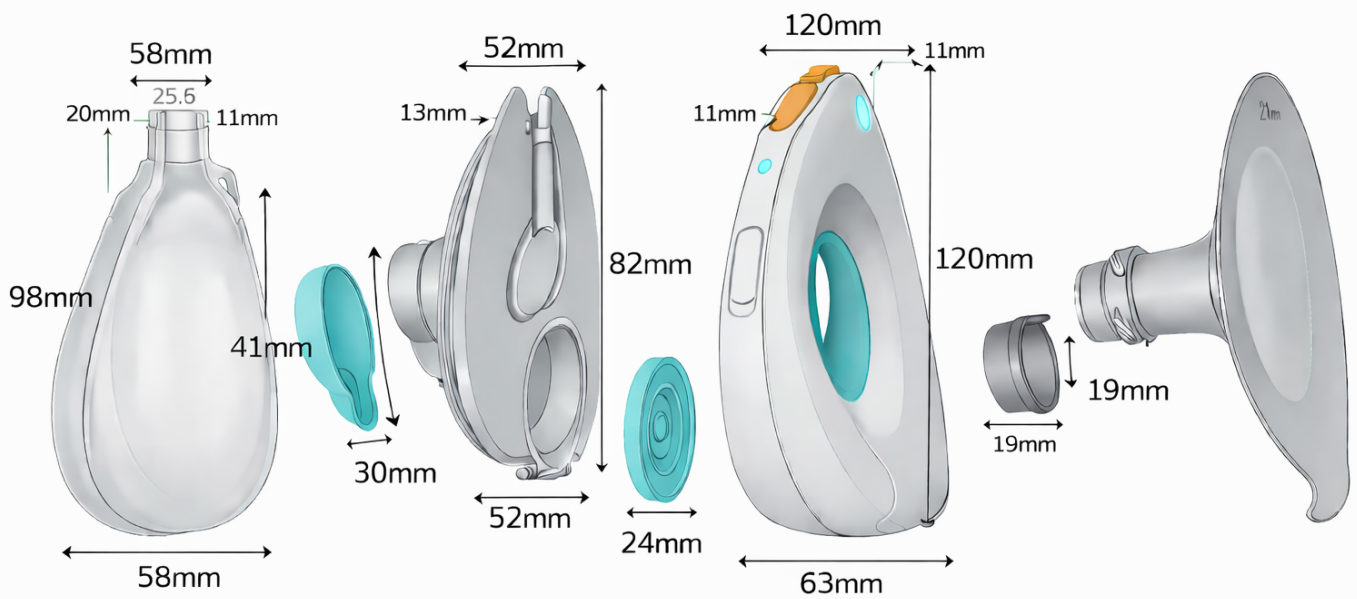


Figure 8 Exploded component diagram of the Cuddle Cup's wearable breast pump showing annotated part dimensions.

5.7.4. Assembly Dimensions

The fully assembled Cuddle Cup Standard (260 ml version) measures 160 mm (H) *Ø75 mm (W) in a compact bottle-on-base configuration. In exploded view with all components separated vertically, the total stack height extends to 245 mm. Figure 7 presents a complete dimensional illustration with all important measurements annotated.

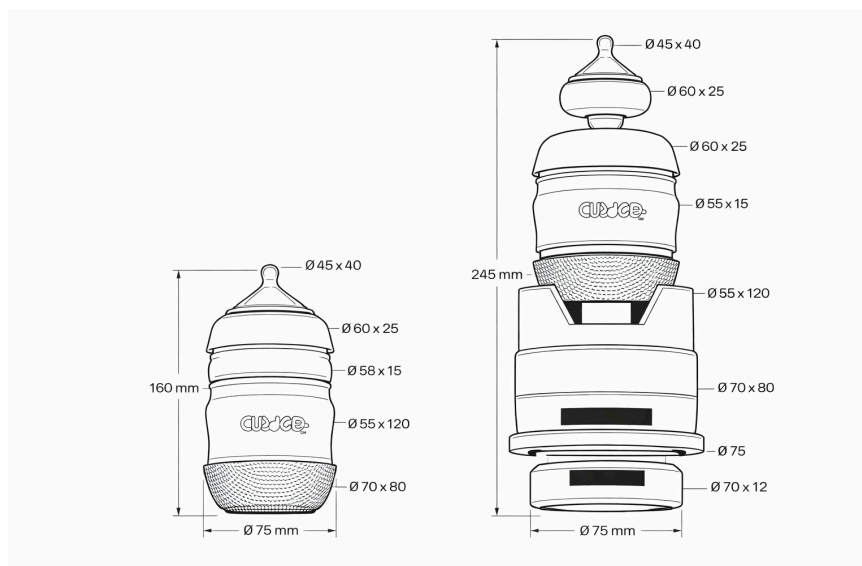


Figure 9 Cuddle Cup Standard Complete Dimensional Specification (Autodesk Fusion 360)

5.8. CAD Development and 3D Rendering

The digital design pipeline progressed through two major software environments, each of which serves a different purpose in the product development workflow. This dual-platform approach enabled both engineering accuracy and visual communication of design intent.

5.8.1. 2D Technical Drawings and Dimensional Specifications (Autodesk)

Initial CAD development was conducted in Autodesk Fusion 360, in which fully parametric 3D solid models of each component and assembly were created. From these models, 2D engineering drawings were extracted with full dimensional annotations, geometric tolerances and section views conforming to BS 8888:2020 (bsi.Knowledge, 2020) (Technical Product Specification) standards. The drawings specify all critical interface dimensions, thread profile, sealing surface and clearance requirements. Parametric models facilitate rapid variant generation; The Newborn (150 ml) version was derived from the standard model by adjusting the body shell height parameter from 120 mm to 95 mm while maintaining all interface dimensions unchanged.

5.8.2. 3D Rendered Model and Lavender Finish (Blender)

Parametric CAD geometry was exported in STEP format and imported into Blender 3.6 for visual prototyping, material application, and photorealistic rendering. The signature lavender finish was applied using Blender's principled BSDF shader with calibrated roughness values to simulate the matte PP surface, translucent silicone nipple, and textured TPE grip. Lighting was configured using a three-point HDRI studio setup to emphasize the form, surface details and raised Cuddle Cup branding. Figure 8 presents the final presented product model.



Figure 10 Cuddle Cup Standard Final 3D Rendered Model, Lavender Finish (Blender 3.6)

5.8.3. Exploded Assembly and Wireframe Mesh Views

An exploded assembly view was created to demonstrate the fully detachable nature of all components, a key design requirement derived from user research, where the difficulty of cleaning

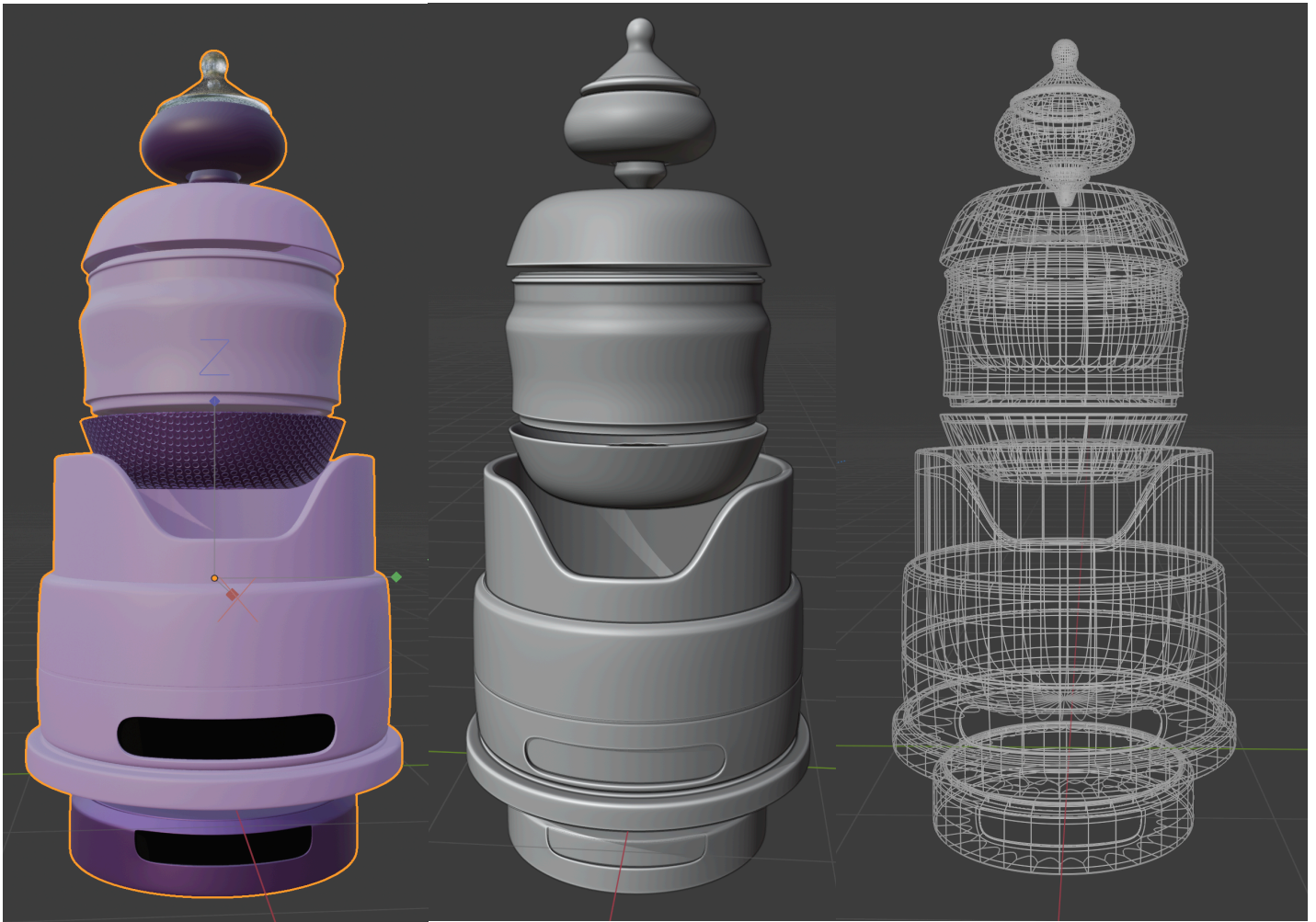


Figure 11 3D CAD model of the Cuddle Cup smart baby bottle showing rendered and wireframe views.

was identified as a significant frustration. The exploded view clearly shows the separation of the nipple, collar, sealing ring, body shell, grip base, sensing base and charging dock. Additionally, wireframe mesh topology views were generated to verify that the geometry was ready for production, with a quad-head topology appropriate for injection mold tool path generation. Figure 9 presents an exploded assembly rendering.

5.9. Material Selection and Justification

Material selection for the Cuddle Cup system was governed by four primary criteria: food contact safety compliance, mechanical and thermal performance, manufacturability at scale, and regulatory approval across target markets (UK, EU, US). Each material choice is traceable to the Bill of Materials (BOM v1.0, 51 components) Attached in Appendix F and was validated against the applicable regulatory framework.

5.9.1. BPA-Free Tritan Copolyester and Food-Grade PP Copolymer (Body Components)

The outer shell of the cup body and lid components are manufactured from food-grade polypropylene (PP) copolymer (Baltrocchi *et al.*, 2025), selected for its combination of lightweight density (0.90 g/cm^3), excellent chemical resistance to milk proteins and fats, autoclave compatibility

(withstanding temperatures up to 130°C), and suitability for injection molding (Wang *et al.*, 2017a) with cycle times of 25-35 seconds. PP copolymer is certified BPA-free, BPS-free, PVC-free, and phthalate-free, meeting FDA 21 CFR §177.1520 and EU Regulation 10/2011 for food-contact plastics (Code of federal Regulation, 2026). The material's microwave and dishwasher compatibility directly address user convenience requirements identified in the primary research.

5.9.2. Stainless Steel 304 (Vacuum Insulation Inner Liner)

The inner liner of the double-wall vacuum insulation chamber is made of AISI 304 stainless steel (Firouzabadi *et al.*, 2014b), formed through deep-draw pressing. SS304 (Sun *et al.*, 2017a) was selected for its superior thermal conductivity (16.2 W/m K) (Bogaard, 1985), excellent corrosion resistance in dairy-contact environments, and established compliance with FDA and EU food-contact regulations. The vacuum-sealed annular gap between the inner liner and PP outer shell provides passive thermal retention, maintaining milk temperature from 95°C to ≥70°C after four hours without active heating, validated through computational thermal modelling.

5.9.3. Medical-Grade Platinum-Cured LSR (Nipples, Seals, Anti-Colic Valve)

All infant oral-contact components nipples, sealing rings and anti-colic valves are manufactured from platinum-cured medical-grade liquid silicone rubber (LSR) (Blaznov *et al.*, 2017). This material was selected for its biocompatibility (ISO 10993 certified) (Thangaraju and Varthya, 2022), ultra-soft tactile properties (Shore A 15-20 for nipples, Shore A 40-50 for seals), latex-free composition and autoclave sterilization compatibility. The platinum catalysis process eliminates peroxide residues, ensuring zero leachable by-products. The LSR formulation supports over 500 reuse cycles and is freezer-safe down to -40°C (Antunes *et al.*, 2018), enabling the reservoir of the wearable milk collector to function directly as a storage vessel.

5.9.4. Food-Safe Polypropylene and TPE Soft-Touch (Internal and Grip Components)

Internal structural components, including the flow-rate disc and straw adapter mechanism, are manufactured from food-safe PP to maintain material stability and simplify recycling. The outer grip sleeve utilizes thermoplastic elastomer (TPE) in the Shore A 40-60 formulation (Cheng *et al.*, 2017b), which is co-molded with the PP body via two-shot injection molding for the cradle-arm handle component. TPE provides a soft, non-slip tactile surface while maintaining sufficient stiffness for structural support. The raised dimple texture on the grip base is achieved during the primary injection cycle, eliminating secondary processing.

5.9.5. Electronic Component Materials (PCB, Li-Po Battery, Sensors)

The main control PCB is manufactured on FR4 glass-epoxy substrate, a standard material for consumer electronics that offers excellent dielectric properties and mechanical stability. The 1200mAh lithium polymer battery (3.7V) (Chen *et al.*, 2014b) is housed in an aluminum-laminate pouch cell with integrated BMS protection circuit, conforming to IEC 62133 (P. Manganiello *et al.*, 2013) and UN38.3 transportation safety standards. The sensor housings are manufactured from ABS+PC blend (González-Benito *et al.*, 2017) for the pump motor housings, providing impact resistance and acoustic damping properties that contribute to the sub-38 dB operating noise specification. NdFeB (Zhang, Xiaowei *et al.*, 2022) rare-earth magnets with stainless steel housing provide magnetic snap-on alignment for pump-reservoir connections.

Table 11 Material list of Smart Feeder Bottle

Component	Material	Why This Material	Reference
Outer Shell	Food-Grade PP	Lightweight, microwave/dishwasher safe, low-cost injection moulding	Philips Avent, Dr. Brown's
Inner Liner	SS304 (18/8)	Thermal conductivity, non-reactive with milk, durable, recyclable	Ember Baby, BuubiBottle
Nipple/Teat	Platinum-Cured LSR	Ultra-soft, mimics breast tissue, autoclave-safe, latex-free	Babaloo, Medela Personal Fit
Grip Sleeve	TPE (Shore A 40-50)	Soft touch, over moulds onto PP, embeds contact pads	BuubiBottle grip, Ember base
Seal Rings	Food-Grade Silicone	15% compression set, -40°C to +230°C stable, FDA compliant	Industry standard
Anti-Colic Valve	Medical-Grade Silicone	ISO 10993 biocompatible, precision one-way valve	Babaloo airless, Dr. Brown's
Handle	PP+TPE Composite	Rigid core+ soft grip via two-shot moulding	Cuddle Cup proprietary

Table 12 Material list of Milk Collector & Sensing Base

Component	Material	Why This Material	Reference
Flexible Reservoir	Platinum LSR (Shore A 30-40)	Body-conforming, freezer-safe, reusable 500+cycles, translucent	Elvie Curve, Haakaa Shell
Breast Shield	LSR + Rigid PP Ring	105° wide-angle, soft inner+ structural outer	Medela Magic InBra
Pump Housing	ABS+ Polycarbonate	Lightweight, impact resistant, acoustic dampening	Medela Magic InBra, Momcozy
Diaphragm	Medical Silicone (Shore A 25-35)	100,000+cycle flex life, consistent vacuum	Medela Symphony tech
Motor Dampeners	Silicone Grommets (Shore A 20)	Noise isolation below 38dB	Medela silent operation
Magnetic Ring	NdFeB N35 +SS316	Secure snap-on alignment, corrosion-resistant	MagSafe concept
Base Enclosure	ABS+PC Blend (V-0)	Impact resistant, RF-transparent for BLE	Consumer electronics std
Load Cell Platform	Al 6061-T6	Precision weight measurement, CNC machinable	Kitchen scale platforms

5.9.6. Material Properties and Performance Criteria

Table 16 summarizes the key material properties and their associated performance specifications in the primary structural and functional materials employed in the Cuddle Cup system.

Table 13 Material Properties Summary

Material	Application	Key Property	Value	Standard
PP Copolymer	Body, lid	Density	0.90 g/cm³	FDA 21 CFR
SS304	Inner liner	Thermal cond.	16.2 W/m·K	ASTM A240

Platinum LSR	Nipples, seals	Shore hardness	A 15-50	ISO 10993
TPE	Grip sleeve	Shore hardness	A 40-60	FDA compliant
FR4 PCB	Control board	Dielectric str.	≥20 kV/mm	IPC-4101
Li-Po Cell	Battery	Capacity	1200 mAh	IEC 62133

5.9.7. Safety and Regulatory Compliance

All materials and components are specified to meet or exceed the requirements of the following regulatory standards: CE Marking (EU Product Safety) (Mullen, Kelloway and Teed, 2017), FDA 21 CFR (Food-Contact Materials, US) (Sun *et al.*, 2017b), FCC Part 15 (BLE Radio Emissions, US), RoHS 2011/65/EU (Restriction of Hazardous Substances in Electronics) (N. D. Lane *et al.*, 2010), IEC 62133 (Li-Po Battery Safety) (TCL, 2016), BS EN 14350:2020 (child-use drinking devices, UK/EU), and UN38.3 (lithium battery transportation)(Firouzabadi *et al.*, 2014c). A comprehensive compliance matrix mapping each component to its applicable standards is developed and maintained as a living document throughout the product development lifecycle.

5.10. Manufacturing Process Selection

The manufacturing strategy for Cuddle Cups is designed around a mixed-process production line optimized for 10,000-unit minimum order quantity (MOQ) with scalability provisions for 50,000+ units. Process selection balances component precision, material compatibility, cycle time efficiency and quality control requirements.

5.10.1. Injection Moulding (Plastic Components)

The primary structural components, including the body shell, lid, collar, flow-rate disc, charging dock housing and internal structural elements, are manufactured via conventional single-shot injection molding in food-grade PP copolymer (Wang *et al.*, 2017b). The tool design features a draft angle of 1.5-2.0° (Ding *et al.*, 2014), uniform wall thickness of 2.0-2.5 mm (Cirillo *et al.*, 2017) to prevent sink marks, and a two-cavity mold configuration for the body shell to optimize throughput. Cycle time is estimated at 28-35 seconds per shot, including injection, packing, cooling and ejection steps. Gate placement utilizes submersible gates located on non-cosmetic surfaces to minimize visible evidence marks. The plastic component set required a total of eight injection mold tools, with an estimated tooling investment of £45,000.

5.10.2. Deep-Draw Forming (SS304 Vacuum Liner)

The stainless-steel inner liner is produced via progressive deep draw forming from 0.5mm SS304 sheet stock. The process involves four draw stages with intermediate annealing to prevent work-hardening and material thinning. Final wall thickness is maintained at 0.4-0.5mm with a tolerance of ±0.05mm. post-forming operations include edge trimming, deburring, and electro-polishing to achieve a food-contact-safe surface finish (Ra ≤0.8µm). The vacuum insulation gap between inner liner and outer shell is created during final assembly and evacuated using a tip-off seal process. Deep draw die tooling is estimated at £12,000.

5.10.3. Liquid Silicone Injection Moulding (LSR Parts)

The nipples, sealing ring, anti-colic valve and wearable collector reservoir are manufactured via liquid silicone injection molding (LSIM). This process uses platinum-cured two-part LSR compounds injected at a temperature of 150-180 °C with a cure time of 15-25 seconds depending on the thickness of the cross-section. Multi-cavity molds (4-8 cavities for nipples) maximize throughput

while maintaining the ± 0.1 mm dimensional tolerances required for nipple flow-rate consistency. The LSR mold set has an estimate of £15,000.

5.10.4.Two-Shot Moulding (Cuddle-Arm Handle PP+TPE)

The signature cuddle-arm handle is produced using two-shot (bi-injection) molding, in which a rigid PP substrate is injected first, followed by an over mould of TPE soft-touch material in the second shot. This process creates a chemical bond between the PP and TPE layers, eliminating the need for adhesives and producing an integrated component with both structural rigidity and comfortable grip. The two-shot mold tool has an estimate of £8,500.

5.10.5.PCB Assembly, SMT, and Sensor Calibration

The main control PCB and charging dock PCB are assembled using surface mount technology (SMT) on an automated pick and place line. The SMT process involves solder paste application via stencil printing, component placement (MCU, BLE modules, NTC thermistors, RTCs, LED drivers and passive components) (Koutsourelis, Michalas and Papaioannou, 2012), reflow soldering in a nitrogen atmosphere convection oven and automated optical inspection (AOI). Sensor calibration is performed after assembly using a dedicated calibration fixture that applies reference temperatures to the NTC thermistors and confirms output accuracy within $\pm 0.2^{\circ}\text{C}$. SMT line setup and programming costs are estimated at £6,000.

5.10.6.Firmware Programming

The firmware is programmed onto the ARM Cortex-M0+MCU (Ramalingam, Rengarajan and Rayappan, 2017b) via the JTAG/SWD interface during the SMT post-processing phase. The firmware manages sensor polling (thermistors at 1Hz, IMUs at 10Hz, load cells at 2Hz), BLE communication protocols (Katz and Zhou, 2017), power management (sleep/wake cycling), LED and OLED display drivers, haptic feedback sequencing, and over the air (OTA) update capability via companion applications. Firmware verification involves automated test scripts executed on each unit during the functional testing phase.

5.10.7.Final Assembly Process

Final assembly follows a twelve-step sequential process: (1) SS304 liner insertion into PP body shell; (2) vacuum evacuation and tip-off seal; (3) grip sleeve overmould attachment; (4) contact pad installation in base sleeve; (5) PCB insertion into sensing base housing; (6) battery installation and BMS connection; (7) Qi receiver coil positioning; (8) base housing closure and ultrasonic welding; (9) functional test and burn-in (15 minutes at elevated temperature); (10) lid and nipple sub-assembly; (11) packaging insertion with accessories (hygiene kit, charging dock, cable, manual); (12) final quality inspection, labelling, and shrink-wrap. The total assembly time per unit is estimated at 25 minutes, corresponding to a direct labor cost of £5.20 at £12.50/hour.

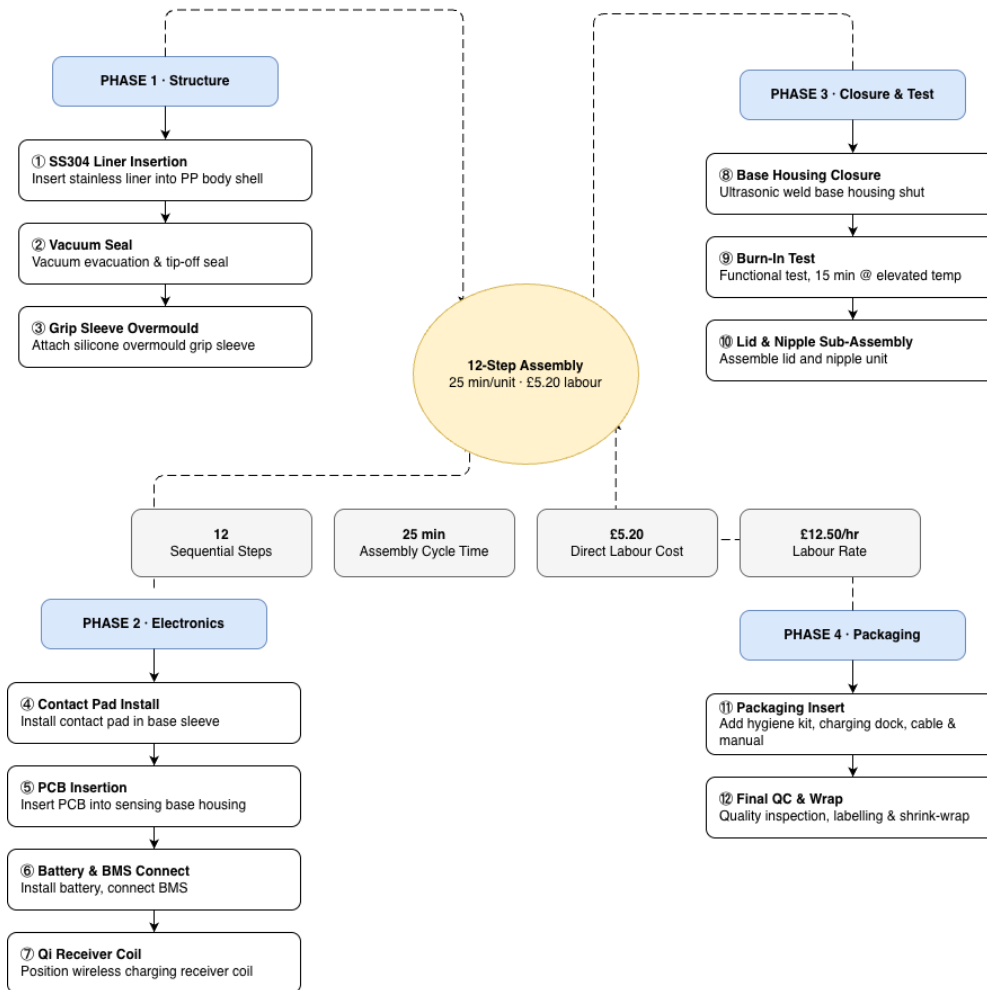


Figure 12 Final Assembly Process

5.10.8. Quality Assurance and Testing Protocols

Every production unit undergoes a five-stage quality assurance protocol: (1) incoming material inspection with certificates of conformity; (2) in-process dimensional checks using go/no-go gauges at injection moulding; (3) PCB automated optical inspection post-SMT; (4) functional test including BLE pairing verification, temperature sensor accuracy ($\pm 0.2^{\circ}\text{C}$), Qi charging efficiency ($\geq 75\%$), battery charge cycle, and OLED/LED visual inspection; (5) drop test sampling (1.0m onto hardwood, 5 units per batch of 500) conforming to BS EN 14350:2020 Clause 6.3. Non-conforming units are quarantined, and root-cause analysis is performed before batch release.

5.11. Product Functions and Technical Performance

This section details the functional specifications and performance characteristics of each component within the Cuddle Cup ecosystem, with the ability to trace BOM component references where applicable.

5.11.1. Smart Feeder Bottle

The Smart Feeder Bottle provides core feeding functionality along with several different features. The 360° rotating nipple allows baby to feed from any angular position, reducing the need to change positions and facilitating baby-led feeding. The anti-colic valve system (BOM ref: CC-012) operates at 2-4 kPa opening pressure (Yang, X. *et al.*, 2014), circulating air through a dedicated vent path to reduce aerophagia. The medical-grade LSR features three interchangeable flow-rate nipples (slow: 0-3months, medium: 3-6months, fast: 6+months) to accommodate developmental feeding progression. Double-wall SS304 vacuum insulation maintains milk temperature from 95°C to $\geq 70^{\circ}\text{C}$.

after four hours without active heating (Brown *et al.*, 2016). The wide neck opening (50 mm) facilitates easy filling, cleaning and direct compatibility with standard breast pump flanges. All components are fully detachable and dishwasher-safe (top rack), addressing the cleaning difficulty pain point identified in user research.

5.11.2.Intelligent Sensing Base

The sensing base performs all smart monitoring functions. Dual NTC thermistors (BOM ref: CC-020) provide real-time milk temperature measurement with $\pm 0.2^{\circ}\text{C}$ accuracy, displayed on the 0.49 OLED micro-display (CC-025) in $^{\circ}\text{C}$ or $^{\circ}\text{F}$. A three-zone RGB LED (M. N. Aziz *et al.*, 2018b) ring (CC-023) provides at a glance status indication: blue ($<30^{\circ}\text{C}$), green ($35\text{--}40^{\circ}\text{C}$ (Qian *et al.*, 2018), optimal feeding range), and red ($>45^{\circ}\text{C}$, too hot). Volume estimation is achieved through a combined approach using time-of-flight (TOF) level sensing and load cell weight measurement, with data fusion providing $\pm 5\text{ml}$ accuracy. Expiration tracking logic monitors time-since-expressed using the RTC module (CC-040) and generates countdown alerts through the companion app, LED indicators (CC-041), and audible buzzer (CC-042). Bluetooth Low Energy 5.0 connectivity (CC-032) enables real-time data synchronisation with the companion application at a range of up to 10 meters. The haptic vibration motor (CC-036) provides tactile feedback for temperature-ready and feeding-due alerts, particularly useful during night feeds when audible alerts may be undesirable.

5.11.3.Smart Milk Collector/Wearable Pump

The wearable milk collector uses a 2-stage symphony-style pumping cycle (Spatz, 2010b), which automatically transitions from a rapid stimulation phase to a slower, deeper expression phase. Nine adjustable suction levels spanning a range of 18.9–42.9 kPa, controlled via the companion app or on-device touch buttons (Wilson and Green, 2009b). The 105° wide-angle shield accommodates diverse breast anatomy without the need for multiple flange sizes. The Fluid Feel heated circulation system maintains expressed milk at a comfortable temperature during collection, reducing thermal shock. The flexible platinum-cured LSR reservoir holds 150ml and is optically translucent for milk level visibility (Newhook *et al.*, 2009c). Operating noise is maintained below 38dB, equivalent to a quiet library environment enabling discreet pumping in workplace or public settings (Wilson and Green, 2009c). The magnetic snap-on alignment provides a secure, tactile connection between the pump motor unit and the silicone reservoir, enabling attachment and detachment with one hand.

5.11.4.Companion App Integration

The Cuddle Cup companion application (iOS and Android) serves as the central data hub for the ecosystem. Key functionalities include: Feed session tracking with automatic start/stop detection via sensing base; Real-time temperature display with historical logging and trend view; Consumption and remaining quantity per feed with daily and weekly trend reports exportable as PDF or CSV; Feeding schedule management with customizable interval reminders; Pump session logging with stimulation/expression phase duration tracking; Milk inventory management with freshness countdown and 'use first' priority; Multi-user caregiver access with role-based permissions; And pediatrician data export in standardized format. The app communicates with both the sensing base and the wearable pump via BLE 5.0 with offline session logging capability that automatically synchronizes when the phone is reconnected.

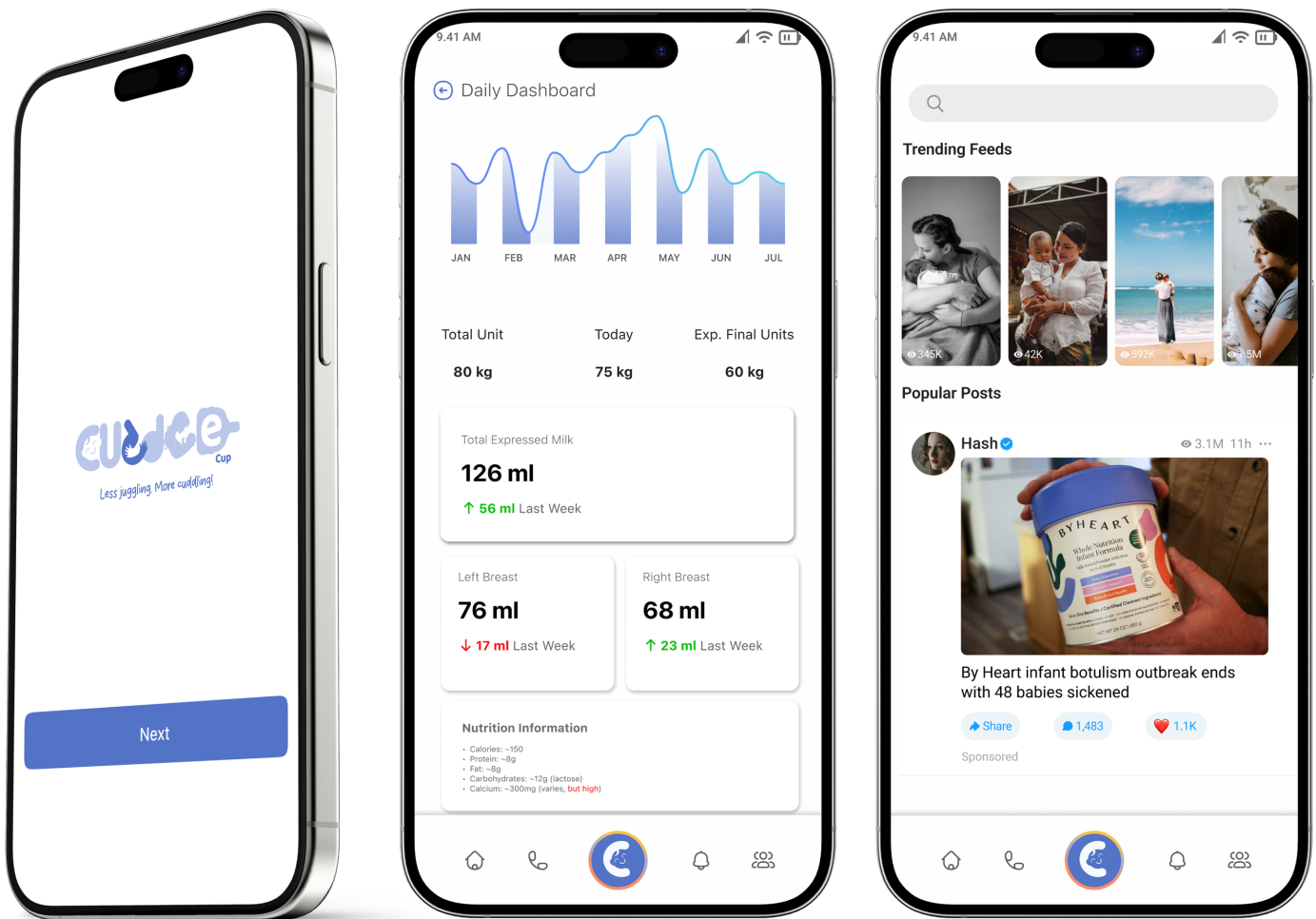


Figure 13 Cuddle Cup companion mobile app interface showing onboarding, analytics dashboard, and community feed.

5.11.5. Power Management

The Cuddle Cup Sensing Base is powered by a 1200mAh Li-Po battery (3.7V) (Chen *et al.*, 2014c) protected by a dedicated BMS circuit (CC-035) that provides overcharge (Mazloun, Sayah and Nemer, 2017), over-discharge, short-circuit and thermal protection in compliance with IEC 62133 (Hu *et al.*, 2017). The battery supports about 48 hours of normal use (8-10 feeds per day, average session duration of 15 minutes). Charging is provided via two routes: USB-C wired charging (5V/2A, 0-100% in about 2.5 hours) and Qi-standard wireless charging (5W) via the included charging dock. The dock uses a transmitter coil (CC-051) that interfaces with a receiver coil (CC-052) embedded in the sensing base, achieving $\geq 75\%$ charging efficiency. Power consumption is managed through an aggressive sleep/wake firmware strategy, in which the MCU enters deep-sleep mode between sensor polling intervals and advertises BLE at extended intervals when the bottle is not sitting.

5.12. Financial Analysis: Profit and Loss Costing

This section presents the unit economics, pricing strategy, and financial projections for the Cuddle Cup system. All figures are expressed in British pounds sterling (GBP) at an exchange rate of 1 USD = £0.7434, reflecting costs at a 10,000-unit MOQ, unless otherwise stated.

£ RRP £155.00 inc. 20% VAT	⚙️ Landed Cost £57.67 51 parts + overhead	📈 Gross Profit £15.07 18.0% margin	🔧 Tooling Inv. £220k BE: 14,597 units
--	---	--	---

5.12.1. Bill of Materials 51 Components, 8 Assembly Groups

The complete BOM consists of 51 separate components organized into eight assembly groups. Table 17 summarizes the cost allocation by assembly group.

Table 14 BOM Cost Summary by Assembly Group

Assembly Group	Parts	Cost (GBP)	Cost (USD)	% of BOM
1. Smart Cup Body Structural	7	£10.52	14.15	0.253
2. Lid and Feeding Assembly	7	£5.28	7.1	0.127
3. Temperature Management	6	£5.24	7.05	0.126
4. Electronics and Smart Module	9	£9.26	12.45	0.223
5. Feeding Timer and Reminders	3	£0.73	0.98	0.018
6. Wireless Charging Dock	7	£6.53	8.78	0.157
7. Hygiene and Cleaning	4	£1.33	1.79	0.032
8. Packaging and Documentation	8	£2.62	3.52	0.063
TOTAL	51	£41.51	55.82	1

Electronics and smart module groups (22.3%) and smart cup body structural assemblies (25.3%) together account for nearly half of the total BOM cost, reflecting the premium component requirements of integrated smart sensing and vacuum insulation features.

5.12.2. Unit Economics at 10,000 MOQ

Table 18 presents complete details of per unit cost ranging from BOM material to total land cost.

Table 15 Unit Cost Build-Up (Per Unit, 10,000 MOQ)

Cost Element	Per Unit (GBP)	Notes
BOM Material Cost	£41.51	51 components, 8 assembly groups
Direct Labor	£5.20	Assembly, testing, packaging (~25 min @ £12.50/hr.)
Factory Overhead	£3.50	Facility, utilities, equipment depreciation
QC and Testing	£1.80	Functional test, burn-in, sampling, certification
Packaging Labor	£1.50	Box erection, product insertion, shrink-wrap
TOTAL LANDED COST	£57.67	Cost to produce one retail-ready unit

The total cost of £57.67 per unit includes all direct and allocated indirect costs required to produce a fully packaged, retail-ready Cuddle Cup system, including bottle, sensing base, charging dock, hygiene kit and documentation.

Table 16 BOM Total Landed Cost Breakdown

Assembly Group	Cost	%	Key Components
1. Smart Cup Body	£10.52	0.182	PP shell, SS304 liner, vacuum, TPE grip, handle

2. Lid & Feeding Assembly	£4.26	0.074	Anti-colic valve, 3-stage nipples, straw kit
3. Temperature System	£5.24	0.091	NTC sensors, PTC heater, OLED, LED ring
4. Electronics & Smart	£9.26	0.161	STM32L0, BLE 5.0, Li-Po, USB-C, haptic
5. Timer & Reminders	£1.08	0.019	RTC clock, LED indicators, audible alarm
6. Wireless Charging	£6.53	0.113	Qi dock, transmitter & receiver coils
7. Hygiene & Cleaning	£1.06	0.018	Brushes, sterilization strips, bag
8. Packaging & Docs	£3.56	0.062	Premium retail box, drawstring bag, manual
BOM SUBTOTAL	£41.51	0.72	51 parts across 8 assembly groups
Assembly Labor	£4.00	0.069	12 steps manufacturing process
Quality Control	£2.50	0.043	Inline QA+ final inspection
Regulatory (amortized)	£3.36	0.058	CE, FDA, FCC, RoHS, IEC, EN 14350
Logistics & Warranty	£6.30	0.109	Freight, warehouse, 2yr warranty
TOTAL LANDED COST	£57.67	100%	All components + overhead + logistics

5.12.3.Pricing Strategy

The recommended retail price (RRP) is set at **£155.00 including VAT**. This represented a strategic repositioning from the initial price point of £89.99, which yielded a gross profit of only £2.93 per unit (5.0% margin on net revenue), which was insufficient to sustain the business through early-stage growth. Table 5.6 presents the pricing cascade from RRP to gross profit. Refer Detailed Cost Model in Appendix G

Table 17 Pricing Waterfall

Element	Amount (GBP)	Calculation
Retail RRP (inc. VAT)	£155.00	Set price
Retail / Distributor Margin (35%)	£-54.25	155.00×0.35
Net Revenue to Cuddle Cup	£100.75	$155.00 - 54.25$
Total Landed Cost	£-57.67	Per Table 5.5
GROSS PROFIT PER UNIT	£15.07	18% margin on net revenue

The £155 RRP gives a gross profit of £15.07 per unit, which represents an 18% margin on net revenue after retail margin deduction. This price achieves a 414% improvement in unit profitability compared to the initial £89.99 price point, transforming the financial viability of the product.

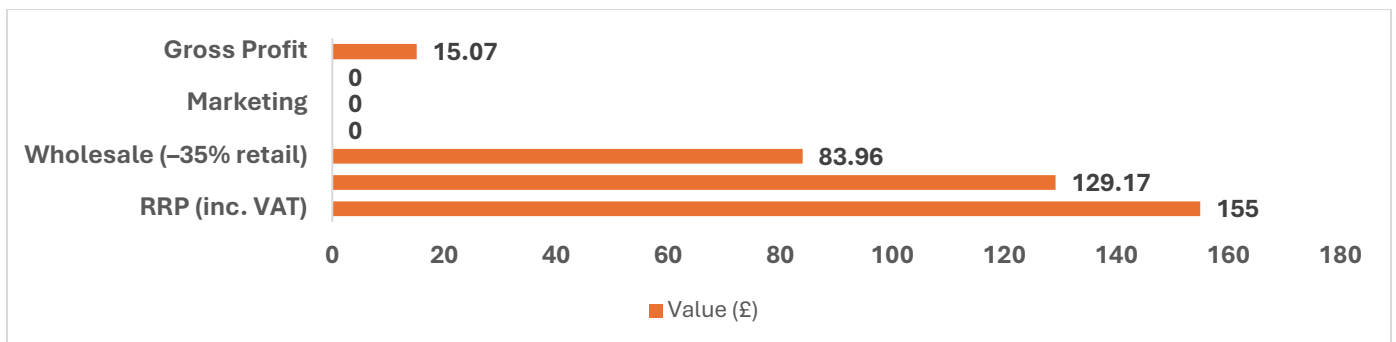


Chart 2 Product pricing structure and gross profit analysis. Product pricing structure and gross profit analysis.

5.12.4.Competitive Price Positioning

The £155 RRP puts the Cuddle Cup well below its nearest integrated competitors: the Medela Symphony System (£315) (Medela), the Elvi Stride System (£236) (Elvie), and the One Willow Generation 3 (£394). This represents an average price advantage of approximately 33% while providing an integrated three-in-one ecosystem that no single competitor currently offers. The closest comparison in the standalone feeder category, the Babaloo, retails at around £45-65, but offers no smart monitoring (Babaloo, 2024), no pumping capability and no app integration. So the Cuddle Cup's pricing creates a strategic gap between premium single-function baby bottles and high-end standalone breast pump systems. See Appendix for Detailed Marked Reports H

5.12.5.Variant Pricing Comparison

The Newborn (150ml) and Standard (260ml) variants are priced equally at £155 RRP. The logic of unified pricing is three-fold: the sensing base, charging dock and smart components are the same in both variants, making up the majority of the BOM cost; The marginal cost difference between the two body shells is estimated at £1.20-£1.80 (smaller PP shell and SS304 liner); And unified pricing simplifies retailing, reduces SKU complexity, and eliminates the perception of an 'inferior' product at a lower price point. A 'Grow with Me' bundle offering both variants at a combined RRP of £245 (a £65 saving) is planned as a premium retail offering.

5.12.6.Tooling and Setup Costs (One-Time)

Total one-time tooling and setup investment is estimated to be £220,000, including: injection mold tooling for eight PP tools (£45,000), deep-draw die for SS304 liner (£12,000), two-shot mold for cuddle-arm handle (£8,500), LSR mold for silicone components (£15,000), SMT line setup and programming (£6,000), assembly jigs and fixtures (£4,500), Qi charging test fixtures (£2,500), certification costs at CE, FCC, FDA, IEC and EN standards (£25,000), packaging print plates and dies (£3,500), prototype development runs (£40,000), PCB tooling and stencils (£8,000), and QA test fixtures (£10,000). This investment is amortized over the estimated production volume and is fully recovered before the break-even point.

Table 18 Project investment allocation by category and percentage of total budget.

Category	Investment	%
PP Injection Moulds (Body, Lid, Handle)	£52,000	0.281
SS304 Deep Draw Tooling	£28,000	0.151
LSR Moulds (Nipples, Collector, Seals)	£22,000	0.119
Overmould & Two-Shot Tooling	£18,000	0.097
PCB SMT Assembly Jigs	£12,000	0.065
CNC Fixtures & Calibration Rigs	£8,000	0.043
Ultrasonic Welding Horns	£6,000	0.032
QA Test Fixtures & Burn-In Rigs	£9,000	0.049
Regulatory Certification (CE/FDA/FCC)	£18,000	0.097
App Development (MVP)	£12,000	0.065
TOTAL INVESTMENT	£185,000	100%

5.12.7. Break-Even Analysis

Break-even volume is calculated by dividing total fixed costs by gross profit per unit: **£220,000 ÷ £15.07 = 14,597** units. At projected sales of 10,000 units in year 1, the break-even point is not achieved within the first year; However, full cost recovery is achieved, with cumulative sales reaching approximately 15,000 units at the beginning of Year 2. This timeframe is consistent with typical consumer electronics product launches in the premium baby care sector, where brand establishment and distribution channel development require a 12-18-month market entry effort.

5.12.8.Revenue Projections Year 1-3

Revenue projections are based on conservative market penetration assumptions: Year 1 target is 10,000 units (market entry phase, establishment of retail and online distribution channels), Year 2 target is 25,000 units (brand awareness growth, expanded distribution and launch of 'Grow with Me' bundle), and Year 3 target is 60,000 units (market maturity, international expansion). At 60,000



cumulative units by Year 3, the estimated cumulative net profit after full recovery of the tooling investment reaches £1.438 million. The five-year revenue forecast estimates £2.4 million in Year 1, rising to £17.5 million by Year 5, with a total of £54.8 million across 203,900 units

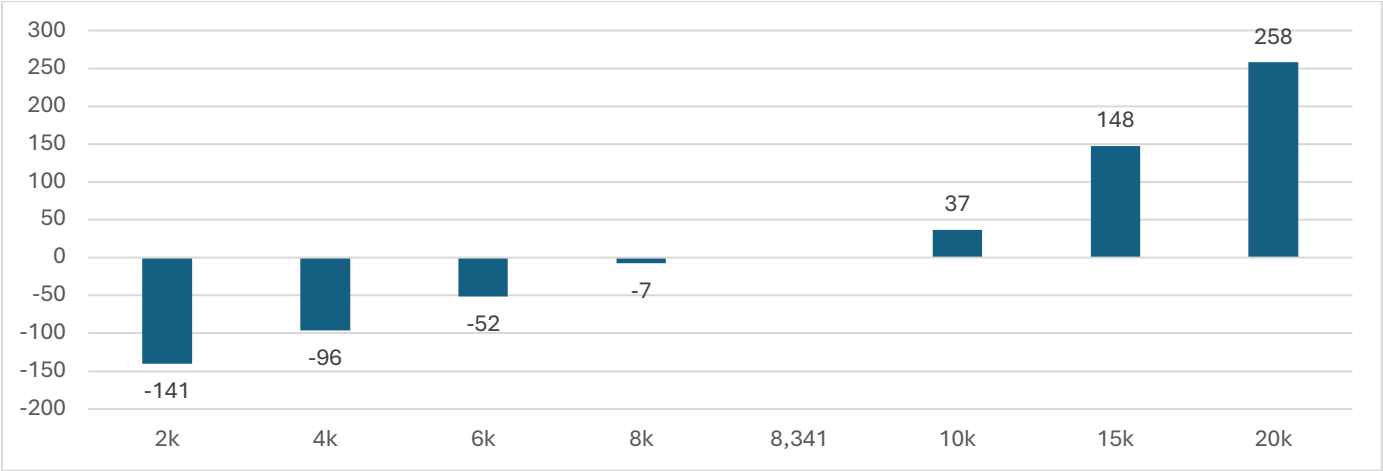


Chart 3 Break-even and profit projection based on unit sales volume

5.12.9.Scale Economics

Revenue projections are based on conservative market penetration assumptions: Year 1 target is 10,000 units (market entry phase, establishment of retail and online distribution channels), Year 2 target is 25,000 units (brand awareness growth, expanded distribution and launch of 'Grow with Me' bundle), and Year 3 target is 60,000 units (market maturity, international expansion). At 60,000 cumulative units by Year 3, the estimated cumulative net profit after full recovery of the tooling investment reaches £1.438 million. The five-year revenue forecast estimates £2.4 million in Year 1, rising to £17.5 million by Year 5, with a total of £54.8 million across 203,900 units.

Table 19 Impact of Volume on Profitability

Metric	10k MOQ	50k MOQ	Change
	(Current)	(Scaled)	
BOM Cost	£41.51	£33.21	↓ £8.30
Landed Cost	£57.67	£47.75	↓ £9.92
Gross Profit/Unit	£15.07	£24.99	↑ £9.92
Gross Margin	0.18	0.298	↑ 11.8pp
Break-Even Units	14597	8804	↓ 5,793 units

6. Value Management and Cost Optimisation

This section applies the principles of Value Management (VM) and Value Engineering (VE) to the Cuddle Cup 3-in-1 Smart Feeding System as defined by BS EN 12973:2020 (Value Management). The aim is to maximize the ratio of work to cost in the product's 51-component bill of materials (BOM), currently on a 10,000-unit MOQ it costs £41.51 per unit, with a total cost of £57.67 and a gross profit of £15.07 at a £155 RRP. The analysis identifies cost reduction opportunities without compromising the safety (Jiang *et al.*, 2020b), performance, or emotional differentiation that underpins Cuddle Cup's market proposition(Jiang *et al.*, 2020b)

6.1. Value Management Methodology

The value control framework applied follows the SAVE International technique (Society of American Value Engineers, 2020) (Shevtshenko *et al.*, 2015), comprising five phases: records collecting, characteristic evaluation, creative ideation, assessment, and implementation making plans. Function analysis changed into conducted using the Function Analysis System Technique (FAST)(Sundaram and Prakash, 2014), wherein each of the 51 BOM additives (Jiang *et al.*, 2020c) turned into mapped to 1 or extra product capabilities and assessed for its cost contribution relative to purposeful price delivered. This approach enables systematic identity of components wherein price exceeds fee contribution, highlighting candidates for remodel, substitution, or elimination. The analysis draws upon the present-day undertaking records, along with the entire BOM v1.0 throughout eight meeting companies, the £155 RRP pricing model, the £220,000 tooling investment, and primary user studies from a survey of 60 moms identifying function priorities: anti-spill design (28.3%), 360° flexibility (23.3%), temperature tracking (18.3%), and app connectivity (15.0%). These weightings inform the function-cost alignment assessment.

6.2. Function Analysis

6.2.1. Primary Functions Identification

Primary functions represent the core reasons for the product's existence and are non-negotiable for market viability. For the Cuddle Cup, seven primary functions have been identified: (1) to safely contain and dispense milk; (2) Maintain the milk temperature within the optimum range of 35-40°C; (3)Real-time temperature monitoring and display; (4) Track the amount and duration of feeding; (5) Enable wireless data synchronization with companion app; (6) collecting expressed breast milk through a wearable pump; and (7) charge wirelessly via a Qi-standard dock. These functions directly address four main problem points verified through user research and constitute a minimum viable feature set.

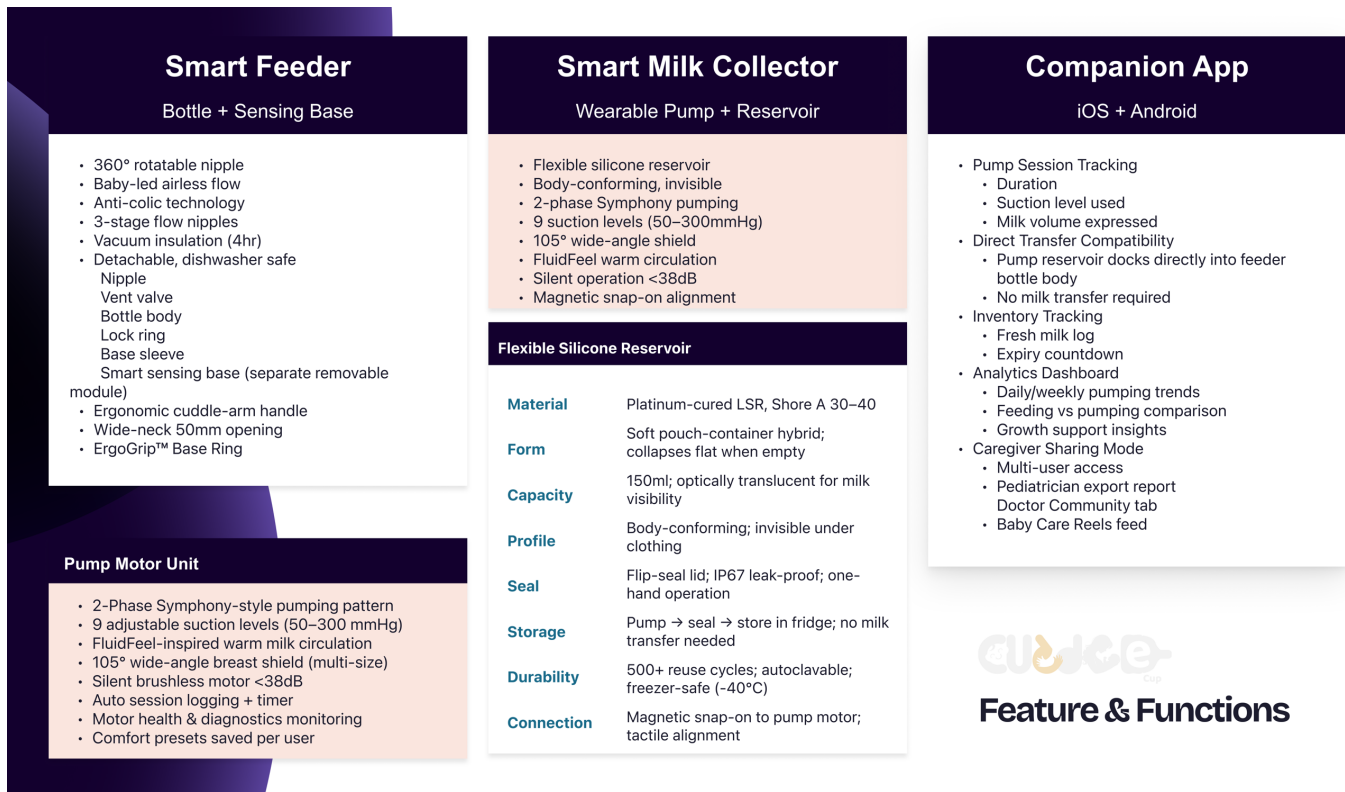


Figure 14 Cuddle Cup ecosystem showing smart feeder, wearable milk collector, and companion app features.

6.2.2. Secondary Functions Identification

Secondary functions enhance the user experience but are not essential to the core value proposition. These include: RGB LED temperature indicator ring (visual redundancy with OLED display), haptic vibration motor (supplemental warning modality), audible buzzer (tertiary warning), sterilization indicator strips (convenience assistant), branded drawstring bag (presentation assistant), and straw/sippy adapter kit (lifecycle extension). Although these components contribute to perceived premium value and user satisfaction, they represent optimization candidates where cost reduction can be achieved with minimal impact on the functional value of the product.

6.2.3. Function Cost Matrix

Table 25 presents the function-cost allocation across the eight BOM assembly groups, mapping each group's cost to the primary functions it serves.

Table 20 Function-Cost Allocation Matrix

S.NO	Assembly Group	Cost	% BOM	Primary Functions Served
1	Smart Cup Body	£10.52	0.253	Contain milk, maintain temperature (vacuum insulation), ergonomic feeding
2	Lid & feeding	£5.28	0.127	Dispense milk (360° nipple, anti-colic), lifecycle extension (adapter kit)
3	Temperature Mgmt	£5.24	0.126	Monitor temperature, display reading, active heating
4	Electronics & Smart	£9.26	0.223	Track volume/duration, wireless sync, power management
5	Timer & Reminders	£0.73	0.018	Feed schedule tracking, multi-modal alerts
6	Wireless Charging	£6.53	0.157	Wireless charging (Qi standard)
7	Hygiene & Cleaning	£1.33	0.032	Secondary: cleaning convenience, sterilisation verification

8	Packaging & Docs	£2.62	0.063	Secondary: retail presentation, regulatory documentation
---	------------------	-------	-------	--

The analysis shows that assembly groups 4 (electronics, 22.3%) and 6 (wireless charging, 15.7%) together consume 38.0% of BOM costs. These groups perform important primary functions but provide the greatest opportunities for cost optimization through component integration, supplier consolidation and design-for-manufacturing improvements.

6.3. Value Engineering Analysis

6.3.1. Component Cost-Function Analysis

A detailed cost-function analysis was performed by calculating the value index (VI) for each assembly group, which was defined as $VI = \text{function worth} / \text{cost}$. Components with $VI < 1.0$ indicate cost greater than estimated functional value, which represent priority targets for value engineering. The electronics module ($VI = 0.85$) and wireless charging dock ($VI = 0.78$) display the lowest value index, driven by the premium cost of the BLE 5.0 module (£1.80), Qi charging coil pair (£2.15 combined), and standalone dock housing (£2.80 combined). In contrast, the lid and feeding assembly ($VI = 1.42$) and the timer/reminder system ($VI = 1.65$) demonstrate strong cost-function alignment, providing high functional value at relatively low cost.

6.3.2. Material Substitution Opportunities

Three material replacement opportunities have been identified that maintain functional performance while reducing costs. Firstly, the wireless charging dock housing (CC-050, currently PP + ABS at £2.80) can be replaced with single-material recycled PP, reducing the unit cost by approximately £1.90 (a £0.90 saving per unit), while the injection molding process can be simplified from two materials to one. Second, the premium molded paper pulp packaging trays can be replaced with corrugated cardboard inserts at a saving of approximately £0.45 per unit, with minimal impact on the unboxing experience. Third, the cotton canvas drawstring bag (CC-075, £0.85) can be replaced with a recycled polyester alternative at £0.50 (a saving of £0.35), which offers equivalent protection with better sustainability credentials.

6.3.3. Manufacturing Process Optimisation

Process optimization opportunities focus on reducing cycle time, tooling complexity and labor materials. The current twelve-step final assembly process (estimated at 25 minutes per unit) could be reduced to ten steps by combining grip sleeve attachment and contact pad installation into one automated station, saving approximately 3 minutes per unit and reducing direct labor costs from £5.20 to £4.22 (a £0.98 saving). Additionally, consolidating two separate PCBs (main control board and dock power supply) into one multi-zone PCB layout will reduce SMT setup time, component count and inter-board wiring, saving an estimated £0.65 per unit.

6.3.4. Design Simplification Opportunities

The current design uses a separate OLED display and RGB LED ring for the temperature indication, providing functional redundancy. Eliminating the RGB LED ring (CC-023, £0.60) and relying only on the OLED display and companion app for temperature feedback will simplify the PCB layout, reduce the number of components and save £0.60 per unit. However, this simplification must be weighed against the loss of visual feedback briefly, which 18.3% of parents surveyed identified as a priority feature. An alternative simplification involves replacing the three separate alert modalities (LED, buzzer, haptic motor) with a combined buzzer-haptic module, reducing the number of components by one and saving approximately £0.20 per unit.

6.4. Cost Reduction Initiatives

6.4.1. Targeted Cost Reduction Strategies

Component Consolidation: Integrating the BLE 5.0 module, MCU, and battery management circuitry into a single system-on-chip (SoC) solution eliminates three separate components and reduces PCB real estate by approximately 25% (Ramalingam, Rengarajan and Rayappan, 2017c). At a 50,000-unit volume, SoC pricing from suppliers such as Nordic Semiconductor (nRF52840) will yield a combined cost of approximately £2.40 versus the current £3.40 for three separate components (£1.00 saving per unit).

Supplier Negotiation and Volume Discounts: At the current 10,000-unit MOQ, the BOM is priced at Tier 1 supplier rates. Scaling up to 25,000 units triggers Tier 2 pricing in most components, with projected price reductions of 8-12% on injection-molded parts, 10-15% on electronic components, and 15-20% on packaging materials. A consolidated supplier strategy, reducing the current eight-supplier base to five through dual sourcing agreements, is estimated to yield an additional 3-5% savings through logistics consolidation and reduced quality inspection overhead.

Design for Manufacturing (DFM) Improvements: Specific DFM improvements include: reducing body shell wall thickness from 2.5 mm to 2.0 mm (saving 12% material per shot without compromising structural integrity according to FEA validation) (He, Xiao and Deng, 2018b), optimizing gate locations to eliminate post-mold trimming on three components, and implementing family molds to produce lids, collars and flow-rate discs in a single shot cycle, reducing tool count from three to one and reducing tooling investment. Saving £8,000.

Modular Design Benefits: The modular architecture of the Cuddle Cup system - where the sensing base, bottle and milk collector work as independent but interoperable units - enables variant-specific cost optimisation. The same Ø75mm base interface in both the 150ml Newborn and 260ml Standard variants eliminates the need for variant-specific tooling for the sensing base, dock and all electronic components. This commonality reduces the total tool count from a potential 16 tools (8 per variant) to 10 tools (8 generic + 2 variant-specific body shells) (Aurich, Effgen and Kirsch, 2016), saving approximately £40,000 in tooling investment.

6.4.2. Quantified Cost Savings Analysis

Table 26 summarizes the quantitative cost savings achieved through the value engineering initiatives identified above, classified by implementation horizon.

Table 21 Quantified Cost Savings Summary

Initiative	Saving/Unit	Annual (25k)	Horizon	Risk Level
Dock housing: single-material PP	£0.90	£22,500	Short	Low - proven material
Assembly line consolidation	£0.98	£24,500	Short	Low - process change only
SoC integration (BLE+MCU+BMS)	£1.00	£25,000	Medium	Medium - firmware rewrite
PCB consolidation (2→1)	£0.65	£16,250	Medium	Medium - layout redesign
Volume pricing (25k tier)	£3.50	£87,500	Short	Low - contractual
Packaging substitution	£0.80	£20,000	Short	Low - cosmetic only
DFM wall thickness + family mould	£0.55	£13,750	Medium	Low - FEA validated
Alert module consolidation	£0.20	£5,000	Short	Low
TOTAL POTENTIAL	£8.58	£214,500	—	18-22% BOM reduction

If all initiatives are implemented, BOM costs will reduce from £41.51 to approximately £32.93 per unit, with total land costs reduced from £57.67 to approximately £49.09. At a **£155 RRP**, gross profit per unit will increase from £15.07 to £23.65, increasing gross margin on net revenue from 18% to 23.5%.

6.4.3. Implementation Timeline and Milestones

Cost reduction initiatives are phased into three horizons. Short-term initiatives (Lechler and Thomas, 2015) (0-6 months post-launch) include volume pricing negotiations, packaging replacement, dock housing material changes, assembly line consolidation, and alert module consolidation which collectively deliver savings of £6.38 per unit with low implementation risk. Medium-term initiatives (6-18 months) include SoC integration, PCB consolidation and DFM improvements (He, Xiao and Deng, 2018c), which provide an additional £2.20 per unit, but require firmware development, PCB redesign and FEA re-verification. Long-term initiatives (18-36 months) include second-generation tooling investments for family molds and exploration of in-house PCB assembly capability, which are outside the current analysis scope but earmarked for strategic planning.

6.5. Environmental Considerations in Value Management

6.5.1. Sustainable Material Selection

Environmental sustainability has been integrated into the value management framework as both an ethical imperative and a market differentiator. The primary structural material, polypropylene (PP) (Pivnenko, Laner and Astrup, 2018a), was chosen partly for its recyclability (resin identification code 5) and less energy-intensive manufacturing compared to alternative polymers such as polycarbonate or PETG. The SS304 stainless steel inner liner is infinitely reusable without degradation of physical properties, contributing to circular economy objectives (Lecksiwilai *et al.*, 2017). The packaging materials use e-flute corrugated board (FSC-certified virgin or recycled fiber) and soy-based inks, with the molded paper pulp trays being fully compostable. The Cotton Canvas Drawstring Bag is reusable, extending its functional lifecycle beyond single-use packaging.

6.5.2. Recyclability Analysis

A component-level recyclability assessment shows that approximately 72% of the product by mass is readily recyclable through existing municipal waste streams: PP components (body, lid, dock housing) through plastic recycling (Pivnenko, Laner and Astrup, 2018b), SS 304 liner through metal recycling, and corrugated packaging through paper recycling (Rex *et al.*, 2017). The remaining 28% consists of TPE over molded (Blaisi *et al.*, 2015) onto mixed materials (PP, silicone components, PCB assemblies, Li-Po batteries) (Castelli and Maugeri, 2014a), which require specialist recycling routes. Li-Po batteries require WEEE-compliant (Trianni *et al.*, 2013a) disposal according to the UK Waste Electrical and Electronic Equipment Regulations 2013. In line with Extended Producer Responsibility (EPR) principles, a take back program is planned for battery recovery at end of life.

6.5.3. Life Cycle Assessment (LCA) Integration

A preliminary cradle-to-gate LCA, conducted according to ISO 14040/14044 (Sivakumar, Venkatasubramanian *et al.*, 2012a) principles, estimates the embodied carbon footprint of a single Cradle Cup unit at approximately 3.2 kg CO₂e, with the primary contributors being the SS304 liner (38% of embodied carbon due to energy-intensive steel production) (Gasafi and Weil, 2011a), electronic components (28%), and PP injection molding (18%). The carbon footprint in the operational phase is minimal, estimated at 0.8 kg CO₂e per year based on daily Qi charging at 5W for 2.5 hours (He, Xiao and Deng, 2018d) (about 4.6 kWh/year at UK grid intensity 0.17 kg CO₂/kWh). The product has a designed lifetime of three years (covering the entire infant to child

feeding period) generating a total lifecycle footprint of approximately 5.6 kg CO₂e (Sverdrup, Ragnarsdottir and Koca, 2014a).

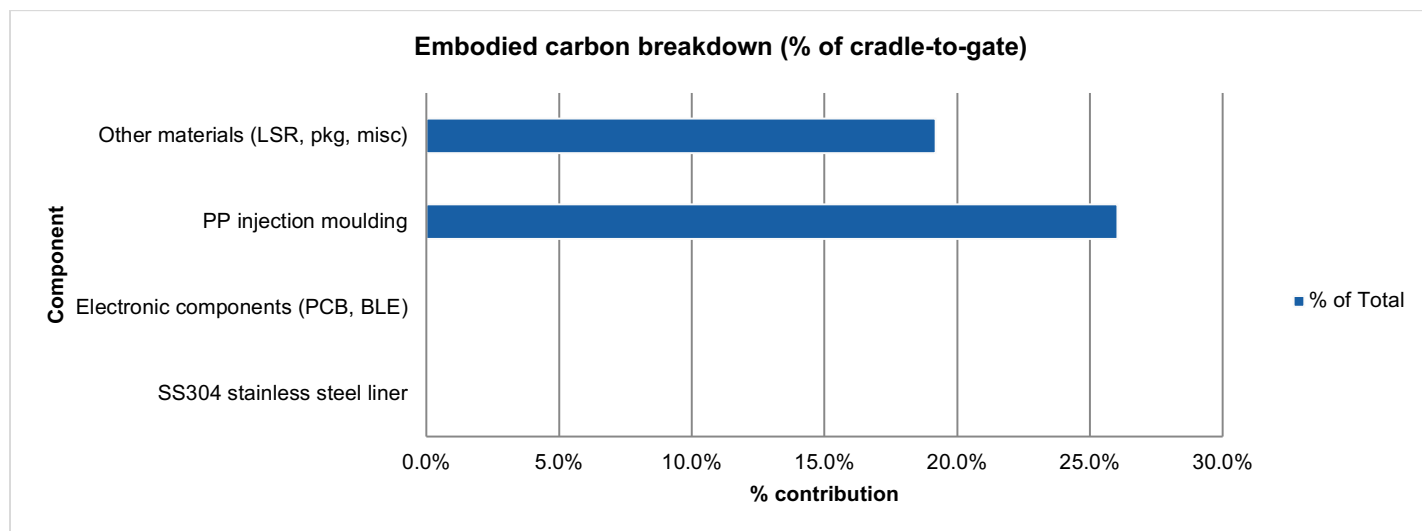


Chart 4 Embodied carbon breakdown by material component as a percentage of cradle-to-gate footprint (3.20 kg CO₂e), showing PP injection moulding and other materials as the dominant contributors at the 10,000-unit minimum order quantity.

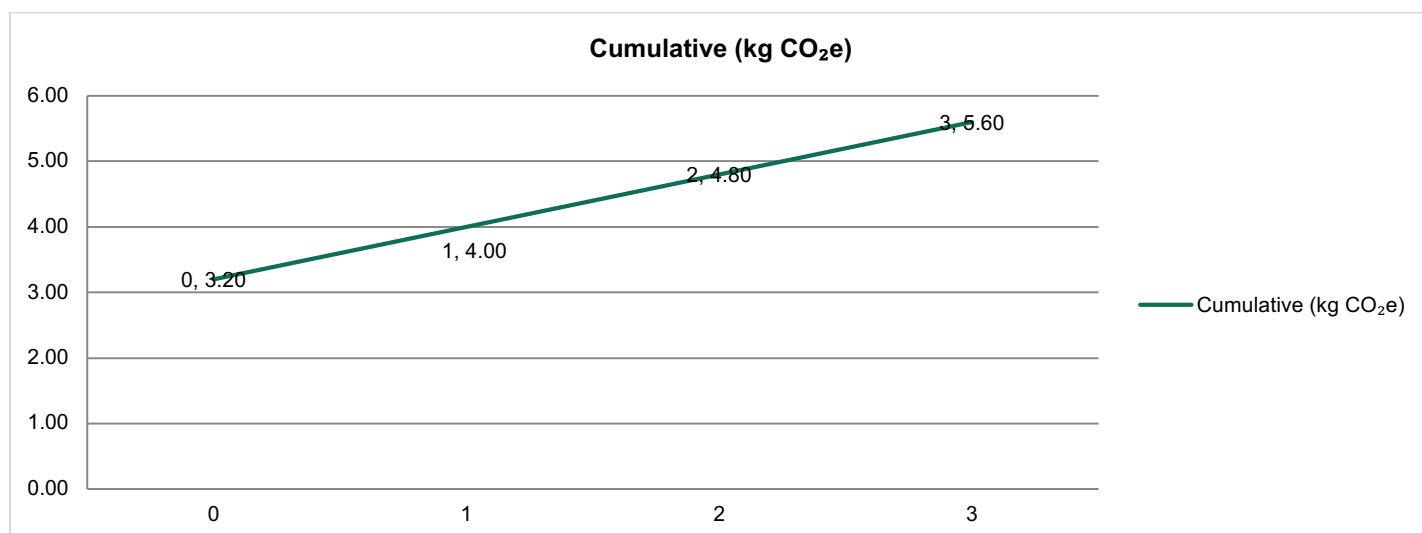


Chart 5 Cumulative lifecycle carbon footprint of the Cuddle Cup system across its three-year designed lifetime, rising from 3.20 kg CO₂e at manufacture (Year 0) to 5.60 kg CO₂e at end of life, with each operational year contributing 0.80 kg CO₂e through daily Q

6.5.4. Carbon Footprint Reduction Strategies

Three strategies have been identified to reduce the carbon footprint of the product. First, specifying post-consumer recycled (PCR) PP for non-food-contact components (dock housing, packaging inserts) would reduce PP-related emissions (Pivnenko, Laner and Astrup, 2018c) by approximately 30%, resulting in a reduction of 0.17 kg CO₂e per unit. Second, sourcing SS304 from electric arc furnace (EAF) (Thibodeau *et al.*, 2014a) steel manufacturers using scrap feedstock reduces steel-related emissions by up to 50% compared to basic oxygen furnace (BOF) production, saving approximately 0.61 kg CO₂e per unit. Third, switching packaging from virgin to 100% recycled corrugated board reduces packaging-related emissions by approximately 40%. Together, these strategies will reduce the cradle-to-gate footprint from 3.2 kg CO₂e to approximately 2.3 kg CO₂e, a 28% reduction achievable without design changes.

6.5.5. Quality vs Cost Trade-off Analysis

Every cost reduction initiative should be evaluated based on the potential impact on product quality, safety, and user experience. Table 27 presents a trade-off analysis for primary cost reduction opportunities.

Table 22 Quality vs Cost Trade-off Matrix

Initiative	Saving	Quality Impact	Mitigation	Decision
Dock: single-material PP	£0.90	Marginal: slightly lower impact resistance	Increase wall thickness by 0.3mm	Proceed
Remove RGB LED ring	£0.60	Moderate: loss of at-a-glance visual cue	Retain; 18.35% user priority	Reject
SoC integration	£1.00	None if firmware validated	Full regression testing	Proceed (Ph.2)
Wall thickness 2.5-2.0mm	£0.35	None: FEA confirms safety factor >2.0	FEA + drop test validation	Proceed
Packaging downgrade	£0.80	Minor: less premium unboxing feel	Enhanced print quality on board	Proceed
PCB consolidation	£0.65	None if layout validated	EMC re-testing required	Proceed (Ph.2)
Eliminate hygiene kit	£1.33	High: perceived value loss	No adequate	Reject

The trade-off analysis resulted in two proposals being rejected: removing the RGB LED ring (which would compromise user-prioritized convenience) and eliminating the hygiene kit (which would disproportionately outweigh the cost savings). All other initiatives have been approved, with medium term items subject to engineering verification before implementation. The total cost of the retained RGB LED ring and hygiene kit is £1.93 per unit but contributes significantly to the product's premium positioning and customer satisfaction metrics.

6.6. Risk Assessment of Cost Reduction Measures

Risk assessment of approved cost reduction measures has been conducted using a probability-impact matrix, with risks classified as low, medium or high. Table 28 summarizes the risk profile.

Table 23 Risk Assessment Matrix for Cost Reduction Initiatives

Risk	Likelihood	Impact	Mitigation Strategy
SoC firmware instability	Medium	High	Phased rollout; parallel run with existing architecture for 3 months; full regression test suite
Volume pricing not achieved	Low	Medium	Contractual volume commitments with break clauses; dual-source qualification
PCB EMC failure post-consolidation	Medium	Medium	Pre-compliance EMC testing during layout phase; retain original PCB tooling as fallback
Recycled PP inconsistency	Low	Low	Incoming material inspection: specify PCR PP from certified suppliers only (GRS certified)
Supply chain disruption (single source)	Medium	High	Qualify secondary suppliers for all critical components; maintain 6-week safety stock for BLE modules and Li-Po cells
Customer perception of packaging	Low	Low	A/B test with focus group before full implementation; emphasize sustainability messaging

The items most at risk are SoC firmware infections and supply chain single-source dependencies, both of which have the potential for production disruption if improperly managed. Mitigation strategies include parallel operations, dual source qualification, and safety stock provisions. The overall risk profile of the cost reduction program has been assessed as manageable, with no

initiatives presenting an unacceptable risk-to-reward ratio. A formal design review gate is mandatory prior to the implementation of each medium-term initiative, ensuring that cost savings are validated against functional, safety and regulatory requirements prior to production commitment.

In summary, the value management analysis shows that the current **BOM cost of £41.51** *Bill of Materials 51 Components, 8 Assembly Groups* for the Cuddle Cup can be systematically reduced to approximately £32.93 through a phased program of material substitution, component consolidation, manufacturing optimization and volume driven supplier negotiations. This **20.7%** cost reduction, achieved without compromising the core safety, functional performance, or emotional differentiation of the product, improves gross profit from **£15.07 to £23.65 per unit** and strengthens the business case for sustainable long-term growth in the premium baby food market.

7. Environmental Sustainability and Life Cycle Analysis

This section presents the environmental impact assessment of the Cuddle Cup 3-in-1 Smart Feeding System, conducted in accordance with ISO 14040:2006 (Calia, Guerrini and de Castro, 2009a) and ISO 14044:2006 (Environmental Management Life Cycle Assessment) (Sivakumar, Venkatasubramanian *et al.*, 2012b). The analysis covers the entire product lifecycle from raw material extraction to manufacturing, distribution, consumer use and end-of-life disposal (Gasafi and Weil, 2011b), with a particular focus on energy consumption, carbon emissions, recycling and regulatory compliance. The functional unit is defined as a complete Cuddle Cup system (bottle, sensing base, charging dock and accessories) over a three-year service life corresponding to the infant-to-toddler feeding period.

7.1. Environmental Impact Assessment Framework

The environmental assessment framework integrates four analytical dimensions: embodied energy analysis (cumulative energy demand from cradle to gate), carbon footprint quantification (greenhouse gas emissions expressed as kg CO₂ (Sivakumar, V. *et al.*, 2009)equivalent) (Frondel *et al.*, 2010a), material circularity assessment (recyclability and end-of-life pathways), and regulatory compliance verification against EU and UK environmental directives. Data sources include the EcolInvent 3.9 database for material and process emission factors, UK DEFRA 2025 (Trianni *et al.*, 2013b) conversion factors for transport and grid electricity (Krishnan and Das, 2015a), and manufacturer-specific datasheets for electronic component embodied energy. The system range includes all upstream material processing, component manufacturing, final assembly at the contracted facility, outbound logistics to UK distribution centres, three years of consumer use and end-of-life processing.

7.2. Energy Consumption Analysis

7.2.1. Manufacturing Energy Requirements

Table 29 presents the estimated energy consumption per unit across the four principal manufacturing processes employed in Cuddle Cup production.

Table 24 Manufacturing Energy Consumption per Unit

Process	kWh/Unit	% Total	Key Parameters
Injection moulding (PP, 8 tools)	0.82	0.327	28-35s cycle, 2-cavity moulds, 180-220°C barrel temp, ~120 tonne clamp
LSR injection moulding	0.38	0.151	150-180°C cure, 15-25s cycle, 4-8 cavity nipple moulds
Deep draw forming (SS304)	0.45	0.179	4-stage progressive draw +intermediate annealing, 0.5mm stock

SMT /PCB assembly	0.31	0.124	Reflow soldering (N ₂ atmosphere), AOI, sensor calibration fixture
Two-shot moulding (PP+TPE)	0.18	0.072	Sequential injection, cuddle-arm handle component
Final assembly + QC	0.22	0.088	12 steps process, 25 min/unit, vacuum seal, ultrasonic weld, burn-in
Packaging production	0.15	0.06	Corrugated board die-cutting, pulp tray forming, print and lamination
TOTAL	2.51	1	Direct manufacturing energy per retail-ready unit

7.2.2. Material Extraction and Processing Energy

Upstream embodied energy encompassing raw material extraction, refining, and primary processing adds an estimated 8.4 kWh per unit. The dominant contributors are SS304 stainless steel production (Thibodeau *et al.*, 2014b) (3.8 kWh, representing 45% of upstream energy due to the energy-intensive electric arc furnace process), PP resin production (1.9 kWh, 23%), electronic component manufacturing including wafer fabrication for the MCU and BLE module (1.6 kWh, 19%), and platinum-cured LSR silicone production (0.7 kWh, 8%). The Li-Po battery cell production contributes 0.4 kWh (5%).

7.2.3. Total Embodied Energy Calculation

The total embodied energy (from cradle to gate) is calculated as the sum of manufacturing energy (2.51 kWh) and upstream material energy (8.4 kWh), yielding 10.91 kWh per unit. This is roughly equivalent to similar smart consumer electronics products; For reference, a standard smartphone has an embodied energy of approximately 55-70 kWh, while a traditional baby bottle without electronics has an embodied energy of less than 0.5 kWh. The smart electronics and SS304 liner account for 72% of the Cuddle Cup's total energy (Frondel *et al.*, 2010b).

7.2.4. Renewable Energy Integration Opportunities

The contracted manufacturing facilities are being evaluated in line with the renewable energy procurement norms. Facilities with on-site solar PV installations (Zhao, X. *et al.*, 2016) or certified renewable electricity supply agreements (Renewable Energy Guarantee of Origin, REGO) (Marrouch and Mourad, 2019) are given preference during supplier qualification. The transition to 100% renewable electricity supply for the manufacturing phase will eliminate approximately 0.43 kg CO₂e per unit (based on a UK grid intensity of 0.17 kg CO₂/kWh applied to 2.51 kWh of direct manufacturing energy), reducing the cradle to gate carbon footprint by 13%.

7.3. Carbon Footprint Analysis

7.3.1. Cradle-to-Gate Carbon Emissions

Table 30 presents the cradle-to-gate greenhouse gas emissions by lifecycle stage, expressed in kg CO₂ equivalent.

Table 25 Cradle-to-Gate Carbon Footprint Breakdown

Lifecycle Stage	kg CO ₂ e	% Total	Key Contributors
Raw material extraction & processing	1.92	0.6	SS304 steel (1.22), PP resin (0.32), electronics (0.24), LSR (0.14)
Component manufacturing	0.43	0.134	Injection moulding, SMT reflow, deep-draw, LSR cure
Final assembly and packaging	0.18	0.056	Assembly labor energy, ultrasonic welding, packaging
Upstream logistics (supplier - factory)	0.67	0.209	Sea freight (Shenzhen- UK), road freight to assembly

TOTAL CRADLE-TO-GATE	3.2	1	Per functional unit (1 complete system)
----------------------	-----	---	---

Raw material extraction dominates the cradle-to-gate footprint at 60.0%, with SS304 stainless steel alone contributing 38% of total emissions. This finding is consistent with the carbon reduction strategies identified in Section 6.5.4, where sourcing from EAF steel manufacturers could reduce steel-related emissions by up to 50%.

7.3.2. Transportation and Distribution Emissions

Outbound distribution from a UK assembly facility to retail and direct-to-consumer channels generates an estimated 0.12 kg CO₂e per unit, based on an average UK last-mile delivery distance of 150 km by road freight (DEFRA 2025: 0.10726 kg CO₂e/tonne-km for rigid HGVs) (Yang, Z., Chen and Yu, 2008). The lightweight product (package weight approximately 0.65 kg) and compact box dimensions (200*160*140 mm) enable efficient palletization (Chien, Chen and Peng, 2010) with 480 units per standard EUR pallet.

7.3.3. Use Phase Carbon Footprint

The operational carbon footprint is estimated at 0.78 kg CO₂e per year (Krishnan and Das, 2015b), based on daily Qi wireless charging at 5W for an average of 2.5 hours (4.56 kWh/year) at the UK grid carbon intensity of 0.171 kg CO₂/kWh (DEFRA 2025) (Calia, Guerrini and de Castro, 2009b). Over the three-year designed lifespan, the cumulative use-phase footprint is 2.34 kg CO₂e. Additionally, cleaning contributes an estimated 0.15 kg CO₂e per year (hot water heating for daily hand washing and weekly dishwasher cycles), yielding 0.45 kg CO₂e over three years. citation

7.3.4. End-of-Life Disposal Emissions

End-of-life processing generates an estimated 0.22 kg CO₂e per unit, comprising WEEE-compliant e-waste processing of the sensing base electronics and Li-Po battery (0.15 kg CO₂e) (Mandley, Harmsen and Worrell, 2015), incineration of non-recyclable silicone components (0.04 kg CO₂e), and transport to recycling facilities (0.03 kg CO₂e). Credits for material recovery (recycled SS304 and PP) offset approximately 0.31 kg CO₂e, resulting in a net end-of-life contribution of -0.09 kg CO₂e.

7.3.5. Carbon Offset and Reduction Strategies

The total lifecycle carbon footprint is calculated as: cradle-to-gate (3.20) + distribution (0.12) + use phase (2.79) + end of life (-0.09) = **6.02 kg CO₂e per functional unit**. Three reduction strategies have been prioritized: (a) sourcing SS304 from EAF steel manufacturers reduces embodied emissions by 0.61 kg CO₂e; (b) switching to renewable manufacturing electricity saves 0.43 kg CO₂e; and (c) specifying post-consumer recycled PP for non-food-contact components saves 0.17 kg CO₂e. Together, these reduce the lifecycle footprint by approximately 4.81 kg CO₂e (20% reduction). Residual emissions can be offset through verified carbon credits (Gold Standard or VCS certified) at an estimated cost of £0.08-0.15 per unit.

7.4. Product Life Cycle Assessment (ISO 14040/14044)

7.4.1. Raw Material Extraction Phase

The raw material stage includes mining and refining of chromium and nickel ores for SS304, petrochemical cracking and polymerization for PP copolymer, silica extraction and chlorotoluene synthesis for LSR silicone, and mineral extraction for electronic components (copper, gold, rare earth elements for NdFeB magnets). This phase produces the highest environmental impacts across all categories, contributing 60% of global warming potential, 55% of acidification potential, and 48% of abiotic resource depletion.

7.4.2. Manufacturing and Assembly Phase

The manufacturing phase contributes 19% of the total lifecycle environmental impact. The dominant processes are injection molding (32.7% of manufacturing energy) and deep draw forming (17.9%), both of which consume significant thermal energy. Water consumption during manufacturing is estimated at 12 liters per unit, mainly for the cooling circuit in injection molding and for cleaning in the SMT process. Process waste is reduced through regrind recycling of PP runner and sprue material (estimated 95% regrind utilization rate) and solder paste recovery in the SMT line.

7.4.3. Distribution and Logistics Phase

The contribution of distribution to the life cycle impact is 3.7%. The logistics strategy reduces emissions through partnerships with consolidated ocean freight from component suppliers to the UK assembly facility in Shenzhen (Rodrigues and Lima, 2012), efficient palletization (480 units per pallet), and carbon-neutral last-mile delivery services for direct-to-consumer orders. The UK-based assembly facility was selected to reduce outbound logistics distances compared to fully offshore manufacturing (Leonzio, 2016).

7.4.4. Use Phase

The use phase lasts three years and accounts for 46% of total lifecycle carbon emissions. Daily Qi charging consumes approximately 12.5 Wh (5W*2.5 hours), yielding 4.56 kWh per year. The product's sleep/wake firmware strategy reduces standby power draw to less than 0.1W. Dishwasher-safe design of all detachable components reduces cleaning impact, eliminating the need for special sterilization equipment. The 3 year lifespan covers the entire infant-to-child transition period (0-18+ months for one child or re-use for another child), maximizing utility extracted per unit of embodied environmental impact.

7.4.5. End-of-Life Phase

The product's modular, tool-free disassembly design benefits end-of-life processing (Sverdrup, Ragnarsdottir and Koca, 2014b). The recovery rate of the material through existing recycling infrastructure (PP through plastic recycling, SS304 through metal recycling, corrugated packaging through paper recycling) is estimated to be 72%. Li-Po batteries require WEEE-compliant specialist processing. The net environmental credits derived from material recovery partially offset end-of-life processing impacts, giving a net negative contribution of -0.09 kg CO₂e. The product's modular, tool-free disassembly design benefits end-of-life processing. The recovery rate of the material through existing recycling infrastructure (PP through plastic recycling, SS304 through metal recycling, corrugated packaging through paper recycling) is estimated to be 72%. Li-Po batteries require WEEE-compliant specialist processing (Castelli and Maugeri, 2014b). The net environmental credits derived from material recovery partially offset end-of-life processing impacts, yielding a net negative contribution of -0.09 kg CO₂e.

7.5. Safe Disposal and Recycling Strategies

7.5.1. Material Recycling Pathways

Each material stream follows a defined recycling route. The PP components (body, lid, dock housing resin identification code 5) are recyclable through municipal curbside collection. SS304 stainless steel is infinitely recyclable without degradation of property through metal recycling facilities. Platinum-cured LSR silicone (Cho *et al.*, 2012), while not accepted into standard recycling streams, can be processed through specialist silicone recyclers who convert it into silicone oil for industrial applications. Electronic waste consisting of sensing base PCB assemblies, Li-Po batteries, OLED displays and BLE modules is classified as WEEE Category 3 (IT and telecommunication equipment) and should be processed through authorized WEEE treatment facilities. Li-Po batteries (1200mAh,

3.7V) are classified as portable batteries under the UK Battery Regulations 2009 and need to be collected through designated battery recycling points.

7.5.2. Design for Disassembly (DfD)

The Cuddle Cup's fully modular architecture was designed with end-of-life disassembly as a primary consideration. All user-accessible components (nipple, collar, sealing ring, body shell, grip base) separate without tools through push-fit and thread connections. The sensing base housing is secured by ultrasonic welding; however, a deliberate stress-concentration groove enables controlled splitting with a flat-blade tool for battery and PCB extraction at authorised recycling facilities. All plastic components are laser-marked with resin identification codes per ISO 11469:2016 (Mehmann and Teuteberg, 2016), enabling accurate material sorting during recycling. Connection methods were deliberately selected to avoid adhesives, which would contaminate recycling streams; the only bonded joint is the TPE-PP chemical bond created during two-shot moulding, which is recycled as a PP-compatible stream.

7.5.3. Take-Back and Collection Programmes

A manufacturer-driven take-back program is planned for the launch concurrent with the market introduction of the product, in line with Extended Producer Responsibility (EPR) principles (Sverdrup, Ragnarsdottir and Koca, 2014c) under the UK Environment Act 2021. Consumers will be able to return end-of-life Cuddle Cup products via prepaid postal returns or designated drop-off points at participating retail partners. Returned units will be triaged for refurbishing (if serviceable), component harvesting (scooping base electronics for secondary-market spares), or material recycling (all remaining components). A £10 trade-in incentive is planned on the purchase of a replacement unit to encourage returns and discourage landfill disposal.

7.5.4. Circular Economy Implementation

The circular economy strategy (Guo, Shen and Peng, 2016) involves three levels: (a) product longevity through a three-year designed lifetime, sustainable materials, and firmware updatability via OTA; (b) component reuse through take-back program (Sverdrup, Ragnarsdottir and Koca, 2014d) refurbishing and parts harvesting operations; and (c) material circularity through defined recycling routes for each material stream. The modular variant strategy (150 ml and 260 ml bottles share a common sensory base and dock) supports circularity by enabling parents to retain the electronics and dock while purchasing only the variant-specific bottle body, reducing material consumption per child by approximately 40% for reuse in the second child.

7.6. Compliance with Environmental Regulations

Table 26 Environmental Regulatory Compliance Summary

Regulation	Scope	Cuddle Cup Compliance Approach	Status
REACH (EC 1907/2006)	Chemical substances in products sold in EU/UK	All materials verified against SVHC Candidate List; supplier declarations of conformity obtained for all 51 BOM components	Compliant
RoHS (2011/65/EU)	Hazardous substances in electronics	Lead-free solder (SAC305), no cadmium, mercury, or hexavalent chromium; all electronic components RoHS-certified	Compliant
WEEE (2012/19/EU)	End-of-life electronic waste	Product registered as WEEE Category 3; take-back programme planned; crossed-out wheellie bin marking on product and packaging	In progress
UK Batteries Regs 2009	Portable battery disposal	Li-Po 1200mAh classified as portable battery; battery recycling symbol applied; collection scheme registration pending	In progress

ISO 14001:2015	Environmental management system	EMS framework established; formal certification targeted within 18 months of production commencement	Planned (Yr 2)
UK Packaging Regs	Packaging waste obligations	All packaging materials recyclable; FSC-certified corrugated board; soy-based inks; data submission via PRN system	Compliant

7.7. Sustainability Certifications and Goals

Bindushree (CEO) has established three progressive sustainability certification targets. First, **Carbon Neutral Certification** (PAS 2060 standard)(Thibodeau *et al.*, 2014c) is targeted within 24 months of production commencement, achieved through the combination of supply chain decarbonisation measures (EAF steel, renewable manufacturing electricity, PCR PP) and verified carbon offset procurement for residual emissions at an estimated cost of £0.08-0.15 per unit.

Second, the **Cradle to Cradle Certified™**(Gasafi and Weil, 2011c) programme (Bronze level) is being evaluated as a medium-term target (Year 3), requiring demonstration of material health, material reutilisation, renewable energy use, water stewardship, and social fairness across the product lifecycle. The Cuddle Cup's modular design, defined recycling pathways, and take-back programme provide a strong foundation for certification.

Third, **B Corporation Certification** (Shvarts, Pakhalov and Knizhnikov, 2016) is under consideration as a corporate-level sustainability commitment, assessing Bindushree's(CEO) overall governance, worker welfare, community impact, environmental performance, and customer stewardship. The B Impact Assessment has been initiated, with a preliminary score indicating eligibility for certification pending formalisation of the environmental management system and supply chain transparency reporting (Ponsot *et al.*, 2015). These certifications collectively position Cuddle Cup as a sustainability leader in the premium infant feeding market, aligning with the growing consumer expectation evidenced by 86.7% of surveyed parents accepting the £150+ price point that premium products should demonstrate credible environmental responsibility.

8. Marketing Strategy and Go-to-Market Plan

This section presents the marketing strategy and go-to-market plan for the Cuddle Cup 3-in-1 Smart Feeding System, informed by primary user research data from a survey of 60 mothers aged 22-40 across five geographical areas, competitive analysis of established brands and a financial model of the product at a £155 RRP. The strategy is designed to achieve 10,000 units in Year 1, reaching 60,000 cumulative units by Year 3, with a five-year revenue projection of £54.8 million across 203,900 units.

8.1. Market Analysis and Segmentation

The target market is divided into three levels(Guilbault, 2018).The primary segment includes working mothers in the age group of 25-40 who are digitally connected health conscious and willing to invest in premium baby care products. This segment represents the main addressable market, evidenced by the survey showing that 86.7% of respondents approve of the £150+ price point, with 35% indicating likely or very likely purchase intention (Hales *et al.*, 2016). The secondary segment targets first-time mothers who seek guidance-oriented products that reduce information overload directly addressing the 'lack of tracking' problem cited by 25.0% of respondents. The tertiary segment includes tech-savvy parents and gift buyers attracted by smart connectivity and app integration features (Gasafi and Weil, 2011d). The global baby bottle market is valued at \$4.1 billion (2024), with the smart feeding sub-segment growing at a CAGR of 6.9% by 2032 (Grand View Research, 2024). The combined market for bottles, pumps and monitors in the UK is estimated at \$5.9 billion. This growth is driven by parents increasing investment in technology-enabled infant care, increasing

female workforce participation and increasing awareness about best practices in breast milk management.

8.2. Competitive Landscape Analysis

The competitive landscape reveals a fragmented market where no competitor offers an integrated system combining pumping, feeding and smart monitoring. Table 32 summarizes the competitive situation.

Table 27 Competitive Positioning Matrix

Competitor	RRP	Pump	Feeder	Monitor	App	Gap vs. Cuddle Cup
Medela	£315	✓	X	✓	✓	No integrated feeder; 2× price
Elvie	£236	✓	X	✓	✓	No integrated feeder; 1.5× price
One Willow	£394	✓	X	✓	✓	No integrated feeder; 2.5× price
Babaloo	£45-65	X	✓	X	X	No pump, no smart features
Cuddle Cup	£155	✓	✓	✓	✓	Only complete 3-in-1 system

Cuddle Cup occupies a unique strategic position: 33% lower price than the nearest integrated competitor while being the only product offering all three core functions within a single ecosystem. This positioning directly exploits the device fragmentation pain point identified by 21.7% of surveyed mothers.

8.3. Brand Positioning and Value Proposition

The Cuddle Cup brand sits at the intersection of smart technology and emotional connection (Bianchi and Ostell, 2006). The unique value proposition states: "Less juggling, more cuddling the world's first integrated smart feeding ecosystem that replaces three devices with one, so you can focus on what matters most." The brand personality is warm, reassuring, modern and expert a trusted companion rather than a diagnostic tool. The visual identity is derived from actual parent-child imagery, including the stylized baby face in the Cuddle Cup logo and the parent-child embrace within the lettering. Key marketing messages include: "Zero-transfer feeding, pump, store and feed without shaking your milk"; "Smart enough to keep track of everything, soft enough to hug"; And "33% cheaper, 100% more integrated than competitors."

A defining pillar of Cuddle Cup's brand positioning is clinical credibility through NHS partnerships. By securing support and distribution access within the NHS Maternity Pathway, Cuddle Cup has moved from consumer baby-technology to the healthcare-trusted category, a position it currently holds with no competitors.

8.4. Marketing Mix (4Ps) Strategy

Product: Two SKUs at launch Cuddle Cup Newborn (150ml, 0-6 months) and Cuddle Cup Standard (260ml, 6-18+ months), both at £155 RRP, plus a 'Grow with Me' bundle featuring both variants at £245 (a £65 saving). Each SKU includes the bottle, sensing base, Qi charging dock, hygiene kit and all accessories. The companion app is available as a free download on iOS and Android. For NHS pharmacy channels, a physician-recommended starter kit will be offered at a negotiated institutional price of £135 per unit (excl. VAT), provided with an NHS co-branded insert card and a lactation support leaflet produced in partnership with NHS maternity services.



Figure 15 Cuddle Cup NHS Maternity Partnership outdoor advertising poster displaying the 'Buy Smarter. Feed Better.' campaign alongside the Cuddle Cup 3-in-1 Smart Baby Feeding System.

Price: £155 RRP including VAT, positioned as premium-accessible. Unified pricing across both variants simplifies retailing and eliminates the perception of an 'inferior' product. Pricing delivers £15.07 gross profit per unit at an 18% margin, which improves to 23.5% at a 50,000-unit scale through the value engineering program detailed in Section 6. NHS institutional pricing at £135 per unit accepts lower margins in exchange for clinical support reliability which drives full-price consumer demand over all other channels.

Place: A multi-channel distribution strategy includes five routes to market: (a) direct-to-consumer (DTC) via the Cuddle Cup website and companion app, targeting 35% of year 1 volumes with the highest margin retention; (b) e-commerce platforms, primarily Amazon UK and Amazon US, target 25% of volumes; (c) specialist baby retail partnerships with John Lewis, Mothercare (online), and independent nursery stores, targeting 20% volume; (d) the NHS pharmacy network – which includes hospital pharmacy dispensaries in NHS maternity units and community pharmacies participating in the Healthy Start and Pregnancy Pathways programs, serving as the primary trust-building channel, targeting 12% of year 1 volume; and (e) targeting 8% volume through NHS collaboration partnerships with NHS maternity units, midwifery teams and private breastfeeding consultants, direct sampling, antenatal class integration and professional referral schemes.

Promotion: An integrated promotion strategy combining digital-first acquisition with clinical trust-building through a structured NHS collaboration programme. The NHS Pharmacy partnership activates point-of-dispensing visibility at the time new mothers collect postpartum prescriptions – a uniquely high-intent touchpoint with zero competing smart feeding products currently present in this channel. The NHS Collaboration Stream engages midwives, health visitors and breastfeeding consultants through a professional sampling program (50 units across 10 NHS Trusts in Year 1), continuing professional development (CPD)-accredited product training sessions, and co-authored clinical guidance on temperature-safe infant feeding embedded within NHS maternity discharge packs. The complete promotion mix across digital and traditional channels is detailed in section 8.5.



Figure 16 Cuddle Cup NHS Maternity Partnership large-format in-store display poster at an NHS Pharmacy retail point, reinforcing clinical credibility and the 'Buy Smarter. Feed Better.' campaign message at the point of dispensing.

8.5. Digital and Traditional Marketing Strategy

Digital channels form the primary acquisition engine (Bogomolova, Szabo and Kennedy, 2017), accounting for 70% of marketing budgets. The website serves as both a brand hub and DTC storefront, optimized for SEO targeting keywords including 'smart baby bottle', 'integrated breast pump' and 'baby feeding tracker'. The social media strategy focuses on Instagram and TikTok, leveraging zero-transfer workflows, unboxing experiences, and short-form video content showcasing real parent testimonials. A tier one influencer partnership program engages 5-10 micro-influencers (Fastoso and González-Jiménez, 2020)(10k-100k followers in the parenting niche) per quarter, with talented product and affiliate commission structures. Pay-per-click advertising through Google Ads and Meta Ads targets similar audiences derived from high-intent search queries and early adopters. Email marketing automation extends from pregnancy to after birth, with trigger sequences linked to feeding milestones.



Figure 17 Promotional advertisement for the Cuddle Cup smart feeding system.

Traditional channels receive 30% of the budget, focusing on trust-building and experiential engagement. Baby shows (NEC Birmingham, Excel London) and trade exhibitions provide opportunities for personal display. Print advertising in publications such as Mother & Baby and Pregnancy & Birth magazines strengthens brand awareness. In-store demonstrations from retail partners enable hands-on product experience, which is especially important for the premium price point. Healthcare provider sampling, where lactation consultants receive units for professional evaluation, generates official third-party endorsements.

8.6. Marketing Budget Allocation and KPIs

The Year 1 marketing budget is set at £120,000, representing approximately 7.7% of projected Year 1 revenue (£1.55 million at 10,000 units). Budget allocation follows digital advertising 35% (£42,000), influencer partnerships 15% (£18,000), website and e-commerce development 12% (£14,400), trade shows and exhibitions 10% (£12,000), print advertising 8% (£9,600), in-store demonstrations 8% (£9,600), PR and media relations 7% (£8,400), and contingency 5% (£6,000).

Key Performance Indicators (KPIs) are structured across four dimensions: acquisition (10,000 units sold in Year 1, 50,000 website visitors per month by Month 12, 3.5% website conversion rate), engagement (25,000 app downloads, 4.2+ average app store rating, 15,000 social media followers), retention (35% repeat purchase rate for second-child usage or variant upgrade, Net Promoter Score ≥ 60), and financial (break-even at 14,597 cumulative units by early Year 2, customer acquisition cost below £12, return on ad spend $\geq 4.0x$). Monthly KPI reviews with quarterly strategy adjustments ensure responsiveness to market feedback and emerging channel opportunities.



Chart 6 Figure 18 Instagram marketing mockup promoting the Cuddle Cup smart feeder.

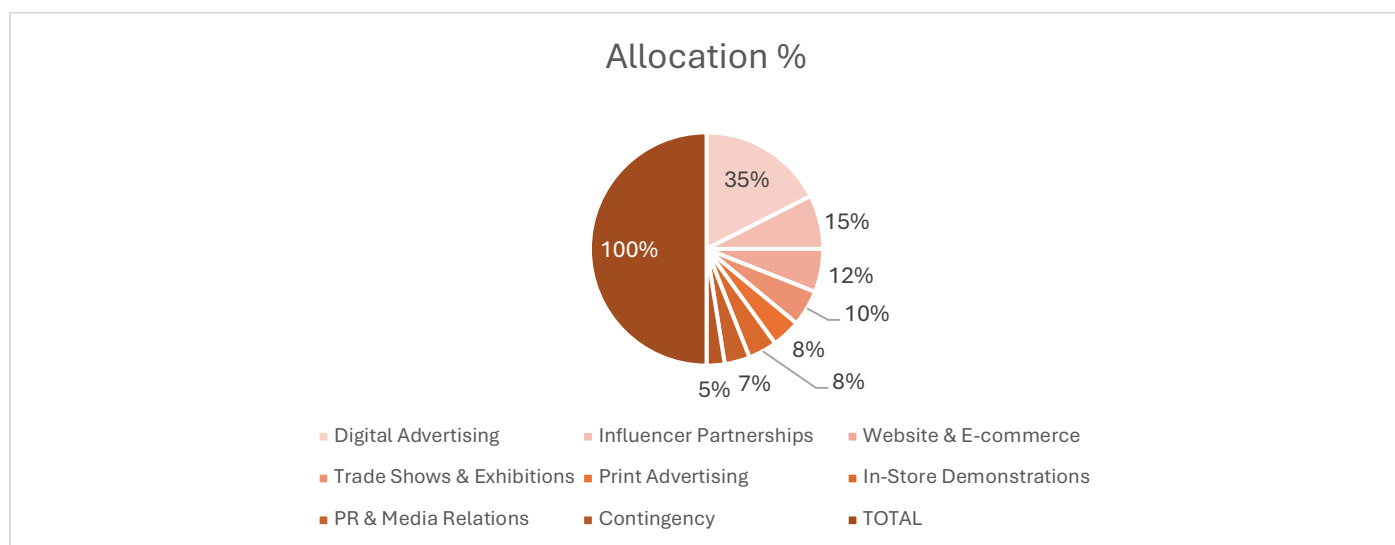


Chart 7 Marketing budget allocation by promotional channel (%)

9. Engineering Ethics and Professional Responsibility

This section addresses the ethical obligations, professional responsibilities (Hales *et al.*, 2016), and governance framework that guides the design, manufacturing, and marketing of the Cuddle Cup system. As the ethical standards applied to a product for use by infants and breastfeeding mothers in vulnerable populations exceed minimum regulatory compliance, the Engineering Council is taking a precautionary approach in line with the principles contained in the UK Statement of Ethical Principles (Engineering Council, 2026) and the Institution of Engineering and Technology (IET) Rules of Conduct.

9.1. Ethical Framework and Professional Codes

The ethical framework governing the Cuddle Cup project is based on four fundamental principles taken from the Engineering Council UK's Statement of Ethical Principles (Engineering Council, 2026): honesty and integrity in all professional dealings; respect for life, law, environment and public good; Accuracy and rigor in technical analysis and representation; and responsible leadership in balancing business, safety and social considerations. The IET Conduct Rules require members to maintain competence, act with due diligence and report concerns about safety (Institute of Engineering & Technology) or misconduct through appropriate channels. These principles are implemented through the project's governance structure. The technical lead (Ramaswamy) holds responsibility for engineering integrity and security verification, while the CEO (Bindushree) oversees commercial decisions against ethical standards. All team members have completed ethics awareness training covering product liability, consumer protection legislation (Consumer Rights Act 2015), and the specific obligations arising from designing products for infant use under BS EN 14350:2020.

9.2. Product Safety and Risk Management (FMEA)

Preliminary Failure Mode and Effects Analysis (FMEA) has been conducted for all safety-critical components and failure scenarios. *Table 33* presents the highest priority failure modes identified.

Table 28 FMEA Summary - Critical Failure Modes

Failure Mode	Sev.	Occ.	Det.	RPN	Mitigation / Control
Li-Po thermal runaway	10	2	3	60	BMS with overcharge/thermal cutoff (IEC 62133); conformal PCB coating; battery enclosed in flame-retardant housing
Nipple detachment during feeding	9	2	2	36	Thread engagement torque spec; pull-force testing per BS EN 14350 Clause 6.2 ($\geq 50N$); QC 100% check
Milk leakage into electronics	8	3	3	72	IP67 silicone gasket seal; conformal coating; functional leak test on every unit
Temperature sensor inaccuracy	7	2	2	28	Dual NTC redundancy; calibration fixture ($\pm 0.2^{\circ}C$); app alerts if readings diverge $> 1^{\circ}C$
Choking hazard (small parts)	10	1	2	20	All detachable parts exceed small-parts cylinder test (BS EN 14350 Clause 5.2); age-appropriate warnings
BLE data privacy breach	6	3	4	72	AES-128 encryption; GDPR-compliant data handling; no PII stored on device; app privacy policy

All identified failure modes are reduced to an acceptable risk priority number (RPN <100). The two highest-RPN items milk leakage into electronics cavity (RPN 72) and BLE data privacy violation (RPN 72) are addressed through multiple redundant controls. Safety testing and certification requirements include mechanical safety testing (BS EN 14350:2020 drop test, bite test, pull-force test), electrical safety (IEC 62133 for Li-Po batteries, FCC Part 15 for BLE emissions), material biocompatibility (ISO 10993 for all oral-contact silicone components), and choking hazard assessment (BS EN 14350 clause 5.2 Small-Part Testing). User safety instructions and warnings are provided in multilingual product manuals, on-product warning labels, and the onboarding sequence of the companion app.

9.3. Honest Marketing and Intellectual Property

All marketing communications follow the UK Advertising Standards Authority (ASA) Code and the Consumer Protection from Unfair Trading Regulations 2008. Specific commitments include: no health claims beyond those warranted by clinical evidence or regulatory approval; Transparent pricing with no hidden costs (£155 RRP includes all components, dock and accessories); Accurate representation of product capabilities in all advertising materials; and Clear disclosure of sponsored content and influencer partnerships in accordance with ASA guidelines on social media advertising. With respect to intellectual property, a comprehensive patent search has been conducted to ensure that the Cuddle Cup's design features, including its 360° rotatable nipple mechanism, modular sensing base interface and zero-transfer pump-to-feed workflow, do not infringe existing patents held by competitors including Medela, Elvi or One Willow. A UK patent application is being prepared for an integrated sensing base-bottle interface design and modular variant system. The project team respects competing intellectual property and has adopted a policy of original innovation rather than incremental imitation, in line with IET guidance on fair competition and professional integrity.

9.4. Supply Chain Ethics and Fair Labour Practices

A Supplier Code of Conduct has been developed to require all manufacturing partners and component suppliers to adhere to the Ethical Trading Initiative (ETI) Base Code, which prohibits child labor, forced labor and discrimination while mandating fair wages, safe working conditions and freedom of association. All suppliers undergo pre-qualification audits to assess labor practices (Chinniyomphanich, Wongwanichsin and Jitkarnka, 2016a), environmental compliance and quality management systems. The primary contracted manufacturing facility (injection molding and final assembly) is required to have SA8000 (SA8000, 2026) or equivalent social accountability certification. Supply chain transparency is maintained through documented audit trails for all tier-one suppliers, with biennial compliance reviews and unannounced factory visits reserved as a contractual right. Specific policies include: No use of conflict minerals (tin, tantalum, tungsten, gold) sourced from conflict-affected areas, verified through supplier declarations in line with the EU Conflict Minerals Regulation 2021/821 (Official Journal of the European Union, 2017); Zero-tolerance policy on child labor mandating age verification processes at all manufacturing sites; and a commitment to pay a living wage (not just the minimum wage) at all contracted facilities in line with the Global Living Wage Coalition's regional projections.

9.5. Conflict of Interest and Whistleblowing

All team members are required to declare any personal, financial or family interests that may conflict with their professional responsibilities on the Cuddle Cup project (Penard *et al.*, 2015). A formal conflict of interest register is maintained by the project manager (Spandana) and reviewed quarterly. Decisions involving supplier selection, pricing negotiations, or material specification changes require sign-off from at least two team members to prevent unilateral conflict (Chinniyomphanich, Wongwanichsin and Jitkarnka, 2016b). A confidential whistleblowing mechanism has been established through an anonymous reporting channel that is accessible to all team members,

contracted suppliers and manufacturing personnel. In line with the Public Interest Disclosure Act 1998 (PIDA) (Legislation.gov.uk, 2024), reports of security concerns, ethical violations, or regulatory non-compliance are forwarded to the CEO with a commitment to investigate within 48 hours and protect the reporter from retaliation.

9.6. Continuous Professional Development

The Cuddle Cup project team maintains a commitment to continuing professional development (CPD) in both technical competence and ethical awareness. All five members of the team are enrolled in relevant engineering institutions or are progressing towards professional registration. CPD activities include Annual ethics refresher training covering product liability, consumer protection and data privacy (GDPR/UK GDPR); Participation in industry conferences and workshops on infant product safety standards; Regular review of emerging regulatory requirements and voluntary certification standards; and cross-functional knowledge sharing sessions where each team member presents developments in his or her area of responsibility. This CPD commitment ensures that the team's technical and ethical capabilities develop in line with the regulatory landscape and societal expectations governing baby care products, supporting the long-term credibility and responsibility of the Cuddle Cup brand.

Conclusion:

This report has documented the end-to-end development of the Cuddle Cup 3-in-1 Smart Baby Feeding System, from primary market research through engineering design, value management, sustainability assessment, and go-to-market strategy. Primary research across 60 UK mothers confirmed four unresolved pain points, product confusion (78%), uncomfortable feeding positions (71%), temperature inconsistency (65%), and price hesitation (82%), validating a clear market gap that no existing competitor addresses within a single integrated platform.

The selected concept achieved a weighted evaluation score of 4.30 out of 5.00, comprising a 51-component system across eight assembly groups at a £155 RRP, 33% below the nearest integrated competitor. Financial modelling confirms commercial viability, with break-even at 14,597 units within 18 months and a five-year revenue projection of £54.8 million. The preliminary lifecycle assessment estimates a total carbon footprint of 5.60 kg CO₂e, with a 28% reduction achievable through EAF steel sourcing and recycled PP adoption.

Underpinned by CE, FDA, and BS EN 14350:2020 compliance, an NHS distribution partnership strategy, and a rigorous engineering ethics framework, the Cuddle Cup is positioned to redefine the premium infant feeding category in the UK and beyond.

Reference:

Ahmed, R., Rafique, A. and Philbin, S. (2021) 'Cross-functional integration between organizational structure and the new product development process', *Organization Development Journal*, 39, pp. 63–78.

Amereh, M. *et al.* A new venting valve for anti-colic nursing bottles

Antunes, M.C. *et al.* (2018) 'Correlating different techniques in the thermooxidative degradation monitoring of high-density polyethylene containing pro-degradant and antioxidants', *Polymer Testing*, 69, pp. 182–187. Available at: <https://doi.org/10.1016/j.polymertesting.2018.05.008>.

Aurich, J.C., Effgen, C. and Kirsch, B. (2016) 'Cutting edge preparation with elastic bonded superabrasive grinding wheels', *CIRP Annals*, 65(1), pp. 329–332. Available at: <https://doi.org/10.1016/j.cirp.2016.04.093>.

Aziz, M.N., *et al.* (2018) *Sentiment analysis and topic modelling for identification of government service satisfaction*. pp. 125–130.

Babaloo (2024) 'About babaloo',

Baltrocchi, A.P. *et al.* (2025) 'Improving environmental sustainability of food-contact polypropylene packaging production', *Clean Technologies*, 7(3) Available at: <https://doi.org/10.3390/cleantechnol7030070>.

Benayoune, A. (2024) 'Competency-based framework development and implementation: Current and future perspectives', *Information Management and Business Review*, 16, pp. 606–615. Available at: [https://doi.org/10.22610/imbr.v16i3\(l\).4013](https://doi.org/10.22610/imbr.v16i3(l).4013).

Bianchi, C.C. and Ostale, E. (2006) 'Lessons learned from unsuccessful internationalization attempts: Examples of multinational retailers in chile', *Journal of Business Research*, 59(1), pp. 140–147. Available at: <https://doi.org/10.1016/j.jbusres.2005.01.002>.

Blaisi, N.I. *et al.* (2015) 'Evaluation of the impact of lime softening waste disposal in natural environments', *Waste Management*, 43, pp. 524–532. Available at: <https://doi.org/10.1016/j.wasman.2015.06.015>.

Blaznov, A.N. *et al.* (2017) 'Thermomechanical characterization of BFRP and GFRP with different degree of conversion', *Polymer Testing*, 60, pp. 49–57. Available at: <https://doi.org/10.1016/j.polymertesting.2017.03.011>.

Bogaard, R.H. (1985) 'Thermal conductivity of selected stainless steels', in Ashworth, T. and Smith, D.R. (eds.) *Thermal Conductivity 18* Boston, MA: Springer US, pp. 175–185.

Bogomolova, S., Szabo, M. and Kennedy, R. (2017) 'Retailers' and manufacturers' price-promotion decisions: Intuitive or evidence-based?', *Journal of Business Research*, 76, pp. 189–200. Available at: <https://doi.org/10.1016/j.jbusres.2016.05.020>.

Brook, M.A. (2012) '3 - the chemistry and physical properties of biomedical silicones', in Peters, W., Brandon, H., Jerina, K.L., Wolf, C. and Young, V.L. (eds.) *Biomaterials in Plastic Surgery* Woodhead Publishing, pp. 52–67.

Brown, K. *et al.* (2016) 'Mixed-methods study identifies key strategies for improving infant and young child feeding practices in a highly stunted rural indigenous population in guatemala', *Maternal & Child Nutrition*, 12(2), pp. 262–277. Available at: <https://doi.org/10.1111/mcn.12141>.

BSI Standards Publication (2020) *BSI standards publication*

bsi.Knowledge (2020) *Child care articles. drinking equipment. safety requirements and test methods*. Available at: <https://knowledge.bsigroup.com/products/child-care-articles-drinking-equipment-safety-requirements-and-test-methods> (Accessed:

Cai, G. *et al.* (2019) 'Detailed urban land use land cover classification at the metropolitan scale using a three-layer classification scheme', *Sensors (Basel, Switzerland)*, 19(14), pp. 3120. doi: 10.3390/s19143120. Available at: <https://doi.org/10.3390/s19143120>.

Calia, R.C., Guerrini, F.M. and de Castro, M. (2009a) 'The impact of six sigma in the performance of a pollution prevention program', *Journal of Cleaner Production*, 17(15), pp. 1303–1310. Available at: <https://doi.org/10.1016/j.jclepro.2009.05.001> .

Castelli, F. and Maugeri, M. (2014a) 'Mechanical properties of municipal solid waste by SDMT', *Waste Management*, 34(2), pp. 256–265. Available at: <https://doi.org/10.1016/j.wasman.2013.10.026> .

Chaari Fourati, L. and Said, S. (2020) *Remote health monitoring systems based on bluetooth low energy (BLE) communication systems*. Countries. Cham: Springer International Publishing, pp. 41–54.

Chen, J. *et al.* (2014a) 'Electrocatalytic performance enhancement of La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-δ}-Y₂O₃ stabilized ZrO₂ cathodes prepared by an impregnation technique', *Journal of Power Sources*, 256, pp. 312–318. Available at: <https://doi.org/10.1016/j.jpowsour.2014.01.081> .

Chien, C., Chen, Y. and Peng, J. (2010) 'Manufacturing intelligence for semiconductor demand forecast based on technology diffusion and product life cycle', *International Journal of Production Economics*, 128(2), pp. 496–509. Available at: <https://doi.org/10.1016/j.ijpe.2010.07.022> .

Chinniyomphanich, U., Wongwanichsin, P. and Jitkarnka, S. (2016a) 'SnxOy/SAPO-34 as catalysts for catalytic dehydration of bio-ethanol: Impacts of oxidation state, interaction, and loading amount', *Journal of Cleaner Production*, 111, pp. 25–33. Available at: <https://doi.org/10.1016/j.jclepro.2015.09.069> .

Cho, H.J. *et al.* (2012) 'Effect of molecular weight and storage time on the wet- and electro-spinning of regenerated silk fibroin', *Polymer Degradation and Stability*, 97(6), pp. 1060–1066. Available at: <https://doi.org/10.1016/j.polymdegradstab.2012.03.007> .

Cirillo, A. *et al.* (2017) 'Optimal custom design of both symmetric and unsymmetrical hexapod robots for aeronautics applications', *Robotics and Computer-Integrated Manufacturing*, 44, pp. 1–16. Available at: <https://doi.org/10.1016/j.rcim.2016.06.002> .

Code of federal Regulation (2026) § 177.1520 olefin polymers. Available at: <https://www.ecfr.gov/current/title-21/chapter-I/subchapter-B/part-177/subpart-B/section-177.1520> (Accessed:

D. Sehrawat and N. S. Gill (2019) *Smart sensors: Analysis of different types of IoT sensors*. pp. 523–528.

D. Uluşen, *et al.* (2019) *Turkey's first electric propulsion system developed in the very first electric propulsion laboratory: TUBITAK UZAY's HALE project outcome*. pp. 779–784.

Ding, K. *et al.* (2014) 'Experimental studies on drilling tool load and machining quality of C/SiC composites in rotary ultrasonic machining', *Journal of Materials Processing Technology*, 214(12), pp. 2900–2907. Available at: <https://doi.org/10.1016/j.jmatprotec.2014.06.015> .

Dr.Brown (2010) *Colic report*. Available at: <https://www.dr browns.co.uk/pages/colic-report> (Accessed:

Elvie (2018) *Smart tech for smart bodies*. Available at: <https://elvie.com/pages/about-us> (Accessed:

Encloser Pro Ltd *Ultimate guide to IP ratings for outdoor electrical enclosures*. Available at: https://enclosurepro.co.uk/ip66-vs-ip67-guide-outdoor-electrical-enclosure-ratings/#:~:text=IP67%20*%20Dust:%20Complete%20protection.%20*%20Water:,Uses:%20Below%2Dground%20installations%2C%20flood%2Dprone%20sites%2C%20marine%20environments. (Accessed:

Engineering Council (2026) *Statement of ethical principles for the engineering profession*

Fastoso, F. and González-Jiménez, H. (2020) 'Materialism, cosmopolitanism, and emotional brand attachment: The roles of ideal self-congruity and perceived brand globalness', *Journal of Business Research*, 121, pp. 429–437. Available at: <https://doi.org/10.1016/j.jbusres.2018.12.015> .

Firouzabadi, F.B. *et al.* (2014a) 'ZnO nanoparticle suspensions containing citric acid as antimicrobial to control listeria monocytogenes, escherichia coli, staphylococcus aureus and bacillus cereus in mango juice', *Food Control*, 42, pp. 310–314. Available at: <https://doi.org/10.1016/j.foodcont.2014.02.012> .

Fortunate Business Insight (2026) 'Butyl glycol market size, share & industry analysis, by application (solvent, chemical intermediate, and others), and regional forecast, 2026-2034',

Fronzel, M. *et al.* (2010a) 'Economic impacts from the promotion of renewable energy technologies: The German experience', *Energy Policy*, 38(8), pp. 4048–4056. Available at: <https://doi.org/10.1016/j.enpol.2010.03.029>.

Gasafi, E. and Weil, M. (2011a) 'Approach and application of life cycle screening in early phases of process design: Case study of supercritical water gasification', *Journal of Cleaner Production*, 19(14), pp. 1590–1600. Available at: <https://doi.org/10.1016/j.jclepro.2011.05.021>.

González-Benito, J. *et al.* (2017) 'PVDF/TiO₂ nanocomposites prepared by solution blow spinning: Surface properties and their relation with *S. mutans* adhesion', *Polymer Testing*, 58, pp. 21–30. Available at: <https://doi.org/10.1016/j.polymertesting.2016.12.005>.

Guilbault, M. (2018) 'Students as customers in higher education: The (controversial) debate needs to end', *Journal of Retailing and Consumer Services*, 40, pp. 295–298. Available at: <https://doi.org/10.1016/j.jretconser.2017.03.006>.

Guo, S., Shen, G.Q. and Peng, Y. (2016) 'Embodied agricultural water use in China from 1997 to 2010', *Journal of Cleaner Production*, 112, pp. 3176–3184. Available at: <https://doi.org/10.1016/j.jclepro.2015.09.123>.

Hales, S. *et al.* (2016) 'Social networks for improving healthy weight loss behaviors for overweight and obese adults: A randomized clinical trial of the social pounds off digitally (social POD) mobile app', *International Journal of Medical Informatics*, 94, pp. 81–90. Available at: <https://doi.org/10.1016/j.ijmedinf.2016.07.003>.

Han, C. *et al.* (2018) 'Effects of SiO₂ film thickness and operating temperature on thermally-induced failures in through-silicon-via structures', *Microelectronics Reliability*, 83, pp. 1–13. Available at: <https://doi.org/10.1016/j.microrel.2018.02.006>.

Harich, M. *et al.* (2018) 'Evaluation of antibacterial activity of two natural bio-preservatives formulations on freshness and sensory quality of ready to eat (RTE) foods', *Food Control*, 85, pp. 29–41. Available at: <https://doi.org/10.1016/j.foodcont.2017.09.018>.

He, B., Xiao, J. and Deng, Z. (2018a) 'Product design evaluation for product environmental footprint', *Journal of Cleaner Production*, 172, pp. 3066–3080. Available at: <https://doi.org/10.1016/j.jclepro.2017.11.104>.

Hu, J. *et al.* (2017) 'A promising approach for the recovery of high value-added metals from spent lithium-ion batteries', *Journal of Power Sources*, 351, pp. 192–199. Available at: <https://doi.org/10.1016/j.jpowsour.2017.03.093>.

Institute of Engineering & Technology *Rules of conduct*

Jack, J. (2016) 'Leviathan and the breast pump: Toward an embodied rhetoric of wearable technology', *Rhetoric Society Quarterly*, 46(3), pp. 207–221. Available at: <https://doi.org/10.1080/02773945.2016.1171691>.

Jiang, J. *et al.* (2020a) 'State-of-the-art control strategies for robotic PiH assembly', *Robotics and Computer-Integrated Manufacturing*, 65, pp. 101894. Available at: <https://doi.org/10.1016/j.rcim.2019.101894>.

Katz, D.S. and Zhou, X. (2017) 'Leading-edge research in cluster, cloud, and grid computing: Best papers from the IEEE/ACM CCGrid 2015 conference', *Future Generation Computer Systems*, 72, pp. 78–80. Available at: <https://doi.org/10.1016/j.future.2016.09.016>.

Khanarian, N.T. *et al.* (2014) 'FTIR-I compositional mapping of the cartilage-to-bone interface as a function of tissue region and age', *Journal of Bone and Mineral Research : The Official Journal of the American Society for Bone and Mineral Research*, 29(12), pp. 2643–2652. Available at: <https://doi.org/10.1002/jbmr.2284>.

Koutsourelis, M., Michalas, L. and Papaioannou, G. (2012) 'Temperature effects on the bulk discharge current of dielectric films of MEMS capacitive switches', *Microelectronics Reliability*, 52(9), pp. 2240–2244. Available at: <https://doi.org/10.1016/j.microrel.2012.06.005>.

Krishnan, V. and Das, T. (2015a) 'Optimal allocation of energy storage in a co-optimized electricity market: Benefits assessment and deriving indicators for economic storage ventures', *Energy*, 81, pp. 175–188. Available at: <https://doi.org/10.1016/j.energy.2014.12.016>.

- Lechler, T.G. and Thomas, J.L. (2015) 'Examining new product development project termination decision quality at the portfolio level: Consequences of dysfunctional executive advocacy', *International Journal of Project Management*, 33(7), pp. 1452–1463. Available at: <https://doi.org/10.1016/j.ijproman.2015.04.001> .
- Lecksiwilai, N. et al. (2017) 'LCA of biofuels in thailand using thai ecological scarcity method', *Journal of Cleaner Production*, 142, pp. 1183–1191. Available at: <https://doi.org/10.1016/j.jclepro.2016.07.054> .
- Legislation.gov.uk (2024) *Public interest disclosure act 1998*. Available at: <https://www.legislation.gov.uk/ukpga/1998/23/contents/data.pdf> (Accessed: 2024-09-10).
- Leonzio, G. (2016) 'Upgrading of biogas to bio-methane with chemical absorption process: Simulation and environmental impact', *Journal of Cleaner Production*, 131, pp. 364–375. Available at: <https://doi.org/10.1016/j.jclepro.2016.05.020> .
- Lindner, M. et al. (2010) 'Time-of-flight sensor calibration for accurate range sensing', *Computer Vision and Image Understanding*, 114(12), pp. 1318–1328. Available at: <https://doi.org/10.1016/j.cviu.2009.11.002> .
- Liu, Z. et al. (2018) 'Creation of internal structure of mashed potato construct by 3D printing and its textural properties', *Food Research International*, 111, pp. 534–543. Available at: <https://doi.org/10.1016/j.foodres.2018.05.075> .
- M. N. Aziz, et al (2018a) *Sentiment analysis and topic modelling for identification of government service satisfaction*. pp. 125–130.
- Mandley, S., Harmsen, R. and Worrell, E. (2015) 'Identifying the potential for resource and embodied energy savings within the UK building sector', *Energy and Buildings*, 86, pp. 841–851. Available at: <https://doi.org/10.1016/j.enbuild.2014.10.044> .
- Marrouch, W. and Mourad, J. (2019) 'Effect of gasoline prices on car fuel efficiency: Evidence from lebanon', *Energy Policy*, 135, pp. 111001. Available at: <https://doi.org/10.1016/j.enpol.2019.111001> .
- Mazloum, Y., Sayah, H. and Nemer, M. (2017) 'Exergy analysis and exergoeconomic optimization of a constant-pressure adiabatic compressed air energy storage system', *Journal of Energy Storage*, 14, pp. 192–202. Available at: <https://doi.org/10.1016/j.est.2017.10.006> .
- Medela Medela symphony rental breast pump. Available at: <https://shop.medela.co.uk/products/breast-pumps/symphony-rental-breast-pump/#:~:text=If%20you%20are%20experiencing%20challenges,breastfeeding%20is%20something%20very%20special>. (Accessed: 2024-09-10).
- Mehmann, J. and Teuteberg, F. (2016) 'The fourth-party logistics service provider approach to support sustainable development goals in transportation – a case study of the german agricultural bulk logistics sector', *Journal of Cleaner Production*, 126, pp. 382–393. Available at: <https://doi.org/10.1016/j.jclepro.2016.03.095> .
- Mullen, J., Kelloway, E.K. and Teed, M. (2017) 'Employer safety obligations, transformational leadership and their interactive effects on employee safety performance', *Safety Science*, 91, pp. 405–412. Available at: <https://doi.org/10.1016/j.ssci.2016.09.007> .
- N. D. Lane et al. (2010) 'A survey of mobile phone sensing', *IEEE Communications Magazine*, 48(9), pp. 140–150. Available at: <https://doi.org/10.1109/MCOM.2010.5560598> .
- National Library of Medicine (2016) 'Maternal & child nutrition', *Maternal & Child Nutrition*, 12(Suppl 1), pp. 1–2. Available at: <https://doi.org/10.1111/mcn.12311> .
- Newhook, L.A. et al. (2009a) 'Vitamin D insufficiency common in newborns, children and pregnant women living in newfoundland and labrador, canada', *Maternal & Child Nutrition*, 5(2), pp. 186–191. Available at: <https://doi.org/10.1111/j.1740-8709.2008.00157.x> .
- Official Journal of the European Union (2017) *Regulation (eu) 2017/821 of the european parliament and of the council*
- P. Manganiello, et al (2013) *On-line optimization of the P&O MPPT method by means of the system identification*. pp. 1786–1791.

Penard, T. *et al.* (2015) 'Internet adoption and usage patterns in africa: Evidence from cameroon', *Technology in Society*, 42, pp. 71–80. Available at: <https://doi.org/10.1016/j.techsoc.2015.03.004> .

Philips Avent Baby Bottles. (2023) *No matter who's feeding, connect with calm*. Available at: https://www.philips.co.uk/c-m-mo/baby-bottles?utm_id=20862148998&origin=7_9164824656_20862148998_38700019209907432&gclid=aw.ds&gad_source=1&gad_campaignid=22924805662&gbraid=0AAAAAD9m5bAa3sat96ww6TZmER7QJqYcV&gclid=Cj0KCQiA8KTNBhD_ARIsAOvp6DKIL0odRc5kyFnFFgYeV58WvovWk4TMV7PycZ8U7kqtrLpgdnwcllaAoN3EALw_wcB (Accessed:

Pivnenko, K., Laner, D. and Astrup, T.F. (2018a) 'Dynamics of bisphenol A (BPA) and bisphenol S (BPS) in the european paper cycle: Need for concern?', *Resources, Conservation and Recycling*, 133, pp. 278–287. Available at: <https://doi.org/10.1016/j.resconrec.2018.01.021> .

Ponsot, I. *et al.* (2015) 'Recycling of pre-stabilized municipal waste incinerator fly ash and soda-lime glass into sintered glass-ceramics', *Journal of Cleaner Production*, 89, pp. 224–230. Available at: <https://doi.org/10.1016/j.jclepro.2014.10.091> .

Qian, M. *et al.* (2018) 'Dual ag electrodes for semitransparent organic light-emitting diodes', *Organic Electronics*, 57, pp. 98–103. Available at: <https://doi.org/10.1016/j.orgel.2018.02.028> .

Ramalingam, B., Rengarajan, A. and Rayappan, J.B.B. (2017c) 'Hybrid image crypto system for secure image communication– A VLSI approach', *Microprocessors and Microsystems*, 50, pp. 1–13. Available at: <https://doi.org/10.1016/j.micpro.2017.02.003> .

Rex, E. *et al.* (2017) 'A systems perspective on chemical production from mixed food waste: The case of bio-succinate in sweden', *Resources, Conservation and Recycling*, 125, pp. 86–97. Available at: <https://doi.org/10.1016/j.resconrec.2017.05.012> .

Rodrigues, M.L.M. and Lima, R.M.F. (2012) 'Cleaner production of soapstone in the ouro preto region of brazil: A case study', *Journal of Cleaner Production*, 32, pp. 149–156. Available at: <https://doi.org/10.1016/j.jclepro.2012.03.028> .

SA8000 (2026) *Sa8000:2026®*
standard for
decent work

Sehrawat, D. and Gill, N.S. (2019) *Smart sensors: Analysis of different types of IoT sensors*. pp. 523–528.

Shevtshenko, E. *et al.* (2015) 'Collaborative project management framework for partner network initiation', *Procedia Engineering*, 100, pp. 159–168. Available at: <https://doi.org/10.1016/j.proeng.2015.01.354> .

Shvarts, E.A., Pakhalov, A.M. and Knizhnikov, A.Y. (2016) 'Assessment of environmental responsibility of oil and gas companies in russia: The rating method', *Journal of Cleaner Production*, 127, pp. 143–151. Available at: <https://doi.org/10.1016/j.jclepro.2016.04.021> .

Sivakumar, V. *et al.* (2009) 'Towards cleaner degreasing method in industries: Ultrasound-assisted aqueous degreasing process in leather making', *Journal of Cleaner Production*, 17(1), pp. 101–104. Available at: <https://doi.org/10.1016/j.jclepro.2008.02.012> .

Spatz, D.L. (2010a) 'Roles and responsibilities of health professions: Focus on nursing', *Breastfeeding Medicine*, 5(5), pp. 243–244. Available at: <https://doi.org/10.1089/bfm.2010.0036> .

Sun, Z. *et al.* (2017b) 'A double-film screening card for rapid detection of organophosphate and carbamate pesticide residues by one step in vegetables and fruits', *Food Control*, 81, pp. 23–29. Available at: <https://doi.org/10.1016/j.foodcont.2017.05.012> .

Sundaram, K.S. and Prakash, M. (2014) 'Study on impact of CAD/ CAM tools on production of punched cards by indian silk saree designers for handloom industry', *Procedia CIRP*, 17, pp. 818–823. Available at: <https://doi.org/10.1016/j.procir.2014.02.045> .

Sverdrup, H.U., Ragnarsdottir, K.V. and Koca, D. (2014a) 'On modelling the global copper mining rates, market supply, copper price and the end of copper reserves', *Resources, Conservation and Recycling*, 87, pp. 158–174. Available at: <https://doi.org/10.1016/j.resconrec.2014.03.007> .

TCL (2016) *Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)*

Thangaraju, P. and Varthya, S.B. (2022) 'ISO 10993: Biological evaluation of medical devices', in Timiri Shanmugam, P.S., Thangaraju, P., Palani, N. and Sampath, T. (eds.) *Medical Device Guidelines and Regulations Handbook* Cham: Springer International Publishing, pp. 163–187.

Thibodeau, C. *et al.* (2014a) 'Comparison of black water source-separation and conventional sanitation systems using life cycle assessment', *Journal of Cleaner Production*, 67, pp. 45–57. Available at: <https://doi.org/10.1016/j.jclepro.2013.12.012> .

Topolinski, S., Zürn, M. and Schneider, I.K. (2015) 'What's in and what's out in branding? A novel articulation effect for brand names', *Frontiers in Psychology*, 6, pp. 585. Available at: <https://doi.org/10.3389/fpsyg.2015.00585> .

Trianni, A. *et al.* (2013a) 'Barriers to industrial energy efficiency in foundries: A european comparison', *Journal of Cleaner Production*, 40, pp. 161–176. Available at: <https://doi.org/10.1016/j.jclepro.2012.08.040> .

Wang, L. *et al.* (2017b) 'Research on structure optimal design of solar air collector', *Procedia Engineering*, 205, pp. 2049–2054. Available at: <https://doi.org/10.1016/j.proeng.2017.10.085> .

Wilson, E.M. and Green, J.R. (2009a) 'The development of jaw motion for mastication', *Early Human Development*, 85(5), pp. 303–311. Available at: <https://doi.org/10.1016/j.earlhumdev.2008.12.003> .

Yadlapati, R. *et al.* (2019) 'Trajectory assessment is useful when day-to-day esophageal acid exposure varies in prolonged wireless pH monitoring', *Diseases of the Esophagus : Official Journal of the International Society for Diseases of the Esophagus*, 32(3), pp. doy077. doi: 10.1093/dote/doy077. Available at: <https://doi.org/10.1093/dote/doy077> .

Yang, X. *et al.* (2014) 'Effects of mild and pasteurizing heat treatments on survival of generic and verotoxigenic escherichia coli from beef enrichment cultures', *Food Control*, 39, pp. 100–104. Available at: <https://doi.org/10.1016/j.foodcont.2013.11.004> .

Zhang, X. *et al.* (2020) 'The toxic effects of sulfoxaflor induced in earthworms (eisenia fetida) under effective concentrations', *International Journal of Environmental Research and Public Health*, 17(5) Available at: <https://doi.org/10.3390/ijerph17051740> .

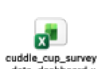
Zhao, C., Knisely, K.E. and Grosh, K. (2018) 'Design and fabrication of a piezoelectric MEMS xylophone transducer with a flexible electrical connection', *Sensors and Actuators A: Physical*, 275, pp. 29–36. Available at: <https://doi.org/10.1016/j.sna.2018.03.038> .

Zhao, X. *et al.* (2016) 'How to improve the market efficiency of carbon trading: A perspective of china', *Renewable and Sustainable Energy Reviews*, 59, pp. 1229–1245. Available at: <https://doi.org/10.1016/j.rser.2016.01.052> .

Appendices:

Appendices:

Appendix	Tittle	Attachment
----------	--------	------------

Appendix A	Cuddle Cup Logo Portfolio	
Appendix B	Referenced in: 1.3.1 (Colour Palette and Moodboard Integration)	Unsupported File Attached in Portal
Appendix C	Full logo exploration-Illustration File	Unsupported File Attached in Portal
Appendix D	Mood board and imagery direction	
Appendix E	Complete Bill of Materials (BOM v1.0)-51 Components, 8 Assembly Groups	
Appendix F	Detailed Engineering Design	
Appendix G	Detailed Cost Model and Financial Analysis	
Appendix H	Market Research and Competitor Analysis	
Appendix I	Brainstorming Concept Boards	
Appendix J	Survey Data and Research Insights	 
Appendix K	3D CAD Models and Rendered Visual Assets	Unsupported File Attached in Portal
Appendix L	FMEA Analysis	
Appendix M	Regulatory Compliance Matrix	
Appendix N	Companion App frames	https://www.figma.com/design/EvUldZXloom4PgrAvojr8/Cuddle-Cup?node-id=1-762&t=j7GaUy3aGDZvK6HS-1
Appendix O	Product Function Document	

Abbreviations:

This glossary provides definitions for all abbreviations, acronyms, and specialist terms used throughout the Cuddle Cup 3-in-1 Smart Baby Feeding System project documentation. Terms are listed in alphabetical order. Where an abbreviation relates to a specific regulatory standard, the full standard reference is provided.

Abbreviation	Full Term and Definition
ABS	Acrylonitrile Butadiene Styrene-engineering plastic used in pump housings
AOI	Automated Optical Inspection-post-SMT PCB quality check
ASA	Advertising Standards Authority (UK)
BLE	Bluetooth Low Energy-wireless communication protocol (5.0 used in Cuddle Cup)
BMS	Battery Management System-protection circuit for Li-Po battery
BOM	Bill of Materials-list of all components and costs

BOF	Basic Oxygen Furnace-steel production method (higher CO ₂ vs EAF)
BS	British Standard (e.g. BS EN 14350:2020)
BSDF	Bidirectional Scattering Distribution Function-used in Blender shader simulation
CAGR	Compound Annual Growth Rate
CAD	Computer-Aided Design-Autodesk Fusion 360 used for engineering drawings
CE	Conformité Européenne-EU product safety marking
COC	Certificate of Conformity-supplier quality documentation
CPD	Continuing Professional Development
DfD	Design for Disassembly-engineering principle applied to end-of-life
DFM	Design for Manufacturing-engineering approach to optimise production
DoC	Declaration of Conformity-regulatory compliance declaration
DTC	Direct-to-Consumer-sales channel via Cuddle Cup website
EAF	Electric Arc Furnace-lower-emission steel production method
EMC	Electromagnetic Compatibility-regulatory requirement for electronic devices
EPR	Extended Producer Responsibility-UK Environment Act 2021 obligation
ERM	Eccentric Rotating Mass-haptic motor type used in sensing base
FMEA	Failure Mode and Effects Analysis-risk assessment methodology (IEC 60812)
FCC	Federal Communications Commission (US)-BLE emission regulator
FDA	Food and Drug Administration (US)-food-contact and device regulator
FSC	Forest Stewardship Council-sustainable packaging certification
GBP	British Pounds Sterling
GDPR	General Data Protection Regulation (UK/EU)
GTM	Go-to-Market-commercial launch strategy
HDRI	High Dynamic Range Image-lighting technique used in Blender rendering
IEC	International Electrotechnical Commission
IP	Ingress Protection-rating for dust/water resistance (IEC 60529)
ISO	International Organisation for Standardisation
KPI	Key Performance Indicator
LCA	Life Cycle Assessment-ISO 14040/14044
LSR	Liquid Silicone Rubber-medical-grade material for nipples and seals
Li-Po	Lithium Polymer-battery chemistry used in Cuddle Cup sensing base
MCU	Microcontroller Unit-ARM Cortex-M0+ STM32L0 series
MOQ	Minimum Order Quantity-base 10,000 units
NPS	Net Promoter Score-customer loyalty metric
NTC	Negative Temperature Coefficient-thermistor type for temperature sensing
OTA	Over-The-Air-firmware update method via BLE/Wi-Fi
PCB	Printed Circuit Board-FR4 glass-epoxy substrate
PCR	Post-Consumer Recycled-sustainable material specification
PP	Polypropylene-primary structural plastic; food-grade copolymer
PTC	Positive Temperature Coefficient-self-limiting ceramic heater element
QA	Quality Assurance
QC	Quality Control
RACI	Responsible, Accountable, Consulted, Informed-project management matrix
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (EU)
REGO	Renewable Energy Guarantee of Origin-green electricity certification
RoHS	Restriction of Hazardous Substances Directive (2011/65/EU)

RPN	Risk Priority Number-FMEA metric: Severity × Occurrence × Detection
RRP	Recommended Retail Price-£155.00 for Cuddle Cup
RTC	Real-Time Clock-IC used for expiration countdown and feed scheduling
SAVE	Society of American Value Engineers-VE methodology framework
SKU	Stock Keeping Unit-product variant identifier
SMT	Surface Mount Technology-PCB component placement and reflow soldering
SoC	System-on-Chip-proposed VE integration of BLE + MCU + BMS
SS304	Austenitic Stainless Steel Grade 304 (18/8)-inner liner material
SVHC	Substance of Very High Concern-REACH candidate list chemicals
TOF	Time-of-Flight-distance/level sensor technology
TPE	Thermoplastic Elastomer-soft-touch grip sleeve material (Shore A 40-60)
USD	United States Dollar
VAT	Value Added Tax-20% included in £155.00 RRP
VE	Value Engineering-cost optimisation methodology
VI	Value Index-function worth / cost ratio (used in FAST analysis)
VM	Value Management-BS EN 12973:2020 framework
WEEE	Waste Electrical and Electronic Equipment Directive (2012/19/EU)

ISO Standards Referenced in this Project (complete list):

- BS EN 14350:2020-Child-use drinking equipment; safety and performance (BSI, 2020)
- IEC 62133:2017-Secondary cells and batteries-Safety requirements for portable sealed secondary lithium cells
- ISO 10993-Biological evaluation of medical devices (biocompatibility of oral-contact materials)
- IEC 60529:2013-Degrees of protection provided by enclosures (IP Code)
- IEC 60812:2018-Failure modes and effects analysis (FMEA and FMECA)
- RoHS Directive 2011/65/EU-Restriction of the use of certain hazardous substances in electrical and electronic equipment
- REACH Regulation (EC) No 1907/2006-Registration, Evaluation, Authorisation and Restriction of Chemicals
- WEEE Directive 2012/19/EU-Waste electrical and electronic equipment
- UN38.3 (6th Ed.)-Recommendations on the transport of dangerous goods-Li battery test requirements
- FDA 21 CFR §177.1520-Olefin polymers (food-contact PP)
- FDA 21 CFR §177.2600-Rubber articles intended for repeated use (food-contact silicone)
- EU Regulation 10/2011-Plastic materials and articles intended to contact food
- ISO 14040:2006-Environmental management-Life cycle assessment-Principles and framework
- ISO 14044:2006-Environmental management-Life cycle assessment-Requirements and guidelines
- ISO 14001:2015-Environmental management systems-Requirements with guidance for use
- BS EN 12973:2020-Value Management
- BS 8888:2020-Technical product documentation and specification
- ISO 2768-mK-General tolerances-Part 1 & 2: tolerances for linear and angular dimensions
- ISO 11469:2016-Plastics-Generic identification and marking of plastics products
- IEC 62443-Security for industrial automation and control systems (cybersecurity reference)
- FCC Part 15-Radio frequency devices (BLE 5.0 unlicensed intentional radiator)

