Expanded Color Gamut in Printing: Applications, Challenges, and Overcoming Obstacles

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Abstract

Expanded Color Gamut (ECG) in printing is a technique that extends the range of colors beyond the traditional CMYK (Cyan, Magenta, Yellow, Black) process by adding additional inks, such as Orange, Green, and Violet (OGV). This configuration allows for more vibrant, accurate color reproduction, especially for complex images and brand colors. ECG improves the visual appeal and consistency of printed materials across different substrates. However, implementing ECG presents challenges, including the need for specialized color separation tools, increased reproduction costs, and the complexity of color management to maintain accurate results across various media.

Expanded Color Gamut is not a new technology, but it's also a step towards a more sustainable future for the printing industry. By allowing print companies to omit spot color inks, ECG eliminates the need for a large ink inventory of pre-mixed spot colors (ink leftovers) or frequent spot color orders from ink suppliers. Expanded gamut printing is fixed color palette printing, where the standard primary colors can be kept in the printing units, and only the printing plates and the substrate are changed. This leads to less frequent print unit wash-ups and allows even the co-printing of jobs, resulting in less use of resources, e.g., organic solvents, and lower substrate consumption. These savings not only make the operation of a print company more efficient and more sustainable but also reduce its environmental footprint, making ECG a win-win for both business and the planet.

Introduction

Expanded Color Gamut (ECG) printing, also known as fixed color palette printing, is gaining recognition as a strategic response to growing demands for print quality, sustainability, and efficiency. ECG expands the conventional CMYK process by adding Orange, Green, and Violet (OGV) inks, enabling the

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simulation of a wide range of Pantone spot colors without the need for custom formulations.

Since 2019, ECG printing has been the subject of extensive discussion in the printing research community, as shown in TAGA proceedings. At least ten presentations and papers have been published in the TAGA Proceedings over the past five years, covering both flexographic and offset applications (Chiu, 2022; Deshpande, 2023; El Asaleh et al., 2020; Habekost, 2019, 2021; Hoffstadt, 2019; Joshi et al., 2021; Lankinen, 2023; O'Hara et al., 2019). These works collectively confirm the potential of ECG to expand the printable color space, simulate most Pantone colors, and reduce the reliance on spot inks.
A particularly comprehensive contribution comes from Lankinen (2021), who evaluated ECG in wide-web flexographic environments. His doctoral thesis introduced an EGP calculator to estimate cost and sustainability impacts, demonstrating that ECG could improve Overall Equipment Effectiveness (OEE) by up to 85% and reduce CO_2 emissions by as much as 51%. His findings suggest that ECG is technically feasible and economically and ecologically advantageous.

Further expanding on the sustainability perspective, Krystosiak, Habekost, and Malone (2024) analyzed ECG's implementation through industry-based simulations. Their findings showed significant reductions in ink waste, make-ready times, and solvent use. In offset environments, switching from traditional PMS-based workflows to ECG resulted in time savings of up to 54 minutes per job. These improvements translate into measurable gains in operational efficiency and support corporate sustainability objectives.

Together, the TAGA body of literature and recent empirical studies confirm that ECG is transitioning from a niche innovation to a scalable, production-ready solution with both environmental and economic value. However, as several authors have highlighted, further efforts are required in educating brand owners and improving process integration for ECG to become a universal standard.
This research is not just a cursory glance at the state of ECG adoption in the printing industry. It's a comprehensive study that aims to collect quantitative data through a structured survey to assess the implementation level of the Expanded Color Gamut. The primary objective is to gain a deep understanding of the current state of ECG adoption, which will inform a detailed research agenda targeting areas requiring further investigation. This thorough diagnosis will guide the development of strategic recommendations for advancing ECG integration, ensuring that the future of the printing industry is built on a solid foundation of knowledge and understanding.

Methodology

Data collected from the survey will undergo quantitative analysis, primarily through descriptive statistical techniques, to identify patterns and correlations between ECG implementation and key industry variables. The results will offer an evidence-based foundation for evaluating the extent of ECG usage and for proposing targeted future actions to enhance its application in the printing industry. In addition to its primary objective, this research aims to determine what prevents printing companies from adapting Expanded Color Gamut into printing processes. It also explores potential strategies for overcoming these challenges and facilitating wider adoption. The authors will use a survey-based research method to understand why printing companies are reluctant to adopt this technology and the potential obstacles and hurdles. Equally important is understanding how ECG has been successfully implemented in the printing industry and the ratio of companies that have adopted ECG technology compared to those that have not.

This research aimed to explore the current landscape of Expanded Color Gamut (ECG) adoption within the printing industry. Key areas of investigation included the knowledge level regarding ECG among printing companies, the reasons motivating its implementation, and the obstacles hindering broader adoption. Despite many companies recognizing the potential of ECG to enhance color reproduction and operational efficiency, widespread usage remains limited due to challenges such as complex color management, potential investment costs, and a lack of specialized expertise.

The study also sought to identify potential reasons that could drive wider implementation of ECG, such as cost savings, improved sustainability, and strategic alignment with customer demands. Furthermore, the research examined the various phases of ECG implementation across the industry, from pilot projects to full integration, and gathered success stories from companies that have already achieved notable results. These insights form the foundation for developing targeted strategies to accelerate the future adoption of Expanded Color Gamut technologies in printing.

This study employed a structured survey-based research method targeting printing companies worldwide. Key areas of focus included:

- Demographic Information: Company size, annual turnover, position of respondents, and primary/secondary printing technologies used.
- Awareness and Knowledge: Assessment of respondents' familiarity with ECG and sources of their knowledge.
- Challenges and Barriers: Identification of primary challenges in ECG implementation.
- Motivations and Strategic Alignment: Analysis of reasons for considering ECG and its alignment with company goals.

– Future Outlook: Estimation of current and future (2035) usage levels of ECG in packaging printing.

Quantitative data were analyzed primarily through descriptive statistical techniques to identify trends and correlations between ECG implementation and key industry variables.

Results and discussion

The survey collected responses from 42 participants representing a wide range of countries. The highest number of responses came from India (6), followed by the United States (4), and Turkey, Canada, Poland, and the United Kingdom, each with 3 participants. Other countries such as Austria, Greece, Slovenia, Portugal, Singapore, Brazil, the Philippines, Finland, Iceland, Algeria, Egypt, Bulgaria, Argentina, South Africa, Malaysia, Belgium, and Indonesia were also represented. This broad international participation shows that the topic of Expanded Color Gamut (ECG) printing is gaining global attention, with interest coming from both developed and emerging markets. It also highlights that the challenges and opportunities related to ECG are not limited to a specific region but are shared across the global printing community.

The survey results show that companies of all sizes participated. The largest group of respondents (11) came from very large companies with more than 500 employees. Companies with 100–250 employees (9) and small companies with 1–4 employees (8) also had strong representation. Mid-sized companies, with 251–499 and 51–99 employees, each contributed 5 responses, while 4 responses came from companies with 5–10 employees. No responses were recorded from companies with 11–50 employees. This distribution suggests that interest in Expanded Color Gamut (ECG) is present across both large corporations and small businesses, although the biggest players seem slightly more active in exploring or adopting this technology.

When looking at company turnover, the survey showed a wide range of participants. The largest group (10 responses) came from companies with an annual turnover of less than 1 million USD. Another significant group (9 responses) preferred not to disclose their financial data. Companies with turnovers between 10–20 million USD (8 responses), 1–10 million USD (6 responses), and over 50 million USD (6 responses) were also well represented. Only a few companies (3 responses) reported turnover between 20–50 million USD. These results show that interest in Expanded Color Gamut (ECG) exists across both small businesses and larger enterprises, although smaller companies seem slightly more active in this survey.

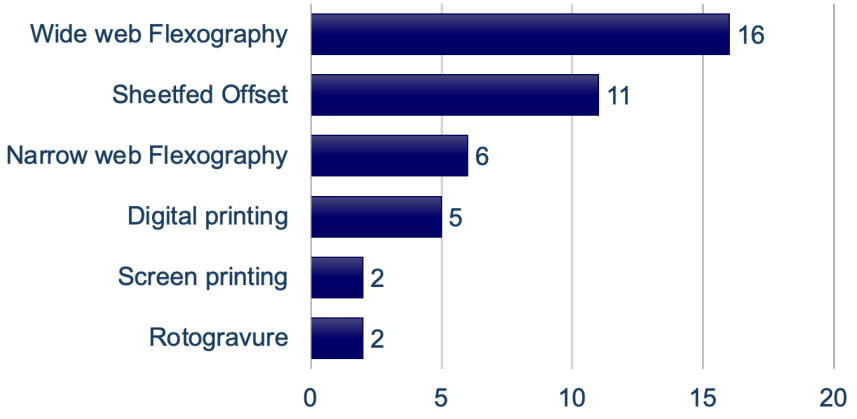

Figure 1. The primary printing technology used

The survey revealed that most companies using Expanded Color Gamut technologies primarily operate in wide web flexography (16 responses) and sheetfed offset printing (11 responses), as seen in Figure 1. Narrow web flexography (6), digital printing (5), screen printing (2), and rotogravure (2) were also represented. In terms of secondary printing technologies, rotogravure and narrow web flexography were the most common (8 responses each), followed by sheetfed offset (7) and digital printing (6). This distribution shows that ECG is being applied across a wide range of printing methods, with flexographic and offset printing leading the adoption both as primary and secondary processes.

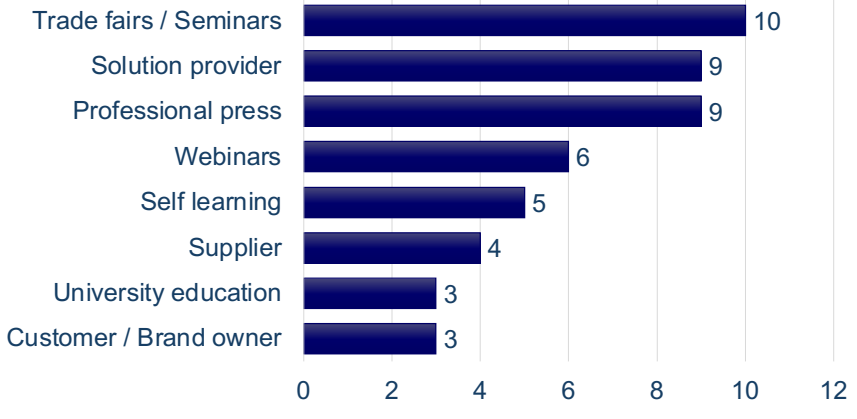

Figure 2. How respondents first learned about ECG

The survey results reveal varying levels of awareness and implementation of Expanded Color Gamut (ECG) printing within the industry. A notable proportion of respondents (20) have successfully implemented ECG and reported positive outcomes. However, others remain at earlier stages: 9 have discussed it without initiating implementation, 8 tried but discontinued it, and a few are either marginally familiar with the concept or entirely unaware. This distribution highlights growing interest and persisting uncertainty around the practical viability of ECG in different production contexts.

When examining how professionals first became acquainted with ECG (Figure 2), the most common sources of information were trade fairs and seminars (10 responses), solution providers (9), and professional press outlets (9). Other learning channels included webinars, self-directed study, and input from suppliers. Interestingly, university education and customer or brand owner influence were among the least cited sources. These findings suggest that industry-led initiatives and commercial platforms currently play a more significant role in spreading awareness of ECG than formal academic training or customer-driven demand.

This part of the survey investigates the primary challenges and barriers encountered during the implementation of Expanded Color Gamut printing based on respondents' knowledge and practical experience (Figure 3). The most frequently cited obstacle was the lack of pressure or demand from customers and brand owners (21 responses), indicating that market-driven motivation is a significant missing factor for ECG adoption. Close behind, technical difficulties in adapting existing workflows and infrastructure were reported by 20 participants, highlighting compatibility and process integration as substantial hurdles.

Figure 3. Challenges and barriers during the implementation of ECG

Other prominent concerns included deficiencies in current printing systems and a lack of internal skills or qualifications (10 responses each), pointing to gaps in equipment readiness and workforce training. Psychological and financial factors

such as fear of new technologies and high investment costs (8 responses each) also emerged as notable deterrents. Interestingly, 7 participants indicated that the benefits of ECG implementation remain unclear, signaling a need for more compelling and transparent value communication. A smaller portion reported facing no major challenges (5 responses), while lack of support from top management was the least cited issue (4 responses), suggesting that internal leadership may not be the primary barrier in most cases.
These insights underscore that the successful deployment of ECG technologies depends not only on technical readiness but also on market dynamics, education, and strategic alignment within organizations.

The next section of the study focused on identifying the key motivations behind the implementation or consideration of Expanded Color Gamut (ECG) technology within companies. Respondents were asked to classify each potential reason as a main reason, an additional reason, not a reason, or not applicable.
The most frequently cited main reasons for adopting ECG were:

- Improving the quality of printed products (18 responses),
- Enhancing production or customer service flexibility (17),
- Reduction of operational costs (15),
- Unlocking new opportunities and business sectors (15),
- Possibility to offer more sustainable products in the market (15).

These results suggest that ECG is primarily seen as a strategic tool for improving product performance, achieving cost-efficiency, and positioning companies for innovation and sustainability. In contrast, motivations such as employment reduction and company promotion were less commonly marked as primary drivers. Notably, employment reduction was explicitly indicated as not a reason by most respondents (30), reflecting the industry's preference to associate ECG implementation with process improvement rather than workforce downsizing.

Respondents' estimates regarding the current and future (2035) implementation levels of Expanded Color Gamut. Currently, the adoption of ECG in packaging printing is perceived to be relatively low. Most respondents estimated that ECG is used in less than 5% of packaging production, with 14 respondents indicating a 2–5% share, and 13 indicating less than 2%. Only a small fraction believe it exceeds 15% of the market (4 responses).
Looking ahead to 2035, the expectations shift significantly. Many respondents (18) anticipate that ECG will be implemented in more than 20% of packaging printing. Additional responses suggest that moderate growth is also expected, with 8 foreseeing a 5–10% share and 5 projecting 10–20%. Only a small number (3 each) predict that adoption will remain below 5%.
These projections reflect strong optimism about the future of ECG technology, with respondents expecting broader acceptance and integration into mainstream packaging workflows over the next decade.

The next part of the research explored how Expanded Color Gamut has been applied across different primary printing technologies and for what specific purposes (Figure 4). Respondents indicated whether they used ECG to substitute spot colors, enhance images, or for both purposes simultaneously.
Wide web flexography emerged as the leading technology associated with ECG usage, particularly for dual purposes – 10 respondents indicated they use ECG for both enhancing images and substituting spot colors. An additional 5 use it only for spot color substitution, and 5 for image enhancement, highlighting flexography as a central platform for ECG implementation.
In sheetfed offset printing, 3 respondents reported using ECG for both functions, and 1 each for spot color substitution and image enhancement. Narrow web flexography followed a similar pattern, with 3 users applying ECG for both purposes and a few using it for just one.

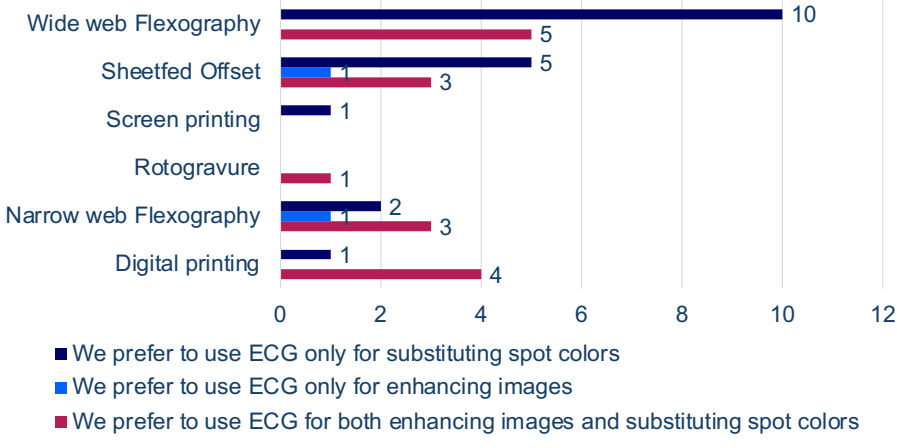

Figure 4. The purpose of the ECG in different printing technologies

Other technologies – screen printing, rotogravure, and digital printing – were mentioned less frequently. Digital printing, interestingly, was selected by 4 respondents exclusively for dual-purpose ECG application, which may indicate growing interest in leveraging ECG within digital workflows.
Overall, the data show that ECG is primarily being adopted in flexographic environments and is most often used to fulfill multiple roles – both enhancing visual output and replacing spot color inks – rather than serving a single isolated function.

The following part of the study examined the level of internal expertise in Expanded Color Gamut (ECG) across three organizational tiers: top and senior management, middle management, and operational employees (Figure 5). Participants were asked to classify the level of ECG knowledge within their companies as lack of awareness, cursory awareness, or practical experience.

Among top and senior management, the most common response was cursory awareness (16), followed by practical experience (11), while 10 respondents noted a lack of awareness. This suggests that although strategic leaders are somewhat familiar with ECG, in many organizations, their understanding remains superficial.

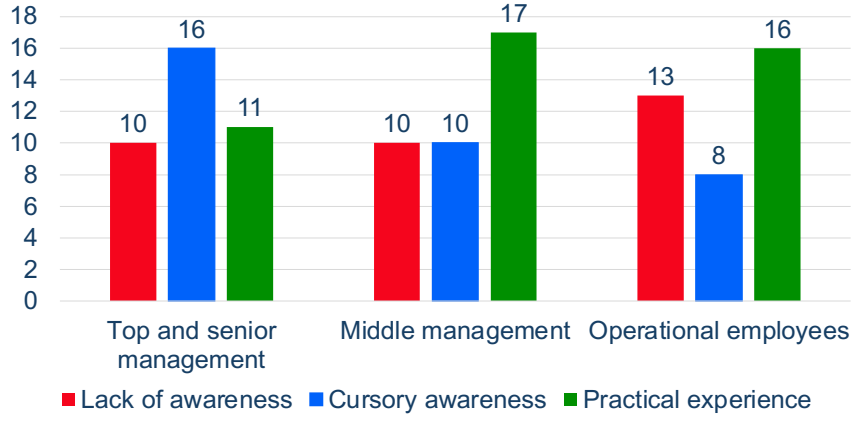

Figure 5. Level of ECG expertise within the company

In middle management, the majority (17) reported practical experience, while 10 respondents each indicated either a lack of awareness or only a basic understanding. This highlights middle management as a key knowledge hub for ECG, likely due to their direct involvement in production planning and process optimization. Operational employees also demonstrated a relatively high level of competence, with 16 indicating practical experience. However, this group showed the highest level of lack of awareness (13), pointing to a knowledge gap at the production floor level that may need to be addressed through targeted training and upskilling.
Overall, the data emphasize the importance of developing ECG expertise across all levels of the organization, especially among those directly responsible for implementation and execution.

The data in Figure 6 illustrate how respondents perceive the alignment of Expanded Color Gamut (ECG) implementation with their company's strategic goals—both now and in the future. At present, most respondents expressed either a neutral stance (16) or agreement (13), suggesting a degree of uncertainty or early-stage adoption where strategic value is not yet fully realized. Only a minority strongly agreed (4), while a small number expressed disagreement (3 in total, including one who strongly disagreed).

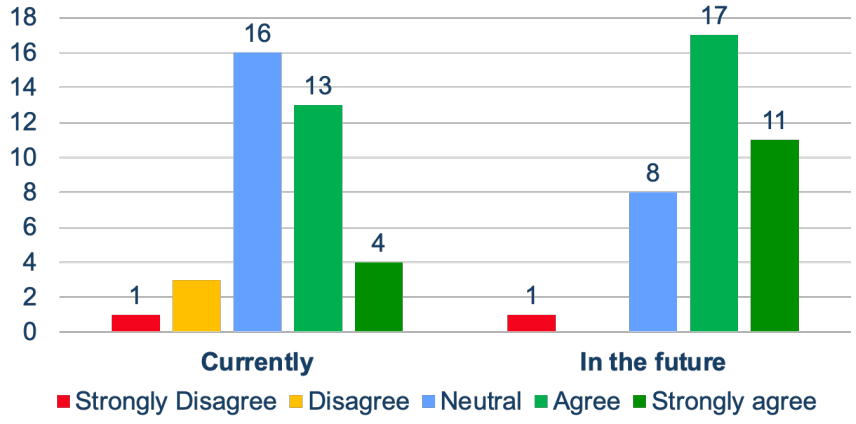

Figure 6. ECG implementation aligning with the company's strategic goals

Looking ahead, expectations shift considerably. A large proportion of respondents anticipate a stronger alignment in the future, with 17 agreeing and 11 strongly agreeing that ECG will support strategic objectives. This forward-looking optimism indicates that companies see ECG not merely as a technological upgrade, but as a tool with growing relevance for competitive advantage, innovation, and long-term planning.
Overall, while current perceptions remain somewhat cautious, the trend points to increasing strategic importance being attributed to ECG within organizational roadmaps.

Talking about the implementation phase and printing technology, this chart (Figure 7) presents the implementation status of Expanded Color Gamut (ECG) concerning different primary printing technologies. It highlights the varying degrees of adoption and engagement across platforms such as flexography, offset, screen, gravure, and digital printing.
Wide web flexography stands out as the most advanced in ECG adoption, with 11 respondents reporting full and successful implementation. A few also attempted implementations but discontinued them (4), indicating both high interest and some operational challenges. Narrow web flexography and digital printing show more varied responses: each has 4 or more mentions across several implementation stages, including successful use, partial engagement, or exploratory discussions.
In contrast, sheetfed offset printing shows limited full implementation (only 1 respondent), and more commonly appears at the discussion (3) or early awareness (5) stage. Screen printing and rotogravure each have very limited representation, with no clear signs of broad ECG adoption. Notably, rotogravure showed at least one successful implementation, while most mentions of screen printing indicated only basic awareness.

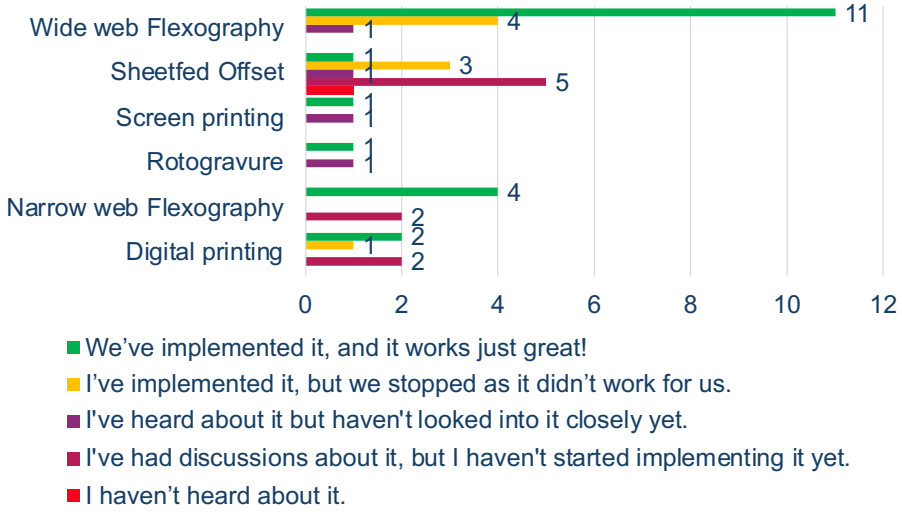

Figure 7. Implementation phase vs printing technology

These findings suggest that ECG implementation is most mature in flexographic environments, particularly in wide web applications, while other technologies remain in preliminary or trial stages. This points to technology-specific barriers or readiness differences that may shape future ECG adoption trends.

Conclusions

The results of the survey showed that Expanded Color Gamut (ECG) technology is recognized and implemented across a wide spectrum of printing companies worldwide, ranging from small businesses to large enterprises. Many respondents, particularly at the senior management level, demonstrated a practical understanding of ECG, although notable knowledge gaps persist at the operational level, pointing to the need for further training and education within production teams.

Companies that have already adopted ECG report clear benefits, including improved color reproduction, enhanced consistency, reduced ink inventory, and greater production efficiency, especially in flexographic workflows. These success stories reinforce ECG's potential as a mature, value-adding technology rather than a niche innovation. However, broader adoption is still hindered by several key barriers: technical challenges related to color management and workflow integration, high initial investment costs, and a general lack of awareness or demand among brand owners.

Despite these obstacles, the outlook for ECG is overwhelmingly positive. Many respondents anticipate that by 2035, the share of packaging printing using ECG (particularly CMYKOGV) will grow significantly, with most estimates ranging

from 10% to over 20%. This projected growth reflects increasing industry awareness and a shift toward more efficient, sustainable, and high-quality printing practices.
To fully realize ECG's potential, the industry must address current limitations by investing in internal expertise, strengthening collaboration with brand owners, and promoting the proven advantages of ECG through evidence-based communication. As technologies advance and educational efforts expand, ECG is expected to become a core component of standardized workflows in the global printing industry.

Future Directions

The insights gathered from this study indicate that the future of Expanded Color Gamut (ECG) printing is promising, particularly within the packaging sector. Respondents expect ECG adoption to increase significantly by 2035, with many anticipating it will be used in over 20% of packaging applications. This projection is reinforced by the growing interest in ECGs' ability to improve image quality, support sustainability goals, and enhance operational flexibility. Moving forward, key areas for development include the advancement of ECG-compatible workflows, improved screening and separation technologies, and continued expansion of ECG education across all organizational levels. Strengthening collaboration between technology providers, printers, and brand owners will be critical to overcoming adoption barriers and accelerating mainstream implementation.

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