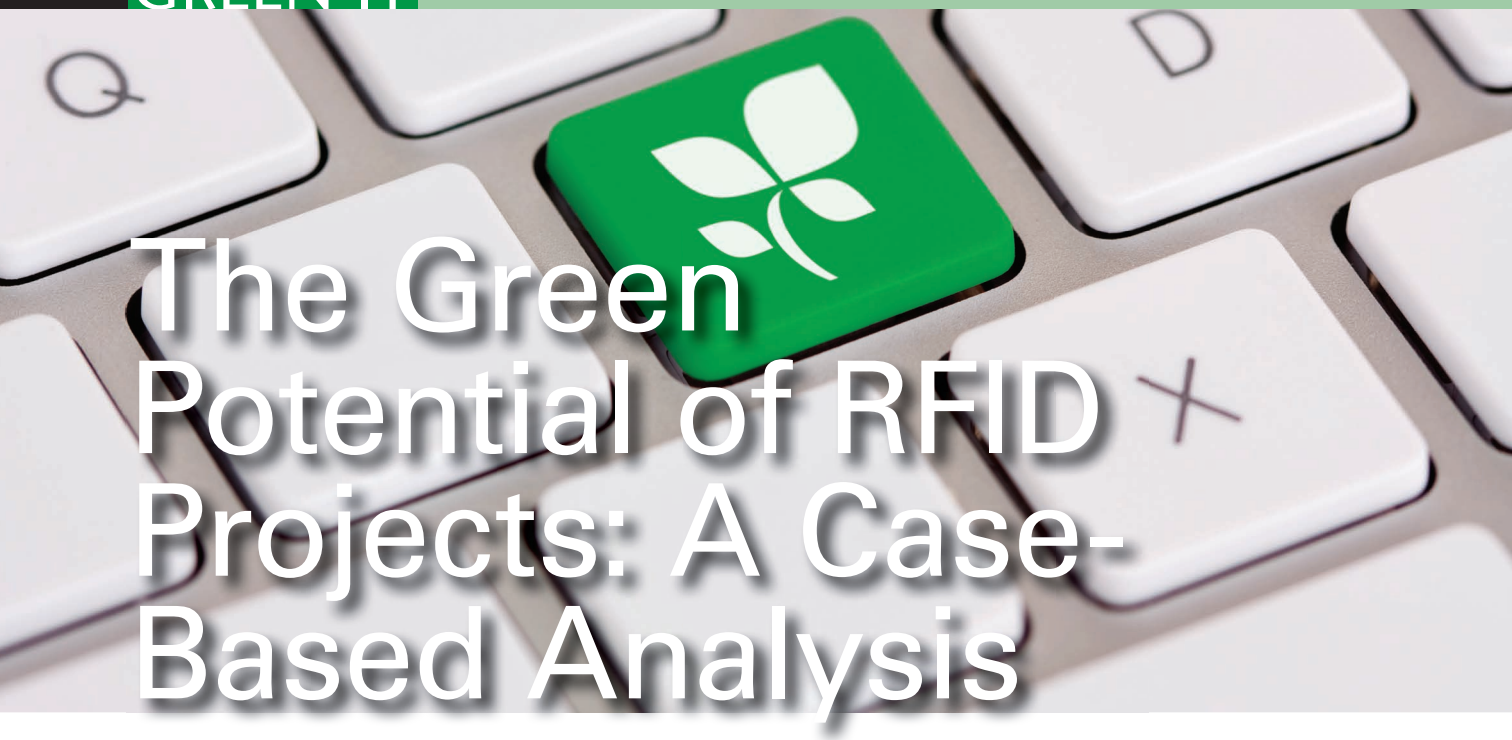

The Green Potential of RFID Projects: A Case-Based Analysis

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Findings from 13 case studies on RFID's use in green projects reveal its potential not only to enhance environmental sustainability but also to reduce costs and generate revenue by creating new commercial opportunities.

RFID has been a popular technology in the areas of supply-chain management, asset tracking, and manufacturing. In general, research related to RFID's potential contributions fall under technological, applications-related, or policy and security issues.[1] However, there's little discussion in the extant literature on the environmentally responsible management of RFID.

Traditionally, information and communications technologies (ICT) have been viewed as having a negative impact on the environment,[2] and RFID, as part of ICT, has earned a similar reputation.[3] RFID is also one of the main technologies of pervasive computing, which consumes enough energy to negatively impact the environment.[4] Furthermore, some experience has suggested that we need to take precautionary measures to prevent the likely negative results from the final disposal of RFID labels.[5] Currently, RFID tags are neither biodegradable nor recyclable.[3]

Nonetheless, RFID could indeed be a part of green IT, not only by adding economic value to organizations but also by improving environmentally responsible practices related to IT—for example, by accurately tracking a perishable item and preventing its spoilage, RFID can save energy in operations ranging from growing and harvesting to packaging and refrigeration.

To explore RFID's potential in green IT, we reviewed 13 case studies, evaluating RFID's contribution to green objectives.

Studying Green RFID Projects

Sustainability has become a developmental priority and political agenda throughout the world. Figure 1 illustrates the growth of green technologies and RFID markets in the past 15 years.[6–8]

To fully appreciate RFID's potential to become a prominent green IT, we embarked on a study of 13 RFID case studies to evaluate the progress of RFID in attaining green objectives. We selected published case studies in which RFID was used

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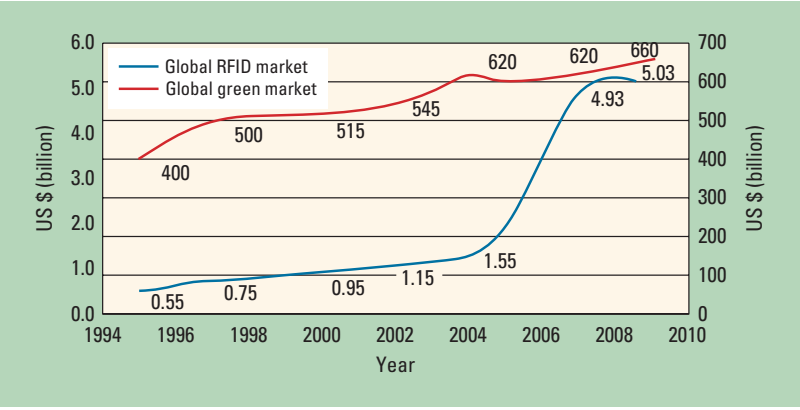

Figure 1. Growth in global RFID and green markets. In 2009, the RFID market grew to US$5.03 billion,[6,7] while the green market grew to $660 billion.[8]

with a strong green objective. Our exploration of the case studies revealed that RFID can indeed be a part of green IT, not only by adding economic value to organizations but also by improving environmentally responsible practices related to IT. In the process, we also studied how green RFID projects are executed and what challenges these projects encountered in their implementation.

Selecting the Case Studies

To avoid underestimating RFID's potential in and contribution to environmental sustainability, we chose case studies that spanned common green applications such as energy efficiency, waste reduction, and recycling.[9] We included green IT cases with full or partial RFID components. Although we didn't specify a time frame in our search for case studies, the returned results were all fairly recent, indicating that green IT is an emerging topic and RFID's use in green IT has only recently become popular.

Another characteristic of the case studies we used is that they're all from the US or Europe. In Europe, there's a high level of cross-national cooperation regarding environmental concerns. The specific applications of RFID technology in the case studies differed depending on the project's nature, but they all predominantly focused on using RFID for recycling and energy efficiency, with some projects dedicated to asset tracking.

The case studies we reviewed report results from a range of commercial enterprises:

- Walmart—uses RFID technology throughout its supply chain, reducing CO_2 emissions.[10]
- Recycle Bank—employs an RFID system in trash bins to allow municipalities to measure the amount of recycling done by a household and give them rewards in return.[11]
- Rewards for Recycling—employs RFID-enabled recycling to give incentives to households for recycling.[12]
- Multi Life Cycle Center—sorts, tracks, and assesses the value of discarded electrical and electronic equipment for reuse or recycling.[13]
- Concept2Solution—uses RFID-equipped recycle bins to remind households to actively participate in recycling programs.[14]
- Promise—uses an RFID-based decision support system to track the process of recycling the plastics used in automobiles.[15]
- Indisputable Key—tracks wood circulating in the supply chain using RFID-tagged logs.[16]
- Smart Vareflyt—uses RFID to optimize the flow of perishable goods along the supply chain.[17]
- Strawberry—prevents the spoilage of strawberries being transported in Switzerland using RFID tags with a temperature sensor.[18]
- The City of London School for Girls—uses RFID to better control room temperatures.[19]
- Nestlé Italy—uses temperature control to reduce spoilage, improve quality, and lower energy-related costs.[20]
- TruckTag—uses RFID to enable faster and automated driver security inspection, reduced congestion, and improved air quality.[21]
- DHL Smart Truck—uses RFID to increase the efficiency of pickups and deliveries.[22]

The Framework

To assess RFID as a green IT, we adopted a closed-loop framework that captures the full cycle of any project by decomposing it into four states: motivation, execution, challenges, and impacts (MECI).[23] Table 1 explains the components of this framework and its relationship with the assessment of green RFID projects.

Analyzing Green RFID Projects

Here we discuss our assessment of the green RFID projects using the MECI framework.

Table 1. Components of the MECI framework in the context of green RFID projects.

Category	Definition	Subcategories
Motivation	Reasons that drive the adoption of green RFID projects	• Financial: revenue generation and cost savings • Operational: efficiency improvement and quality control • Strategic: compliance with regulation and preservation of environment health
Execution	Strategy and processes that get executed during the project	• Unit level: execution level at which the project is positioned • Project progress: extent of completion of the project • Partnerships: degree to which the project involves multiple parties
Challenges	Difficulties faced during project implementation	• Technological: technological hurdles that hampered the operations or continued to affect the organization • Informational: informational obstacles that affected the performance of the system
Impacts	Anticipated and unexpected consequences from the project implementation	• Environmental sustainability: improved environmental practices brought by the project • Business value: costs saved and revenues generated due to the project • Social responsibility: welfare created by the project for local and global communities

Our goal in doing this analysis is to develop a deeper understanding of the RFID projects with green objectives.

Motivation

The motivation behind an organization's strategic decision can be explicitly stated or implied. The motivations for the 13 case studies fall under three categories.

Financial. Financial motivation commonly drives organizations to engage in green RFID projects. Both cost savings and revenue generation motivated the case study RFID projects. For example, Promise is an RFID-based decision support system that tracked the entire process of recycling plastics used in automobiles and reduced operational costs.[15]

On the revenue-generation front, an RFID tag equipped with a temperature sensor has prevented the spoilage of strawberries being transported in Switzerland, resulting in an 8 percent increase in profit.[18]

Operational. In terms of operational objectives, the need for new functionalities and efficiency improvement has driven the development of green RFID. This has prompted some to refer to these activities as "IT for green," rather than green IT. Naturally, as RFID systems reduce waste and energy consumption while improving quality, people start to realize the joint opportunity for improvement in operational efficiency and environmental sustainability. Efforts to make the globe greener don't necessarily stand in the way of economic prosperity.

Strategic. Strategic concerns that include goals related to environmental sustainability have also motivated organizations. Some organizations have taken a passive position to fulfill promised social responsibilities or to comply with newly enacted regulations, whereas others have actively promoted the concept of improving environmental health. Concept2Solution has equipped recycling bins with RFID tags that can identify neighborhoods and households that don't actively participate in recycling programs.[14]

With rising public concern and regulatory pressure, companies can benefit from a proactive approach. Organizations that proactively adopt green IT are more likely to adapt to further changes in environmental regulations. Furthermore, such organizations are more likely to capitalize on the experience of exploring green IT and to become more at ease with building a socially responsible brand image.

Execution

The factors that affect the project execution include the unit level at which RFID is implemented, the project's progress toward completion, and any partnerships involved in the project's organization.

Unit Level. The unit level at which RFID is adopted affects the degree of accuracy, level of efficiency improvement, and cost.

For example, Recycle Bank executes its RFID system at the object level—in trash bins.[11] The lower the unit level, the higher the accuracy and cost. The Indisputable Key project attaches RFID tags to each and every log to accurately track the

wood being circulated in the supply chain, despite the high costs.[16] However, the unit level can't go too low; it's bounded by technological feasibility and budgetary constraints.

Project Progress. The progress that RFID projects have made is an indication of their overall technological maturity and organizational mastery.

Big corporations seem to have made more progress in green RFID projects, given their stronger financial capabilities, their operational advantages, and pressure from the public. This is evidenced by Walmart's embrace of RFID technology and its mandate on all its suppliers to comply with the RFID standard.[10] Walmart's green RFID projects have moved from the pilot to implementation phase. On the other hand, DHL's Smart Truck Initiative is still in the pilot stage because critical technological functionalities have yet to be realized.[22] Inaccuracy in RFID read rates remains an unresolved issue.

Some small companies have advanced farther than the pilot stage in recycling-related activities because the technological hurdles are lower and the operational demand is moderate. Reward for Recycling, an RFID-enabled recycling business, is seeking expansion, indicating that its model has worked locally and has the potential to succeed on a larger scale.[12] Another pilot project, the Multi Life Cycle Center, has used RFID for sorting, tracking, and value assessment of discarded electrical and electronic equipment for reuse, remanufacturing, or recycling.[13]

Partnerships. The number and kind of a project's partnerships indicate the resources it requires for completion as well as its scope. Most of the case studies in this article refer to green RFID projects involving not only private companies but also public organizations.

Consider Indisputable Key. It's a widely coordinated project involving forestry companies, government bodies, and academic institutions, reflecting the difficulties in addressing environmental problems that require resources and cooperation from multiple parties. It also reflects the fact that the scope of the environmental problem has crossed over traditional organizational boundaries. In spite of coordination and communication costs, the resources acquired through partnerships can tackle large environmental problems that single organizations can't solve.

Challenges

RFID projects with green objectives inevitably face challenges, including technological issues, informational problems, and organizational difficulties.

Technological. Technological problems are the most visible and require immediate attention. Six of the projects we studied are still in the pilot stage, tackling technological issues such as reliability, accuracy, and metal interference.

In the case of DHL, the tags can't achieve 100 percent read rate accuracy when the duration of the reader-tag interaction is too short,[22] yet it's impractical to completely prevent short reader-tag interaction. Concept2Solution's key challenge has been ensuring that the workers don't forget the step that activates the RFID system.[14]

Informational. Informational problems become apparent when RFID systems don't act alone but integrate with other electronic systems.

For example, Smart Vareflyt's RFID system worked properly in isolation but not when integrated with existing data systems.[17] Informational problems occurred when actual and registered data differed, data wasn't updated, or data corrections required additional resources. Similarly, Nestlé Italy's system accuracy rate is, on average, only 80 to 90 percent because system performance relies not only on the functionality of the RFID components but also on the connection between the RFID system and the rest of the enterprise system.[20]

Additionally, one of the most intractable challenges hampering RFID's development is privacy and security concerns. As companies and public organizations continue to seek partnerships, resource sharing poses challenges that require addressing high-level organizational issues. In the case of Smart Vareflyt, the toughest challenges weren't just the data integration issues at the informational level but also the fair sharing of information and resources and enforcement of competition law at the organizational level.[17]

Impacts

The objectives of the green RFID projects must be reasonably attainable so that people are properly motivated and willing to commit resources and time. Green RFID projects might not improve environmental health as fast as the globe needs, but the subtle shift in how a business operates can gradually accumulate to produce a much larger benefit over time.

Green RFID projects have impact in three dimensions: environmental sustainability, business value, and social responsibility.

Environmental Sustainability. Most of the case studies achieved environmental sustainability, albeit in varying degrees. The case of Walmart showed that the larger the scale, the bigger the impact. Walmart's pilot RFID implementation to replace its bar code system reduced its CO_2 emissions by 3.2 percent because its distribution trucks made fewer trips owing to better product visibility and tractability and improved inventory management.[10]

The TruckTag project was another interesting application targeted at environmental sustainability. The RFID-based tags enabled faster, automated driver security inspections, reduced traffic congestion, and improved air quality by reducing the idling time of the trucks' engines.[21]

Business Value. Most companies hope to reduce costs when implementing green RFID projects.

The City of London School for Girls reduced installation cost of an under-the-floor RFID-enabled wireless temperature sensor network by 80 percent compared to that of a wired network, and gained better control over the temperature of each room using RFID.[19] Nestlé has similarly used RFID for temperature control to reduce spoilage, improve quality, and save 10 percent in energy-related costs. Furthermore, although the direct cost savings is impressive, the indirect cost savings (such as insurance savings as a result of reduced spoilage and improved quality) is also noteworthy.

Some organizations adopt RFID in the hope of generating more revenue. By proposing a new business model, Recycle Bank and Reward for Recycling offered coupons to residents who recycle, which prompted more families to recycle. It has also allowed Recycle Bank to increase its revenue through collection of more recyclable products. Using RFID, Recycle Bank has saved the equivalent of more than 318,000 trees and 21 million gallons of oil.[11]

Social Responsibility. The impact of green RFID projects isn't limited to environmental health and business value. The perceived environmental investment by companies adds value to the relationship between customers and the companies—because customers think better of companies who they perceive as investing in the environment. Nestlé Italy capitalized on an ice-cream management system enabled by RFID to effectively do green advertising, thereby adding value to their brand image.

Pressured by public demand, big corporations have an urgent need to fulfill their social responsibilities. To keep up with a promise to cut carbon emission, DHL's Smart Truck project has reduced fuel consumption and CO_2 emissions by automating package scans to speed package handling by drivers and cut truck engines' idling time during delivery.

With more socially conscious enterprises, the positive impacts can extend into the communities in which they're located. Residents and local economies have already redeemed over US$1 million by using their Recycle Bank points.

Lessons Learned

Table 2 summarizes our assessment using the MECI framework. The case studies show RFID's potential to become a positive force in efforts to counter climate change, improve energy efficiency, control waste, and address other environmental challenges. It's reasonable to assume that organizations in the selected case studies are more pioneering in terms of green RFID technology than the rest that remain silent about how they use RFID.

Given the current stage of RFID development in green-related implementations, the decision to initiate these projects was motivated by a mixture for self-interest and pressure to improve the health of the environment. The motivation for 10 case studies revolved around preserving the environment. In terms of execution, we found that all of the firms described in the case studies entered into partnerships to accomplish the projects. Companies with limited resources teamed up with other interested organizations to share profits and risks. Even large corporations found

Table 2. Analyzing the motivation, execution, challenges, and impacts of green RFID projects.

			Walmart	Recycle Bank	Reward For Recycling	Multi Life Cycle Center	Concept2Solution	Promise	Indisputable Key	Smart Vareflyt	Strawberry	The City of London School for Girls	Nestlé Italy	TruckTag	DHL Smart Truck
Motivation	Financial	Revenue generating		✓	✓										
		Cost saving	✓			✓		✓	✓	✓	✓	✓	✓		
	Operational	Additional functionalities	✓	✓			✓	✓	✓	✓	✓		✓		
		Improve quality and efficiency	✓	✓						✓	✓		✓	✓	✓
	Strategic	Comply with regulations						✓						✓	✓
		Preserve environmental health	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		
Execution	Unit level	Low (specific object)	✓	✓	✓				✓						
		High (operational unit)	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓
	Progress	Pilot				✓	✓		✓		✓		✓		✓
		Implementing	✓	✓	✓			✓		✓		✓		✓	
	Partnership	Public						✓			✓				
		Private		✓	✓		✓					✓	✓	✓	
		Mixed	✓			✓			✓	✓					✓
Challenges	Technological	Accuracy					✓			✓			✓		✓
		Reliability			✓		✓								
	Informational	Data validity								✓					
		Data integration								✓		✓			
		Data security and privacy								✓		✓			
Impacts	Environmental sustainability		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	
	Business value			✓	✓	✓	✓		✓		✓	✓			
	Social responsibility			✓									✓		✓

that new challenges are better tackled with more resources from others.

Also, for 10 firms, the execution occurred at the higher operational unit level rather than a lower object level. This is likely because of the high costs involved in implementing these projects at lower levels. Table 2 gives the impression that the projects didn't encounter too many challenges, but many of the projects were still in an early stage of completion. In some cases, the organizations involved might have chosen not to identify the challenges in published case studies. Finally, the studies' impact on environmental sustainability was quite strong, with 10 case studies supporting that area.

Our analysis of the case studies shows that the challenge for RFID to be green IT is to avoid sacrificing profits for environmental health or vice versa. The dilemma of trying to simultaneously grow the economy, environment, and society is by no means solvable without new technologies that make sustainable green practices possible. Whether RFID is green is less important than how RFID can be made greener. As more companies publish case studies on the green use of RFID, future research can focus on synthesizing and learning innovative ideas from them.

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