Cash:

A ROADMAP TO SUSTAINABILITY

Reconnaissance

CONTENTS


Coins and minting


Substrates: paper


Substrates: polymer


Substrates:
BoE on polymer


Banknote printing


Print: process, foils, ink

Destruction (end of life)


Cash management
operations


Cash centre operations


The environmental focus


The future cash cycle

DEFINITIONS

RECIPE IMPACT ASSESSMENT METHOD

The Dutch National Bank (DNB) study referred to in this report uses the impact assessment method **ReCiPe 2008 (H)**. This takes three endpoint indicators into account (human health, ecosystem quality and resources). The methodology allows the conversion of the three endpoint indicators by weighting into a single environmental indicator, the so called **Eco-indicator 99**. The value of the Eco-indicator 99 is expressed in points **(Pt)**. Using this indicator allowed the DNB to compare the environmental impact between cash and debit cards, products that are substitutes.

GLOBAL WARMING POTENTIAL (GWP)

GWP is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO2). GWP is 1 for CO2. For other gases it depends on the gas and the time frame.

GREEN HOUSE GASES/CO2E

The seven '**Green House Gases (GHG)**' are normally defined and measured in accordance with the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). Their footprint is measured in the number of CO2 equivalents (**CO2e**). Standard ratios are used to convert the various gases into equivalent amounts of CO2, based on their global warming potential (GWP).

LIFE CYCLE ASSESSMENT (LCA)

Life cycle assessment or **LCA** (also known as life cycle analysis) is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service. For instance, in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave).

LIGHT EMITTING DIODE (LED)

LED is a semiconductor light source that emits light when current flows through it. LED lighting products produce light up to 90% more efficiently than incandescent light bulbs.

ISO14001

ISO 14000 is a family of standards related to environmental management that exists to help organisations minimise how their operations negatively affect the environment; comply with applicable laws, regulations, and other environmentally oriented requirements; and continually improve the above.

1.0 FOREWORD

The idea for 'Cash: A Roadmap to Sustainability' came from the 2021 UN Climate Change Conference (COP 26), but the inspirational energy within it comes from the thousands of individuals and numerous organisations working to be 'good citizens' in the cash 'industry'.

Cash is, perhaps, the world's most used global product. Despite digitalisation, cash is, and will remain, a key component of the payments eco-system, itself a driver of economic activity as well as social inclusion. But in addition to being a key and universal tool for payments, cash needs – along with all other components of modern life – to be sustainable as well.

We spoke to over 30 businesses, central banks, mints and state printing works around the world in preparation of this paper and drew from 106 case studies from 24 organisations. The case studies detail the steps they have already taken to reduce the environmental impact of their part of the cycle – no green washing here.

The examples given range from the simple (changing to LED lighting) to the more complex (changing from single use plastic seals to cloth bags) to those based on major investment decisions (putting in solar power or investing in different equipment).

Some changes were entirely within the control of the organisation while others required co-operation with others. Some involved changes to materials, needing extensive trials. Others required process changes and others still for staff to work differently. Some were corporate decisions, others were implementing staff suggestions. Across the cash cycle, there are examples of what can be done for every size of organisation, with small and large budgets, quick and long term, whichever country you are in.

This paper tells the story of an industry not driven by legislation or customer tender requirements, but an industry doing the right thing for the right reasons. It is a story of what is possible and offers hope for the future.

We would like to thank all the organisations who helped in this report, as well as all the contributors and, in particular, our sponsors – listed below. Without their support, it would not have been possible.

John Winchcombe, Editor

OUR SPONSORS

CCL Secure

DeLaRue

Giesecke+Devrient

KOENIG & BAUER

KOMORI

LOOMIS

LUMINESCENCE
Sun Chemical Security

PORTALS

VAULTEX

2.0 EXECUTIVE SUMMARY

This report records the work of an industry to be a 'good citizen'. The industry is the 'cash industry', which includes private and public organisations involved with the production of banknotes and coins, their distribution, circulation use and end of life.

Sustainability is more than just the environment. It also encompasses resilience, equality, economic and financial stability, social inclusion and empowerment, all of which are bolstered by cash as a private and universal means of payment available to all, irrespective of social and economic status, connectivity, possession of bank accounts or access to alternative means of payment.

However, the purpose of this report is to focus on the environment and the impact of cash in terms of carbon, resources used and pollution.

WHY WAS THIS PAPER WRITTEN?

Irrespective of the move towards digital payments around the world, cash is a key pillar of the payments eco-system – virtually every person on the planet uses cash and the majority of the world's population depend on it. Despite what you read, this will, and many argue should, continue for some time still. In that context, this paper is an important record of progress made in making cash more environmentally sustainable.

24 organisations have contributed 106 case studies on changes they have made to reduce their environmental impact and the results achieved to date. The case studies are by no means exhaustive; instead, they are a representative selection of a myriad of initiatives by organisations throughout the cash cycle, all working towards the same objectives.

As such, they enable this report to share best practice with the global cash industry of what is possible, and to demonstrate to readers that the industry is listening, acting and making a real difference.

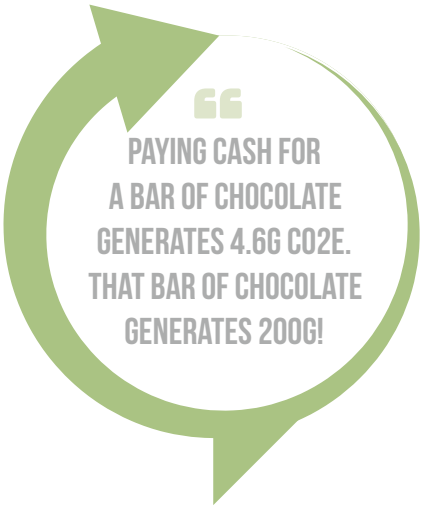
HOW DOES CASH COMPARE WITH ALTERNATIVE PAYMENT OPTIONS?

The most comprehensive research about the environmental impact of payments remains a paper published by the Dutch National Bank in 2018 (see page 6). It showed that each cash transaction created 4.6g of CO2e[1]. When we consider that a 40g bar of milk chocolate generates 200g CO2e[2], or a transaction based on distributed ledger technology such as bitcoin uses about 279g CO2e on average[3], perhaps the figure for cash is not such a big number.

Since the Dutch paper was published, the number of Dutch ATMs has fallen by 56%[4] and the number of cash transactions by 74%. Such big changes will have reduced cash's carbon footprint significantly.

On the other hand, while the carbon footprint of digital payments is hard to quantify[5], it does require substantial hardware, software and considerable energy consumption for payment data processing, data management and communications whether at the point of sale, on the internet or paying using mobiles. As the number of digital transactions rises, particularly those made using mobile devices and wallets, at the absolute rather than the per transaction level the digital impact must be increasing very significantly.

Cash is physical and therefore visible. Digital payments are not as digital as they claim: cards – often plastic – need to be produced, as do point-of-sale (POS) terminals. They also generate a paper trail as payment receipts are printed. Either way, there is no such thing as a free lunch regarding payments.



1 The Bank of England figure was 4.71g CO2e
2 The Sustainability Footprint Of Chocolate – Better Meets Reality/Dark Chocolate Bar Carbon Footprint | 0.95kg CO2e (co2everything.com)
3 Bitcoin Energy Consumption Index – Digiconomist
4 Facts and figures on the Dutch payment system in 2020 | Dutch Payments Association (betaalvereniging.nl)
5 The Öko-Institut's Jens Gröger estimated that internet search queries emit about 1.45g of CO2

WHAT HAS THE CASH INDUSTRY ACHIEVED?

Every contributor to this report, however they interact with the life of cash, has demonstrated an awareness of the need to act responsibly, a willingness to change and hard evidence of the improvement they have achieved.

The companies are doing much more than just adhering to ISO 140001 and 50001 and sourcing green energy, important though these are. They are taking action, devoting time and resources and investing to do better. Many projects have been initiated from the bottom up within the organisations.

The table below shows the spread of projects in different areas across the cash cycle.

Category	Energy	Carbon	Water	Recycling, reduce,reuse	Chemicals	Site	Fossil fuel	Other	Total	%
Coins	3		2	3		2	1		11	10
Paper	3	3	4	3				1	14	13
Polymer	1	2		2				1	6	6
Materials	9		1	2	2	1			15	14
Print	11		2	4		2			19	18
Cash Management	1			19		1			21	20
Sorting	2	1		3			7		13	12
End of life	2		2	2		1			7	7
Total	32	6	11	38	2	7	8	2	106	
%	30	6	10	36	2	7	8	2		

For example:

- Seven organisations invested in solar, hydro, wind or tidal power.
- 10 organisations are sourcing 100% renewable energy.
- 23 UK organisations are actively working together as part of a charter to achieve net zero emissions and reducing plastics.
- Producers have signed up to an industry sustainability charter.
- Polymer end of life recycling offered to customers as a service.
- Cash-in-transit companies invested in telematics and routing optimisation to reduce fossil fuel usage, and are trialling or deploying electric or hybrid vehicles.

WHERE NEXT FOR CASH AND PAYMENTS?

To avoid green washing, this report focuses on progress made and delivered rather than future promises. It focuses on the here and now, with examples backed up by data of what is already being achieved. But it also sets a course for the future for an industry that is ambitious to address its environmental challenges. There is no shortage of plans and future actions. This paper includes actions relating specifically to the future of cash.

People should use cash with confidence, knowing that it is being created and managed responsibly and carefully so that its environmental footprint is minimised whilst its social benefits are maintained.

The cash industry has worked hard to ensure cash is a product for today and is committed to keeping it fit for use for years to come.

3.0 ENVIRONMENTAL IMPACT OF THE CASH CYCLE

Very few independent studies have compared the environmental impact of different payment methods or attempted to quantify the end-to-end impact throughout the cash cycle. The one that comes closest is the DNB report of 2018 (see below), which is referenced heavily in this report since, although it refers to the Dutch cash cycle only (and is not therefore a blueprint for or necessarily typical of other countries), it is the only report that covers the impact of both cash in its entirety and card payments.

Cash cycles around the world are complex, serving virtually every person on the planet. Their environmental impact depends on a wide variety of factors, including but not limited to the efficiency of the denominational structure, the durability of the cash used, the issuers' clean note and recirculation policies, how modern the infrastructure is and how well it is maintained, whether cash logistics are optimised, the geographic circumstances, the extent to which cash is used versus other payments, and also the extent to which renewable energy sources are used. We attempt here to summarise the most relevant information related to the cash cycle.

Two points are worth emphasising when considering the environmental impact of coins, banknotes and the cash cycles that they operate in.

1. The environmental impact of payments is generally small compared to all other goods, services and other sources of emissions.
2. The physical nature of cash has a different environmental impact than other payment types, which will help provide contingency and resilience for the overall payments landscape.

KEY PAPERS

- In October 2018 the Dutch National Bank (DNB) published its Working Paper 610, 'Life Cycle Assessment of Cash Payments'[1]. Its analysis used the ReCiPe endpoint (H) impact method to understand the euro coins and banknotes used in the Netherlands. The study put their impact into the context of the whole Dutch economy and compared this impact with debit cards.
- The Bank of England published its 'Carbon Footprint Assessment: Paper vs. Polymer £5 & £10 Bank Notes' in July 2017[2]. The study was carried out using PAS 2050:2011 (BSI, 2011) and the Carbon Trust confirmed the work done. The Reserve Bank of Australia and the Bank of Canada have also published similar studies and equivalent methodology is being employed by suppliers in the cash industry.
- The UK's Institute and Faculty of Actuaries objectively assessed and balanced the economic and environmental arguments around a cashless society. Its interim paper 'A Cashless Society: Benefits, Risks and Issues', documented a log of 20 risks and issues[3].It followed with an addendum focusing specifically on the environmental perspectives of a cashless society[4].
- Lotfi Belkhir and Ahmed Elmeligi published an article on the energy used in the information and communications industry whilst looking at trends out to 2040 (see Journal of Cleaner Production 177 (2018) 448 463)[5]. Data relating to digital payments is not readily available, so this article contains useful data and raises relevant points of concern.

In addition, over 20 organisations, including central banks, have provided information about their environmental work. The author of this report has only used information about what has been done and what has been achieved to avoid 'green washing'.

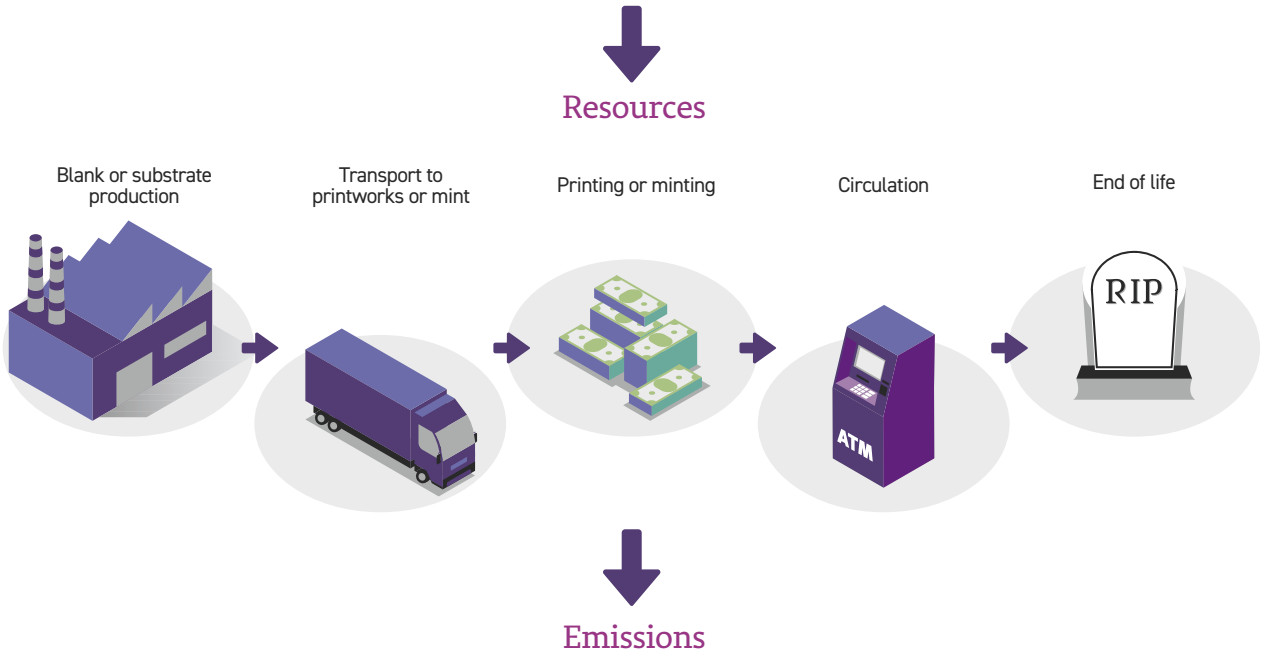
1 Life cycle assessment of cash payments (dnb.nl)
2 Carbon Footprint Asssessment (bankofengland.co.uk)
3 A Cashless Society – Benefits, Risks and Issues (Interim Paper) – disclaimer.pdf (actuaries.org.uk)
4 Issue 21 – Environmental Sustainability of a Cashless Society (actuaries.org.uk)
5 Assessing ICT global emissions footprint: Trends to 2040 & recommendations - ScienceDirect

WHAT IS THE CASH CYCLE?

The cash cycle describes the life of cash from the input of raw materials through to the production of banknotes and coins and then their circulation ending with their return for destruction.

Simplistically the life of cash can be split into production and operational stages. The operational phase has the largest impact on climate change (88% according to the DNB study), with transport and ATM electricity as the main contributors.

The cash industry continues to take steps to minimise the impact of all stages[6].

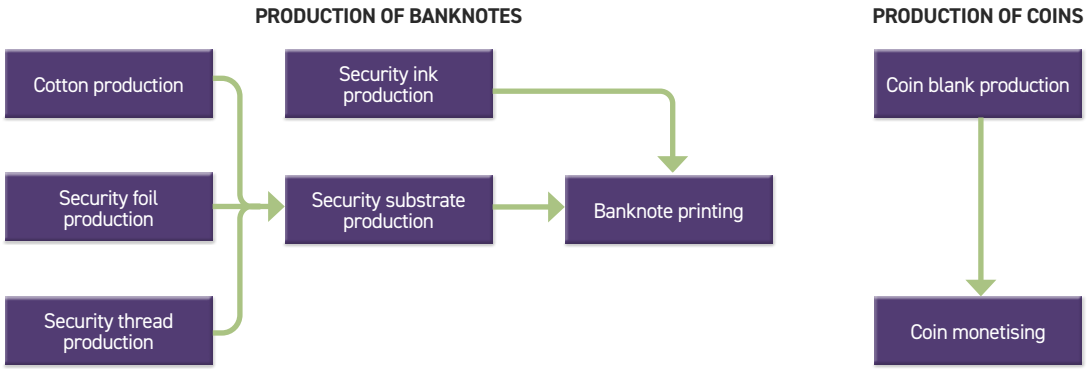


Production Related Activity

Production differs for banknotes and coins.

Banknotes are technically sophisticated and highly secure items that must interact with multiple machines and users throughout the cash cycle. Their production involves the manufacture of the individual substrates and multiple security features, which are ultimately combined into the overall banknote and then printed.

Coins must also interact appropriately with machines and users in the cash cycle, but their production involves fewer processing steps and components.



Schematic overview of coin and banknote production. (Note: Polymer banknotes do not require security threads and use a secure polymer substrate base instead of cotton. Coins can be solid or plated metal – increasingly the latter).

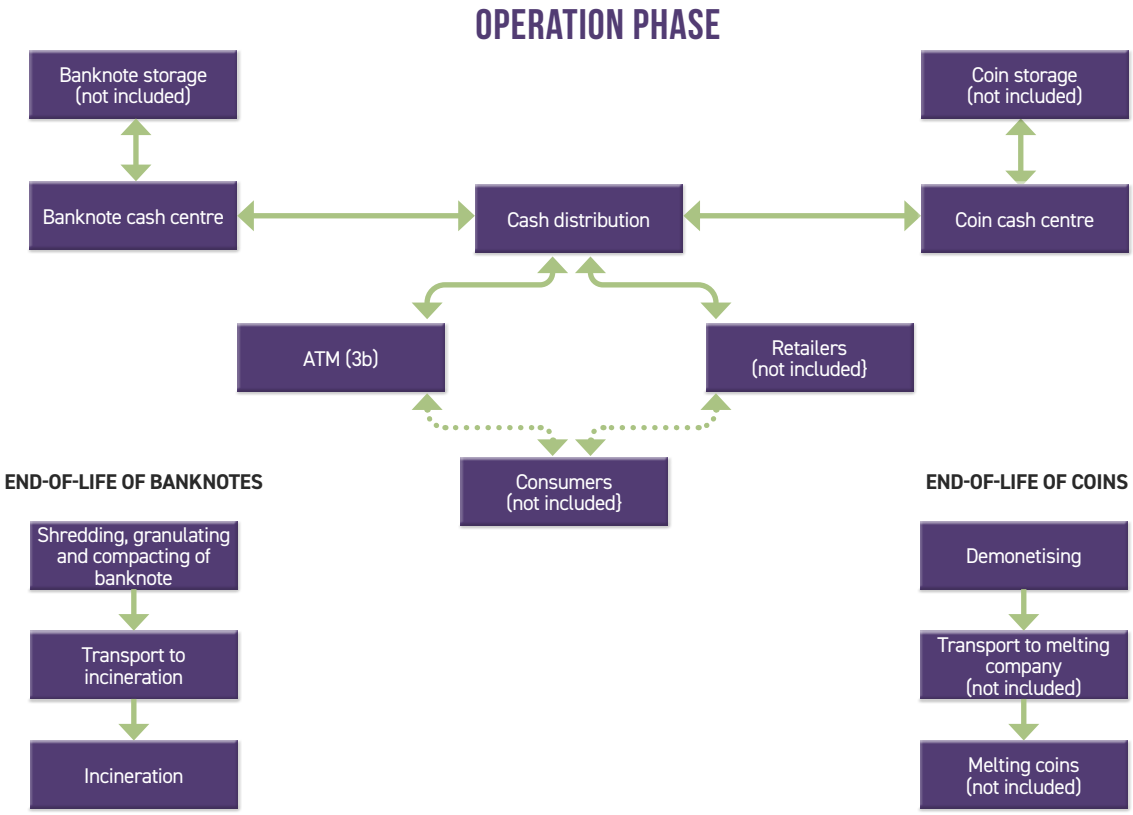
6 Cash Goes Greener (cashmatters.org)

Operational Related Activity

Cash cycles around the world all have the same aim, to ensure the right amount of cash is in the right place at the right time so that it is available where and when needed. To this extent they all involve storage of cash (typically at the central bank or banknote issuing authority, but also in vaults at cash centres and financial institutions), distribution of cash and ultimately destruction or recycling when the cash reaches the end of its useful life or is being demonetised.

The distribution of cash frequently involves a network of logistic firms, cash centres, bank branches, retailers and ATMs. In countries with a strong mobile money network (such as Kenya's M-Pesa network), the mobile money operators also support the distribution of cash.

The operational phase outlined in the DNB study[7] used below is broadly representative of many cash cycles, although different treatments are available at the end of the useful life of a banknote (for instance recycling, incineration, landfill or composting).



Schematic overview of the cash payment system, with sub-system compartments and unit processes.

Putting the Environmental Impact of Payments into Context

Cash related emissions are equal to only 0.009% of total Dutch emissions.

The results indicated that the cash payment system's impact on climate change was 24 times smaller than that of the Dutch economy as a whole, relatively modest compared to the overall impact of goods and services produced for the Dutch economy.

The results show that the cash payment system's impact on climate change is somewhat lower, but of the same order of magnitude, than the impact of the debit card payment system, when scaled with their respective economic values.

There are also other industries and areas that could bring a bigger aggregate benefit if they were to reduce their impact. In recent years, proof-of-work cryptocurrencies such as Bitcoin have reached the news for their significant levels of energy consumption. The energy usage of Bitcoin is dramatically more than that of the cash cycles of the world, despite serving nowhere near the global population served using cash. At the same time the energy usage of Bitcoin is also cited as equivalent to that of all the fridges in America, or 5% of air conditioning globally[8].

7 Life cycle assessment of cash payments (dnb.nl)

8 Cambridge Bitcoin Electricity Consumption Index (CBECI) for comparisons of the relative impacts of fridges, lighting, air conditioning, data centres and data networks. See Final consumption – Key World Energy Statistics 2020 – Analysis - IEA for other general facts and statistics.

While cash payments have a relatively small impact, the cash industry (and broader payments industry) has a duty to reduce its environmental impact as broadly as possible. There are still inefficiencies and opportunities to lower its impact further. More durable banknotes, lower energy manufacturing processes, greener transportation, greener electricity sources, recycling of worn-out cash and less energy intensive infrastructure in the cash cycle are some of the collective actions that the industry can take – indeed, already is taking.

It is also possible to dramatically minimise the number of banknotes and coins required by ensuring that the denominational mix is appropriate for its needs (for instance ensuring that the right value banknotes are in place so that a $100 payment can be made with a $100 banknote instead of 5 x $20 banknotes). Similarly, some countries are dispensing with their lowest denomination coins (which have no purchasing power) and rounding prices, thereby removing significant quantities of physical change and the associated environmental costs.

The MPt of a debit card was 470 MPt compared with 637 MPt for cash, 36% lower. The GWP for debit cards was 3.8g CO2e compared with 4.6g CO2e for cash, 21% lower (see further notes on page 10).

Wider Sustainability and Resilience in Payments

Every way that we pay and store value comes with some type of environmental impact.

Cash is typically thought of as being a physical object only, but there is also an energy requirement at the point of production and in parts of the cash cycle such as ATM machines.

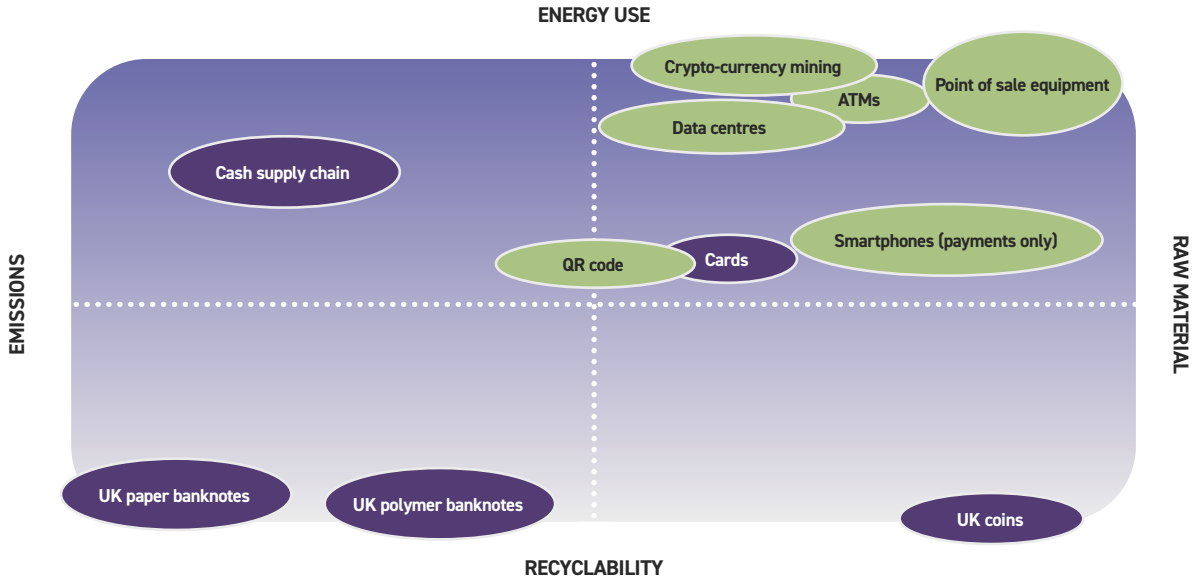
Mobile, electronic and online payments are typically thought of as only digital but require extensive physical infrastructure to support the digital processes (eg. servers in data centres) and point-of-sale hardware, which also uses electricity to operate. Card payments, meanwhile, also involve the creation, distribution and destruction of plastic cards, whilst the hardware such as smartphones and computers that are used for digital payments (amongst a myriad of other uses) are significant and growing consumers of precious and rare earth metals.

The matrix overleaf, adapted from **Environmental Sustainability of a Cashless Society** (**actuaries.org.uk**) summarises the main environmental impact areas for the different types of payment methods.

Cash has a particularly important role to play in a sustainable future payments landscape because it draws on different raw materials compared with digital payments and can still be used in the event of disruption to power, computer or communication systems. This diversity adds useful resilience to the overall payment system.

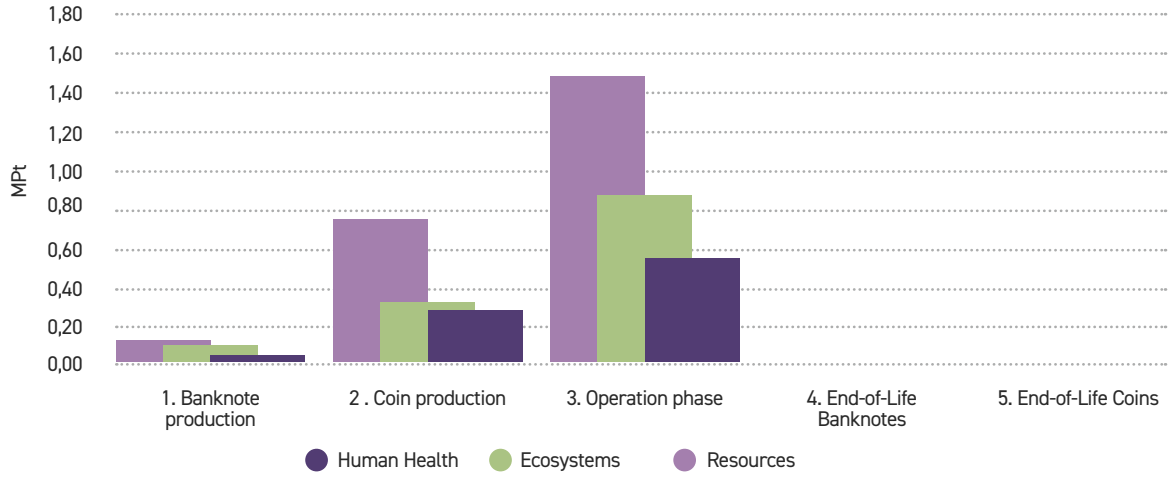
GLOBAL WARMING POTENTIAL (GWP)

The Global Warming Potential (GWP) is a relative measure of how much heat energy the emissions of 1 tonne of a gas will absorb over time, compared to the emissions of 1 tonne of carbon dioxide (CO2). It was developed to provide a common unit of measure that allows the relative environmental impacts of different gases to be compared. The larger the GWP, the more that a given gas warms the Earth compared to CO2 over that time period.



Means of payment and underlying infrastructure: environmental footprint.

THE ENVIRONMENTAL IMPACT OF CASH



End-point indicators per sub-system. Data source: DNB LCA.

Within the cash payment system, the midpoint category with the largest impact was fossil depletion (24%). Metal depletion (22%) had the second largest impact*, followed by climate change human health (20%), climate change ecosystems (13%), particulate matter formation (11%) and human toxicity (6%).

i. Production

The production phase accounted for 32% of the environmental impact. Banknote production created 0.12 MPt, and coin production 0.75 MPt (Eco-indicator-99 – see Definitions).

Banknote production was responsible for 4% and coin production 8% of the cash cycle's carbon dioxide equivalent (CO_2e) emissions based on the Intergovernmental Panel on Climate Change (IPCC) Global Warming Potential (GWP) methodology.

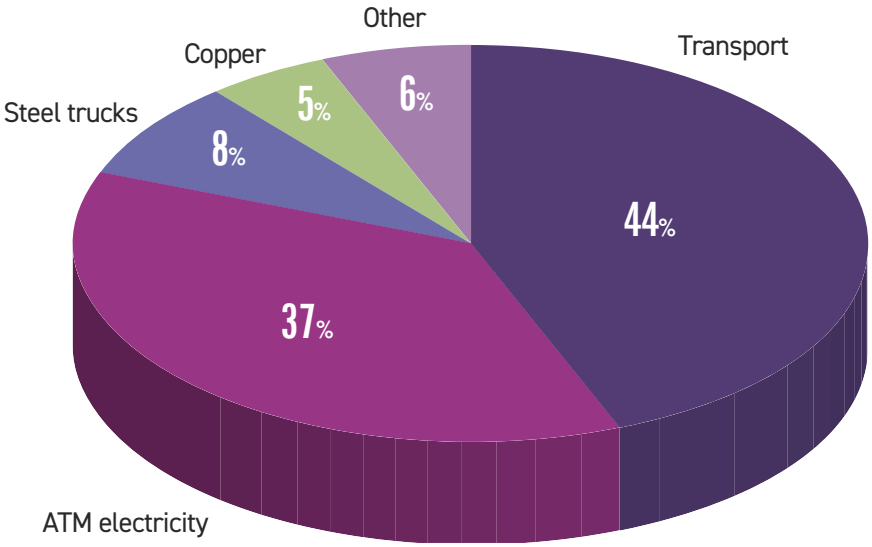
*However, regarding the DNB study's conclusion that metal depletion for coin production plays a large role in the higher environmental impact of cash compared with the average debit card transaction, that study was (as already noted) specific to the Netherlands, and was based on euro coins that are mainly alloys. But nearly 50% of circulating coins are now made of stainless steel (plated or otherwise), which sharply reduces consumption of copper, zinc and nickel in particular, and which are also lighter to transport and 100% recyclable.

Moreover, the DNB study assumes that when copper, a scarce resource, is used in coins, the copper is entirely lost. But the majority of copper alloy coins are in fact recycled at the end of their lifecycle and the metal is recovered. This means that most of the metal resources used in coins are not lost, but only 'borrowed'. If this had been included in the calculations of the Eco-indicator of coins (Pt), they would have been about half of what was in the report, eg. 0.35-0.40 MPt instead of 0.75 MPt.

ii. Operations

The operational phase accounted for 64% of the environmental impact. Operations were responsible for 1.49 MPt.

The operation phase also had the largest impact on climate change (88%), with transport and ATM electricity the main contributors of the CIT operations, c. 60% of transport is to refill ATMs with banknotes. The other 40% is to supply retailers with notes and coins, of which the latter accounts for c. 20%.



Relative contribution to total CO2 equivalents per unit process.

EUROSYSTEM ENVIRONMENTAL FOCUS

In 2004 the Eurosystem carried out a life cycle assessment (LCA) of euro banknotes based on ISO 14040 series of standards for the whole banknote life cycle. The original study was the foundation of implementing environmental measures since then (and is currently being renewed).

The ECB has actively worked to promote the environmental sustainability of the euro and its cash cycle. This starts with requiring suppliers to be accredited to ISO 14001 Environmental Management Systems, which the ECB then monitors and regulates. Each year the Eurosystem monitors key consumption and emissions data from all accredited manufacturers.

The ECB's Directorate of Banknotes, working with the national central banks (NCBs) of the Eurosystem, is increasing the ratio of sustainable cotton in the substrate of euro notes to 100%. Varnish is used on the €5, €10 and €20 denominations to increase their note life. This reduces their environmental impact since notes circulate for longer, requiring fewer to be manufactured and destroyed at the end of their life.

The ECB's first environmental forum involved NCBs and suppliers and is focusing on waste management and efficiency, the assessment of life cycle activities and sustainable materials.

4.0 COINS AND MINTING

Coin producers (mints) are primarily state-owned. The majority of mints produce coins for their countries only, while a handful operate on the commercial market too. In addition to circulating coins, mints usually produce commemorative coins, medals and bullion products as well. Some mints also produce their own blanks.

This section reports on work done by mints to reduce their environmental impact. Using the IPCC Global Warming Potential (GWP) method, coin production is responsible for 8% of the climate change impact of the cash cycle.

The ReCiPe endpoint (H) impact method shows coins having an MPt of 0.75, 32% of the total, largely due to the use of copper. But, as noted on page 10, method does not factor in that the copper is recycled. Had this been considered, the MPt is roughly half, at 0.35-0.40 Mpt. Indeed all coins are melted down and the metal reused when they return from circulation.

Also noted on page is that the DNB study covers euro coins, all but the three lowest denominations of which are alloys (a combination of copper, zinc and nickel). The three lowest coins are plated. Plated coins – comprising stainless steel with a very thin coating of copper, zinc and/or nickel – were introduced in the late 1980s with the objective of saving money, and now comprise over 40% of all circulating coins. New coin denominations or designs are more often than not plated, while some countries are dispensing with plating altogether and specifying coins made solely of stainless steel (10% of all coins). Plated, and stainless steel, coins are not only more cost-effective, they are also much lighter than alloys (saving on transportation and handling costs), use less metal and are much easier to recycle.

The DNB study also doesn't use data for blanks, the sourcing and composition of which has a substantial bearing on the overall impact of coins on the environment. Some countries, for example, source blanks and base metals from around the world, others (such as the UK's Royal Mint), make their own blanks on-site and/or source their metals locally.

Main Areas of Environmental Impact

- Electricity (MWh)
- Water and wastewater
- Solid waste for landfill

CASE STUDY SUMMARIES

- **Royal Australian Mint (RAM)** – funding solar panel investment, better processes, less water.
- **Royal Dutch Mint (RDM)** – solar power generation, reduced usage of electricity and materials, elimination of fossil fuels, waste recycling.
- **Royal Mint (TRM)** – renewable energy generation, lower energy and water consumption, move to reusable packaging.

4.1 ROYAL AUSTRALIAN MINT

The Royal Australian Mint (RAM) is Australia's national mint and sole producer of circulating coins for Australia. RAM produced 91 million circulating coins in 2020.

RAM also produces circulating coins for other countries (50 million in 2020), and manufactures a vast array of collector coins, investor products, medals, medallions and tokens for domestic and international clients.

The manufacturing processes which have environmental impact include blank preparation and electroplating, and minting the coins.

Funding Solar Panel Investment

In 2016 and 2019 RAM installed 924 and 300 solar panels on the roof of its facility respectively. By 2020 21% of RAM's electricity used for business purposes was supplied by solar generation, reducing CO2 emissions by 510.80 tonnes.

SOLAR PANELS	2017	2018	2019	2020	TARGET 2021
Electricity generated by solar panels (kWh)	428,473	431,826	321,737	421,500	~421,000
Percentage of the total electricity for business use	15%	15%	15%	21%	21%

The actual energy generation of the solar panels is affected by the weather. So the annual yield of electricity from the solar panels has fluctuated over the past 3-4 years in line with weather fluctuations.

RAM funded the solar panels by making a Power Purchase Agreement (PPA) with an electrical service provider (ESP). The ESP paid for the installation and owns, operates and maintains the system for 15 years. At the end of that period, RAM then owns the installation. RAM receives a discounted electricity supply compared with its current electricity tariff during the ESP ownership period, reduces the carbon intensity of its energy supply and replaces a percentage of its peak electricity consumption. The PPA means that RAM has generated electricity savings from day one without capital investment.

Better Processes, Less Water

Wastewater treatment consumes a lot of clean water: RAM's data showed that two units of clean water had to be used to treat one unit of wastewater. In October 2020 it implemented phase one of a two phase project to reduce its clean water consumption. Phase one was based on process improvements:

- Using sodium hydroxide to partially replace calcium hydroxide for the pH adjustment.
- Optimising the process conditions and process control of the flocculation process.
- Introducing an upgraded computerised process control system to make the process control more accurate and more consistent.

Through the set of process improvements of Phase One, RAM:

- Reduced the clean water consumption to a one-to-one unit basis in 2021, with potential for further improvements from further fine tuning of the process condition of the flocculation process.
- Reduced the wastewater discharge by 30% alongside the decrease of clean water consumption.
- Reduced the solid waste for landfill from the previous 11-12 tonnes a year to 7-8 tonnes in 2021[1]. It could be further reduced to about 6 tonnes by fine tuning the flocculation process conditions.

1 As less undissolved calcium hydroxide solid was introduced into the wastewater treatment system by using sodium hydroxide, the solid waste generated from wastewater treatment has been reduced accordingly.

WASTEWATER (WW) TREATMENT	2017	2018	2019	2020	TARGET 2021
Clean water consumed for WW treatment (tonne)	4,009	4,356	4,093	1,954	750
Treated WW discharge (tonne)	6,014	6,534	6,140	3,125	1,500 (110 T/month up to July)
Clean water / Treated WW Discharge (ratio)	0.67	0.67	0.67	0.63	0.5
Solid waste generated from WW treatment for landfill (tonne)	11.5	11.5	11.5	10.1	7.7

Phase 2 (currently in development for internal approval) is expected to be commissioned in 3-4 years time, with the goal of recycling and reusing 75% of wastewater generated from coin manufacture.

4.2 ROYAL DUTCH MINT

Moving to a new site is an opportunity to innovate. In 2020 the Royal Dutch Mint (RDM), an organisation founded in 1567, did just that. Unlike the RAM, the RDM buys in coin blanks and then mints coins, which is a cold forging process. The environmental footprint of cold forging is primarily limited to electricity and a small volume of lubricants.

The total investment in the new plant was almost €20 million, but RDM calculates that its carbon footprint and environmental impact has reduced by virtually 100% compared with the previous site as it is now on a gas free site with on-site solar energy production that is expected to exceed its own consumption.

RDM took the opportunity to do better in three key areas:

- How it organised itself – the building, staff and materials
- Water treatment
- Waste recycling.

The RDM's new state-of-the-art production facility, also referred to as 'the Dutch Vault', in Houten, Utrecth.

Organising for a Low Carbon Footprint

Solar power generation: the new site has an energy neutral carbon footprint which it has achieved by using no fossil fuels on the site. It generates electricity using its own solar energy plant on the roof – it is expected to generate more than 700,000 kWh each year, matching its expected demand.

Lower electricity demand: to reduce its electricity requirements the building:

- Uses LED lighting throughout the building and uses timers on power plugs to reduce sleep usage.
- Has an advanced Heating, Ventilation and Air Conditioning system that re-uses the heat of the minting presses to heat the building in winter. In summer it uses the cold night air to cool the building while, at the same time, removing heat of the minting presses from the building during the day.

Electric forklift trucks: the site only uses electric forklift trucks, using power from the site's solar energy plant.

Commuting: staff are encouraged to use public transport or to cycle to work through smart travel expenses coverage and bike purchase plans. As a result, only 72% of staff still drive to work.

Less water: other initiatives include capturing rainwater and using it to flush lavatories and water the gardens.

Less materials: at a micro level, all office printers are set up to print double sided and printing is only in grey tints, no colour. There are also fewer printers than in the old site. The result of these changes has been approximately 30% less paper and 15% less ink usage.

Materials: cardboard is now sourced from 'Forest Stewardship Council' suppliers for packaging as much as possible and if plastic packaging is required, RDM looks to work with recyclable plastics. Material movement within the site only uses re-usable boxes.

RDM is working with customers to amend specifications to reduce the environmental impact while maintaining full functionality. For example, seeking to move central banks to using 120 micron rather than 200 micron packaging plastic since the lower weight plastic still meets wear and tear criteria for handling and transportation.

Chemicals: RDM has been able to reduce the use of chemicals and production time in its machines and processes by optimising the process parameters and monitoring the time and consumption.

Productivity: automation has allowed RDM to produce about 50 million circulation coins for each member of staff (full time equivalent, or FTE), office and production. The industry average is estimated between 10 and 20 million circulation coins per FTE.

Water Treatment

RDM now uses a local specialised recycling company to treat process water with high levels of metal particles. RDM, and its ISO 14001 auditor, calculated that a dual approach of using an external expert company and treating water flows with lower levels of metal particles in its own integrated water purification system would give the best ecological outcome. The recycling company captures and refines metal particles in wastewater. The result is that scarce resources, such as metals, are fully recycled and do not pollute wastewater or other waste flows.

As a result, the metal particles in the wastewater have decreased significantly. The wastewater is now of such high quality that the environmental impact is no longer significant.

Waste Recycling

All waste on site is now sorted, with material recycled where possible. Non-metal valuable materials are offered to interested parties who collect the waste for re-use. This has led to a decrease in waste of approximately 50% compared with the previous site.

4.3 THE ROYAL MINT

The Royal Mint (TRM), which has a history spanning 1,100 years, is the sole provider of UK coins and the leading exporter of coins in the world. In addition to circulating coins, it has a large and growing business in commemorative coins, as well as bullion and investment products, and services related to coin circulation and reclamation. It also has its own proprietary process for mono-ply plating of coin blanks. It is based in Llantrisant, in Wales, produces over 3 billion coins per year, and supplies coins and blanks to around 40 countries.

The Royal Mint's 'Delilah' wind turbine.

On-Site Renewable Energy Generation

TRM has installed a direct wired 850 kW Vestas V52 Wind Turbine at its site. TRM decided to buy and refurbish a second-hand wind turbine, re-using rather than buying new. TRM is located in Wales, and so the wind turbine has been painted in 'daffodil' green and yellow – being one of the national emblems of Wales – and named 'Delilah', after a favourite Welsh rugby anthem. Each year 'Delilah' produces approximately 800 MWh of electricity.

Additionally, TRM has three small solar arrays which generate electricity for individual buildings, covering consumer coin production, the engineering department and visitor's centre. These have been used in a trial to inform a further expansion in solar (possibly to the roof spaces).

In the financial year 2020/21 the wind turbine and solar arrays generated about 3% of TRM's electricity needs. 100% of its grid electricity is renewable.

CO2 Emissions from Electricity and Gas Use

The Energy Performance Indicator measures the kWh per tonne of coins produced for the entire site, with a goal of reducing it by 2% (year-on-year). To achieve this, TRM identifies areas of significant energy use, people who influence the energy use, and conditions that affect the energy use. It then monitors and measures variables that it can influence to reduce its energy use to make its processes more efficient and streamlined in the production process. The result has been a 30% reduction in CO2e in four years.

	2016	2017	2018	2019	2020
Elect T(e) CO2e	23,156	20,080	15,821	15,343	12,719
Gas T(e) CO2e	3,857	3,826	3,762	3,900	6,130
Total CO2	27,013	23,906	19,582	19,243	18,849

Water consumption

A large volume of water is consumed within the coin manufacturing process and, as such TRM uses both potable (mains) and abstracted water in its processes.

Water Abstracted (River Water) m^3	
2020-21	250,000
2019-20	260,000
2018-19	313,000
2017-18	362,000
2016-17	457,000

Over the last five years, changes in processes and equipment have resulted in reduced amounts of abstracted river water being used on site.

During 2019-20 104,000m^3 of the abstracted river water was returned to the river a few hundred metres downstream from the abstraction point.

Future Diversification

In a new business venture, TRM is investing in new technology from a Canadian start-up, Excir, to retrieve precious metals from the circuit boards of end-of-life phones and laptops. It has conducted trials where gold with a purity of 999.9 has been recovered. The technology has the potential to recover palladium, silver and copper.

TRM is targeting the UK's share of some 50 million tonnes of e-waste produced each year, of which only 20% is currently estimated to be recovered.

5.1 SUBSTRATES: PAPER

Banknote paper is made from cotton or a combination of paper and polymer (see next section for all-polymer substrates). The cotton is a by-product of the textile industry, providing an early and enduring example of recycling in the banknote industry. In a few countries, the by-products of local crops such as abaca or flax are used to supplement the cotton.

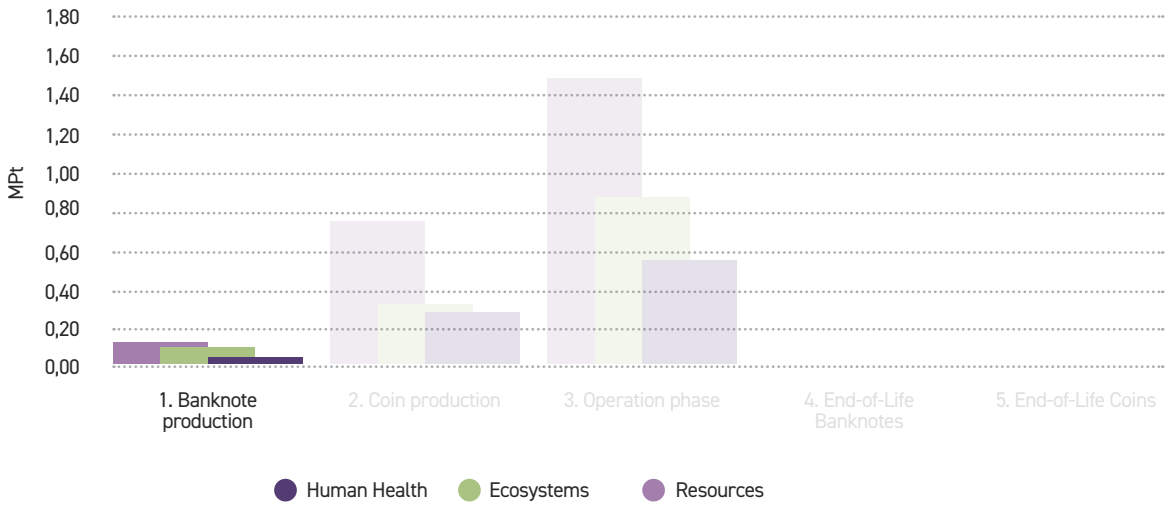
In an increasing number of countries, paper banknotes are finished with a protective coating or vanish to prevent ink abrasion and the ingress of dirt, thereby increasing their lifespan.

Although the DNB report broke down production into each process step, the ReCiPe endpoint (H) impact method shows that banknote production represents a relatively small proportion of the total.

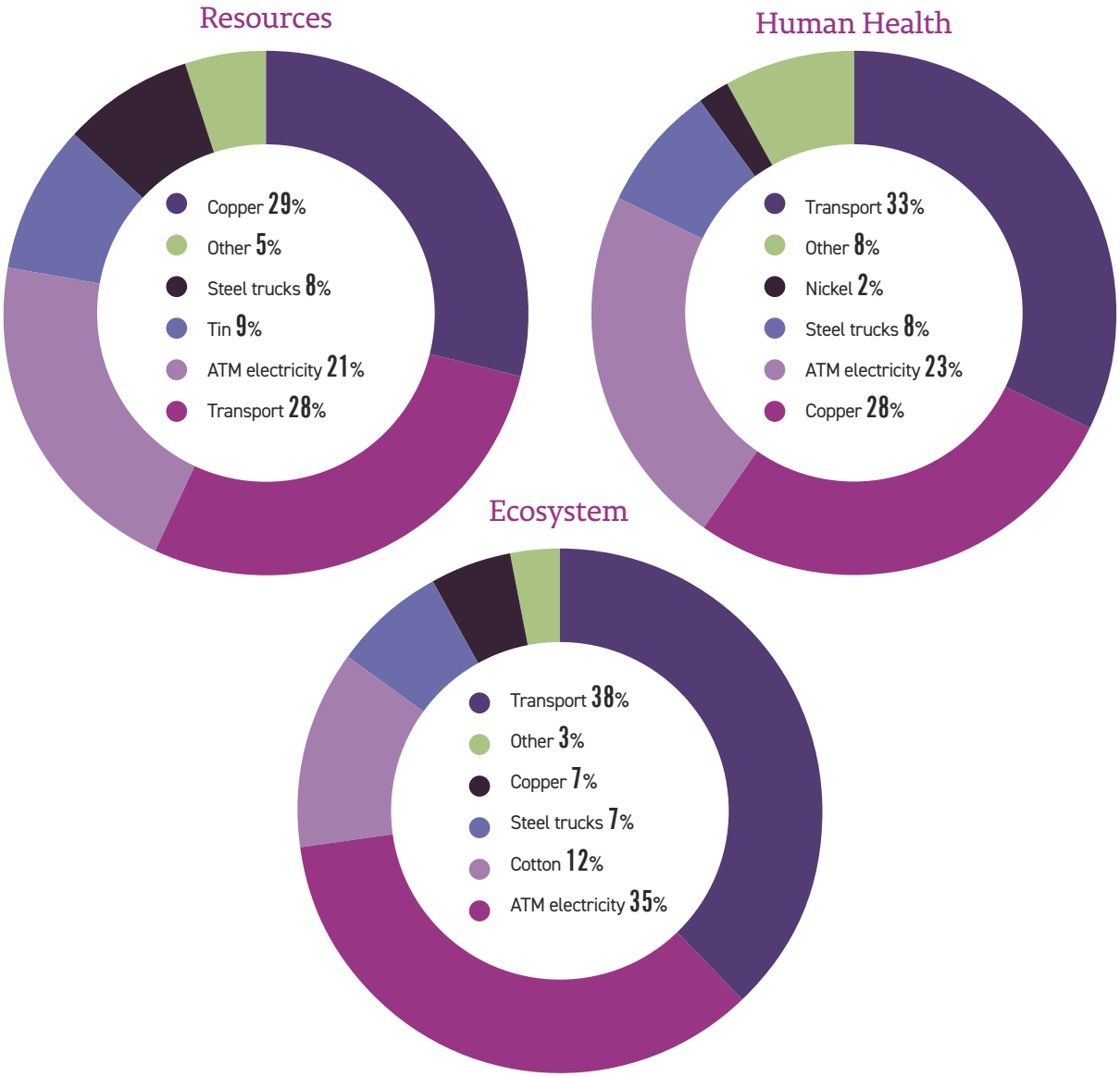
Three types of cotton were used for the DNB's indent of euro banknotes, ie. traditional cotton (60%), organic cotton (35%) and fair trade cotton (5%). Organic cotton is grown without the use of any synthetic agricultural chemicals such as fertilisers or pesticides and the explicit use of only rain water (GOTS, 2017). The Eco invent process for cotton has been adapted to better reflect the environmental impact of organic cotton by removing the use of water and chemicals.

Main Areas of Environmental Impact

- Electricity (MWh)
- Water and wastewater
- Cotton, used as the main raw material



End-point indicators per sub-system – banknote production.



Overall relative environmental impact per unit process on the Endpoint indicators Resources, Human Health and Ecosystems.

Paper manufacture is captured in the 'other' category in these pie charts.

CASE STUDY SUMMARIES

- **Louisenthal** – reduced usage of water and energy, energy generation.
- **Portals Paper** – reduced usage of water, energy and raw materials.
- **VHP** – reduced usage of water and energy.
- **Crane Currency** – less water, re-using cotton.

5.1.1 LOUISENTHAL

Louisenthal, a producer of banknote paper and security features, is a subsidiary of the German banknote printer Giesecke+Devrient. While its banknote paper mill and security thread production are co-located in Gmund am Tegernsee in Bavaria, the second plant which only produces security paper, is located in Königstein in East Germany on the River Biela.

The Louisenthal paper mill in Tegernsee is located within the drinking water catchment area for Munich, making water treatment particularly important. It uses the River Mangfall to generate electricity and to provide water for the paper making processes. The challenge in Königstein is that the plant discharges its water directly into the River Biela, which means very strict requirements need to be fulfilled to guarantee no negative impact on the whole river ecosystem.

Water Usage

Both Louisenthal plants have installed a biological wastewater treatment plant in which bacteria are used to purify the process water. The bacteria are then separated and recycled using a membrane filtration system and the purified water is reused in production. In Tegernsee, this has enabled a 40% reduction in water consumption from 1,600 m^3 a day to 900 m^3. Since 2017 the site has left more water in the river than required to by law – 1,000 l/s rather than the previous 350 l/s. The site has a sensor-controlled, fully automatic water inlet valve that only takes as much water from the river as the site actually needs.

Energy Usage

When paper is made, the newly formed paper has to be dried quickly as it is made. This involves the use of considerable heat, but a lot of heat requires a lot of cooling. To make sure that its paper retains the right dimensional properties, it is necessary to control the climate in the production rooms all year round.

From November to April, this is done passively using water from the Mangfall. That has allowed a savings of around 1.5 gigawatt hours of electricity a year since 2009, the equivalent of some 600 tonnes of CO2. In the very cold months, Louisenthal has to heat the production rooms, which it does using waste heat from the production processes. That has saved another 2,000 metric tonnes of CO2e a year since 2013.

Energy Generation

The banknote paper mill and security thread production at the Tegensee site are co-located. 10% of the power used on the site is supplied from its three hydro-electric water turbines. This saves 1,230,000 kg CO2e each year. Louisenthal has also installed two fish ladders so that fish can bypass the mills weirs and populate the Mangfall more easily than in the past.

There is also a Combined Heat and Power (CHP) plant which, combined with the hydro-electricity generation capacity, generates 25% of the site's needs.

The fish ladder installed alongside the River Mangfall.

A combined Heat and Power plant generates 25% of the Tegensee site's energy needs.

5.1.2 PORTALS

The River Test, one of the world's finest for trout fishing.

UK-based Portals Paper is the second largest commercial manufacturer of paper for banknotes. The water from its papermaking processes is discharged into the River Test, one of the top 10 trout fishing rivers in the world, so it has always had to ensure the highest standards in its wastewater treatment. It has also invested some £21 million in the past three years to increase efficiencies and reduce the environmental impact of its operations.

Water Management

Papermaking is a 'wet' process and therefore, by default, requires substantial amounts of water from processing the pulp through to the paper manufacturing.

To achieve this sustainably, the amount of freshwater used needs to be minimised, whilst the wastewater needs to be fully cleaned and filtered before it is returned to the local environment.

To maximise water efficiencies, Portals has invested in the latest water filtration technologies across its sites. Powerful filters clean the waste by removing fibres and chemical residues, purifying the water as it completes the filtration process. The water is then reused in the production process or discharged back into the local river as clean if not cleaner than it was when it was taken out at the start of the process.

This project, which was part of a larger £3.5 million investment, was undertaken in 2020-2021, with a further £250,000 investment planned for the coming year in additional water redistribution projects.

Portals has made incremental improvements to reduce water usage, investing in site maintenance and optimising the paper machine vacuum systems that remove water from the paper.

These improvements have reduced water usage by 30% since 2015, down from 5.5 million m^3 to circa 3.8 million m^3.

Energy Reduction

Portals has reduced its energy usage through the implementation of the more energy efficient technology and improved planning and resource management.

A £4.2 million investment in stock preparation and refining processes in 2019-2020 resulted in a reduction of 528 kWh per tonne of stock processed, equivalent to a 25% reduction in energy usage and 4% reduction in carbon emissions.

This investment, which includes the implementation of a continuous stock preparation process, has resulted in a 50% reduction in machinery, with outdated batch process equipment (involving five breakers and 11 refiners) being replaced with advanced cylindrical refiners whose geometry combines gentle and uniform fibre treatment through controlled intensity refining.

A paper mill needs to create heat to dry out the extremely high-water content contained in newly formed paper. Portals has a Combined Heat and Power (CHP) plant to create this heat and to generate its own energy for use across the site (including providing heat and electricity to the office areas). The mill self-generates approximately 80% of its own energy requirements and any surplus energy is provided to the UK National Grid – providing in the region of 330 Gwh annually. Using this waste heat to generate electricity (via the CHP plant) reduces energy costs by 25% typically.

Reducing cotton usage

Cotton is the principal raw material of banknote paper as cotton fibres help produce a paper that is durable and will last in circulation. Specifically, a combination of cotton comber waste and cotton linter pulp makes the best banknote paper. The comber waste is a by-product of the global cotton spinning industry, whereas linter pulp is a sheeted product made from the fibres from the cotton seed – both parts of the cotton plant which otherwise have a limited use.

Whilst cotton is naturally biodegradable, Portals has invested in a fibre recovery programme to reduce its cotton usage. The latest filtration technology allows cotton fibres that were previously lost through production processes to be recovered and fed back into the paper making process. This investment, alongside further optimisation of existing equipment, has resulted in a 6% reduction in the requirement for cotton over a three year period.

5.1.3 VHP

VHP, based in the Netherlands, is part of the French banknote printer Oberthur Fiduciaire.

In 2020 the VHP paper mill reduced by 20% its CO2 emissions compared to 2018. This was achieved by optimising existing processes and outsourcing one process to a specialised producer.

The preparation process for banknote paper is water and energy intensive and uses chemicals that are environmentally unfriendly. 80% of the preparatory bleaching and refining of the cotton is now outsourced to a specialist company.

VHP has invested in the latest technology for high consistency last stage refining. The result has been a more consistent and higher quality cotton pulp for its paper making.

VHP now uses:

- 25% less energy than in 2018
- 15% less fresh water than in 2018.

The effluent water of the factory is much cleaner, creating 40% less Clinical Oxygen Demand and Biological Oxygen Demand.

This change also means there are now no chemical processes on the site.

5.1.4 CRANE CURRENCY

Crane Currency is a banknote printer, papermaker and supplier of security features, with facilities in the US, Sweden and Malta.

Crane's paper mill in Tumba, Sweden is located close to water sources, with well-developed processes for the steam manufacturing needed for drying paper and purification for returning the processed water back to nature. Today, all wastewater from the facility is sent to a local wastewater treatment plant (WWTP) that separates the cotton fibre fines from the wastewater, which are then either used as fuel for biogas generation or as soil fertiliser.

A new filtration system will be operational in the first half of 2022. It will reduce the amount of water and fibre processed by the WWTP by approximately 35% per year by enabling the reuse of filtrated water back into the production process. The yearly water savings will be around 500,000 m^3.

At the same time, the new system will capture cotton fibre for reuse, separating approximately 108 tonnes of fibres and solids per year. The reused cotton fibres will help offset the amount of cotton processed during the papermaking process, expanding a water-savings project into a water and material savings initiative.

5.2 SUBSTRATE: POLYMER

Main Areas of Environmental Impact

- Electricity (MWh)
- Polymer waste

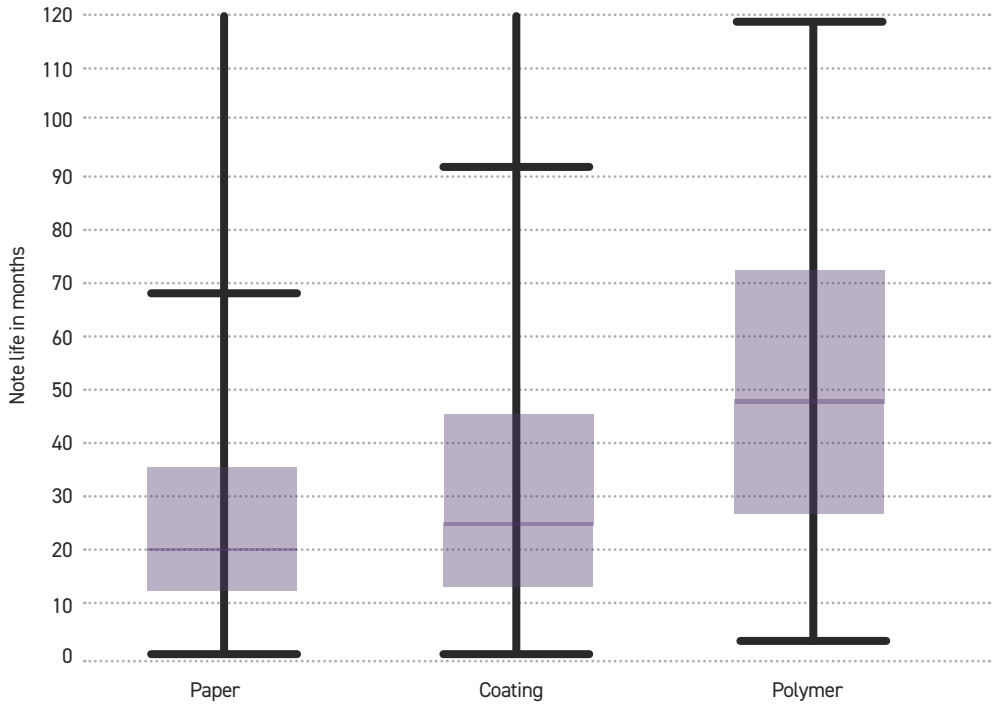
Polymer banknote substrate is used in 4% of the world's banknotes by volume, although many more by number of denominations or countries. Australia, Canada, Mexico and the UK are some of the more prominent users of polymer substrate, although large economies such as China, the eurozone, India, Russia and the US remain on paper.

Analysis by the Bank of England, Bank of Canada and Reserve Bank of Australia shows that polymer banknotes have a lower environmental impact than cotton-based banknotes (see the BOE CFA section of this report – page 26 – for the details).

Polymer notes last longer in circulation than paper notes on average, meaning that the reduction in the number of notes needing to be produced and associated transport results in polymer having a lower impact overall.

Increasing note life is the key to this performance and the papermakers and printers have also innovated to increase their note life (as can be seen in the chart below). Longer living banknotes have multiple environmental benefits. The banknotes need replacing less often, which requires less raw materials over time. As the banknotes are replaced less frequently, they require fewer deliveries from the supplier to the central bank. Transport is also reduced in the cash cycle since notes are being returned to the central bank less frequently for final sorting and destruction.

NOTE LIFE COMPARISON



Source: DLR Analytics™ – calculated directly from 12,500 central bank data points.

The end-of-life section of this report contains data about the impact of different methods of destruction at the end of life (see page 41). The ability of polymer notes to be recycled is important to reduce their total impact and both suppliers, CCL Secure and De La Rue, have worked hard to help their customers with end-of-life and manufacturing waste recycling options.

In early 2021 a review of known destruction methods and survey responses, covering 43 banknote issuing authorities in total, found that 92% of those disposing of their polymer banknote waste were either recycling their banknotes or moving towards recycling their banknotes. Two more had yet to generate enough waste to warrant destruction or recycling. In contrast 96% of those on paper banknotes and mixed/composite substrate sent their banknote waste to landfill or for incineration.

CASE STUDY SUMMARIES

CCL Secure – energy usage, supply chain emissions, recycling.

De La Rue – energy usage, carbon emissions, waste and recycling.

5.2.1 CCL SECURE

CCL Secure manufactures its GUARDIAN™ polymer banknote substrate at three locations in Australia, the UK and Mexico. The Clarity™ C film used in the production of GUARDIAN is produced by its sister company Innovia Films at facilities co-located with CCL Secure in Australia and Mexico.

This study focuses on the achievements of CCL Secure's UK facility. Some additional examples of work done at the other sites is mentioned in the case study.

CCL Secure's new recycling facility for polymer, owned by CCL sister company Innovia, at Zacapu in the Mexican state of Michoacán.

Energy Usage

CCL Secure's UK site has reduced on site gas and electricity consumption, lowering carbon intensity from 1.46 kg CO2e/kg of product to 1.07 kg CO2e/kg of product at the end of 2020.

It has achieved this by introducing a smart building management schedule. This software uses monitors and controls to optimise energy use. The factory, and individual items of equipment, are scheduled to be turned on and off in line with production schedules and building use.

- An automatic Monitoring and Targeting system (aM&T) has been implemented called Carbon Desktop. Carbon Desktop is based on sub-meters on all services and equipment. Ratios have been determined for key metrics and the actual performance is compared against the goal (for example, energy required per tonne of product produced). The business is then actively managed to optimise performance.
- A conscious decision has been taken to run operations based on CCL Secure's regional structure. This has reduced the mileage travelled by materials and personnel. In 2020, transport accounted for 2.7% of the UK site's CO2e/kg, down from 7.9% in 2018 (the base line year). CCL Secure manufactures the base polymer used in banknotes co-located in two of its three sites, reducing the distance travelled to under 300 metres.
- The company has introduced process innovations such as low carbon heat and electricity generation, although the details of this are confidential. This has allowed some raw material supply to be manufactured in-house.
- Reuse of solvents through, for example, heat recovery or the ability to recover solvents which can be reused in the production processes.
- Reduced base load of gas and electricity by better insulation and lighting solutions. All internal lighting is now LED, with external lighting to follow in 2022. In the three years to 2020 gas usage has reduced in actual terms by 45%, electricity by 13%, steam by 36% and water by 20%, while the volume of material produced has increased.

Reducing Scope 3 Smart Supply Chain Emissions

Scope 3 emissions – which includes supply chain emissions – significantly contribute to carbon intensity. Scope 3 emissions reduced from a carbon intensity of 5.78 kg CO2e/kg of product in 2018 down to 4.48 kg CO2e/kg of product at the end of 2020.

This was achieved by working with Verco Global to create a comprehensive materiality assessment. CCL Secure established the embedded carbon of all incoming materials. It assessed the carbon footprint of bought in supplies from raw material to the point where the product entered the site. This data was used to make decisions about sourcing and whether producing those products in-house would be beneficial. 15 products are now being manufactured in-house that were previously bought in.

Creating a smart supply chain has required an investment of over £40.5 million since 2016.

Recycling and Waste

At CCL Secure sites globally, 100% of all polymer waste is recycled. All CCL Secure sites are on track to have zero landfill by 2023.

Furthermore, when withdrawn from circulation, the GUARDIAN™ polymer banknote substrate can be recycled. CCL Secure's SPARTAN™ polymer banknotes can also be recycled. Today just over 90% of CCL's customers recycle their banknotes at the end of their useful life, with only a minority of print works and central banks not doing so.

Where local recycling is not possible, CCL Secure offers its customers a service to recycle shredded polymer material. A new recycling facility in Mexico[1] serves Central and Latin America and the Caribbean. The UK facility serves Europe, the Middle East and Africa. The Asia Pacific Region will be served from Australia. A number of customers – print works and central banks – already use this service. It can also offer the services of YES Recycling, who recycle the polymer waste created when CCL Secure's GUARDIAN polymer is printed for the Bank of England by De La Rue.

CCL Secure is part of a larger business, CCL Industries, whose businesses include Innovia Films. The polymers created by Innovia Films in cooperation with CCL Secure are all bank-grade – defined as polymer created exclusively for banknotes and no other purpose. Another CCL Industries company – CCL Labels – is another polymer specialist. Between them, these three parts of CCL Industries have well-established and comprehensive recycling capabilities for the polymers they produce.

Other

CCL Secure has committed that all Bank of England substrate produced in its UK production facility will be carbon neutral by 2022. This is part of a broader aim of doing the same for other customers.

In addition, CCL Secure has set a target for all of its sites around the world to be carbon neutral by 2030. The pathway to carbon neutrality involves some short-term carbon offsetting – in accordance with the internationally recognised PAS2060 standard – but offsetting is not part of the long-term strategy.

5.2.2 DE LA RUE

De La Rue produces its banknote polymer substrate, known as SAFEGUARD®, at its Westhoughton production site in the UK. The polymer used in SAFEGUARD is also part of a secure bank-grade supply chain, with SAFEGUARD being supplied to De La Rue international print sites and 15 other secure commercial/state print works globally (as of October 2021).

Reducing carbon footprint

Reduction in gas usage and energy-efficient heat recovery: since 2001 gas has been replaced with waste solvent fumes, while neutralising exhaust fumes (known as Auto Thermal). Heat recovery coils are used to reclaim energy via heat exchangers used in the printing unit dryers, which further reduces gas usage. This approach has historically reduced gas usage by 50% compared to systems where this approach isn't adopted. In 2021, De La Rue invested in a high energy efficiency Regenerative Thermal Oxidiser, which will reduce gas usage by an additional 30%, meaning that overall gas usage is 80% lower than it otherwise would be.

1 This recycling centre in Zacapu is owned by Innovia Films, part of the CCL Secure group. It turns old polymer banknotes into polypropylene pellets which are used in a wide range of new plastic products, including garden furniture, building materials and long-life clothing.

Process and efficiency improvements: on-site energy consumption per tonne of goods produced has reduced by over 25% in the 12-month period up to June 2021. This was via a combination of product and production process improvements, for example improved polymer construction with lower waste and better energy utilisation through metering.

Investment in the latest equipment: De La Rue is investing £20 million in the latest polymer production equipment. This becomes operational in December 2021, with improved monitoring and inline feedback. The result will be a reduction in carbon emissions by 5% from more efficient equipment and lower waste levels.

Mono-recycling of polymer waste: 100% of De La Rue's polymer substrate waste and UK banknote polymer waste is recycled via YES Recycling.

Reduced waste during printing: as a printer De La Rue monitors its polymer banknote production and has created experimental design trials to optimise SAFEGUARD for banknote manufacture. Recent trials have significantly improved SAFEGUARD so that one of the three main print processes now creates 2.3% less waste than before (and the others are equivalent or improved). It also consistently prints 25% faster than before (now matching or surpassing the speeds of paper printing), reducing machine time.

Recycling Polymer

De La Rue operates the Bank of England's print works at Debden. As part of the transition to a polymer series of banknotes, De La Rue was required to ensure that the waste from the production and circulation of polymer notes could and would be recycled. Banknotes are seldom thrown away at the end of their life but returned to the bank, creating a closed loop system.

100% of De La Rue's polymer waste is now recycled.

Based on its experience in manufacturing its own polymer substrate, and printing polymer both at Debden and in its own printing factories, De La Rue now offers its customers an assessment service to evaluate and qualify local and regional recycling requirements and solutions.

As part of this service, De La Rue carries out impact assessments to help customers quantify whether to use a paper or polymer substrate and the implications on the carbon footprint of their design choices (see the print section of this report for more details).

In the UK, De La Rue worked with YES Recycling on changes to previous processes necessary to recycle polymer compared with handling paper-based products.

Banknote polymer is suitable for mono-material recycling, which means banknote polymer waste must be kept separate from other materials. One of the main advantages of mono-material sorting is its enhanced recycling capacity, which favours a circular economy, as well as requiring less energy consumption for future production. This requires some straightforward changes, such as introducing procedures to ensure that polymer waste is not contaminated with any non-banknote polymer or other materials and segregating waste. Some minor changes included switching to polypropylene cable ties from nylon cable ties to reduce sorting of waste materials. In some instances, chemical analysis was needed to ensure that materials could be recycled.

Between 2016 and August 2021 the Debden site has recycled about 1,150 tonnes of polymer waste. Today 100% of De La Rue's own polymer waste from the production process is recycled and 90% of the polymer used by its customers around the world, not just the Bank, is recycled.

If customers outside of the UK do not have suitable local or regional recycling, De La Rue is able to offer YES recycling to its non-UK customers. Whilst it may seem counter-intuitive to ship end of life banknotes long distances by sea, the comparative carbon output is significantly lower per km than any other form of travel, meaning that closer, land-locked recycling alternatives may have a higher carbon footprint.

5.3 SUBSTRATES: BANK OF ENGLAND CFA ON POLYMER

The Bank of England published its 'Carbon Footprint Assessment: Paper vs. Polymer £5 & £10 Bank Notes' in July 2017[1]. The study was carried out using PAS 2050:2011 (BSI, 2011) and the Carbon Trust confirmed the work done.

This study is consistent with the findings of that by the Dutch National Bank (DNB). Unlike the DNB report, this study did not include coins and did not put banknotes in the context of other payment options.

It is reported here because of its focus on banknotes manufactured on polymer substrate compared with a paper substrate, a major difference compared with euro banknotes, which are all produced on paper substrate.

FINDINGS OF THE BANK OF ENGLAND CARBON FOOTPRINT ASSESSMENT (CFA)

Like the DNB, the Bank found that the environmental impact of banknote manufacture is small. For a paper, non-ATM issued £5 banknote, 32% of the total impact, while circulation is responsible for 68%.

	PAPER		POLYMER	
	£5	£10	£5	£10
MANUFACTURING	59	65	30	31
CIRCULATION	128	406	127	405
TOTAL	187	471	157	436

Kg/CO2e for 1000 notes for 10 years.

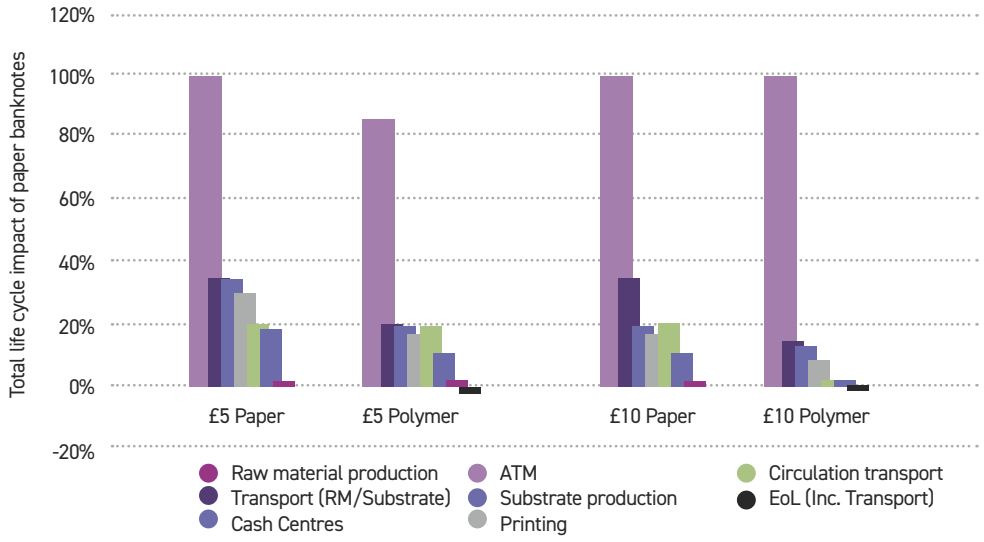
Within circulation, the most significant element is the electricity to power ATMs, responsible for 60% of the total banknote carbon footprint. Transportation accounts for the majority of the rest.

KEY CONCLUSIONS RELATING TO POLYMER AND PAPER BANKNOTES

Production

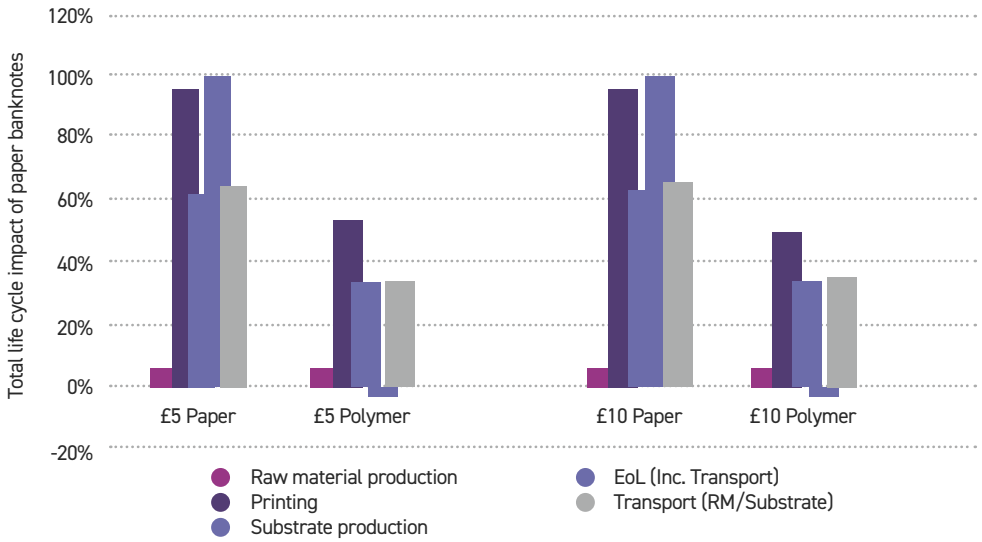
The carbon footprint assessment was based on the provision and use of 1,000 banknotes over 10 years, considering an average bank note life cycle where notes are introduced into circulation through an ATM.

Manufacturing is a small part of the carbon footprint in absolute and percentage terms whether paper or polymer, £5 or £10. The high impact associated with the use of ATMs means that the relative differences between the paper and polymer substrates appear fairly small. The differences are clearer when impacts from circulation are excluded.



Contribution by life cycle stage to global warming potential (fossil and biogenic).

1 Carbon Footprint Asssessment (bankofengland.co.uk)



Contribution by life cycle stage to global warming potential (fossil and biogenic) excluding impacts from circulation.

For a single note, paper banknotes have a lower production impact than polymer banknotes. However, at end of life paper notes are composted, resulting in Green House Gas (GHG) emissions, whereas polymer bank notes are recycled, effectively reducing their GHG emissions.

The better durability and resulting longer lifetime of the polymer notes means that many fewer are required to be produced during a given period of circulation. The study assumed a note life for polymer 2.5 times longer than that of a paper note. As a result, when measured based on functionality, the polymer notes have lower GHG emissions than paper notes. Logically therefore, any solution that extends note life offers similar benefits.

Operations

How often a banknote circulates between issue and destruction is the key determinant of its carbon footprint. The more it circulates, the more often it is transported, sorted and issued, and the more time it spends in ATMs – contributing to power and transportation costs.

	Velocity[2]	Circulations before removal	Total circulation
£5 paper	5.1	4	20.4
£10 paper	1.6	12	19.2
£5 polymer	5.1	8	40.8
£10 polymer	1.6	28	44.8

Life in circulation - paper and polymer £5 and £10 notes. (Note: based on polymer lasting 2.5 times longer than paper notes).

The paper's sensitivity analyses show that polymer £10 notes need last only 6% longer than paper notes to have lower overall GHG emissions. For £5 bank notes no additional lifetime is required.

The GWP for £5 notes is significantly lower than £10 banknotes because they remain in circulation for longer between sorts.

2 Velocity means the time between sorts to check fitness and authenticity by Note Circulation Scheme (NCS) members.

COMMENTS ON THE BANK'S STUDY

The GWP score for a low denomination note that stays a long time in circulation may be lower than the figures suggest, since these notes may be changing hands more frequently than the assumptions used in the study. Low denomination notes, which are used for those small everyday purchases that make up the majority of cash transactions, may, therefore, have a GWP score closer to a digital payment.

Putting to one side other benefits, the lower per note GHG impact of paper notes compared with polymer notes suggests that notes that do not circulate should be made of paper, ie. high value 'store of value' notes. However, on a functional basis, polymer notes have a lower GHG even for high denominations.

Unlike other products, banknotes are not thrown away at their end of life. They are returned to the central bank, creating a near perfect circular economy. This provides the opportunity for banknotes to be managed to minimise their end of life impact, whether made of polymer or paper.

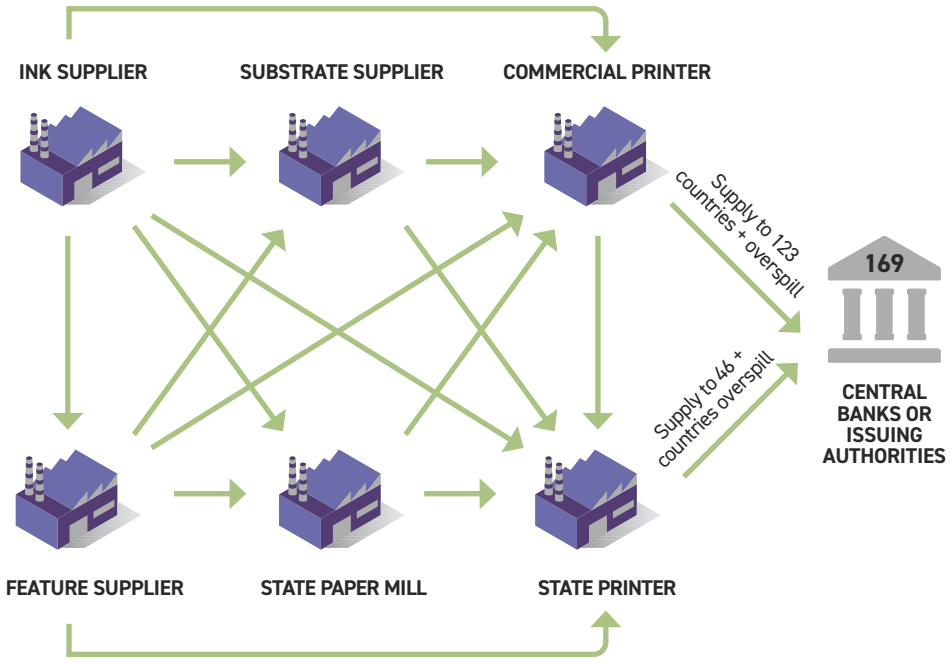
The CFA measures the impact of cotton from farm to paper mill. This follows the best practice of LCA methodologies. It is worth bearing in mind that the cotton used for banknote production is waste material from the textile industry that is unsuitable for making clothes.

6.0 BANKNOTE PRINTING

Banknote printers are either state-owned (by the government or the central bank, and known as SPWs) or privately-owned. The majority of SPWs print only for their own country, although some also operate on the commercial market. The private printers predominantly supply those countries without an SPW, and also undertake overspill work for SPWs.

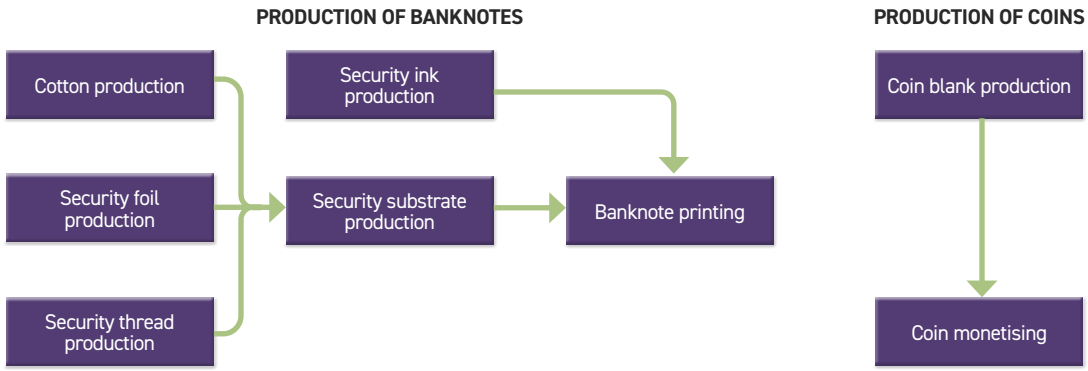
This section reports on work done by banknote printers to reduce their environmental impact. The makers of the printing equipment, security foils and security inks are reviewed in the next section (see page 36).

Currency Supply Chain

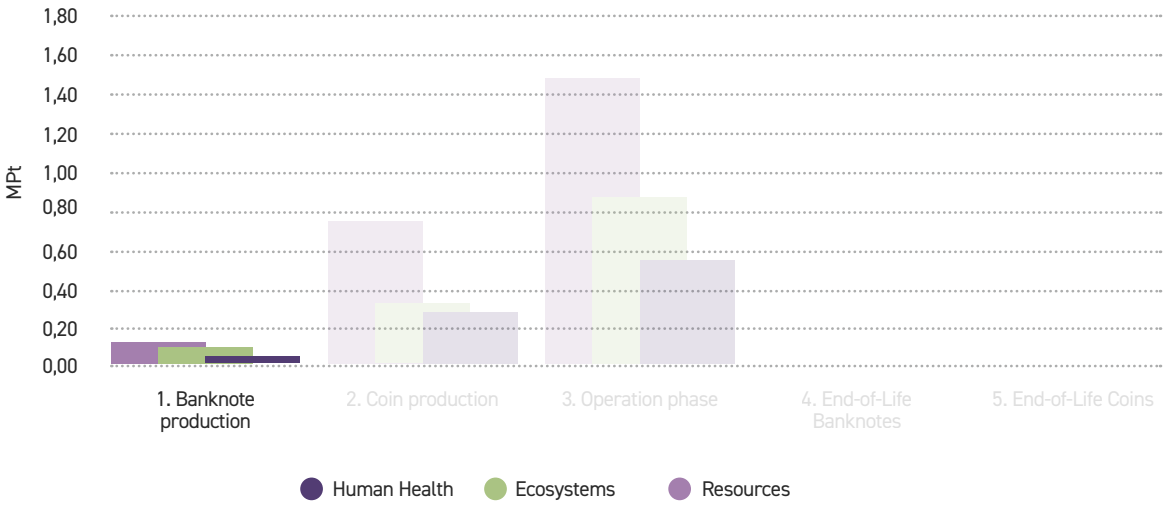


Main Areas of Environmental Impact

- Electricity (MWh)
- Water and wastewater
- Solid waste for landfill



Although the DNB has broken down production into each process step, the ReCiPe endpoint (H) impact method shows that banknote production represents a relatively small proportion of the total.



End-point indicators per sub-system – banknote printing.

Banknote production was responsible for 4% of the cash cycle's CO2e based on the IPCC Global Warming Potential (GWP) methodology.

Outcomes Sensitivity Analysis

SUB SYSTEM	MINIMUM	BASELINE	MAXIMUM
Production of banknotes	0.12 MPt	0.12 MPt	0.12 MPt
Production of coins	0.72 MPt	0.75 MPt	0.85 MPt
Operation phase	1.38 Mpt	1.49 MPt	1.59 Mpt
End of life banknotes	-0.0025 MPt	-0.0025 MPt	-0.0025 MPt
End of life coins	8.6 Pt	8.6 Pt	8.6 Pt
Total	**2.22 MPt**	**2.35 MPt**	**2.56 MPt**

CASE STUDY SUMMARIES

- **De La Rue** – less energy, less waste, carbon neutral banknotes.
- **Crane Currency** – wastewater management.
- **Giesecke+Devrient** – energy generation, Green Banknote project.
- **Oberthur Fiduciaire** – energy management, energy generation, wastewater management, waste recycling, reduced material usage.

6.1 DE LA RUE

Reducing Energy Requirements.

Energy monitoring is used to track the cost per tonne of product output and makes it easier to identify initiatives that will have an impact. The energy used per tonne of output reduced from 3,633 kWh in the financial year 2020 to 3,139 kWh in the financial year 2021. This has been achieved by initiatives such as using sub-metering to monitor energy usage on large process equipment at the Debden print works in the UK (which De La Rue operates on behalf of the Bank of England). This is now being rolled out to all print sites. Automated timers and sensors routinely turn off lights, equipment and air conditioning across sites when not needed.

The Samoan 10 tala, the world's first carbon offset banknote.

Smart building design: is deployed to minimise energy requirements. A 'cool roof' was installed at De La Rue's Malta print works which has reduced indoor temperatures by up to 2°C, consequently reducing the cooling demand for the building. A 'cool roof' is covered with a thermal waterproofing resin membrane to reduce heat intake by 90%. De La Rue has recently announced a major expansion of its Malta site, and this will use materials with heat storage benefits. The recent De La Rue investment into expanding its polymer and security feature manufacturing facility includes the re-commissioning of 569 solar panels.

Replacement or repair/upgrade of older equipment: is routinely carried out to cumulatively minimise energy consumption. In Malta, De La Rue saved approximately 2.5 million kWh per annum due to investment in new chilled water networks, a centralised compressed air system and replacement of old equipment. Energy efficient lighting in Malta reduced annual energy consumption by 630 MWhz, the equivalent of approximately 140 households.

100% renewable power: De La Rue's electrical power sourcing is based on 100% renewable power in the UK. This contributed to a 73% decrease in emissions from electricity consumption at its UK sites in the financial year 2021 from 1,210 tCO2e to 328 tCO2e.

Reducing waste: better segregation of the waste types and improved recycling led to a 2% reduction in the amount of waste sent to landfill across all De La Rue sites. (See the polymer section – page 25 – for information on the treatment of polymer waste).

Carbon Offsetting and Carbon Neutral Banknotes

Since 2019 De La Rue has helped central banks wanting to quantify the impact of their banknotes through every aspect of their lifecycle and offset that impact by investing in a project that meets the Quality Assurance Standard (QAS) for carbon offsetting.

De La Rue's Carbon Neutral Banknote service uses an internationally recognised Environmental Impact Assessment Tool, which aligns to PAS2050 and has been specially adapted to model De La Rue facilities and operations. This tool quantifies the impact of banknotes through every stage of their lifecycle (from raw materials and transport through to banknote circulation and end of life destruction). It enables customers to assess their choice of banknote substrates and security features and quantify the impact of the end-of-life options for their banknotes.

The Environmental Impact Assessment Tool uses Sphera, a provider of data and insight driven software for environmental analysis, and gets background data from the GaBi 2019 database along with its own industry knowledge and experience. It then uses GaBi life cycle assessment software in accordance with the Life Cycle Assessment standard ISO 14040:44. The assessment covers primary factors associated with the lifecycle of the banknotes, such as global warming potential and non-renewable primary energy demand, along with the secondary factors such as abiotic resource depletion potential, acidification potential, eutrophication potential and photochemical ozone creation potential.


carbon footprint

This certificate acknowledges that

De La Rue

have offset 49.2 tonnes of Carbon Dioxide

On behalf of The Central Bank of Samoa

by supporting the VCS (688) certified Indonesia Geothermal Power Project, which will reduce carbon emissions via the displacement of fossil fuels.

This helps to combat climate change and sustain our environment for future generations.

John Buckley, Managing Director, Carbon Footprint Ltd.

www.carbonfootprint.com 01 July 2019

Calculating the carbon footprint
offsetting carbon emissions
helping to combat climate change

In 2019 the Central Bank of Samoa decided to offset the new 10 tala banknote it was issuing to commemorate Samoa hosting the first ever 'green' Pacific Games. De La Rue carried out an environmental impact assessment comparing the current paper substrate with a polymer-based substrate.

After the methodology had been approved via a third party audit, De La Rue then worked with the Bank to identify a bona fide offsetting project, selecting the Wayang Winda Phase 2 geothermal power project in Indonesia. This geothermal power project will create 117 MW of electricity, displacing fossil fuel generated power – making the Central Bank of Samoa the issuer of the world's first carbon offset banknote.

6.2 CRANE CURRENCY

Water Filtration Plant

In 2017 Crane Currency built a new printing plant in Malta. Recently it has invested €2.6 million in a new water treatment plant to purify and recycle the water used to clean intaglio printing plates during the printing process, known as wiping solution.

The solution uses an ultra-filtration process which is wastewater free. The plant uses ceramic membranes that enable very high percentages of wiping solution recovery, while also eliminating the use of chemicals necessary in traditional water treatment plants.

Approximately 500,000 litres of solution are used each week and 98% of this solution is recovered and re-used. The process has an impressive 0% water waste rate, an important benefit since Malta has no natural water resources.

The wastewater treatment plant at Crane Currency's printworks in Malta.

Crane chose this solution because it removes the need for a precipitating agent and the processing of the filtered residue is much easier, avoiding the need to ship it for processing in mainland Europe. The small volume of remaining intaglio solution residue is treated as solid waste and there is interest to use this by-product in asphalt and road surfacing. In time, this volume will be reduced further through a drying process.

The next phase of this project will see the installation of a spray-dryer. This technology enables an 80% volume reduction of waste after the ultrafiltration process. The system uses a spray method whereby the ink sludge is sprayed in an air-heated column and transformed into a fine powder. This process enables a low energy operation to achieve a high reduction of waste volume.

This second phase of the project is expected to be fully operational by the end of 2021.

Other Waste

The factory also creates a small volume of solid waste from the printing operation, for example printed trim and similar. This is rendered non-secure and used locally in animal husbandry applications, eg. animal bedding.

Low Energy Site

Crane's Malta factory was specified to have a low environmental impact. The printing hall was insulated and designed to be energy efficient bearing in mind that the average daytime temperature in August is over 30°C. During a maintenance period the heating, ventilation and air conditioning system was turned off in the print hall for two days. The internal temperature only rose by four degrees from 22° to 26°.

All lighting uses low energy bulbs. The roof top was built to accommodate solar panels and this starts next year.

6.3 GIESECKE+DEVRIENT (G+D)

Print works: Solar Power

G+D has a facility in Malaysia for the production of banknotes and other security documents. At the end of 2020 it installed 4,315 solar panels on the roofs of the factory, in total 1.7 MWp covering an area of almost 9,000 m^2. The power generated supplies 10% of the plant's electricity requirements and contributes to CO2e savings of 638,000 kg each year.

Over the last five years, the CO2e emissions at all G+D`s printing works (besides Malaysia, one is located in Germany) have decreased by 23%. This number also reflects the overall reduction of carbon emissions looking at the whole production of banknote substrates, security features and printing works, which shows a reduction of carbon emissions of 26% over the last five years.


Solar panels on the top of the banknote printing plant at Shah Alam in Malaysia.

The increase of renewable energies in the purchased electricity mix has supported this improvement, but also other efficiency projects implemented in the production sites have contributed to the ongoing reduction.

Environmental protection and the reduction of the footprint is not only based on the reduced and improved use of energy. G+D has always focused on the disposal of the waste generated in the production processes, and no production waste from any G+D site is put into landfill. Some of the waste is even recycled by other companies for construction purposes.

The Green Banknote Project

In 2022, G+D will produce a 'green' banknote, meaning one with a significantly improved carbon and water footprint during its production and circulation lifetime. In a holistic approach, the whole lifecycle of a banknote will be covered. This includes alternative fibres, newly developed inks and other recycled raw materials covering all important value streams of production (substrate, foil and printing). Besides the raw materials, the energy and water consumption in the production is being evaluated. Production is taking place in the existing facilities with existing processes in order to prove subsequent feasibility for customer projects.

		CO2 EMISSIONS SCOPE 1+2 [T CO2]
Area of banknote production (substrate, threads, printing, etc.)	2016	84,078
	2017	79,197
	2018	69,725
	2019	74,806
	2020	61,841

	Amount of self produced electricity from renewable sources (%)	Amount of renewable energies in the electricity mix (%)	Residual material going to the landfill (%)	Waste recycling rate (%)	Water recycling rate (%)
2020	8%	64%	0%	39%	65%

Data for all of G+D's operations – papermaking, security material and banknote printing.

6.4 OBERTHUR FIDUCIAIRE

Oberthur Fiduciaire began a structured approach to limit its environmental footprint and reduce its carbon footprint in 2012 in an initiative termed Earth365.

ENERGY MANAGEMENT

Based on ISO 14064 (scope 1, 2 and 3), Oberthur Fiduciaire reduced its energy consumption from 1,327 tonnes CO2 in 2014 to 450 tonnes in 2020. The company is working to achieve ISO 50 001 certification.

This reduction has been achieved by:

Monitoring the Source of Energy Consumption

- 85% of overall site electricity consumption is now measured including feedback of process values (chilled water, compressed air)
- Investments in over 100 systems and software for monitoring electricity, water, gas, etc.

Adopting Some Quick Win Actions

- Switch to LED lighting
- Replace light switches by presence detection
- Replacement of inverters by new generation

- Suppression of pneumatic agitator on printing by electrics
- Control of the lighting of the aisles of the mobile pallet racks in the strong room depending on their use
- Preventing unnecessary energy consumption by structured processes to find leaks and insulation faults in heat transfer fluid pipes as a daily routine activity by production staff.

Optimisation of Cooling System

Chiller facilities and chilling compressors have been refurbished with new technology developed in partnership with Oberthur Fiduciaire's supplier using ammonia and adiabatic exchanger: the advantage of ammonia is it represents a zero Global Warming Potential, unlike common refrigerant which present a GWP of about 1,774 kg CO2/kg (in the case of a leak). The energy efficiency of the installation is about 20% above the best practice standard.

Heat Recovery

This was implemented on the compressed air infrastructure and chilling compressors which, in 2020, collected 780,000 kw/h and 12,000,000 kw/h respectively, together representing over 7% of the annual energy consumption.

With this investment, when the external temperature is above 8°C, the installation stops consuming gas, with a significant positive impact on Oberthur Fiduciaire's carbon footprint.

Variable Adjustments of Facilities

The buildings and facilities on the site represent 40% of Oberthur Fiduciaires's energy consumption. To reduce this the following actions have been taken:

- **Air treatment:** each of the 20 air-handling units have been adapted to allow the control of speed and fresh air flows according to working status of each piece of printing equipment. Fresh air and air flow rates are automatically adjusted throughout the day.
- **Boiler room:** fixed flow pumps have been replaced by variable flow pumps controlled by programmable logic controllers.
- **Compressed air:** replaced fixed speed ten bar compressors with permanent magnet variable speed (IE 4) compressors and added eight bar permanent magnet variable speed compressors – IE 5 motors.

The result of these actions has been to improve energy performance by 14% over the last four years.

100% Renewable Energy in Rennes

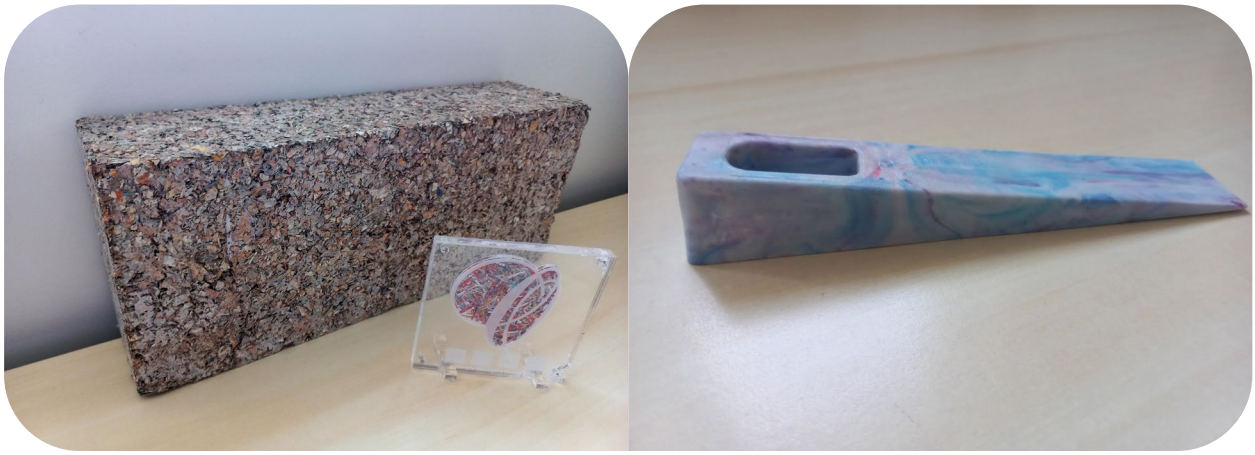
Since 1 June 2020 Oberthur Fiduciaire has been purchasing 100% green electricity from EDF (Electricité de France), part of which is generated by its own 43 solar panels. The energy is generated from a tidal barrage (the company's plant in Rennes in France is about 60 km from the coast).

The impact on this change has resulted in a dramatic reduction in Oberthur Fiduciaire's energy related carbon footprint measured in kgs of CO2/1,000 printed sheets of banknotes produced. Before this change, Oberthur Fiduciaire generated 2.2kgs CO2/1,000 printed sheets produced. After the introduction of tidal barrage generated electricity, its CO2 emissions reduced to 0.45 kgs of CO2/1,000 printed sheets produced. Its banknote manufacturing plant in Rennes is the world's first facility to produce banknotes using 100% renewable energy from the sea.

Oberthur Fiduciaire has a second banknote manufacturing plant in Sofia in Bulgaria. Since January 2021 it has been powered with hydroelectricity.

Energy Reduction

UV drying is an important part of the printing process, but is energy intensive, representing 10% of the manufacturing plants energy consumption. Oberthur Fiduciaire has invested more than €2.2 million in activities to reduce this and to find alternatives.



Recycling material turned into paper wedges.

Independent wastewater treatment modules.

WASTEWATER MANAGEMENT

Oberthur Fiduciaire has managed to recycle 100% of its wastewater through a treatment process, saving 1,200m³/year. This has been achieved by:

- Testing 34 solutions to determine the best way to treat wastewater.
- Developing, with a local supplier, a solution to treat the wastewater created by various production processes such as intaglio printing, pre-press preparations, threads and ink production, using evaporation at low temperature without pressure.
- This process was developed and adapted over 2015 and 2016. Oberthur Fiduciaire, and its supplier, created independent treatment modules built like Lego with cleanable filter media beds, which have a unit capacity of 10m³/d.
- The recycled water is demineralised and used in the production process, limiting the residual carbon impact to a strict minimum.
- This installation, which took a long time to develop, has made it possible since 2020 to recycle 100% of the water produced and to generate a very low volume of sludge.

Oberthur Fiduciaire achieved its goal of zero industrial liquid discharge in 2020.

RECYCLING

Oberthur recycles more than 80% of the 4,000 tonnes of waste that it generates each year at its Rennes and Sofia plants. To achieve this, it has set up more than 62 different recycling processes which allow it to avoid CO2 emissions higher than the emissions generated by the ultimate waste.

A practical example of the company's recycling efforts is provided by the paper wedges used in the printing process to keep stacks of paper flat so that they feed efficiently into the printing press. Historically these have been made of plastic. Oberthur Fiduciaire has been focusing on reducing its use of plastic and ran a project to replace its plastic wedges with ones made with recycled waste from its factory.

The project team consciously set out to work with a local young company and to create a low-tech solution. Today waste is collected from the manufacturing plant and transferred to a local factory where it is shredded, mixed and injected into an extruder at a specific temperature. The extruder uses a mould that generates the required wedge shape.

These wedges are used by Oberthur Fiduciaire's production sites, and the rest are sold directly by the local company for a range of other uses.

Oberthur Fiduciaire has developed four other projects of the same type, which now use over 1,000 tonnes of its waste while also strengthening its local industry network.

CUSTOMER ENVIRONMENTAL SERVICE

Oberthur Fiduciaire offers customers a service to help them measure and decrease the carbon footprint of the banknotes being produced for them. Analysis is done, with the customer, of ways to improve the carbon footprint of their banknotes taking into account their requirements. This service involves measuring 347 factors relating to the carbon footprint of banknotes.

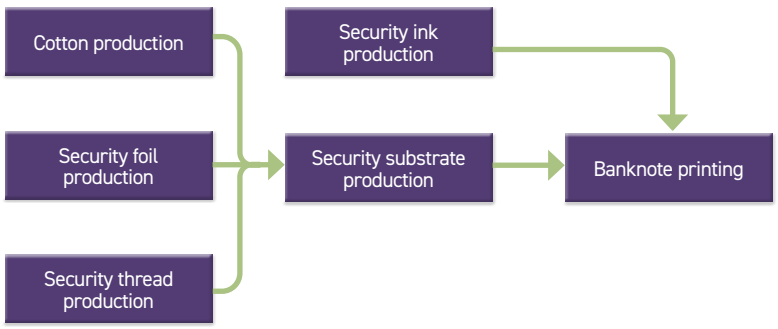
7.0 PRINT: PROCESS, FOILS, INK

This section covers the sector of the cash industry responsible for the printing and finishing equipment that is used to produce banknotes, along with the inks and features such as foils that are applied as authentication and anti-counterfeiting devices.

Main Areas of Environmental Impact

- Electricity (MWh)
- Water and wastewater
- Chemicals, waste and materials

PRODUCTION OF BANKNOTES



Note: Polymer production does not involve security threads.

CASE STUDY SUMMARIES

- **Koenig & Bauer Banknote Solutions** – energy reduction, reduced waste and material consumption, development of an advanced production site.
- **Komori Currency Technology** – eco-factory projects covering energy generation and reduction, waste reduction, water conservation.
- **KURZ** – energy generation, energy and materials reduction.
- **Luminescence** – move to multi-use cleaning materials.

7.1 KOENIG & BAUER BANKNOTE SOLUTIONS

Koenig & Bauer Banknote Solutions, part of the Koenig & Bauer Group, has been providing end-to-end systems for banknote production since the 1950s. Its hardware and software covers design, origination, pre-press, printing presses, along with application, finishing and packaging equipment. Its head offices are located in Lausanne, in Switzerland.

Energy reduction

Reduction of electricity consumption: intaglio printing requires a wiping solution, which needs to be pre-heated before it can be used. In the other part of the intaglio printing process, some parts need to be cooled down using thermoregulation. To save and reuse energy, a synergy has been created between thermoregulation and the supply of wiping solution using a PowerSave Unit. Thanks to this solution combined with compressed air, Koenig & Bauer is able to save approximately 83kW per hour.

If all intaglio printing presses used this system, the carbon footprint of banknote printing could be reduced by approximately 45,000 tonnes of CO_2 per year.

Replacing UV drying lamps by LED: to cure inks during or at the end of the printing process, presses are usually equipped with conventional UV lamps. Koenig & Bauer offers UV LED instead. As a result, no air extraction is needed, and energy consumption is reduced by approximately 45% per machine.

Additional benefits are that UV LED lamps have a much longer lifetime and do not contain mercury or produce any ozone.

If all Koenig & Bauer customers used this new LED technology, CO2 emissions would fall by approximately 10,000 tonnes annually.

Reduction of Waste and Materials

In pre-press, intaglio platemaking uses toxic compounds at several steps of the process with nickel and chromium baths. A new solution, PlateCoat, avoids the production of harmful hexavalent chromium through the use of a vacuum deposition unit based on PVD (physical vapour deposition). It also uses less energy than the previous approach.

Reduction of Waste and Resources

A special recycling process allows the reuse of wiping solution consumed during intaglio printing. The latest generation of AquaSave II DEC has a recycling rate of 90% and significantly reduces the consumption of chemicals. As an example, the filter aid perlite consumption is reduced by over 90%.

To optimise the use of resources, including inks, Koenig & Bauer has developed technology that reduces ink consumption by up to 25%. It matches the paper to the length and position of the printing plate, optimising ink usage. The chablon size, being in direct link with the ink consumption, can be drastically reduced without altering the printing quality.

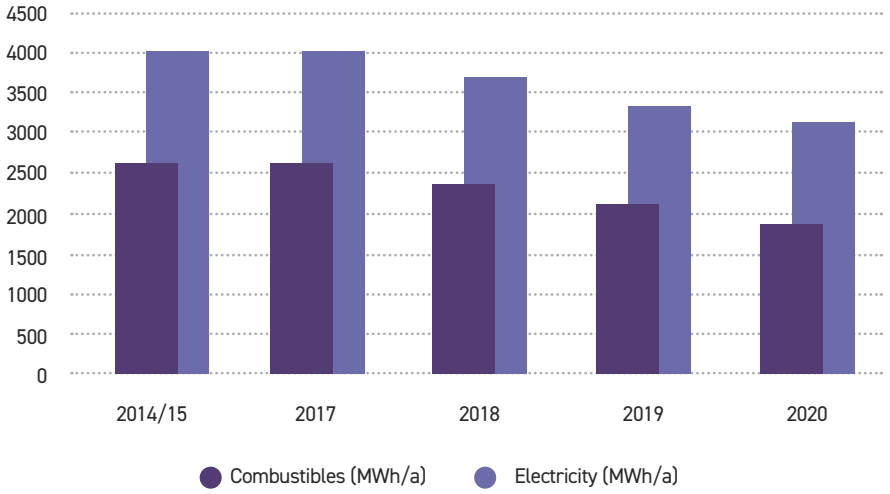
If all intaglio presses were fitted with this technology, the savings would be about 2,500 tonnes of ink a year while preventing 5,000 tonnes of printing waste, and its associated CO2.

A current project will allow ink to be applied only where it is needed, reducing ink consumption by as much as a further 25%, a total of 50%.

Environmentally Friendly Premises

In 2009 Koenig & Bauer built a new facility in Lausanne, which was designed to be environmentally sensitive. The building has:

- A green roof, allowing bio-diversity, cooling of the building and absorption of rainwater.
- A free-cooling system that uses cold air from outside when temperatures are sufficiently low to generate cool air for the building.
- A mechanical ventilation system that uses air from outside. Through a light well, air is aspired in the building and is used for ventilation.
- A city district heating system that provides hot water (mostly produced by an incineration plant) which heats the building. Thanks to a double absorption system, the hot water is also used to produce cold water needed for the pre-press area, as well as air conditioning for the production sections.
- A staff mobility plan promotes the use of train and bus transport paid for by the parking fees of employees coming to work by car. The company participates in the Bike to Work initiative.
- Green electricity comes from local hydro-electricity plants.



Lausanne building electricity and fuel consumption over the last five years.

7.2 KOMORI CURRENCY TECHNOLOGY

Komori Currency Technology is part of the Komori Group, the world's largest privately-owned manufacturer of printing presses. These include security printing presses, which are produced at the company's principal production facilities in Tsukuba, Japan.

Energy Generation and Reduction

The roof of the Tsukuba production plant, about the size of a football pitch, has solar panels, with a capacity of approximately 500 kWh. In 2018 nearly 610,000 kWh was generated and used within the factory and offices. In 2019 the figure was 590,000 kWH and 270 tonnes of CO2 was reduced.

In December 2018, the plant's air conditioning system was upgraded to use air-cooled heat pump chiller units, which were certified by Japan's Ministry of the Environment as having the highest level of energy efficiency. The impact has been to reduce how much gas was used by 35%. In addition, the volume of water used during the summer months was reduced by a third.

Solar panels on the 'football pitch-size' roof of Komori's Tsukuba plant in Japan.

As a result of these two investments, the entire Komori group across the globe reduced CO2 emissions by approximately 965 tonnes in 2019.

Water Conservation

Devices for water conservation have been installed on all plumbing fixtures that use domestic water (toilets, sinks, showers etc). These devices reduce the amount of water used by installing them on the faucets. When the fixtures are used, the devices adjust the rate of flow using water pressure.

Waste Reduction

Komori has reviewed the recycling process for all industrial waste and materials at Tsukuba, leading to improved separation of waste. In 2018 Komori reduced 1,105m^3 of water resources and in 2019 14,182m^3 , a 15.3% decrease year-on-year.

Komori has achieved zero industrial waste emissions at all of its production sites since 2004.

Komori has turned waste into valuable materials and strengthened the separation of its waste, while also continuing its efforts to achieve zero emissions (zero waste for final disposal at a land fill). As a result, it generated proceeds amounting to 11 million yen per year in waste-related costs in fiscal 2018.

Eco-Products

Komori estimates that around 95% of the environmental impact of printing machines come from their usage.

Manufacturers and users can reduce the impact of their presses and equipment through continuous assessment, diligent manufacturing and by introducing technology which reduces the impact which print has on the environment. Technologies are available to reduce make ready times, reduce paper waste and cut the use of VOCs (Volatile Organic Compounds) from printing operations. For example, since 1982 the dampening systems on Komori offset presses allow alcohol free printing in most instances and this reduces 10-15% of alcohol compared with presses that are not alcohol free.

Pollutant Release and Transfer Register

In fiscal 2018, Komori's emission and transfer volumes of substances subject to Japan's Pollutant Release and Transfer Register (PRTR) law had decreased by 36.5% year-on-year to 3,979 kg. This compares to just below 8,000 kg in 2016.

7.3 KURZ

KURZ provides foil-based banknote security features and technology to over 80 central banks around the world and its products are used on more than 300 different banknotes.

In 2014, an energy management system certified to ISO 50001 was integrated into the existing environmental management system. Photovoltaic systems were installed on the roofs of the KURZ German production sites in Fürth and Sulzbach-Rosenberg. Today, 100% of the electrical energy at KURZ Germany already comes from renewable sources.

KURZ's ground-mounted open-space photovoltaic system will provide energy for its Sulzbach-Rosenberg site.

Green Energy

In order to move another step closer to the goal of a CO2-neutral production process, KURZ has invested in the expansion of self-used photovoltaic systems at its Sulzbach-Rosenberg site, its production facility in Germany accredited by central banks for banknote foil production. A new ground-mounted open-space photovoltaic system is currently being built covering about 8.5 hectares. It will cover a significant part of the electricity demand at the production site (20-25%). This corresponds to CO2 savings of 6,100 tonnes per year.

Saving Resources Through Optimal Use

KURZ also optimises its thermal exhaust air purification systems. For example, by adjusting the volume flow rate to an optimal operating point or by regulating the temperature through the maximum allowed NO (nitrogen oxide) threshold, natural gas can be saved. A positive 'side effect' of this is a reduction in how much energy is used.

Less air exhausted results in a higher solvent concentration. The solvents are used to generate their own energy and heat and as a result less natural gas is required in the incineration plant (RTO[1]). For every 1,000 m^3 of unpolluted exhaust air saved, 2 Nm^3 of natural gas and thus 5 kg of CO2 is saved.

KURZ has reduced its requirement for compressed air in its production processes by replacing inefficient pneumatic drive systems. It has changed its UV high-pressure lamps to UV LED lamps, as well as introducing LED room lighting. It has installed charging stations for e-vehicles. The savings from this change are still under evaluation.

R&D for Reducing the Carbon Footprint

KURZ is working on a number of projects to reduce its carbon footprint, for example, by using even thinner PET carriers. Investigations into the recyclability of PET substrates are currently underway in order to open up new opportunities for use. Alternative carrier materials from renewable sources are also being researched regarding process suitability and application. As a partner to central banks, printers, and substrate manufacturers, KURZ itself is working also on ongoing projects to reduce its carbon footprint.

7.4 LUMINESCENCE

Luminescence Sun Chemical Security (Luminescence) is part of Sun Chemical/DIC - the world's largest manufacturer of inks, pigments and coatings. Its headquarters and production facilities are located in Harlow in the UK, and it also produces banknote inks at its euro-accredited facility in Thourotte, France.

1 Regeneration Thermal Oxidisation

Luminescence Harlow		Energy (MWh)	CO2 emissions scope 1+2 (tCO2)
Base line year: Nov 2019-Nov 2020	2019	No Data	No Data
Area of banknote production (substrate, threads, printing,etc.)	2020	90	18

	Amount of self produced electricity from renewable energy(%)	Amount of renewable energies in the electricity mix (%)	Residual material going to landfill (%)	Waste recycling rate (%)	Water recycling rate (%)
2020	0%	98%	16%	85%	0%

Site data: Harlow

SunChemical Thourette		Energy (MWh)	CO2 emissions scope 1+2 (tCO2)
Area of banknote production (substrate, threads, printing,etc.)	2018	43.82	9
	2019	15.1	3
	2020	10.6	2

	Amount of self produced electricity from renewable energy(%)	Amount of renewable energies in the electricity mix (%)	Residual material going to landfill (%)	Waste recycling rate (%)	Water recycling rate (%)
2020	0%	17%	0%	24%	100%

Site data: Thourotte. The Thourotte site uses significant amounts of electricity generated by nuclear energy, hence the low % of renewable energy used.

Luminescence's move to multi-use cleaning materials which can be laundered has cut 23.1 tonnes per year of incinerated waste, saving 500 kg CO2.

The Problem

Due to the nature of the products that Luminescence manufactures, the cleaning of mixing vessels, utensils, and other manufacturing equipment is carried out by hand. Luminescence would buy in 'rags' consisting of cotton-based clothing items that had been cut down into a convenient cleaning size and shape, shrink wrapped into 10 kg packs, then shipped to site on pallets. These bulk packs weighed 750 kg.

The rags would be saturated with cleaning solvent and used to clean the ink off the surface of the manufacturing equipment. Once used they would be deposited in a flame-proof container. These containers would be picked up bi-weekly by a licensed waste handler who would take them to a waste handling centre where they would be disposed of by incineration.

The rags were found to be inefficient for cleaning, as they quickly became saturated by ink. There was also 5-10% wastage because some of the rags were not suitable for cleaning as they left a high level of lint on the surface of the manufacturing equipment. The rags generated 23 tonnes of waste per year, which in turn created 0.42 tonnes of CO2. The preparation, packing and shipping of these rags also generated additional CO2.

The Solution

Luminescence engaged the services of Lindstrom Ltd to supply a laundered cleaning cloth service. Lindstrom supplies the cloths and, once used, collects and launders them. Once clean, the cloths are returned and reused.

This service has many advantages in comparison to the previous process, namely:

- The cleaning cloths are designed to work in the company's manufacturing environment, which means that one cloth gives the cleaning performance of three or four of the old style rags[2].
- All the cleaning cloths are reused and can be laundered and re-used multiple times.
- Lindstrom are ISO 14001 certified. Their laundry system has been developed to be extremely efficient.

What has been Achieved

By using a laundered cleaning cloth service, Luminescence has:

- Reduced its waste by 23 tonnes per year.
- Reduced CO2 emissions by 0.42 tonnes. This is equivalent to 250 CO2 fire extinguishers, or a petrol motor car being driven for three months.
- Improved its cleaning efficiency, which has shown a reduction in the amount of cleaning solvent used.

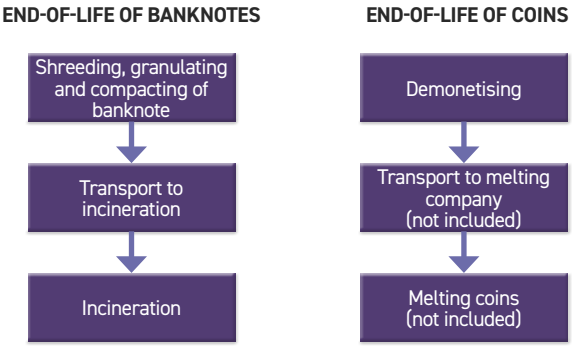
2 https://lindstromgroup.com/uk/printers-cloths-and-wipers/?_ga=2.118190602.2095399485.1632730509-1415546029.1631366101

8.0 END OF LIFE – NOTE AND COIN DESTRUCTION

Secure destruction of banknotes and coins – either waste from production or, once in circulation, when they reach the end of life – is a key part of the cash cycle.

Main Areas of Environmental Impact

- Electricity (MWh)
- Disposal of waste material



The typical lifespan of banknotes varies widely – anything from a few months for low denomination heavily used notes to several years for high denomination rarely used notes. Banknotes reach the end of life when they are no longer fit for circulation, or if they are being demonetised. When they have reached their end of life, banknotes are either incinerated, sent to landfill or recycled into other products.

Coins have a much longer lifespan – many years if not decades – and rarely return from circulation. Their end of life is generally due to demonetisation or defects. And when they are taken out of circulation, they are melted down and the metal recycled.

Using the euro as an example, if banknotes are considered unfit by DNB, they are instantly shredded. The shredded banknotes are granulated, compacted, and delivered in bags of 600 kg. The banknotes are then transported to a municipal solid waste incinerator and the banknotes are incinerated with the rest of the garbage.

The data about the net energy gained from burning one tonne of waste was collected from a municipal waste incinerator. This amounted to 1,800 kWh per tonne. The total thermal and electric energy consumed during this process per tonne of waste is 0.142 MWh per tonne for electricity (14 MWh total) and 0.433 MWh per tonne for thermal energy (45 MWh total) (European Commission, 2006).

For coins, only a very small number need to be destroyed or demonetised. Once a large number of coins have been demonetised, they are transported to a melting company. The DNB's LCA does not take the impact of melting into account because the metal is not reused for the production of new coins but for other products. Therefore, resulting impacts should be accredited to the production of the future products (see page 11).

Outcomes Sensitivity Analysis

SUB SYSTEM	MINIMUM	BASELINE	MAXIMUM
Production of banknotes	0.12 MPt	0.12 MPt	0.12 MPt
Production of coins	0.72 MPt	0.75 MPt	0.85 MPt
Operation phase	1.38 Mpt	1.49 MPt	1.59 Mpt
End of life banknotes	-0.0025 MPt	-0.0025 MPt	-0.0025 MPt
End of life coins	8.6 Pt	8.6 Pt	8.6 Pt
Total	**2.22 MPt**	**2.35 MPt**	**2.56 MPt**

WHAT HAPPENS TO A BANKNOTE AT THE END OF ITS LIFE?

Data on how central banks dispose of their banknotes is hard to obtain. However, a 2021 survey by De La Rue of 43 issuing authorities and printers showed that:

- **38%** sent to landfill.
- **17%** incinerated.
- **30%** locally recycled or moving towards local recycling.
- **5%** had a new series and had not yet accumulated enough waste to warrant destruction.
- **9%** selected 'other' as their response (this may include compositing, which is known to be used for paper banknotes at the end of their useful life).

CASE STUDY SUMMARIES

De La Rue – modelling of the impact on carbon footprints of different disposal options at the end of banknote lives.

Hunkeler – eliminating on-site movement at Landqart, reducing HGV movements in Madagascar, managing and reducing energy usage in Democratic Republic of Congo.

8.1 DE LA RUE

De La Rue has been disclosing its carbon impact to the Carbon Disclosure Project since 2011 and utilises a data-driven approach towards minimising its year on year environmental impact.

Carbon Footprint Modelling Results

Using its extensive lifetime data from around the world, De La Rue has modelled the CO2e/kg for the lifecycle of different banknote denominations when produced on polymer or paper substrate. The results found:

- Across all options landfill is, by some margin, the worst option for disposal.
- For paper, composting[1] offers the best solution.
- For polymer, recycling offers the best solution.

The results were calculated by looking at a million notes of a low value denomination, a mid-value denomination typically used in an ATM and a high value note which hardly circulates.

Statistics for Three Average Denominations

BANKNOTE TYPE	BASELINE	OPTION 1		OPTION 2	
	Initial baseline carbon footprint (assumes landfill)	Changing to paper composting and polymer blended recycling	% Change vs Baseline	Changing to paper composting & polymer recycling as monomaterial	% Change vs Baseline
High usage paper note	142,483	136,774	-4.0	Same as option 1	Same as option 1
High usage polymer note	72,686	71,894	-1.1	68,859	-5.3
Low usage paper note	72,736	70,453	-3.1	Same as option 1	Same as option 1
High usage polymer note	36,343	35,947	-1.1	34,429	-5.3

CO2e/Kg (Kilograms of carbon dioxide equivalent).

Composting

Composting is a reasonable solution for paper and is beneficial compared with landfill (-4%). Cotton does not break down in the soil as well as wood pulp paper.

Polymer Recycling

Blended polymer recycling involves mixed plastics and, therefore, only gives an element of credit of around 50% from the European standard on the emissions from plastic waste recycling. Mono-material recycling enables new polypropylene pellets to be made, albeit lower quality, and reused in a circular economy approach for plastic moulding. As they are recycled pellets, they have a lower carbon impact than virgin polypropylene. They represent a carbon impact of -5.2% better than landfill if the manufacturing waste from substrate and end of life banknotes are all recycled.

The full report, including all assumptions and modelling, can be found in the Annex.

See the Polymer section (page 25) for case studies by De La Rue on its recycling work.

8.2 HUNKELER

Hunkeler is a Swiss-based supplier of specialist destruction equipment for high volume high security waste, able to handle cotton or polymer banknotes. It has provided three customer case studies to illustrate reductions in environmental impact at end-of-life.

LANDQART

Landqart AG makes banknote paper and substrate for identity documents for the Swiss government. It has recently invested in new equipment and processes to destroy waste securely.

The new process is significantly more efficient because all process steps are now co-located, meaning paper does not have to be transported between processes. The system is closed with a conveyor belt moving the paper between processes. Previously the roll splitting had been in a different location and the steps were not connected.

1 Banknotes made with cotton substrate can be used as compost on farmland. The Bank of England used composting for its cotton-based denominations. Compost is used as a soil improver, but it also contains some nutrients that can offset the use of chemical fertilisers and thus credit the product system. The nutrient content of compost is dependent upon the feedstock and the composting conditions. Its main benefit is as a soil improver rather than a fertiliser – see page 32, Carbon Footprint Asssessment (bankofengland.co.uk).

A conveyer belt has been installed that puts re-usable shredded material back into the front of the process in a shredded state that is easily dissolvable, reducing energy and time having to re-work the fibres ready for use. This reduces the quantity of new cotton needed. The shredder is 20% faster than previously.

The output from the shredder is compacted into briquettes or into the new compactor and reused as admixtures in the manufacture of other products such as cement.

CENTRAL BANK OF MADAGASCAR

The Central Bank of Madagascar has significantly reduced the number of secure Heavy Goods Vehicle (HGV) movements required for note destruction.

The central bank has installed new medium size banknote destruction equipment at six branches around the country to complement the existing destruction equipment, which is at the central bank's head office site in Antananarivo.

The primary objective of this investment was one of logistics. Madagascar is a large country, almost as large as France. Roads can be in very poor condition so it can take several days to travel to the head office site. This creates a security risk for the vehicles and creates CO2 and pollution from the HGVs. The central bank has, therefore, chosen the strategy of decentralising the processing of banknotes for sorting and destruction.

The central bank had built up a significant backlog of notes awaiting sorting and destruction which was taking up considerable space and creating a security risk. With this new capacity, the central bank is able to clear these notes, making this space available for other uses.

The new systems destroy banknotes at the rate of 250 kg/hour (three of the systems) and 100 kg/hour (the other three systems). These machines are run regularly every week. Although firm figures are not available, this must be saving monthly, if not weekly, movements of secure HGV transportation around Madagascar to Antananarivo, representing a significant environmental benefit.

CENTRAL BANK OF THE CONGO

The Central Bank of the Congo (Democratic Republic) has installed a new multi-stage shredding process in its print works. The equipment uses Hunkeler's Energy Saving System (ESS).

The ESS regulates the performance of pneumatic suction systems according to the prevailing requirements. At 80% air volume a fan requires only 60% of the electrical energy. The mechanical load on the ducts and pipes is comparably low, and so maintenance costs are avoided.

The basis of the ESS is a differential pressure control system where a frequency converter dynamically controls the fan performance. When customers have inline and offline shredding, when both aren't running at the same time the software responds, allowing the ventilator to lower the suction power to an appropriate level. This allows a 20% energy saving.

A VPN links allowing software upgrades, remote equipment monitoring and troubleshooting reducing the maintenance required.

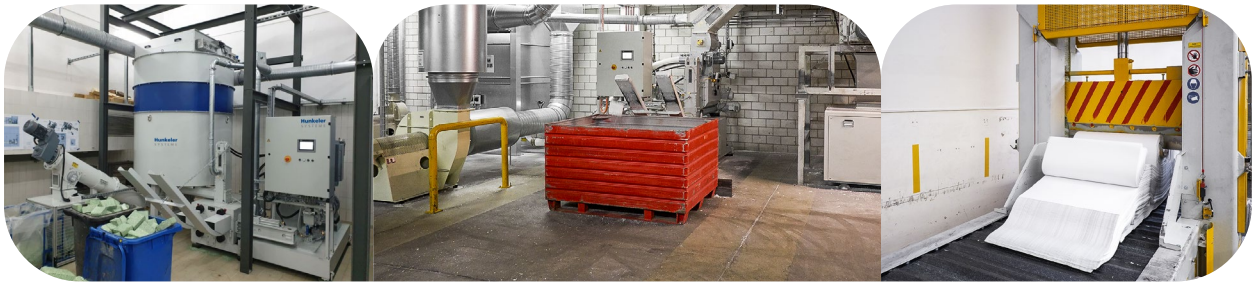
How Energy Can be Efficiently Used – Only Use Energy if Needed

Pneumatic suction systems are a core element of destruction systems of the inline banknote sorters. Usually, they are kept in a state of high readiness and intensively operated. At the start of the working day, these systems need to be started up ahead of the time when operations will start. Similarly at the end of the working period, they require time to 'power down' before being switched off.

Both of these 'warm-up' and 'warm-down' periods use unnecessary, unproductive energy. Hunkeler has developed an automatic switch-off assistant, ASA. It activates a suction system as soon as production starts and automatically switches the system off during breaks and at the end of the day. This allows an energy saving of up to 20%, depending, of course, on the exact set up.

Energy Management System (ESS)

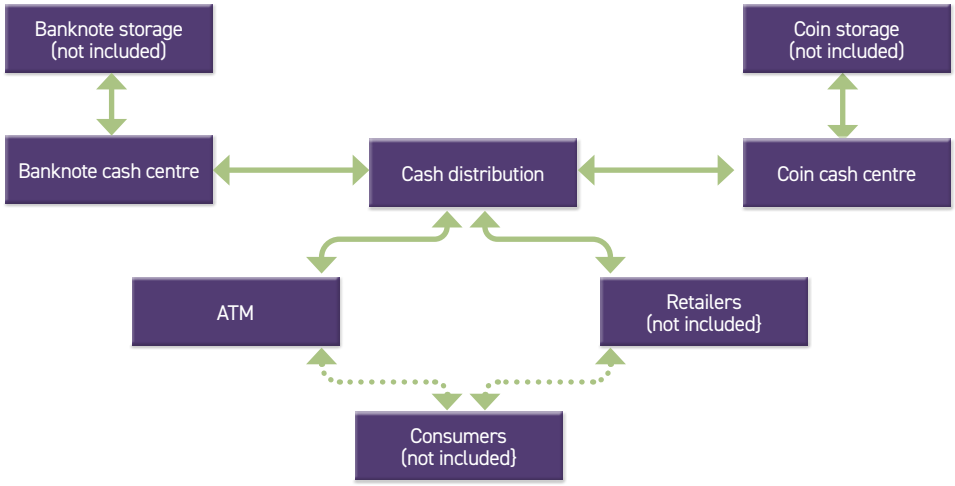
Hunkeler's ESS shows where and how much energy is used in the production system. This data allows an exact usage profile and can be deduced so that energy flows can be precisely managed, resources efficiently used and operating costs accordingly lowered.



9 CASH CENTRE OPERATIONS

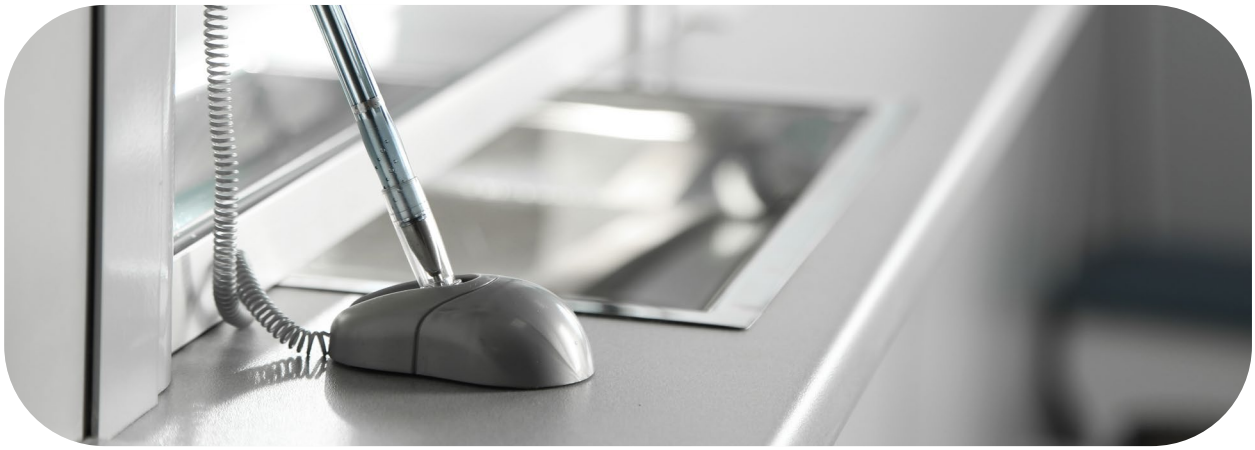
Although the operational phase accounted for 64% of the environmental impact, sorting operations at banknote cash centres (where cash is processed – ie. counted and sorted for fit versus unfit notes before the former are put back into circulation) – use relatively little electricity and cash shipments in and out of their sites tend to be bulk movements.

OPERATION PHASE



Main Areas of Environmental Impact

- Electricity (MWh)
- Plastics



CASE STUDY SUMMARY

Vaultex is one of the four members of the Note Circulation Scheme members in the UK. Vaultex is a joint venture of Barclays and HSBC banks handling all of their note sorting. It is a member of the UK Cash Industry Environment Charter group (see page 56).

Examples of reducing its environmental impact include less waste to landfill, less energy used, and engaging its people in achieving its goals.

9.1 VAULTEX

REDUCED LANDFILL PERCENTAGE BY 13 POINTS IN TWO YEARS

ENERGY CONSUMPTION REDUCED BY 32% IN FOUR YEARS

REDUCTION IN PAPER 25,000 SHEETS OF PAPER SAVED

REPLACING PLASTIC BAGS 215,500 SINGLE USE PLASTIC BAGS A YEAR REPLACED

REPLACING PLASTIC SEALS 430,000 SINGLE USE PLASTIC SEALS A YEAR REPLACED

REMOVING USE OF PLASTIC COATED NOTE WRAPPERS TARGETING SAVINGS OF 4.14 MILLION NOTE WRAPPERS PER YEAR

ENVIRONMENT KEY PERFORMANCE INDICATORS

Percentage of Waste Diverted from Landfill

	2018/19	2019/20	2020/21
Target	70%	75%	80%
Result	68%	80%	81%

The majority of waste consists of plastic packaging that helps keep customer cash safe in transit. The packaging material used is specified not by Vaultex, but by other stakeholders in the cash cycle.

In 2017, the markets for the plastics Vaultex had previously recycled started to close off. As a result, Vaultex struggled to achieve its aim of diverting 70% of all waste away from landfill. Until then it had seen recycling the plastic, or converting it to renewable energy, as the way to avoid landfill and to have the most positive environmental impact. In response to the challenges of recycling, in 2019 Vaultex changed its strategy to focus not on recycling, but on repurposing and reducing instead.

Vaultex has worked with plastic processors local to its sites to ensure that none of its plastic ends up in landfill. It is working with other cash industry stakeholders to develop and trial reusable solutions that avoid the need to use plastic.

Percentage of IT & Telephony Waste Diverted from Landfill

	2017/18	2018/19	2019/20	2020/21
Target	100%	100%	100%	100%
Result	100%	100%	100%	100%

Vaultex has been able to maintain a zero-to-landfill approach for all of its IT & telephony waste since 2016 through its relationship with Tier 1 suppliers. In 2021 Vaultex started working with Revive-IT during the pandemic to repurpose old equipment – such as desktop PCs and keyboards – to aid people in local social mobility cold spots without access to resources for home schooling.

Now that restrictions have been lifted, the PCs have been moved into shared areas of schools – giving even more children access to equipment they couldn't previously access.

Percentage of Energy Consumption Reduction

	2017/18	2018/19	2019/20	2020/21
Target	Maintain	Maintain previous year baseline	Maintain previous year baseline	Maintain previous year baseline
Result (KwH)	0.6% reduction (7,557,839 KwH)	8.74% reduction (6,897,121 KwH)	7.56% reduction (6,449,640 KwH)	8.9% reduction (Year-end October)
Result (Metric tonnes (CO2e))	3,047.150	2,819.92	2,306.26	2,058.43

Vaultex has invested heavily in the infrastructure of its buildings and equipment to improve its energy efficiency. This has included the installation of 'PowerPerfector' technology in its four largest sites. This technology reduces voltage into its buildings and optimises the energy that is used, significantly reducing consumption and carbon emissions.

The introduction of a Building Energy Management System (BEMS) provides real-time data to allow the identification of opportunities to save energy, for example scheduling heating and cooling systems using timers, and identifying downtime when energy-sapping equipment can be turned off.

Vaultex monitors and reports its carbon emissions through the Carbon Disclosure Project. This allows it to monitor its contribution not just as a single entity, but part of its wider supply chain.

Green Path: 'Engaging our People in Achieving Our Goals'

In September 2019, as part of its new focus on reducing waste and finding new ways to improve its environmental impact, Vaultex adopted an approach based on getting its people, the experts that work the processes and handle the materials day-in, day-out, to drive the change.

The impact of allowing people to suggest and make the changes has led to many of the most successful changes that have been made.

1. A team Leader at Kings Cross suggested removing the second ATM countback stickers, which has now led to a reduction in the number of stickers of 619,000 a year.
2. Another team leader suggested removing multiple automatic print-outs that were subsequently shredded or disposed of. The initiative reduced how much paper, ink and energy was used by the printers.
3. Moving to natural rubber for elastic bands, which degrade faster. Vaultex is currently exploring the possibility of a recycling scheme in which one of its partner banks returns rubber bands, so elastic bands are continuously reused in a loop.

Reductions in paper: a coin processor at the Dagenham site had the idea to utilise the 'scan-to-file' printer function for coin route sheets instead of printing them off.

Vaultex had written into its policies that all coin route documentation data should be kept for seven years based on its interpretation of data protection regulations. It was then faced with the problem of online storage capacity for that data. Its internal risk department concluded that rather than adopt the maximum requirement, keeping data for seven years, one year was sufficient.

The next challenge was how to create an IT solution which moved from paper storage to online storage without taking up too much storage space and without adding administration tasks which would require more staff. The solution was to use the 'scan to file' printer function and to automate this so that it moves coin route sheets from their scan to file location to an online archive after three months, and then deletes those documents after the 12 month retention period.

After an initial trial period in Dagenham, this approach was rolled out to all sites in January 2021, saving 25,000 sheets of A4 paper a year.

Replacing plastic with reusable cloth bags: Vaultex's internal processes used a significant number of single use plastic bags for workstation coins. The bags would be sealed, transferred from the cash centres to their accompanying coin departments, opened and emptied before being thrown away.

A Bristol cash processor suggested introducing a reusable cloth coin bag for these internal transfers. The Bristol site researched and assessed a solution from a supplier, 'The Clever Baggers'[1], before running a small pilot. The solution was:

- 100% cotton (biodegradable, compostable material).
- Able to hold around 10 kg of coins with a drawstring which would close the bag and hold at any angle.
- Available in a variety of colours to enable different cash centres to be identified when there was more than one cash centre's coin coming into a coin centre.

Whilst the move from single use plastic bags to reusable cloth bags created a small cost saving for Vaultex, it needed to get the initial investment right. As a base rate the project team recommended that centres ordered a minimum of two days worth of bags. However, the final number was left to centre manager's discretion based on their:

- Volumes
- Potential delays in processing due to unforeseen circumstances
- How often as a site they would be able to washing the bags
- Potential for human error (cut or ripped bags).

Some of Vaultex's coin centres were geographically separated from the cash centre, so there was the challenge of how the reusable bags would be returned to the originating cash centre. An agreement was reached with the carriers that the bags could be returned on existing transport runs. This created the problem if there was one coin centre receiving coin bags from two cash centres, how did Vaultex staff differentiate how many bags originated from which cash centre without the use of seals and barcodes? This was overcome by using different coloured bags for different sites.

The change, which was implemented in August 2020, has resulted in a saving of 215,500 single use plastic bags a year, equating to 3.75 tonnes of plastic.

Replacing plastic seals with padlocks: every time a Vaultex cashier moves away from their workstation they must ensure their cash is secure. Historically, padlocks with keys were used, but due to problems with lost keys or forgotten padlocks, one time plastic seals were introduced. As part of the Green Path initiative, many cashiers reported the significant number of plastic seals used in a day and the need for a better solution.

Returning to reusable locks was the answer, but with the challenges of overcoming the historical problems and implementing the change across the entire business.

Vaultex has invested in numerical padlocks for every cash processor. To avoid the issue of forgotten numbers, a central log of numerical passcodes is kept and can be accessed by a number of representatives across each centre.

This apparently small internal change has made a massive impact, saving 430,000 single use plastic seals a year, equating to 2.6 tonnes of plastic. Aside from the significant environmental benefit of the change, it also saved Vaultex an average of £15,000 a year – money that can now be reinvested back into environmental initiatives.

Removal of note wrappers: the Green Path initiative led to a project to reduce how much plastic was used to wrap cash. The initial project evolved to see how it could remove note wrapping plastic altogether without affecting service quality or the presentation of cash to the end customer. Brainstorming, scrutinising each step of the process and then testing took place before Vaultex's partner banks were approached and a trial was arranged with its Leeds site.

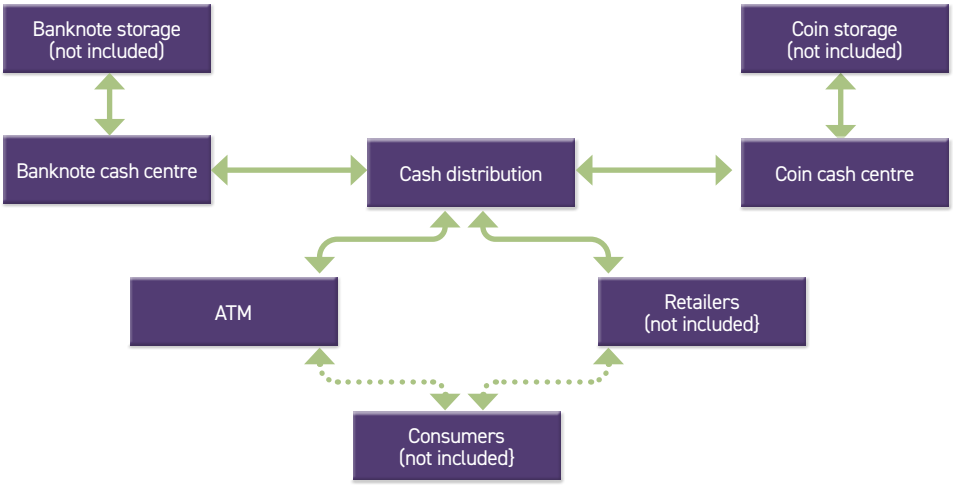
The pilot identified that thicker elastic bands would remove any doubt that cash bricks would stay intact in transit. The pilot was then extended, before being rolled out nationwide. Since 12 July 2021 all of one product type belonging to one of its partner banks have been without note wrappers. This has the potential to save 4.14 million note wrappers per year.

1 The specific bag used by Vaultex can be found here: Black Cotton Drawstring Bag 25x36cm | Drawstring Packaging Bags | The Clever Baggers

10 CASH MANAGEMENT OPERATIONS

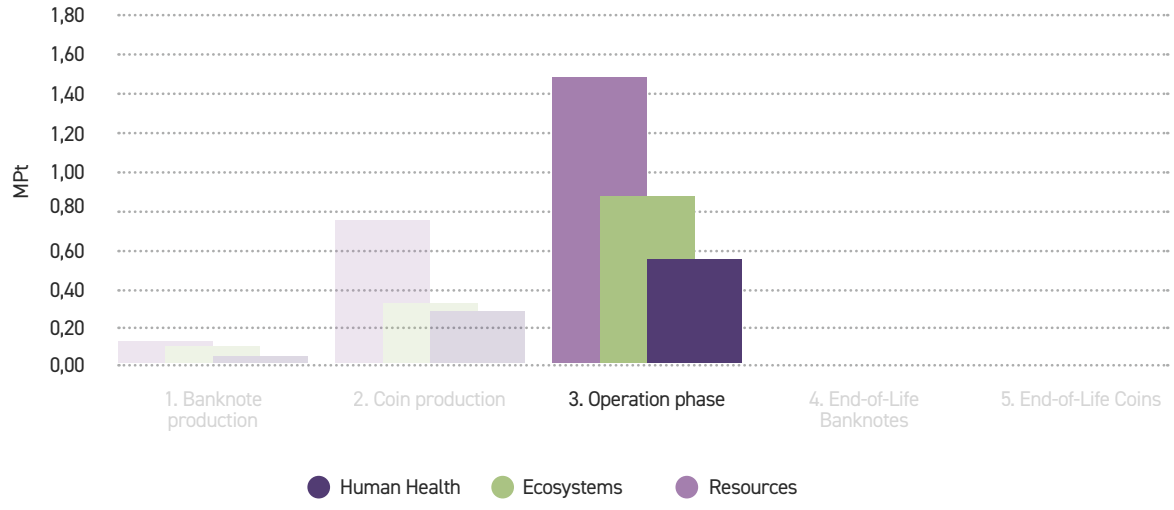
The operational phase of cash (distribution, processing, storage, recirculation) accounts for 64% of the environmental impact. Operations are responsible for 1.49 MPt and have the largest impact on climate change (88%), with transport and ATM electricity the main contributors.

OPERATION PHASE

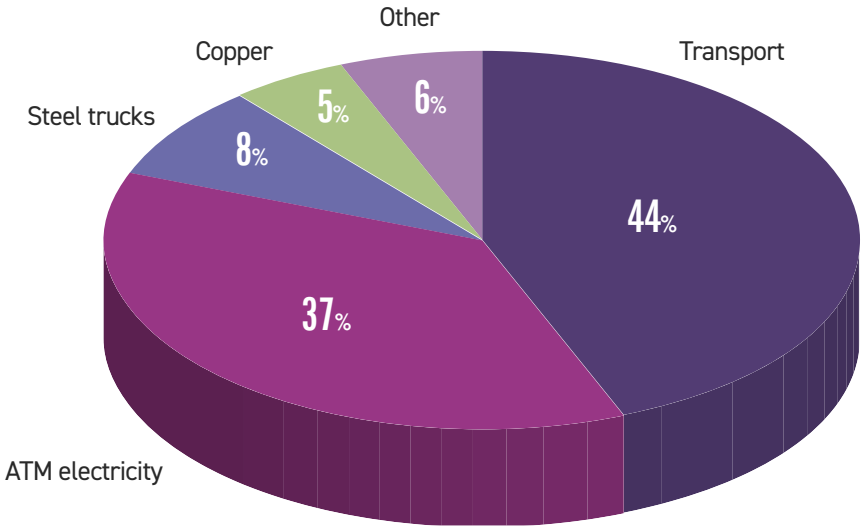


Main Areas of Environmental Impact

- Direct CO2 emissions (tonne)
- Electricity (MWh)
- Plastics



End-point indicators per sub-system.



CASE STUDY SUMMARIES

- **Loomis** – between 2017 and 2020 Loomis has reduced direct CO2 emissions by 8%, plastic bag usage by 19% and reduced energy consumption by 29%.
- **G4S** – reduced fossil fuels.
- **Post Office (UK)** – reduced fossil fuels, reuse of elastic bands.
- **Prosegur** – carbon offset.
- **Bangko Sentral ng Pilipinas** – reduced emissions.
- **Diebold Nixdorf** – reduced ATM impact, operational and supply chain improvements.
- **Glory** – new product development. waste reduction, reduced CO2 emissions.

Outcomes Sensitivity Analysis

SUB SYSTEM	MINIMUM	BASELINE	MAXIMUM
Production of banknotes	0.12 MPt	0.12 MPt	0.12 MPt
Production of coins	0.72 MPt	0.75 MPt	0.85 MPt
Operation phase	1.38 Mpt	1.49 MPt	1.59 Mpt
End of life banknotes	-0.0025 MPt	-0.0025 MPt	-0.0025 MPt
End of life coins	8.6 Pt	8.6 Pt	8.6 Pt
Total	**2.22 MPt**	**2.35 MPt**	**2.56 MPt**

Relative contribution to total CO2 equivalents per unit process.

10.1 LOOMIS

Loomis carries out cash-in-transit (CIT) and cash management operations in 24 countries in Europe, the Middle East, Latin America and the US. Across the board reductions have been achieved.

CO2 EMISSIONS	2017	2018	2019	2020	Target 2021
Changes in direct CO2 emissions/ operating volumes (Scope 1)	156,124 tCO2e	-2%	-5%	-8%	-30%
Fuel consumption/km	0.22	0.21	0.21	0.21	Decrease
Share of fleet with telematic software	20%	27%	76%	68%	100%

PLASTICS	2017	2018	2019	2020	Target 2021
Change plastic bag volume, in thousands, kg	1,810	-9%	-22%	-19%	-30%
Share recycled/non- fossil plastic in safety bags	5%	10%	24%	33%	60%
Share sorting plastic at source	7%	10%	16%	17%	Increase

SMART ENERGY SOURCING	2017	2018	2019	2020
Average energy consumption kWh/m^2	-	167	118	119

Hybrid and Electric Vehicles

- 12 ECO hybrid armoured vehicles were introduced in Spain. Results were a 25% reduction in CO2, 23% less fuel used and 10% less maintenance required. A fully electric zero emissions armoured car is being trialled in Germany. More vehicles are now planned for Europe, starting in Portugal.
- A fleet optimisation policy, introduced in Spain in 2019, increased vehicle occupancy and is now being introduced elsewhere.
- Loomis UK will release hybrid vehicles into its fleet in October 2021. Work is underway to release fully electric CVIT vehicles during 2022. Solar panels on vehicles are being introduced to optimise systems battery performance, eliminating the need to plug into mains overnight.
- Since 2017 Loomis UK has been working with its manufacturers towards changing its CVIT/ATM fleet to lighter 3.5 tonne, and under, vehicles which are up to 22% more efficient in fuel consumption.
- All vehicles within the Loomis UK fleet have been fitted with telematics since 2017 with a reduction in idling of 7% and an overall fuel reduction of 6.1%.

Renewable Fuel

If standard diesel is replaced with 100% hydrogenated vegetable oil (HVO), or at least a high percentage of HVO, CO2 emissions can be reduced by as much as 80%. Where HVO 100 is available, this is the fastest way to reduce CO2 emissions. Unfortunately, it is not widely available outside of Scandinavia. One company has extended its use of HVO 100 beyond Scandinavia. 7% of its US fuel is now HVO 100 and it has signed a contract in Spain to use it.

Power Usage

- In Brazil 15 sites installed photo voltaic panels, generating 70% of their annual energy requirement in 2020. The 2021 estimate is 95%. As a result, in 2021-23 this will be extended in Europe and the rest of Latin America. In addition, the company is developing a control system for electrical and air conditioning installations.
- In 2015 the company started installing LED lighting technology and all lighting will use this by 2023.

Plastics

- In Spain, Portugal and Germany virgin polymer material is being replaced with post-consumption recycled polyethylene (based on European Nature Cycle and Blue Angel certification).
- A sustainability requirement is not part of all European tenders for plastic bags used in CIT services.
- A project has begun to create the first compostable CIT bag which will be made from 100% biodegradable materials. A trial has been successfully completed.
- One company has reduced the number of different plastic bag formats and designs from 106 to 11. It has also specified thinner materials consisting of 80% recycled plastic.
- In the UK, since 2019 all internal cash movements have been carried out using reusable sacks. Customer trials are being carried with customers to allow the use of reusable cash bags. This will reduce the plastic used in the cash collection cycle by 84%.
- A reduction of 50% in cage seal usage in the UK has been achieved during 2021 through procedural changes, with work going on to produce a fully recyclable seal.
- All Loomis UK suppliers are working towards the WRAP 2025 plastic pact commitment.

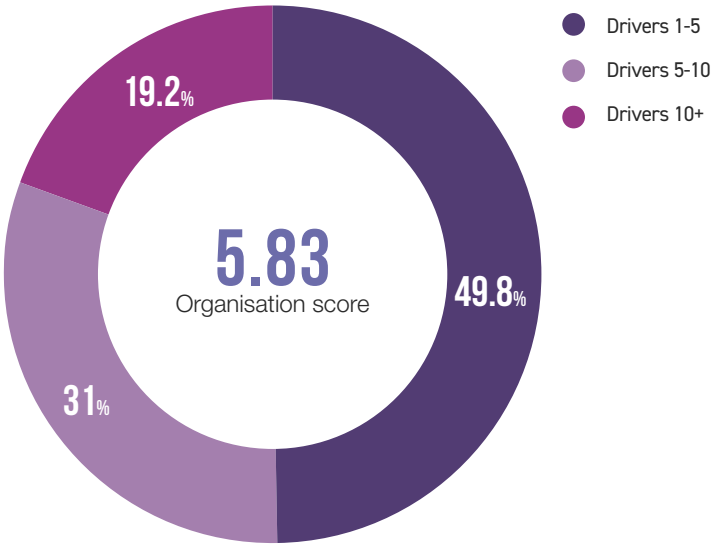
10.2 G4S

IMPACT OF REAL-TIME DATA SYSTEMS

G4S is a CIT and cash management services provider that operates 1,123 vehicles in the UK, largely light commercial vehicles. The nature of the work means journeys are largely urban, 'stop/start' and involving engine idling while cash is off-loaded or picked up. As a result, driver performance plays a significant role in the environmental impact of the vehicles.

At the end of 2019, G4S started a programme to provide training to support the introduction of a real-time data system for drivers, and the business, on their performance, as well as a dashboard and record for their review. The data addresses safety and vehicle management as well as environmental performance, providing a drive score and comparative ranking relative to other (anonymised) drivers and a journey event record and vehicle efficiency score. This approach has been integrated into a review system to encourage continuous improvement.

The result in the first six months was significant. Vehicle idling across the fleet fell 43%, saving two tonnes of CO2e. This was achieved by the number of drivers rated with performance in the top third possible rising from 16% before the programme to 39%. In the first seven months of 2021 idling has continued to fall at the rate of 13% month-on-month, the equivalent of 300 hours per month that no longer sees engines idling, saving 800 tonnes of CO2e per annum. Fuel efficiency has improved 2.4% on a like-for-like basis between last year and this period. Today the number of drivers in the top third has risen from 39% to 49.5%.



RAG Score Allocation

10.3 POST OFFICE

Introduction of Telematics

In 2017/18, the UK's Post Office's cash-in-transit (CIT) fleet recorded an average of 20.6 miles per gallon (mpg). The fleet was equipped with basic telematics used for tracking and vehicle locating purposes. Although drivers were aware of the presence of telematics, there was no direct interaction with the data and no regular means of receiving feedback through the system.

The Post Office introduced the MiX Telematics RIBAS system in 2018/19, which uses a basic in-cab display that highlights incidents of over-revving, excessive idling, harsh braking, harsh acceleration, and speeding. The system alerts drivers to any of these behaviours as they occur, accompanied by an app that gives feedback on their driving style. Management data also means line managers can see performance on a weekly basis and can proactively discuss results with the drivers.

Overall, the cash-in-transit fleet has saved 232 tonnes of CO2 per year. Between 2017/18 and 2020/21, the fleet's average miles per gallon (mpg) improved by 11.8%. Focusing on the pre-pandemic data, the fleet average miles per gallon (mpg) improvement in the year after the RIBAS system was installed was 5.3% with the same set of vehicles. This further improved for 2019/20, giving an overall improvement of 6.3% between 2017/18 and 2019/20.

Further improvements have been evident in 2020/21 with the setting of bonus-worthy objectives for area and shift managers.

CASH-IN-TRANSIT FLEET	2017/18	2018/19	2019/20	2020/21
Annual mileage	4,984,836	5,088,711	4,875,019	4,602,496
Litres used	1,099,808	1,064,906	1,010,308	909,046
Gallons used	241,846	234,247	222,237	199,962
Emissions tonnes	2,852	2,762	2,620	2,358.17
Average mpg	20.61	21.72	21.91	23.02
% Increase in MPG	N/A	5.3%	1.1%	4.9%

Elastic bands

The Post Office re-uses 80 kg of elastic bands each week in the UK. It is starting work with a charity, 'Scrap Store', to provide it with surplus elastic bands.

10.4 PROSEGUR CASH

Prosegur Cash provides CIT, cash management and end-to-end ATM services in 20 countries around the world, including Australia, Indonesia and several countries in Europe and Central and South America.

Prosegur has started a CO2 emissions offset project with the aim of reaching its carbon neutrality commitment before 2040, ten years ahead of the Paris Agreement.

The project aims to reduce emissions of methane, a greenhouse gas 25 times more harmful than CO2, from municipal waste treated at the CTR Santa Rosa landfill in Brazil. This landfill is located in the state of Rio de Janeiro, in the municipality of Seropédica, very close to the city of Rio de Janeiro.

The objective of the CPA-1 CTR of the Santa Rosa landfill is to avoid 50% GHG emissions into the atmosphere by capturing and burning the methane generated by the decomposition of organic waste from the landfill and generating electricity through it. An important part of the landfill gas is used as renewable fuel for the generation of electricity from waste from the municipalities of Rio de Janeiro, Seropédica and Itaguaí.

So far, this project has prevented the emission of more than 2.5 million tonnes of CO2 into the atmosphere.

Elsewhere, Prosegur Cash operates electric armoured trucks in Germany and hybrid armoured trucks in Spain. It is now using compostable plastic bags in Europe. It has reduced fuel consumption per km of its armoured vehicle fleet over the last three years by 1.5 tonnes of CO2.

10.5 BANGKO SENTRAL NG PILIPINAS

In October 2020, in response to supply chain issues presented by COVID, the Bankgo Sentral ng Pilipinas (BSP) started a new scheme called the Cash Service Alliance (CSA), open to commercial banks to allow direct exchange of banknotes between them rather than having to source banknotes only from the BSP.

The BSP created an online facility which allowed banks to work together to match excess fit notes held with banks who needed additional notes. BSP introduced guidelines about how this should work. In the first seven months, 130 million notes were exchanged with a face value of P100 billion, representing 33% by volume and 36% by value of the cash needs of the banks.

Between March and May 2021 the Philippines went into another strict lockdown because of the pandemic. A further 44 million notes were exchanged with a face value of P34 million.

CSA has allowed fewer transportation trips to and from the BSP, reducing fossil fuel usage and emissions. In August this year, a fully automated version of CSA was launched, and this has resulted in even better demand and supply matching between banks.

10.6 DIEBOLD NIXDORF

Diebold Nixdorf provides physical and digital payment solutions to the banking and retail sector. It has 31% market share of global ATMs and 1.3 million installed electronic point-of-sale (POS) systems. It works in 100 countries with 22,000 staff.

Reduced ATM impact

Diebold Nixdorf reports that the operations component necessary to keep an ATM network up and running throughout each terminal's lifecycle makes up around 80% of all the emissions generated during the lifetime of an ATM. Modern ATMs are, therefore, designed to have a lower environmental impact.

Diebold Nixdorf's DN Series™ of ATMs is made from recycled and recyclable materials and is 25% lighter than most traditional ATMs, reducing CO2 emissions in the manufacturing, processing and transportation of components and terminals. They use LED technology and efficient electrical systems, allowing up to 50% power savings versus traditional ATMs.

Operational and Supply Chain Improvements

Since 2015, Diebold Nixdorf has reduced more than 16,500 metric tonnes of CO2 emissions. It is working to collect, monitor and report data and use it to drive reductions in emissions and energy consumption worldwide.

Emissions Scope 1	2015 (Baseline)	2016	2017	2018	2019
CO2 (Metric tonnes)	101,839	100,794	96,403	87,127	85,223

It has achieved this through initiatives such as:

- Planting 6,000 trees to offset the paper receipts issued by ATMs. It has worked with Telemark Diversified Graphics (TDG), a long-standing provider of ATM thermal receipt paper, and the Arbor Day Foundation, to plant one new tree for every 115 pounds (52 kg) of paper purchased through TDG. Through this partnership, over 6,000 trees have been replanted, offsetting those used in the production of each receipt paper order.
- In 2020, Diebold Nixdorf's product stewardship programs in North America, Brazil and Germany diverted more than 8,000 tonnes of material from entering landfills by re-using the parts for existing equipment or by recycling the end-of-life materials to downstream recyclers.
- Since 2018, the company has reduced its physical operating footprint by nearly 40% through its real estate transformation efforts and by leveraging remote and flexible work arrangements.
- Diebold Nixdorf is gradually converting the lighting in its production sites and office space to energy-efficient LED lighting. To date, it has installed more than 6,500 LED lighting systems in its global offices and production sites.

Reducing the Cash Cycle Environmental Impact

Diebold Nixdorf has provided suggestions for its customers to reduce their environmental impact based on reducing branch footprints using modern technology. Traditional banking branches are open spaced. At an average 102 kg CO2 emissions per square meter, reducing just one branch from 300 m^2 to 200 m^2 could reduce carbon emissions by more than 10 tonnes each year.

This can be achieved by:

- Using 'ATM as the branch' strategy. In areas where a full branch doesn't make sense, a modern self-service terminal with enhanced functionality can take the place of a traditional teller, providing everything from cash in/cash out to bill paying, money transfers and other complex transactions, perhaps with additional remote services via full-service video capabilities.
- Newer ATMs use technology that requires less energy through LEDs, ambient light sensing, and more efficient modules with smarter power supplies and electronics. Additional new technology can deliver even more contributions to a positive environmental impact:
  - Larger cash cassette capacity lengthens CIT intervals.
  - Improved design such as optimised note paths increases reliability, lowering the average number of yearly interventions per system.
  - Advanced retract capabilities lower or even eliminate interventions needed when customers forget to take their money.
- 'Green Self-Service' allows automated shutdowns during closing hours. In a 300-ATM network, power savings of 687 kWh per year per system can end up saving the same emissions that 4,070 trees can absorb.
- Recycling ATMs create a closed loop cycle in which bank customer deposits can be used to replenish ATMs. The opportunity of in-branch recycling can further reduce CIT stops when cassettes are interchanged between systems in one location. Based on concrete cash flow data of a retail bank, a reduction of 75% in cash replenishments can be realised through the use of cash recycling technology. When ATMs with recycling technology replace standard cash-out ATMs and deposit solutions for cash-in transactions, CIT visits can fall by 156 per year. Based on average emissions of CIT visits, 1,700 kg CO2 can be saved per ATM per year.
- ATMs connected by the (Internet of Things (IoT)) can facilitate faster, more seamless fixes, as service experts can proactively address ATM issues at the individual terminal level using information generated from aggregate fleet data. In 2019, for example, the increased use of IoT in the US enabled Diebold Nixdorf to reduce on-site ATM visits by 60,000, which led to the reduction of 1,500 tonnes of CO2 emissions, based on an average journey of 25 miles/40 km.

10.7 GLORY GROUP

Glory develops and manufactures cash handling machines and systems such as cash management systems, vending machines and automatic service equipment.

New Product Development

The Glory Group set a goal to reduce CO2 emissions by 30% by 2030 compared with its 2005 levels by its products during their use. 22% of its new products released during the fiscal year 2019 were designated as G-Eco products. Its coin and banknote recyclers for cashiers for financial markets use 20% less electricity during operation compared to their predecessors, and achieved recyclable rates of 85%.

As an example, Glory developed its Recycle Jet air duster to remove dust and other contaminants from electronics and precision machinery filled with carbon dioxide (CO2) injection gas recovered as an industrial by-product instead of chlorofluorocarbon (CFC) alternatives. This reduced its Global Warming Potential (GWP) to 1/1,430 of the existing products. It has a reusable and detachable cylinder to minimise waste.

Waste Reduction

Glory has set up a nationwide network of more than 100 service locations so that technical staff can collect used cylinders during routine maintenance work and then send the cylinders to affiliated carbon dioxide filling facilities to be refilled with injection gas. The number of filled cylinders in fiscal year 2019 was about 53,356, reducing CO2 emissions by around 27,745 tonnes.

To use resources more effectively, Glory is:

- Improving production processes and raising parts manufacturing yields
- Reducing the number of manufacturing trials
- Factories and offices are going paperless
- Returnable containers are being used for deliveries from suppliers
- Cushioning materials are being re-used for intra-group parts shipping.

Financial year	Waste volume	% change
2015	2,119	
2016	2,201	-3.9
2017	1,991	-9.5
2018	1,716	-13.8
2019	1,578	-8.0

Overall waste is down 25.5%.

Reducing CO2 Emissions

In the years before the pandemic, Glory had reduced CO2 emissions worldwide by nearly 19%. Actions taken included:

- Installing power monitoring systems (demand monitoring functions)
- LED lighting
- Human detection sensors at business sites to reduce lighting
- Solar power system on the roof of the head office
- Switching transport from trucks to railways and ships
- Lighter weight packing materials.

Financial year	CO2 emissions	% change
2015	16,317	
2016	16,706	+2.4
2017	16,716	+0.1
2018	15,135	-9.5
2019	13,230	-12.6

11 THE ENVIRONMENTAL FOCUS ACROSS THE CASH INDUSTRY

There are a wide range of organisations that represent the cash industry, although no one overarching body. Central banks, mints and government papermills and print works co-operate formally and informally together and with the wider industry, as well as attending and contributing to private sector initiatives and events.

In this section we look at work by an innovative cash sector initiative in the UK, along with manufacturers of banknotes represented by the International Currency Association (the ICA), the International Association of Currency Affairs (IACA), an association that brings together central banks and the private sector, and the ATM International Association (ATMIA).

CASE STUDY SUMMARIES

- **UK Cash Industry** – environmental charter for energy, plastics and carbon emissions.
- **ICA** – sustainability.
- **IACA** – sharing best practice.
- **ATMIA** – increasing circulation, reducing cash movements.

11.1 UK CASH INDUSTRY ENVIRONMENTAL CHARTER

In September 2020 NatWest Bank brought together organisations working across the UK cash cycle to work together to reduce the environmental impact of cash. They proposed a Cash Industry Environment Charter with commitments, targets and a road map of change and this was signed in January 2021. Eight organisations signed the Charter and a further 14 organisations are members of the group.

This industry-wide effort is believed to be unique, demonstrating what can be achieved.

Following a series of follow-up meetings, 36 organisations[1] from across the cash cycle are now working to improve the environmental performance of the UK's cash cycle. In line with the Charter's targets, they are focusing on energy, plastics and CO2 to establish best practice and to drive change.

With UK Finance acting as the Charter co-ordinator, monthly meetings have created a community willing to share data, information and ideas. Here is a snapshot of their achievements.

1 The 'owners' of the UK's cash, the Bank of England and the Treasury, banknote and coin producers the Royal Mint and De La Rue, 13 commercial banks, two retailers, five machine suppliers, two ATM management companies, two cash-in-transit (CIT) companies, four industry suppliers, four associations/media organisations including the British Retail Consortium and UK Finance.

Energy Working Group

The target is to use 100% renewable electricity for own operations by 2022. 10 of the 24 organisations signed up or supporting the Charter have achieved this target. Six organisations have made substantial progress but are not yet at 100%. Data is awaited from seven organisations.

In terms of reducing energy usage, a number of challenges were identified:

- Equipment turnover is low and, therefore, the focus needs to be to work with suppliers on reducing energy usage on existing equipment.
- Environmental requirements often conflict with cost and reliability priorities.
- Security is always the number one priority.

The plan agreed is that in 2021 companies will endeavour to move to using 100% renewable energy for their own operations and work with procurement to encourage their supply chain partners to do the same[2]. By 2024 this should be a requirement on suppliers. In 2021 data should be gathered so that in 2022 energy efficiency standards can be set.

Plastics Working Group

The target is to eliminate single-use non-recyclable plastic in note centres by 2030 (25% reduction by 2023, 50% reduction by 2025). For coins, to reduce the use of single-use non-recyclable plastic, by weight, to less than 45% by 2030 (less than 70% by 2023, less than 60% by 2025). UK legislation has already set a requirement of less than 55% by 2030. The base line is 2019's figures.

Each organisation has provided detailed information of the plastics they use and projects to reduce them. Information is being shared on materials used, suppliers, recycling options and changing processes. There are active discussions about what works and what can be changed.

Examples of changes in **recycling**:

- Using natural rubber plastic bands because they degrade faster.
- Film wrap – currently working with suppliers for a 30% recycled element to the sachet and big bagger film. Likely to be Q4, Q1 2022 when available for full production.
- PBNE (Plastic Bank Note Envelope) – recyclable and recycled via closed-loop recycling scheme.
- Now using biodegradable branch pouches that will degrade in landfill conditions within 2-3 years.

Examples of (**reduction**) less materials:

- Trials to remove plastic banknote envelopes (PBNEs).
- Trialling use of reusable liner in place to replace PBNEs – may be possible to use in a branch setting.
- One coin site to trial blue tint 60 micron film. Have moved on to trial 40 micron in three sites.
- Have ceased using identifying seals on backing assets.
- Seals – reduced internal movements to two seals from four.
- Production of lower denominations of coin by The Royal Mint will be packaged in reusable metal containers rather than single use cardboard boxes.

Examples of **reusing** materials:

- Move to cloth bags for moving some cash and coins.
- Trials of reusable branch pouches (400 tonnes used a year).
- For rubber bands, looking to create a continuous loop with the customer.
- Elastic bands – received from branches – donated and/or reused, with excess to landfill.

Carbon Working Group

The target is to achieve net zero carbon for each organisation's own operations by 2030 (based on a 2019 base line):

The obstacles identified include:

- The availability of data.
- An infrastructure challenge due to electric vehicles and rural locations.
- Engagement, particularly in the supply chain.
- The development of policies that have not considered the environment.
- That Scope 3 does not allow off-setting. Even if it did, publicly funded organisations must use UK based offsets, and these may not be available.

2 'Endeavour', because they need to work consistent with goals already set by their own businesses.

UK Cash Industry Environmental Charter

The main aim of the UK Cash Industry Charter[3] is to provide a cash industry ambition and a course of action to tackle climate change in the three key areas identified (plastics, renewable electricity and CO2).

In recent years, recognition of the issue of climate change has increased. In 2018, the Intergovernmental Panel on Climate Change published a special report on the impacts which would be seen if we fail to limit warming to a 1.5° rise above pre-industrial levels. In 2019, the UK government declared a climate emergency in the UK and passed legislation mandating that all greenhouse gas emissions in the UK be brought to net zero by 2050.

We recognise the urgency of this situation, while also recognising that businesses must find ways to continue to operate in this changing world.

This Charter shows our ambition by working towards a set of targets, our commitment to working collaboratively across the industry and the roadmap of initiatives identified as the key areas of focus that will help towards driving significant change in the cash industry.

We, the signatories to this Cash Industry Charter on Climate Action, affirm our commitment on behalf of our companies/organisations to work across the industry to achieve:

- The Charter Commitments
- The Charter Targets
- The Charter Roadmap

Charter Commitments

- Champion climate action within the cash industry through an enhanced and trust-building dialogue with relevant stakeholders.
- Take significant climate action across the cash industry by working collaboratively with stakeholders and environmental advocates to develop and implement a shared strategy including targets and plans.
- Quantify, track and report our greenhouse gas emissions and plastic usage consistent with standards and best practices of measurement and transparency.
- Commit to prioritising materials with low-climate impact without negatively affecting other sustainability aspects.
- Support the movement towards a circular economy and acknowledge the positive impact this will have towards reducing climate impacts within the cash industry.
- Commit to continuously pursue energy efficiency measures and renewable electricity in our properties, products and services.
- Reduce our emissions to as close to zero as possible before offsetting the remaining emissions. Where offsetting is adopted, the projects which are invested in are considered carefully and are accredited to a standard such as VCS and Gold Standard, which have clear frameworks for accounting, auditing and registering carbon credits.

Charter Targets

- **Carbon** – Achieve Net Zero for 'Own Operations & Business Travel' by 2030
- **Plastic**

  a) Eliminate single-use non-recyclable plastic in note centres by 2030 (3yrs 25%, 5yrs 50%, 10yrs 100%)

  b) Reduce single-use non-recyclable plastic in coin centres to below 45% of plastics waste (by weight) by 2030 (3yrs <70%, 5yrs <60%, 10yrs <45%)
- **Energy** 100% Renewable Electricity – Own Operations by 2022

3 Current supporters of the initiative are: ACBI, Allied Irish Bank, Bank of England, Cummins Allison, De La Rue, G4S, Giesecke+Devrient, Glory, HSBC, IBM, LINK, Lloyds Banking Group, Loomis, NatWest, OneBanks, Post Office, Santander, Tesco, The Royal Mint, TSB, Ulster Bank, Vaultex, Virgin Money

11.2 ICA: INDUSTRY COMMITMENT TO SUSTAINABILITY

The International Currency Association (ICA) was formed in 2016 to be the voice of the global banknote and coin industry. Its members cover the design, production, manufacture and distribution of banknotes and coins. Its member companies, many of whom may be rivals in business, none the less have come together as a coalition-of-the-willing to become 'force multipliers', protecting the role of cash as a public good, guaranteeing freedom and privacy as well as social inclusion.

In September 2020 ICA members signed up to the ICA Sustainability Charter. It has a sustainability framework that includes economic and social equality as well as the environment. The Charter takes a life-cycle approach, providing the opportunity and tools for everyone in the industry to contribute to a more sustainable future.

The charter calls on members to:

- Promote the adoption of circular economy principles by designing waste and pollution out of the production process with sustainable solutions and recycling initiatives.
- Integrate sustainability criteria throughout all aspects of current and future processes and projects.
- Reduce their environmental footprint by:
  - Reducing consumption of water and raw materials
  - Re-assessing the chemicals used in production
  - Increasing recycling.
- Decrease emissions through:
  - Innovation and new technologies
  - Increased use of renewable energy
  - Emissions reduction objectives.

The ICA's Sustainability Committee is leading the membership in implementing the Sustainability Charter, including establishing opportunities for open exchange amongst members on their own sustainability challenges and journeys.

ICA members contributing to this paper are Crane, De La Rue, Giesecke+Devrient, Koenig & Bauer Banknote Solutions, Komori, Kurz, Louisenthal, Luminescence and Oberthur Fiduciaire.

11.3 IACA: SHARING BEST PRACTICE

The International Association of Currency Affairs (IACA) is a group of 61 organisations, including 36 central banks and monetary authorities, and 25 supplier and other organisations in the currency community. IACA provides in-person and virtual forums and other programs that allow its members to share information and to act together for the benefit of the community.

In 2020, IACA initiated an award open to all organisations in the community to recognise environmental sustainability projects. The goal of the award is to disseminate information about efforts related to banknote or coin production, services, or distribution that demonstrate:

- improved environmental stewardship
- innovative best practices
- pollution prevention, or
- resource conservation.

IACA solicited nominations that demonstrated organisations' commitment to:

- make, use, or re-use materials in ways that move from waste to sustainable resource management
- conserve or manage energy, water, or other resources more efficiently
- reduce harm to the environment in other ways.

At a recognition event, IACA presented videos from one central bank and four suppliers that described the results of their environmental sustainability initiatives. This was followed up by a webinar to allow the nominees to offer additional details. Hundreds of members of the community viewed the event and webinar to hear these contributions to environmental sustainability.

IACA will hold similar events in the future to recognise further environmental improvements and to showcase the significant efforts of the currency community to reduce the environmental effects of currency production and distribution.

11.4 ATMIA: INCREASING CASH RECIRCULATION, REDUCING CASH MOVEMENTS

ATMIA represents the global ATM industry with more than 11,000 members from over 650 companies located in 70 countries across every element of the ATM ecosphere. These include financial institutions, independent ATM deployers, equipment manufacturers, processors and ATM service and value-added solution providers.

The number of bank branches in many countries has been in decline for well over a decade and this trend of bank branch closures has opened up the threat of 'cash deserts', where there is no ready access to cash for some communities and businesses.

The introduction of cash-recirculating ATMs, which can typically process both notes and coins while allowing the subsequent withdrawal of this cash by ATM users, allows the recycling of cash with far fewer movements and processes. Where this happens, the carbon footprint of cash is significantly reduced. To accelerate the use of cash recirculating ATMs, ATMIA is campaigning for changes to allow Universal Cash Deposits by ATMs.

Universal Cash Deposit may be defined as an interoperable system within an ATM network, or across multiple networks, for accepting cash deposits at enabled ATMs on an 'interbank' basis, whereby a customer from one bank may deposit cash at ATMs owned and operated by other banks or by Independent ATM Deployers (IADs).

ATMIA is driving what is known as the 'Next Gen ATM' project which aims to create a new, globally interoperable API app model for ATMs based both on industry-wide consensus and on a vendor-agnostic level playing field. It sees this as vital for innovation allowing ATMs to evolve and to allow ATMs both to provide access to cash and to reduce the environmental impact of cash by reducing cash movements.

12 THE FUTURE CASH CYCLE

Central banks are already playing a core role in reducing the environmental impact of cash. Change has started and will, no doubt, become more widespread. Examples include:

1 Specifying longer lasting notes: coated papers, varnished banknotes, hybrid banknotes, polymer banknotes.

2 Less Movement of Notes and Coins

- Recirculation through:
  - Note Held to Order schemes
  - Investment in equipment allowing localised recirculation (smartsafes, deposit and recirculation ATMs, teller cash dispensers, teller cash recyclers etc).
- Better data
- Direct exchange of surplus notes between cash handling institutions
- Coin deposit programs
- CashTech – the application of software solutions to make cash accessible.
- Cashback, eg. UK legislation allowing cashback without a purchase in a shop.

3 Cash Management as a Utility

- Shared or pooling of ATM networks, eg. Netherlands Geldmaat
- Shared cash sorting, eg. UK's Vaultex
- Shared bank branches, eg. UK's Post Office Banking Hubs and OneBanks.

4 Use of Green Energy Throughout the Industry

5 Lower Impact Vehicles and Equipment

- Driving telematics, bio-fuels, electric vehicles
- Low energy ATMs, eg. DBS Bank's investment in the latest ATMs
- Dynamic route management software.

6 Less Materials

- Returnable cash boxes
- Reusable/recyclable packaging materials
- The adoption of standards such as GS1 allowing data sharing and standard packaging.

7 Co-operation and Information Sharing

eg. UK Cash Industry Environmental Charter, International Currency Association, Mint Directors Conference working group etc.

8 Central Bank and Finance Ministry Initiatives

- Adoption of new materials in coins making them lighter and reducing the use of high value materials through the use of plating
- Rounding up of prices along with eliminating low denomination coins, eg. one and two cent coins in some eurozone countries
- Regulation of equipment and processes to allow recirculation of notes and coins while maintaining quality and security.

CASHTECH COMPANIES

Enabling cash to be used for online purchases

- **Cashway**, a Paris-based provider of cash services, including virtual banking agency, bill payment in cash, and cash payment for online shopping.
- **Kasssh**, a UK-based start-up that allows consumers to pay online purchases with cash.
- **Pipit Global** provides a digital platform connected with payment institutions in developing nations to accept cash payments from their diaspora.

Alternative to coins

- **Shrap** offers a digital alternative to coins that allows people to pay in cash and receive change for low-value transactions free of charge, conveniently and anonymously.

Making cash accessible

- **Socash**, a Singapore-based start-up building Asia's largest distribution network for cash.
- **Sonect**, a Swiss company that turns every cash register into an ATM. Thanks to the Sonect platform, cash can be withdrawn easily, largely independent of infrastructure, and therefore cost-effectively.
- **Viafintech**, headquartered in Germany, offers a wide range of services from cash withdrawals and deposits to cash payment options for bills and online purchases, cashless payment methods, and gift-card solutions.

13 OUR SPONSORS

CCL SECURE

THE POLYMER BANKNOTE PEOPLE

CCL Secure Ltd,
Station Road, Wigton,
Cumbria CA7 9BG, UK
uk@cclsecure.com
+44 16973 69340

WEBSITE

For more than three decades, CCL Secure has led the world in the design, manufacture, and innovative development of polymer banknotes. Today, its GUARDIAN™ polymer substrate is used in 75 billion banknotes worldwide.

As the company with decades of experience of leading the transition to polymer, CCL Secure is also the leader in recycling. In March 2021, it was awarded the Central Banking Currency Services Initiative Award as a result of its global support for recycling and for wider reductions in its environmental impact.

As well as being more durable, tougher to counterfeit, and more hygienic to handle than paper, CCL Secure's polymer banknotes are naturally more environmentally friendly. Numerous independent lifecycle assessments carried out by central banks have consistently shown that polymer outperforms paper across a wide spectrum of environmental measures.

As the world's leading polymer banknote experts, CCL Secure only use bank grade polymers, developed in association with sister company Innovia Films (part of CCL Industries). These are polymers that are used exclusively for banknotes – nothing else.

DE LA RUE

DeLaRue

De La Rue PLC,
Jays Close, Basingstoke,
RG22 4BS, UK
currency@delarue.com
+44 1256 605000

WEBSITE

De La Rue has provided banknotes to central banks around the world since 1860, designing over one third of all circulating banknotes and manufacturing up to 7 billion banknotes a year at facilities in Sri Lanka, Kenya, Malta and the UK. This represents more banknotes designed and manufactured by De La Rue than any other commercial supplier.

De La Rue's SAFEGUARD® polymer substrate was first issued on a circulating banknote in 2013 and was developed in response to customer demand. Since the introduction of SAFEGUARD® the number of banknote denominations on polymer substrate has more than tripled, reflecting the ongoing demand for cleaner, greener, more secure and more durable banknotes.

Today De La Rue provides fully finished banknotes, polymer substrate and security features for paper and polymer banknotes, encompassing all major technologies. De La Rue is also the only supplier of polymer substrate to also manufacture banknotes, enabling an ongoing feedback loop that has led to a substrate truly optimised for manufacture.

With every product designed and integrated to the highest possible standards of security, functionality and aesthetics, De La Rue is the first choice for many central banks around the world.

Giesecke+Devrient

Giesecke+Devrient GmbH,
Prinzregentenstr 159, 81677
Munich, Germany

alexandra.geiger@gi-de.com

+49 89 41190

WEBSITE

GIESECKE+DEVRIENT

Giesecke+Devrient (G+D) is a global security technology provider headquartered in Munich, Germany. Founded in 1852, the company has a workforce of around 11,500 employees and sales of €2.31 billion in the 2020 fiscal year. A total of 74 subsidiaries and joint ventures across 32 countries ensure customer proximity worldwide.

Technology that engineers trust is G+D's core area of expertise. As a trusted international partner, G+D secures the essential values of enterprises and public institutions around the world. We create innovative security solutions for the reliable protection of analog and digital payment transactions, the digital connectivity of people and machines on the Internet, the protection and management of identities, and secure digital infrastructures.

G+D Currency Technology provides solutions for secure end-to-end cash management, banknote paper, banknotes, technologically advanced security features, banknote processing machines of different sizes and complete cash centre solutions.

KOENIG & BAUER

Koenig & Bauer Banknote Solutions, Avenue du Grey 55, 1018 Lausanne, Switzerland

info-bns@koenig-bauer.com

+41 21 345 70 00

WEBSITE

KOENIG & BAUER

Koenig & Bauer Banknote Solutions, a global provider of high security printing solutions, has been supporting its customers worldwide to efficiently produce highly secure and aesthetically pleasing banknotes since 1952.

Koenig & Bauer Banknote Solutions has a worldwide presence with its main sites in Germany, Austria and Switzerland.

To keep cash universally accessible, the company acts as the key partner that drives innovative banknote production technologies and services. Its complete high security printing solutions support the longevity of the most secure, robust and sustainable means of payment around the world.

To help its customers optimise their production processes, Koenig & Bauer Banknote Solutions connects expertise for the sustainability of cash.

KOMORI

Komori Corporation

11-1 Azumabashi 3-chome, Sumida ku, Tokyo 130 8666, Japan

currencysolutions@komori.co.jp

+81 3560 87815

Komori Currency Technology

Units 2 and 3 Tillingbourne Court, Dorking Business Park, Station Road, Dorking, Surrey, RH4 1HJ, United Kingdom

info@komoricurrency.co.uk

+44 1306 876331

WEBSITE

KOMORI CURRENCY TECHNOLOGY

Komori is a company that inspires customer Kando, providing beyond customer expectations and this is the philosophy that will prevail going forward.

The banknote and high security printing industry is changing with the creation of more sophisticated anti-counterfeiting measures and even more complex printing techniques. Komori designs and manufactures printing equipment that addresses these issues and endeavours to offer products and technologies that are the best solutions for our customers.

Environmental issues confronting society have become more serious than ever before. In response, Komori is steadily implementing its 'Green Project' and achieving solid results.

In addition our customers include printing companies which are facing an urgent need to improve their labour environment. We will therefore step up our initiatives to help them achieve this.

LUMINESCENCE
Sun Chemical Security
a member of the DIC group

Luminescence Sun Chemical Security, The Fairway, Bushfair, CM18 6NG, Harlow, United Kingdom

sales@luminescence-scs.com

+44 1279 456400

WEBSITE

LUMINESCENCE SUN CHEMICAL SECURITY

Luminescence International Ltd has been a leading manufacturer of innovative security inks since 1987. In 2018 it was acquired by SunChemical-DIC, the world's largest supplier of inks, coatings and pigments, further expanding its global reach.

Luminescence Sun Chemical Security offers a full range of innovative inks for the production of highly secure and aesthetically pleasing banknotes. It has five production locations in three countries and employs about 200 people.

LOOMIS UK

Loomis specialises in creating efficient cash flow in society. Our business has a 160-year history working with financial institutions, independent ATM providers, retailers, public sector bodies and a huge range of other businesses ranging from the very small to the very large. We have a presence in over 20 countries, operate over 400 offices and employ more than 24,000 people.

Loomis is here to help manage the public flow of cash, completing the circle from banks to consumers to retailers and back again. We provide cash management solutions to any organisation that handles cash, whether they need to transport cash securely, eliminate opportunities for fraud or analyse and understand their cash flow in detail.

Operating in Argentina, Austria, Belgium, Brazil, Canada, Chile, Czech Republic, Denmark, Dubai, Finland, France, Germany, Hong Kong, India, Norway, Portugal, Slovenia, Slovakia, Spain, Sweden, Switzerland, Turkey, the UK and the US, the Group has successfully implemented far reaching changes in recent years, creating conditions for increased group wide innovation and knowledge sharing within our market. Our international presence provides the benefits of a global network of secure cash handling facilities with a substantial fleet of armoured vehicles and highly-trained staff, and we also have a strong local presence in every community we serve.

Loomis is committed to a sustainable future which is integrated into our company governance.

LOOMIS UK Limited, 6th Floor Regus, East West Building 2, Toll House Hill, Nottingham, NF1 5FS, United Kingdom

Andrew.Cowens@loomis.com

+44 7810 500056

WEBSITE

PORTALS PAPER

For the last three centuries, Portals has been manufacturing security products for use in critical applications such as banknotes, passports, vehicle registration documents and birth and marriage certificates.

Throughout this time Portals have established themselves as a leader in innovation, with the Portals name being synonymous with pioneering innovations in the security paper industry.

Today, Portals produces materials for more than 12 billion banknotes, 200 million brand labels, 70 million passports and 60 million certificates each year, for use in more than 100 countries around the world.

Portals International, Station Road, Overton, RG25 3JG, United Kingdom

info@portalsinternational.com

+44 (0) 1256 770770

WEBSITE

VAULTEX

Vaultex UK Ltd,
303 Bridgewater Place,
Birchwood Park, Warrington,
Cheshire, WA3 6XF

csr@vaultex.com

+44 8446 001947

WEBSITE

VAULTEX

Vaultex UK is a joint venture between Barclays Bank and HSBC to provide their end-to-end cash management needs. Vaultex is a member of the Bank of England's Note Circulation Scheme.

Vaultex operates throughout the UK with 10 cash and coin centres and one support office, which have all contributed to the delivery of a consistent customer service level of 99% since its inception in 2007. Vaultex strives to be the most innovative end to end cash management company, and a recognised leader for efficient cash services around the world.

As a global leader in cash management, Vaultex aims to surpass the expectations of its stakeholders in every area, including environment sustainability. As such, it is a signatory of the Cash Industry Environmental Charter and has a strong appetite for collaboration and innovation when it comes to reducing its environmental impact.

Despite starting out as a cash processing company, Vaultex has expanded its portfolio to create thriving managed services and international consultancy arms.

Vaultex takes great pride in having a strong sustainability strategy in alignment with the UN sustainability goals. It would like to share its knowledge and experience and to work with other cash cycle stakeholders to identify industry level opportunities for positive change.

To learn more about our business and commitment to reducing its environmental impact please contact Sarah Magnier-Ashton – Head of Culture & CSR at **csr@vaultexuk.com**

14 ANNEXES

Please click on  below for a link to further information about their work:

CCL SECURE

Guardian™ Polymer Banknote Sustainability Report

DE LA RUE

Currency Sustainable Confidence

G+D

The life of a banknote

G+D

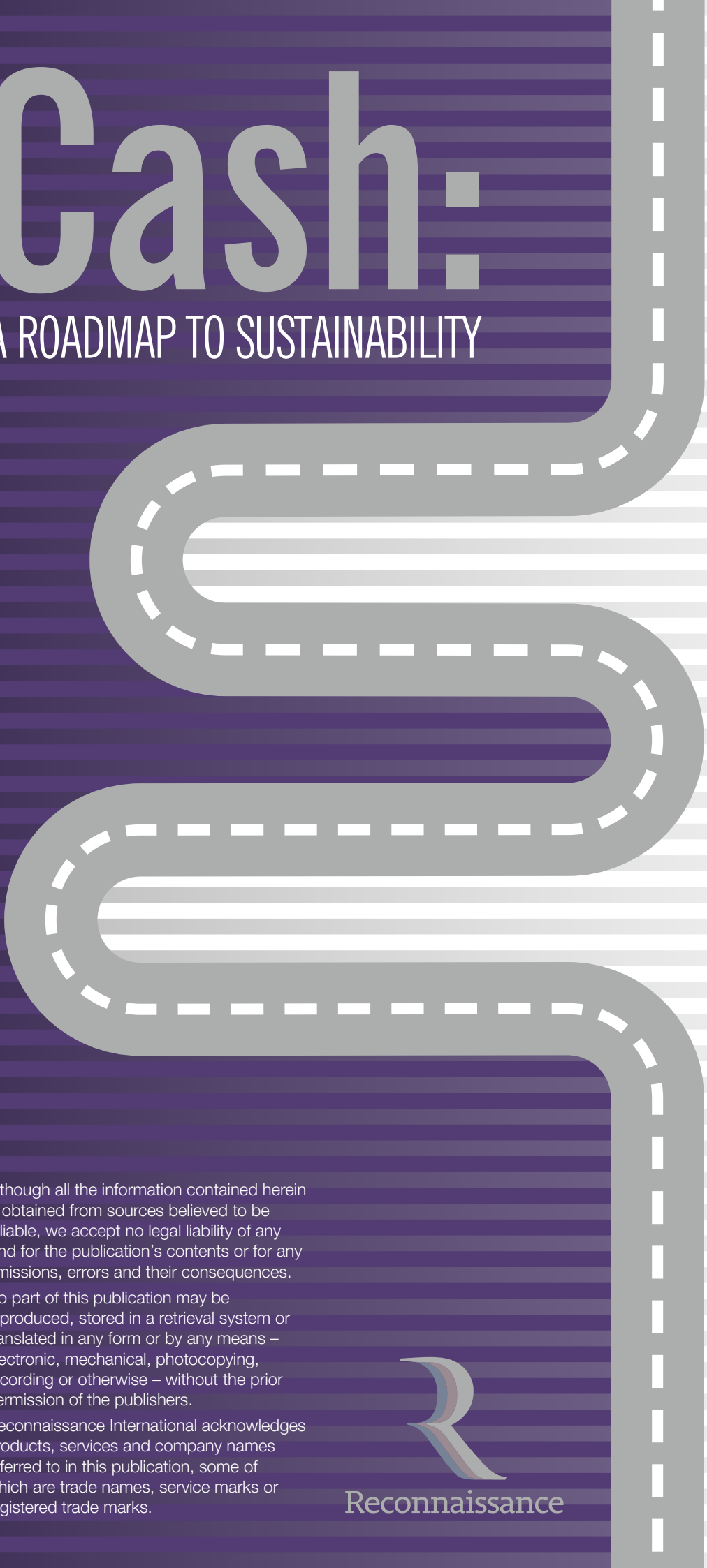
Progress Report 2020

LOOMIS

Sustainability

Cash:

A ROADMAP TO SUSTAINABILITY



Reconnaissance

Published by

Reconnaissance International Ltd

1B Ground Floor
The Beacon
Beaufront Park
Anick Road
Hexham
Northumberland
UK
NE46 4TU

+44 (0) 1932 785 680
info@recon-intl.com
www.reconnaissance.net