XEIKON

WHITEPAPER SUSTAINABILITY

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A division of FlintGroup

SUSTAINABILITY, REPURPOSING CARBON IN DIGITAL PRINT

Aspects of sustainability for repurposing carbon to feed and maintain a renewable carbon cycle

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Section 1

THE PRESERVATION OF CARBON AND WHY IT MATTERS

Sustainability is a word that pops up in a lot of communications, marketing materials and company presentations. The word dominates conversations and shapes many real goals and targets. Brands are focusing on sustainability because consumers favour it and because governments are preparing legislation, regulation and taxation as part of their efforts towards zero-carbon dioxide emissions. We all have an interest in boosting recycling rates and minimising waste to help bring down our Greenhouse Gas (GHG) emissions and the graphs below show that still a lot has to be donessions.

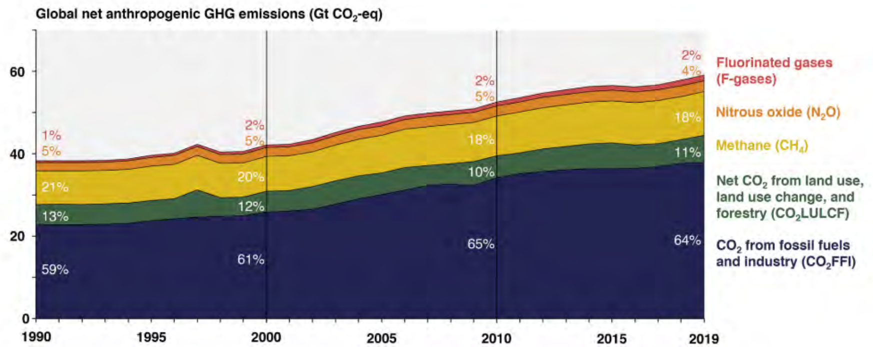

Figure 1 : top left : The global evolutions of GHG emissions in the last 30 years (https://www.epa.gov/system/files/styles/colossal/private/images/2023-08/Fig-1-Global-GHG-Emissions-by-Gas.png?itok=yi68bJn9)

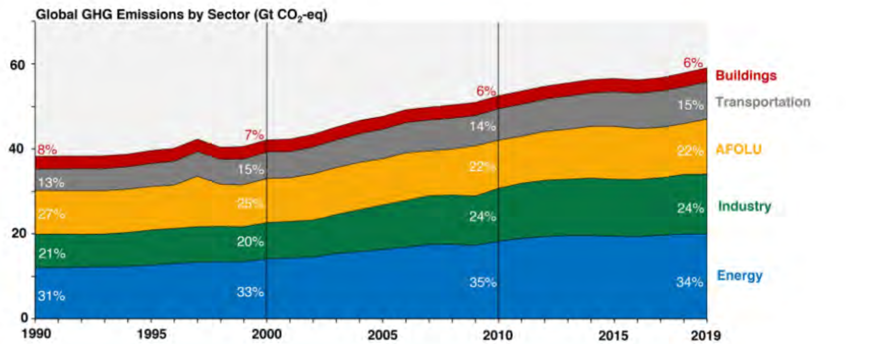

Figure 2 : bottom left : GHG split by economic activity (AFOLU = Agriculture, Forestry, and Other Land Use) (https://www.epa.gov/system/files/styles/large/private/images/2023-08/Fig-2-Global-GHG-Emissions-by-Sector.png?itok=hjyHDjpZ)

We must take care of the planet's resources and reduce the amount of CO2 pushed into the atmosphere, causing temperature increases and potentially irreversible climate change. With this in mind, we must organize ourselves globally so that we can efficiently re-use raw materials available now on the surface of the earth without adding any new converted from coal, gas or petroleum. The graphs show that we still have a long way to go ! E.g. the nearly 35 % reduction effort in EU-27 in the period from 1990 (4,600 Megaton = 21 % global contribution) to 2020 (3,000 Megaton = 8 % global contribution) has completely been wiped out by the activities in other areas in the world (global CO2 emissions increased with 58 % of from 22,000 megaton to 38,000 Megaton)

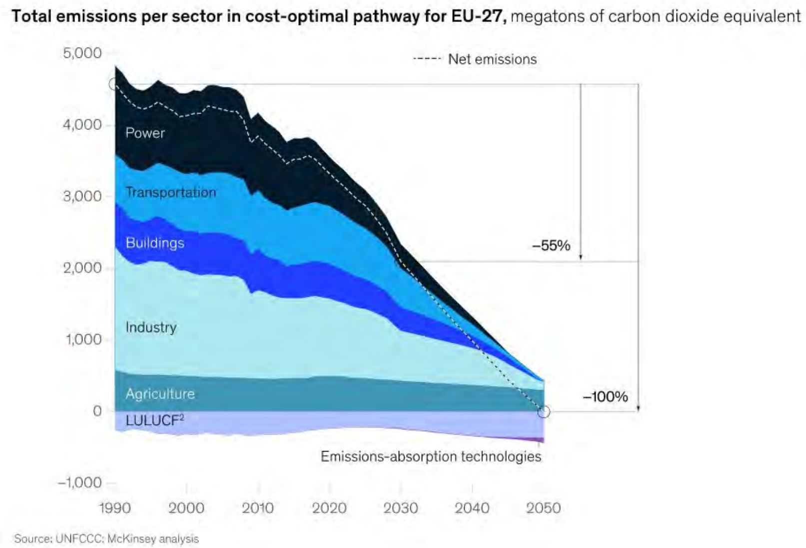

Figure 3 : right : Reduction GHG in EU from 1990 and goal towards 2050 (https://www.consultancy.eu/illustrations/news/detail/2021-08-24-070537355-The-power-sector-would-reach-net-zero-emissions-before-the-others.jpg)

THE PRESERVATION OF CARBON AND WHY IT MATTERS

Beyond recycling

Recycling is not a new idea and it has had various degrees of success; but much more can be done. We have been familiar with the conventional recycling model for paper for a long time. In Europe the recycling rate is over 70% (Figure 4), al- though rates vary by mate- rial. The 2022 Euro- pean Union (EU) Packag- ing Waste Directive aims to reduce packaging waste by 15% by 2040 per Member State per capita, compared to 2018.

For the graphics industry we can break recy- cling streams into two groups: paper based and film based materials. Not all paper can be collected within a short time period (book, tissue paper, toilet paper, compostable plant buckets, and so on). But in many countries newspapers, magazines, much packaging and particularly direct mail materials are effi- ciently collected and reworked into new paper or board materials. It is clear that for making new white paper deinking, whereby colourants are removed from the substrate so that it can be re-pulped, is mandatory and systems for doing this are well-established.[1]

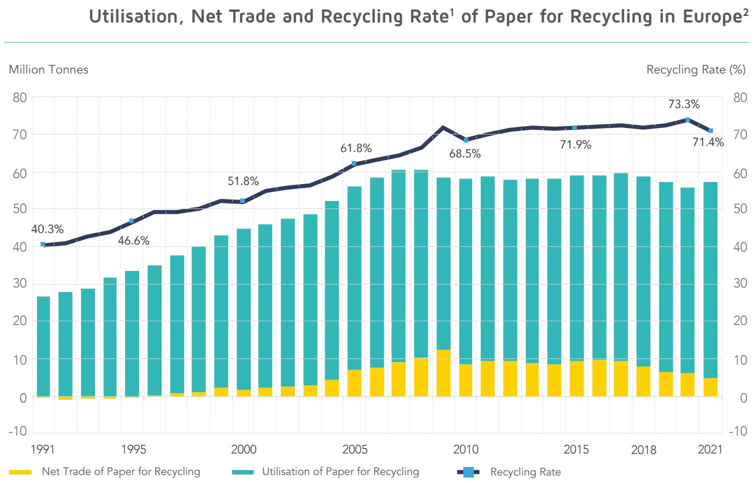

Figure 4 : Utilisation, net trade and Recycling rate of paper for recycling in Europe
https://www.cepi.org/wp-content/uploads/2022/07/Key-Statistics-2021-Final.pdf

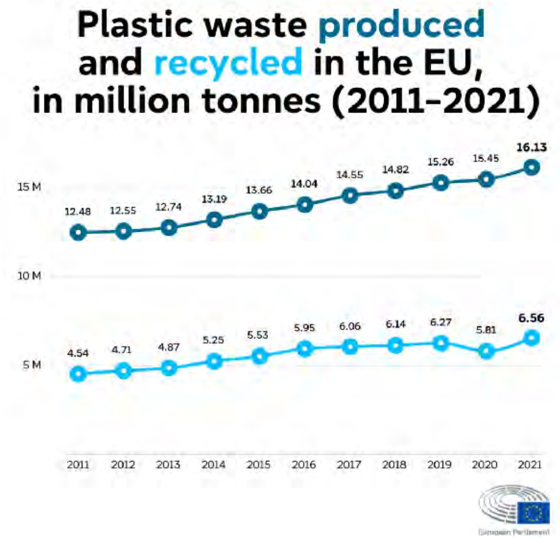

Figure 5 : Plastic waste produced (upper) and recycled in the EU (lower)
https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures

The situation for plastic materials is however completely different and very much less focused on recycling. In 2020 in Europe, approximately 50 million tons of plastic was produced. In the same year 15 million tons was collected as waste, mainly from packaging and household goods. Of this amount only 37 % was recycled through chemical and mechanical reprocessing. The rest, a staggering 63 %, was irretrievably lost by burning and landfilling.

[1] See ISO 21993 and ISO 12507 for further details.

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More than 40 % of the plastic waste was incinerated (with some heat recovery) and converted to CO_2. 20% of the waste was landfilled rendering it lost for future use. This is very scary if we look at the forecast for the demand for carbon in the next 30 years. The mismanaged part is directly visible in our environment (global warming, nature, rivers, oceans, …)

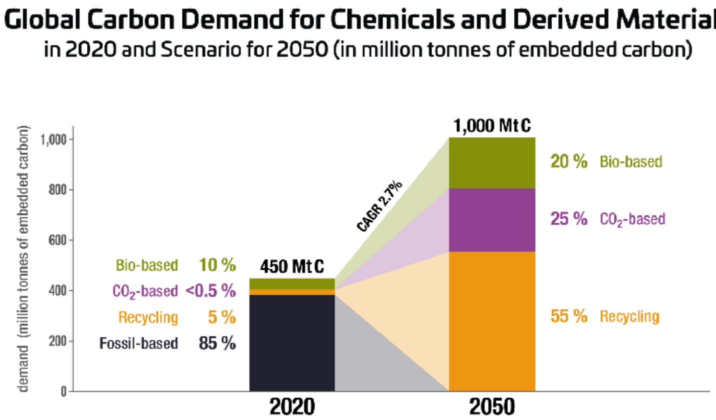

Figure 6 : Needed evolution from fossil carbon to renewable carbon
https://renewable-carbon.eu/publications

Our future society will be anything but carbon free

We use carbon in many products necessary for life such as pharmaceuticals, detergents and foodstuffs. Based on projections for population growth and development from organisations such as the United Nations, we can expect our need for raw carbon to more than double in 2050.[2]
The increase in demand will have to happen simultaneously with moves to stop extracting carbon from the earth's subsurface. This means that we must improve how we recapture carbon, so that it can be reused rather than being burnt and turned into planet warming CO_2.

It is generally accepted that to do this we must move away from dependency on fossil fuels towards increased use of renewable fuel sources and reprocessed waste. For reasons of cost, energy requirements in printing processes will continue to fall. Cost expectations will help to accelerate the printing industry's shift away from fossil fuels towards alternative renewable energy sources. Moving away from a dependency on fossil fuels means we will have to make sure that mankind finds alternatives for the carbon needed in sufficient quantities to support the world's population.[3]

There can be no more digging up of gas, oil and coal to provide in the necessary carbon, but rather we should look for models that allow us to use the carbon found in waste. Such models demand more effective and more efficient waste management and processing.

There is no indication that we will not need organic molecules, such as carbon, in the future. On the contrary, carbon is a vital chemical to support our planet's future demands. We should be able to reuse the carbon available right now using chemical and mechanical processing, instead of extracting more carbon from the ground. To support industries such as packaging, construction and pharmaceuticals we need an alternative to extraction so that we can turn useful carbon into the required molecules by repurposing waste. Once used carbons should not be burned or landfilled, but instead recycled and reused. "Decarbonisation" is often used to point to that change. It means "switching from the use of fossil fuels such as coal, natural gas or oil to carbon-free and renewable energy sources as quickly as possible", but it could give the impression that we have to move away from carbon which is definitely not the case. Therefore Xeikon likes more the wording "renewable carbon" or '"defossilisation", but it is hard to reverse or adjust a certain more or less established term used… (https://www.creavis.com/en/spotlights/defossilation-vs-decarbonization-172689.html)

[2] https://www.un.org/en/global-issues/population
[3] https://www.destatis.de/EN/Themes/Countries-Regions/International-Statistics/Data-Topic/Environment-Energy/Environment/G20_CO2.html

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Recovering carbon from plastics

There are three options for plastics reprocessing. Mechanical recycling requires collection and sorting of the plastics according to their chemical properties, so that they can be reused as the same material, for example the transparant polypropylene (PP) foils used in packaging. This material can be deinked, washed and reused to make a new packaging substrate based on its previously used and reclaimed iteration. Polyvinyl chloride (PVC) waste is already widely collected and reused to make PVC windows or garden furniture, and this model can be developed and expanded for more PVC based goods.

Chemical recycling involves heating the waste plastic using sustainable energy sources and without the presence of oxygen or creating the monomers again by selective hydrolysis of e.g. polyesters or polyamides. The waste material is not burnt, but rather it is processed into its chemical components so that they can be used as new raw materials. The reuse of carbon from collected, sorted and washed transparent PET bottles creates an important resource for Xeikon.

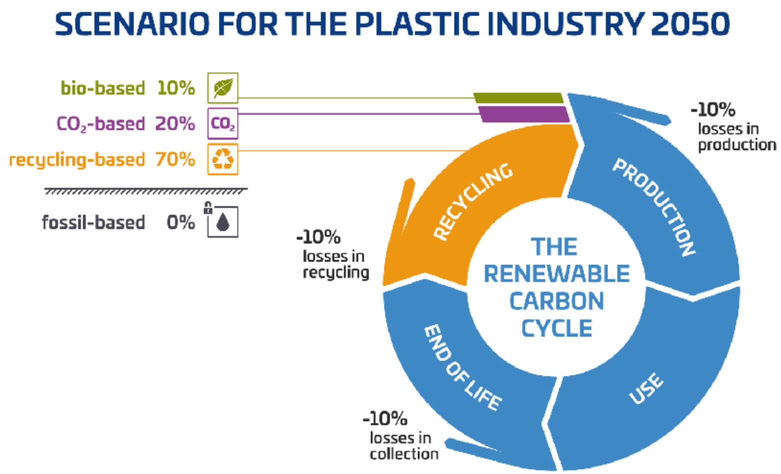

Figure 7 : the non fossil carbon cycle where a part of the carbon that cannot be recycled is added by bio and CO_2 sources. www.renewable-carbon.eu/graphics

We can deconstruct transparent waste PET bottles, to obtain the raw materials that are the basic building blocks of a toner resin. The resin based on chemical recycling, is 100 % equivalent and as foodsafe to a fossil fuel based toner resin and we can use 50-60 % of these PET building blocks in our QB[4] toner resin system. The third way of making new carbon building blocks without the need for fossil material is to convert captured CO_2 back into methanol or other carbon molecules. The process uses hydrogen made from sustainable sources plus additional bio chemical processes, the so called “green hydrogen”.

[4] QB is the toner based on a BPA free toner resin and used in all simplex machines creating printed material suitable for all kinds of (food)packaging and labels

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These are three ways of closing the carbon circle, but unfortunately not all carbon material can be collected or recycled. The carbon component of detergents, medicines, washing products, sun protection lotions and so on is unavoidably lost. To replenish the carbon required as a raw material for these products requires new carbon. This carbon can come either from renewable sources or from biocarbon such as wood pulp, grasses and vegetable sources. Plants can be grown for the cellulose required to create a source of useful carbon, not only for food, but also as a means of maintaining carbon volumes at a stable level in the cycle. Our need for carbon can continue to grow in line with our needs, as well as providing a raw material for industrial products. Biomaterial should not be used to make biofuels because this wastes carbon that has a much more valuable contribution to make.

We will need carbon for packaging, construction, making useful chemicals, and as a materials source, but not anymore as an energy source that converts carbon to CO_2 as a result of energy creation. Since we now are using petroleum, gas, coal as a source for materials and energy, this will have to change. The carbon we now have available (as CO_2, as material) will have to be kept as useful carbon to make the molecules we need. After usage, these carbons should not be burned or landfilled but reused and recycled.[5]

The importance of hydrogen

We are increasingly aware that energy supplies for transportation, industrial and domestic electricity and chemical processes will have to come from non-carbon, renewable sources like wind, solar, hydro and nuclear power. We will need hydrogen in sufficient quantities to convert current and future CO_2 back into useful chemicals.[6]

Plastics used in food packaging require much better systems for collection, sorting, deinking and mechanical recycling. They also require treatment using non-fossil-fuel heat sources and hydrogen so that they can be converted into usable monomers and other basic chemicals. Biobased sourcing is important, but the use of recycled material is much more vital if we are to keep the renewable carbon cycle turning. According to research by EcoEnclose, developers of sustainable packaging materials, "There is no bioplastic, currently on the market, that meets our vision for circularity and our standards for sustainable input materials."[7] Working on behalf of the European Union, consultants CE Delft estimate that requirements for plastics obtained by chemical and mechanical recycling will be three times as high as for biobased plastics.[8] In the Netherlands the percentage of recycled and bio based plastics is expected to be 41% and 15% respectively by 2030.

But the sustainable future will be much more than biobased alone. Biobased plastics are primarily based on natural resources, often grown as monocrops with a substantial water footprint. Using virgin products of this kind can have a detrimental impact on the environment. The alternative is to use existing materials that have undergone sustainable reprocessing to create new raw materials.
The complexity of the input materials will have to be reduced in such way that separation, collection and recycling is made easier and more efficient. In such a model solvents can still be used, but reuse and/or recycling will be key and burning will be unacceptable. Also the carbon used in ink components will have to be biobased or recovered, but it will not be based on petroleum anymore. Polymers and pigments made from different chemical sources are being developed and after use such inks will have to be removed from the substrates and reprocessed to keep the captured carbon in the circle.

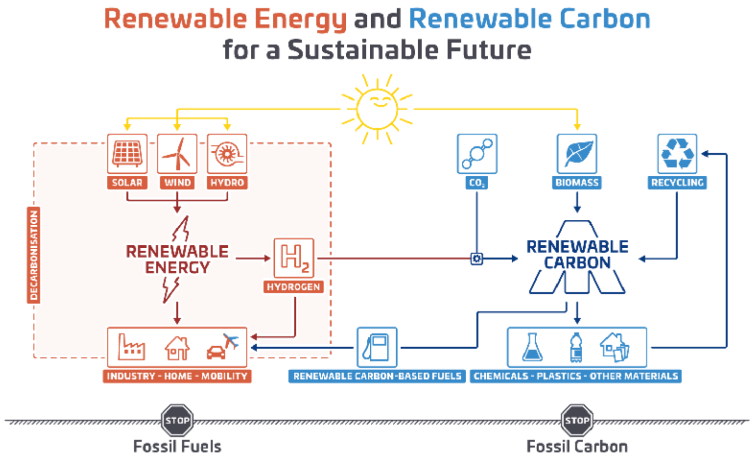

Figure 8 : Future sustainable energy and carbon cycles showing the huge importance of green hydrogen. www.renewable-carbon.eu/graphics

[5] https://www.nature.com/articles/s41467-021-26090-5/figures/1
[6] https://www.nature.com/articles/s41467-021-26090-5/figures/
[7] https://www.ecoenclose.com/blog/recycled-content-versus-bioplastics/
[8] https://cedelft.eu/wp-content/uploads/sites/2/2022/03/CE_Delft_200289_Mandatory_percentage_of_recycled_or_bio-based_plastic_Def.pdf

Section 2

XEIKON'S DRIVE TO REPROCESSING CARBON AND THE CIRCULAR ECONOMY

Sustainability has been part of the Xeikon culture for a long time. Xeikon does not want to take part in greenwashing, but only to refer to actual impactful change. Claiming to be CO_2 neutral by planting trees is not what we deem impactful and it is not the actual change we all need to strive for.

Xeikon has been actively reducing our corporate carbon footprint (CF) and environmental impact for many years. The company's actions in the short term and the mid-term to reduce our carbon footprint include initiatives such as reducing energy emissions, cutting the number of business trips and switching to electric cars. Xeikon converted its factories to use 100 % green energy already in 2009 combining the heat generated by producing pressurized air to heat up the buildings and is putting solar panels on all company buildings to provide a source of emissions-free electricity.

As being part of the FlintGroup (Xeikon as Digital Division) we also want to align ourselves with the global sustainable targets of the group. (https://www.flintgrp.com/sustainability/). This means defining specific goals for Products, People and Planet aspects.

In order to make the right goals, we need to have a very good idea about our actual carbon footprint. Ramboll as a consulting company (www.ramboll.com) investigated our business data for the last 5 years and based on that we can say that nearly 30 % of our CF is mainly linked to the raw materials we use to make the printers and the consumables, 30% to logistics, 10 % to the CF linked to the usage of our machines and 20 % to travel, commuting and company cars and a small fraction linked to residual energy consumption. This defines automatically the focus areas.

In 2009 Xeikon reduced our Carbon Footprint by 20 % when we switched to 100 % green electricity for all our operations in Belgium. The office and production locations use biobased cleaning agents, switched to LED lights, have constant energy management programs in place and continue to install solar panels (up to 2500 in Lier and nearly 600 Heultje). Company cars are being switched to full electric or hybrid vehicles. Reusing more carbon and metals on short term should keep the sustainability aspect high on the agenda of every colleague and will continue to be central to our business culture and ethic so all environmental impact mitigation efforts are continuing.

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XEIKON'S DRIVE TO REPROCESSING CARBON AND THE CIRCULAR ECONOMY

One third of Xeikon's global carbon footprint, comes from the chemicals used in our toners, inks and the steel and aluminum used to build our printing machines and consumables. If we focus deeper into the raw materials we use, there are three main categories : one third is toner resin, one quarter is linked to aluminum and a sixth is the steel used in the digital printing engines.

As explained earlier the need for reusing carbon is paramount, so Xeikon has initiated a plan to introduce cleansed collected transparent PET bottles as the raw material for the making of new toner resin.

As can be seen from Figure 9 "How incorporate the monomers from recycled PET into toner resin", the monomers of the collected PET are redistributed into our toner resin in such way that we make an equivalent toner resin as we would have made using petroleum based products. There is no compromise in the final quality or performance of the toner resin and we have measured no additional carbon footprint impact with the new process (e.g. higher energy during the synthesis).

The second phase of this program is to move completely away from fossil-fuel based monomers and to use the remainder of the chemicals from biobased or other renewable sources of other chemical recycling streams, as described above. This is chemical recycling and the circular economy in practise. For the moment the QBE toner already contains 10 % of non PET recycled monomers as well and the exercise is currently running in R&D to do the the analogue switch for the QB-Titon toner (combining RPET and recycled monomers).

For the aluminium part, we are researching the possibility to reuse the high quality aluminum drum to make new OPC (Organic PhotoConductor) drums. The purity of the aluminum for our OPC drums is so high to guarantee the optical and electrical performance, that it is not possible to use recycled aluminium for these drums. But Xeikon is looking to use recycled metals for non critical parts in the engine and other drums. We also want to be sure that in the meantime no high quality aluminium or metal parts from our engines are landfilled or not recycled at the location where they have been used.

A third topic we want to highlight in view of the circular economy and moving away from new fossil based hydrocarbons. Therefore we have spent quite some time to replace our polyethylene (PE) based toner bottles with paper based toner bottles with a sustainable coating suitable for recycling.

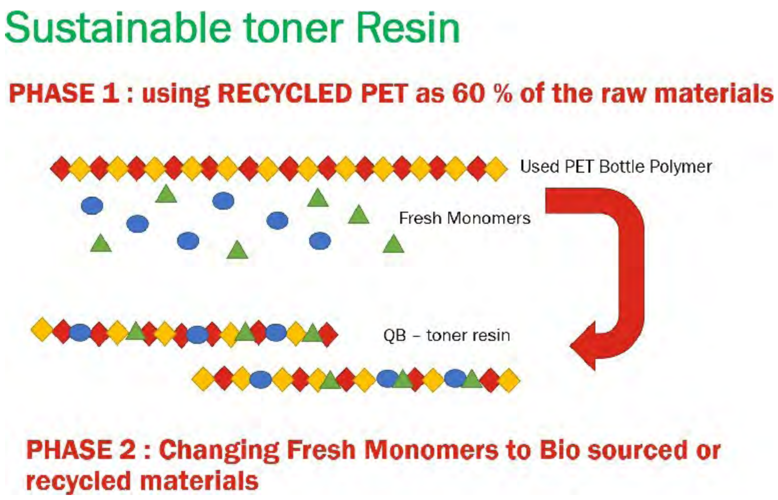

Figure 9: How recycled PET and other recycled monomers are combined to make new toner resin

Unfortunately the technical challenges are still too high at this moment to have a quick implementation of this approach. We also have a program running for some time to re-use - to refill our plastic bottles, but we quickly saw the limitations. The sustainability of the process is undermined by the fuel consumption and associated increased carbon footprint for collecting and shipping the bottles back to the toner plant in Belgium, which means that we are limited in collecting distance to keep this way of working still sustainable. The third approach implemented now is a simple and safe way of decapping the toner bottles and have a fast and simple cleaning tool to remove the little toner which is left. This approach allows our Xeikon users to generated clean enough PE bottles so that local recycling as hard PE can be done instead of landfilling or burning. On top of that we started also a fourth track where we are looking to use recycled PE material in order to make new bottles. All these tracks off course have to guarantee the same quality, storage behaviour and performance of our toners.

Just to make the list complete, it is also very important to mention that also in our waterbased IDERA inks for corrugated printing, all alcohols used as humectants (to reduce the evaporation of the ink at the nozzles) are biobased. This gives a "fossil free" content of more than 85 %. This amount of renewable carbon will have an impact on the carbon footprint of the printing process as shown later.

XEIKON'S CARBON FOOTPRINT CALCULATOR AND SUSTAINABILITY SCORECARD

An initiative for transparency, study and awareness

A division of FlintGroup

Section 3

CARBON FOOTPRINT : SEEING THE FOREST FOR THE TREES

When people embark on carbon footprint calculations, it is very easy to become quickly overwhelmed. A simple Bing search on the internet for the precise term "carbon footprint calculator," yields nearly 800,000 results (August 2024). Trying to narrow this down for the printing industry only, does not necessarily make it easier. There are however valuable contributions to be found including ISO 22067-1:2022 : Graphic technology : Requirements for communication of environmental aspects of printed products[9] and Intergraf's Recommendations on CO_2 emissions calculation in the printing industry[10].

These publications help print service providers and printing companies alike understand the environmental impact of their activities and also specify requirements and criteria for communication of environmental aspects within the print production supply chain. But the scope of these frameworks is very broad and not all required information on various parameters might be readily available. Moreover, it is also possible that some parameters are out of the control of the printing company and very hard to influence depending on its company size. So how to decide what exactly should be taken into account ? What about the substrates used, what about the logistics and supply chain involved and, what about the fact that the printed material is deinkable or not ? What about possible solvent use and post evaporation ?

At Xeikon we believe that transparency brings understanding. Our aim as a digital print solutions and press manufacturer is to aid prospects in their decision making process by providing clear data on the carbon footprint of the printing process. This will allow them to gain insight in the process as well as enable a first comparison between different technologies. In that way we want to bring a valuable contribution to more comprehensive, future models.

OUR APPROACH : STARTING WITH ENERGY

Assuming that the same substrate could be used for printing with inkjet, liquid toner and dry toner, it would allow us to take the substrate out of the equation. We know substrate can be very dominant in this type of calculations and by removing it we avoid complexity like origin, sustainable composition or not, transport, thickness, and recycling, to name just a few, and get more detail out of the printing process. It is also known that the contribution of the substrate in the total footprint of a printed product is so large that it minimizes the impact of printing itself. This makes is challenging to compare the differences and study the impact of certain changes. So in summary we've examined the impacts of specific printing processes and have attempted to compare the like-for-like.

With this starting point in mind, we decided to focus on parameters that can be measured on site. When a digital printing press is running, it is well known what the speed, the width of the substrate and the amount of colors is. With the right measuring devices it is perfectly possible to measure the amount of electric energy that was consumed during the print run expressed as kilowatt-hour (kWh) per square meter (m^2). This kWh can then be converted to gram CO_2– the amount of CO_2 decreases each year due to more sustainable energy/lower CO_2 emitting electricity production (Figure 10)

Depending upon the location this kWh conversion to grams of CO_2 is different (see Figure 11 for EU).

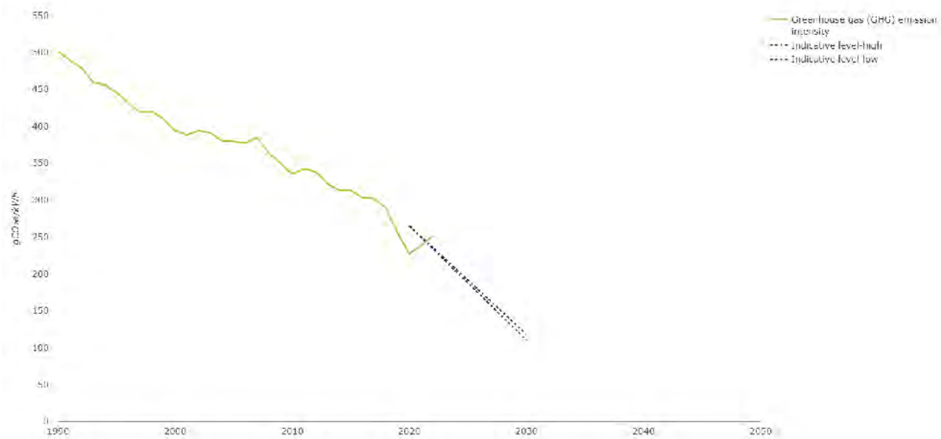

Figure 10 : Evolution of CO_2 per kWh (electricity) in EU over the past year
Source: https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1

[9] https://www.iso.org/standard/72489.html
[10] https://www.intergraf.eu/communications/publications/item/331-intergraf-recommendations-on-co2-emissions-calculation-in-the-printing-industry

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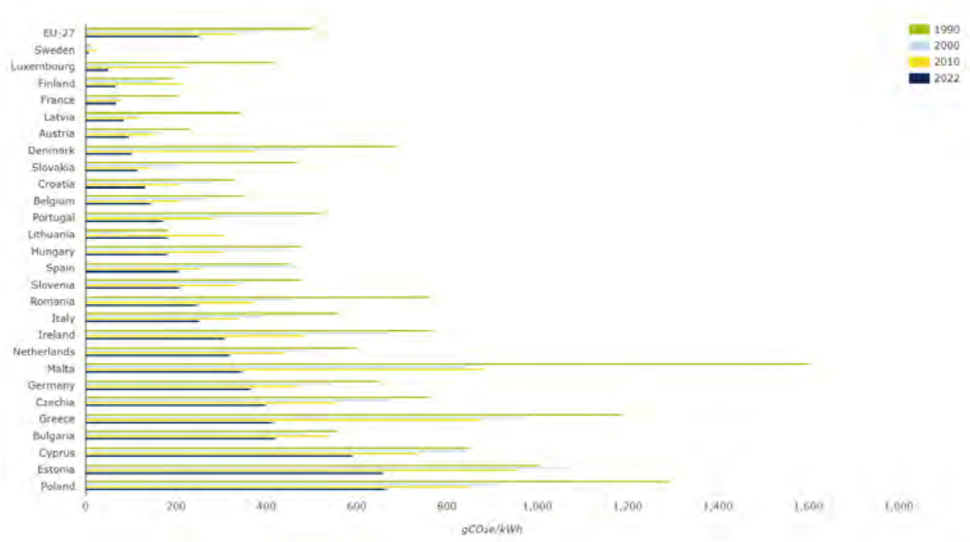
OUR APPROACH : STARTING WITH ENERGY

The part of green and renewable electricity is dependent on the amount of solar, hydro and wind energy in that area. In the data shown for the model, we are using the average volumes for the European Continent but the calculator can be adjusted per state/region. For now we use the factor that 1 kWh equals 251 g of CO_2 .

In Figure 12 we show an example of the energy measurement data (expressed in Wh/m^2) during the printing of the Xeikon CX500. At this moment we have gathered data of different technologies and vendors, and this list is still growing : UV inkjet (UV IJ) with different curing technologies, Dry toner electrophotography (DEP), liquid toner electrophotography (LEP) and water based inkjet (WB IJ). The 3-dimensional graph shows printing width (expressed in mm), printing speed (expressed in meters/minute) and energy consumption (expressed in Wh/m^2). In this case, as shown in the graph, the most energy efficient way to operate this press, is printing as fast as possible on the widest possible substrate. The printing energy of most digital presses (dry EP, liquid EP and UV IJ) is quite constant and independent of the amount of ink used, so the higher the amount of square meters per time produced, the lower the kWh per square meters.



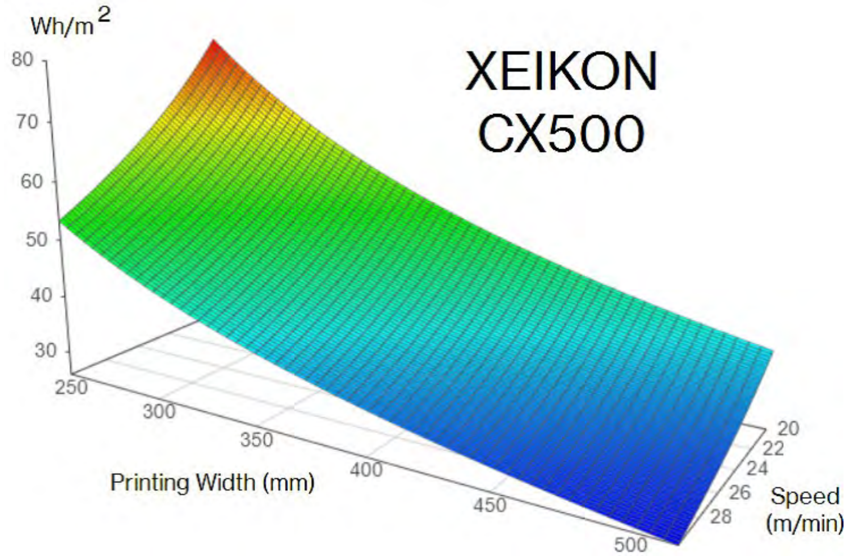


Figure 11 : Greenhouse gas emission intensity of electricity generation per country
Source: https://www.eea.europa.eu/en/analysis/indicators/greenhouse-gas-emission-intensity-of-1

Figure 12: Real measurements during printing for the Xeikon CX500
(>> 1000 A3 equivalents requested by ISO 20690)

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OUR APPROACH : STARTING WITH ENERGY

For UV inkjet, dry and liquid EP the amount of energy is mainly dependent upon the printing speed (and thus in some cases also on the number of colors used) but it is independent on the amount of ink used in the design. For water based inkjet this is not true since the amount of ink/water that is jetted has a big impact on the amount of drying energy needed before the rewinding or putting the next sheet on top of the previous one. The relation between drying and page coverage is shown in Figure 13, where 100% can be e.g. 100% of one process color, or 25% of each of the four process colors. Between 0-30 % page coverage the amount of energy is quite constant and mainly dominated by the basic operating of the machine (basic drying, motors, hardware, …)

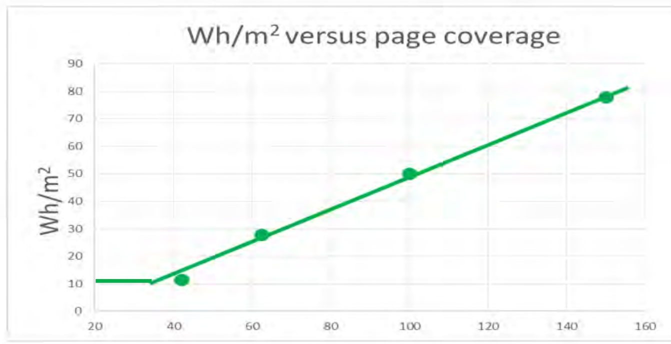


Figure 13 : Relationship between ink coverage and drying energy for water based inkjet

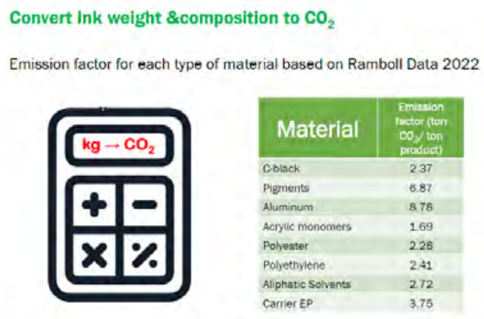
On a more general note, an evaluation of the impact of different print parameters on the power consumption per print technology can be found below in Table 14, where X marks if the parameter has an influence on the power consumption for the specific process DEP (dry toner electrophotography), LEP (liquid toner electrophotography), UV IJ (UV inkjet), WB IJ (water based inkjet).

	DEP	LEP	UV IJ	WB IJ
Total Page coverage %	-	-	-	x
Printing Width	x	x	x	x
Printing Speed	x	x	x	x
# of colors/clicks (*)	-	x	-	-

Table 14 : parameters impacting the power consumption per print technology (*) is only true when the image is collected before transferring. In the LEP V12 system the energy is independent from the amount of colors

INK/TONER AS A NEXT PARAMETER

Now that we know the amount of energy used during the printing (as a function of the printing speed, substrate width and numbers of colors) we can now focus on the amount of ink that has been used to print a certain design. Therefore we look at the individual emission factors of the ingredients used to make the ink (or colorant in a more general sense) and convert them to the amount of ink used (expressed in 100 % page coverage – See Table 15). The amount of pigment is quite independent of the technology, meaning the same amount of pigment is required for all technologies (this is true for analogue and digital). A general consumption 95 % CMYK (equally divided) and 5 % white has been taken for the label market. The amount of ink which has been used in the layer thickness for the baseline of 100 % page coverage is the amount needed to get an optical density of 1.4 for the colors and 1.8 for black resulting in the Table 16. All the CO_2 / m^2 values of the different marking systems give the same equal amount of reflection color density (1,4 for CMY and 1,8 for K), meaning 100 % page coverage. It is clear from Table 7 what is the CF impact of using recycled PET and renewable carbon in the QBE toner system compared to the QB toner system without this recycled carbon.



Material	Emission factor (ton CO_2/ ton product)
C-black	2.37
Pigments	6.87
Aluminum	8.78
Acrylic monomers	1.69
Polyester	2.28
Polyethylene	2.41
Aliphatic Solvents	2.72
Carrier EP	3.75

Figure 15: showing the emission factor per component.

weight %	thickness dry (micron) 100 % coverage	g CO2/m2 for 100 % PC of dry layer
UV Inkjet	7.0	15.4
AQ Inkjet	1.3	2.8
liquid toner	1.5	3.4
dry toner QA	3.5	12.8
dry toner QBE	3.3	8.2
dry toner QBT	3.8	13.0
QB-I/CH/IC (2023)	3.3	12.0

Table. 16: showing the layer thickness in micron for 100% coverage and the corresponding g of CO2/m² for that layer.

Section 3

WASTE AS THE LAST PARAMETER

The last part of the calculation is the waste generated during the printing process. Since this is digital printing we disregard start-up waste for all technologies and assume we only print what is needed. So we focus on the major consumables that are replaced frequently such as fuser drums and belts, photoconductor elements, transfuse belts, developer, developer units, flushing liquids, imaging oil, ... Table 17 shows the numbers used for the different aspects which have been taken into account based on the composition and weight of all the consumables used during printing . This list is not exhaustive but we believe the most dominant factors have been included.

The required data for a printing head is difficult to obtain, so here we chose the carbon emission value of producing two smartphones as they represent a comparable complexity to produce (70 kg CO_2 per mobile phone) based on the following reference : https://greenly.earth/en-us/blog/ecology-news/what-is-the-carbon-footprint-of-the-iphone. The amount of imaging oil is very much determined by the type substrate and page coverages. From different sources (covering each millions of square meters printed on a yearly basis) we received data going from 3 gram imaging oil waste per square meter printed all the way to 14 grams. This is a very wide range and therefore we took the average of the two extremes to incorporate this aspect into the calculations ; 8,5 g/m^2 with an emission coefficient of 2,47 for isopar L as aliphatic solvent, adding 21,01 g CO_2 per square meter printed. For the packaging we looked at the average weight of the PE packaging of the ink and the toner. The parts taken into consideration for this calculation were the aluminum drums for OPC's and fusers for Xeikon machines and the developing units for the liquid toner machines. Due to lack of information of the composition of the OPC and transfer belts of the liquid toner technology there were not included for the moment. The differences in waste for the dry toner is related to the amount of toner in the bottles and the covering power of each toner system as well.

g CO_2/m^2	solvent	parts drums developer dev units	heads (g CO_2/g ink)	bottles & packaging
UV Inkjet			0.74	0.50
AQ Inkjet			0.74	0.70
dry toner QA		6.28		1.88
dry toner QB				1.71
dry toner QBE				1.47
dry toner QBT				1.81
liquid toner	21.01	2.91		0.50

Table 17 : most important consumables per technology type and their contribution in gCO_2/ m^2 for 100 % coverage

PUTTING IT ALL TOGETHER : THE SUSTAINABILITY SCORECARD

Since we now have a) the energy part, b) the ink part and c) the waste part, we can start calculating the carbon footprint for the different designs on different platforms and compare these 3 aspects.

The carbon footprint calculator incorporate several options that can be tuned on a case by case basis; Green Electricity or not, the geographical location (country or state), variations in printing speed, page coverage, ink type and printing width. In order to score the 3 main aspects and make that score visual, we introduced a very well-known pictogram that is being used in the consumer market, as shown below, where codes A to G represent the respective values in g CO_2/ m^2 in the table (Figure 18).

Together with the carbon footprint score and the visual, we also offer a survey of known and possibly unknown aspects of the different printing technologies, toner systems with respect to compliance and important composition aspects. And this makes the sustainability scorecard complete (Figure 19).

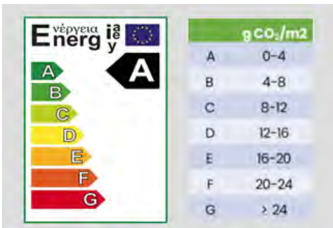


Figure 18 : visual representation of the scoring, with explanation of the codes.

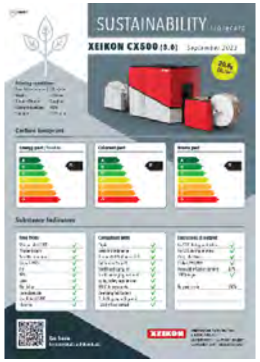


Figure 19 example of a Sustainability Scorecard of the CX500 (EU version)

Section 3

THE VALUE OF THE CARBON FOOTPRINT CALCULATOR AND SUSTAINABILITY SCORECARD

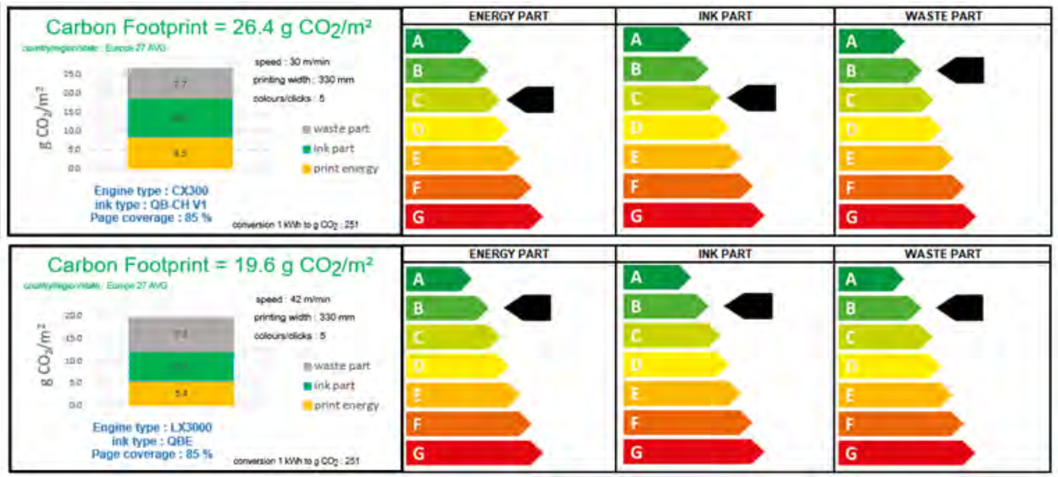


Figure 20 : Data from CX300, printing at 30 m/min (status 2023) versus LX3000, printing at 42 m/min with QBE toner (2024), showing a 25 % reduction in CF on all 3 parts of the contributing aspects (energy, toner and waste) for an average European Printer.

The initial goal however of this calculator is not to rank different engines or technologies. The tool has been made to investigate and study the changes in carbon footprint impact of adaptations we wanted to implement (like using recycled PET in out toners, using bio-based humectants in our Idera inks, increasing the speed of printing without changing the power supply of the presses, … and this based on some scientific based approach and easy to explain calculation. An example is shown in Figure 20 where we compare the CX300, printing at 30 m/min with QB-IC toner with respect to the new Lion (LX3000) printing with QBE toner at 42 m/min.

This tool thus demonstrates that Xeikon has a solid grasp of its carbon footprint and together with the other information in this whitepaper, understands the key areas where it needs to focus to achieve an additional 40% reduction by 2030.

Secondly, the availability of these tools, shows that Xeikon is actively studying the contributors of carbon footprint in the digital printing process (energy, ink and waste). This does not only enable a factual evaluation, but also facilitates the prediction of the possible impact of further improvements in the print technology or composition.

While the first two points are mainly directed internally, the third element pertains to sharing information with customers, prospects and industry professionals. Together with the CF score, they receive an insight in the compliance and important composition aspects of different printing technologies and toner/ink systems. They also can see what is the impact of recycling and or a possible switch to green electricity on their locations. Reducing the carbon footprint of Xeikon thus also reduces the carbon footprint of our customers and it gives them a basis to implement the aspect of carbon footprint reporting to their customers. It is not a standard but at least it gives a start to exchange some information which is in our view always better then not being able to tell/share anything at all.

Section 3

CONCLUSION

In view of environmental concerns among citizens, consumers, producers and legislators, the impact of Environmental Social and Governance (ESG) and Corporate Social Responsibility (CSR) on business behavior is growing.

Major schemes such as the Paris Climate Agreement, the UN Sustainable Development Goals, and (closer to home) the EU Green Deal define the high-level ambitions. However these ambitions have to be underpinned by objective, measurable criteria. In Europe the Corporate Sustainability Reporting Directive (CSRD) will enter into force in 2025, and this implies that larger brand-owners will already start requiring harmonized data from their smaller and medium size labels and packaging suppliers. Data they also need for comparisons between alternative labels and packaging solutions and processes.
But although European Sustainability Reporting Standards (ESRS) will be introduced, currently different interpretations, calculation methods, standards and tools exist along the supply chain. No wonder that PSPs and label converters are looking for guidance and support. One example is FINAT: they have embarked upon an initiative to help the industry understand the principles and tools, and to offer guidance towards implementation and harmonization. https://www.finat.com/documents/1155/finat-pcf-lca-leaflet-final.pdf

In section 1 we pointed out the sense of urgency towards the reduction of emissions in order to keep the planet a comfortable place to live for ourselves and the generations to come. Our Sustainability Program, and the carbon footprint calculator and Sustainability Scorecard in particular, aim to contribute and support PSPs and label converters in mapping the impact of their operations on the environment. By promoting transparency and providing comprehensive information, we aspire to set a precedent that other industry vendors will adopt. Xeikon remains open for discussion and further refinements if this is required to gain more common support ground and acceptance.