WHITEPAPER

Circular Shipbuilding Early Days, Clear Future

2024 UPDATE ON DEVELOPMENTS IN THE ROTTERDAM REGION

Circularity is a hot topic in many sectors, including the maritime, offshore and port industries. What is happening in the ecosystem of shipyards, suppliers, service providers and stakeholders? Can it be done? Read about intentions, initiatives and issues in this paper.

ROTTERDAM.
MARITIME CAPITAL OF EUROPE.

Introducing Circularity in Shipbuilding

"Being circular goes beyond sustainability. It starts at the drawing board, rethinking how and when you need materials, the options to reduce the use of key materials and resources, and how to minimize the footprint of the project and related processes. To become fully circular, you must develop sustainable methods in every aspect of the supply chain, from raw materials to finished products and from operational use to end-of-life, although 'end-of-life' becomes an obsolete term in a truly circular supply chain, of course."

Rosanne van Houwelingen
Project Manager Innovation
Netherlands Maritime Technology

"As the global population grows, so does the demand for steel, making recycling essential. We need to better utilize what we have. From this perspective, you could say that scrap metal is the new gold. Why? Because steel production generates significant emissions, and in the mining industry there are still a number of sustainability challenges to be overcome. Our product, separated, sorted and processed metal materials, is more sustainable than iron ore as such, since it's already in circulation. In principle, this process can be repeated forever."

Tjeerd Jager
Director Ferro Netherlands
EMR (European Metal Recycling)

Circular shipbuilding: Why and what is it?

Shipyards, shipowners, and other stakeholders in the shipping industry are experiencing significant changes in market conditions, regulatory frameworks, and in both the availability and reliable supply of (raw) materials. As a result, those involved in designing, building and decommissioning ships must develop the capacity to assess the economical and environmental footprint of their activities. That means shipyards, maritime suppliers and service providers, knowledge institutes, shipowners, regulatory bodies – *everyone* in the entire, front-to-end supply chain. And talking about 'end', there is no 'end' in the circular mindset.

In the greater Rotterdam region, several companies, research institutes and other stakeholders are investing in reduce-reuse-recycle experiments and collaborative projects. Seeing the necessity of this, the Port of Rotterdam Authority, the Province of South-Holland, the City of Rotterdam, and other cities in the region stimulate these collaborations.

DEFINITION

There's not one, exact definition of circularity or circular manufacturing, let alone circular shipbuilding, but taken together, here's a workable description:

> Circularity in shipbuilding refers to the application of circular economy principles within the maritime industry. It emphasizes the creation of a closed-loop system, a system that operates on the principle of designing-out waste and pollution, where resources are used, recycled, and reused to minimize waste and environmental impact throughout the entire lifecycle of a ship.

In a circularly operating industry, products and components are not discarded as low value residual or waste materials. Instead, they are recycled and reused after thorough inspection and processing, thereby also raising their value. Obviously, this is not yet the way 'things' work in the maritime industry.

However, it seems that consensus is slowly growing that there is a necessity to shift from traditional production and sales methods to new methods, designs and products that are crafted to ensure an optimal lifespan, and that can be adapted more than once to stay relevant for users.
Or, when reuse is not feasible, to focus on recovering valuable metals, especially because research reports suggest that there might be a *foreseeable* end to the availability of, for example, copper, aluminium, nickel, cobalt, and other materials. One forecast shows several industrial metals running out by 2050.

Note that there are different opinions on the scarcity of materials in the future!

"I'm proud to say that we are making progress, both in policy and on the drawing table, and in practice through concrete projects. However, our ambitions often exceed what is currently possible. This is logical, but makes fully circular shipbuilding quite challenging. From ideation, materials origins and design all the way to building, operations and decommissioning - and everything in between - the process must be financially viable for all stakeholders, be it through commercial benefits or via subsidized compensation. The extra work involved for all parties to make this happen must have motivational incentives that appeal to the global maritime marketplace, not only to the ideals of the early adopters. That said, we've already started and invest in experiments, because Damen acknowledges the urgency and importance of circular shipbuilding."

Dewi Wesselman
Project Manager ESG & Digitalisation
Damen Shipyards Group

Dewi Wesselman

Key principles of circular shipbuilding

When planning to 'go circular', there are several elements to incorporate into your process. A useful, and widely accepted, way to structure circularity is with the '10R Strategy':

10RS OF CIRCULAR MANUFACTURING

The 10R model provides guidance on how to reuse resources as much as possible, while reducing waste and environmentally harmful methods to a minimum.

The 10 Rs are

Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recover.

For shipbuilding, they can be visualised as follows:

TECHNICAL CYCLE OF THE BUTTERFLY DIAGRAM AND 10R-MODEL

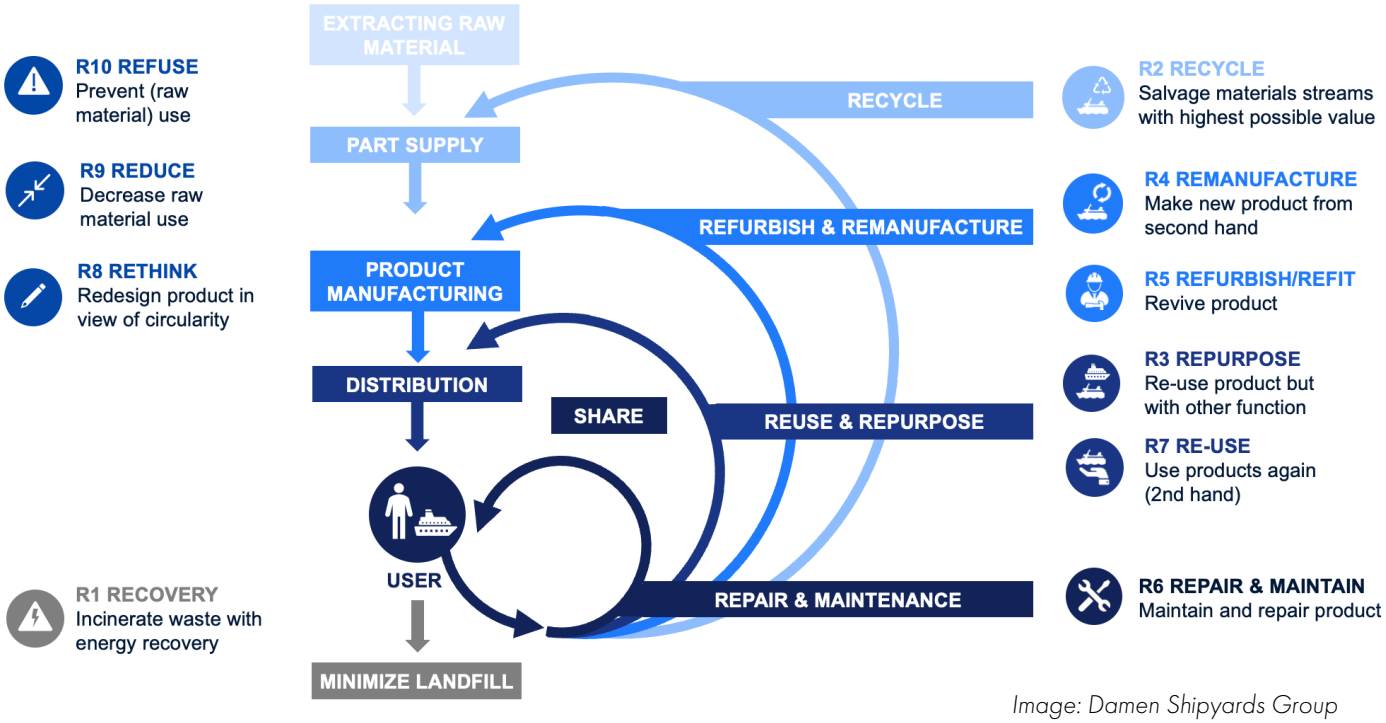

Image: Damen Shipyards Group

WHAT DOES THIS MEAN IN PRACTICE?

Which elements should actively be taken into account?

What are the key principles of a circular shipbuilding process?

1. DESIGN FOR LONGEVITY

Durable materials: use materials that can withstand prolonged use and harsh marine environments

Modular design: incorporate modular components that can be easily replaced, upgraded, or reused, extending the vessel's operational life

2. RESOURCE EFFICIENCY

Efficient use of materials: optimize material use during construction processes to reduce waste and resource consumption

Energy efficiency: incorporate energy-efficient technologies, tools and practices in ship design, construction, operation and decommissioning to minimize fuel consumption and emissions

3. LIFECYCLE THINKING

Lifecycle assessment: *evaluate* the environmental impact of a ship, again throughout its entire lifecycle: from ideation, design and construction to operation (and everything that comes with it in terms of maintenance, repair, vessel-related services, use of fuel, anti-fouling, even onboard drinking water etc.) and end-of-life recycling

Sustainable practices: *implement* practices that minimize negative environmental impacts at each stage of the ship's lifecycle

4. END-OF-LIFE MANAGEMENT

Recycling, reuse, remanufacture: develop systems for the dismantling of ships at the end of their operational life that ensure that materials are recovered and reused – and perhaps even remanufactured (check out the Maritime Remanufacturing Network).

Safe disposal: ensuring that any waste or hazardous materials are disposed of in a safe and environmentally responsible manner

5. INNOVATIVE MATERIALS

Recycled materials: utilize recycled materials in ship construction to reduce the demand for original resources, e.g. iron ore or oil

Bio-based materials: explore the use of bio-based and biodegradable materials that have a lower environmental impact

6. COLLABORATION AND PARTNERSHIPS

Industry collaboration: work with various stakeholders, including suppliers, shipyards, scientific institutes, and regulatory bodies, to discover and promote circularity practices

Knowledge sharing: share knowledge and best practices within the industry to drive collective progress towards circularity

By incorporating these principles, the shipbuilding industry can move towards a more circular, hence more sustainable business model, benefiting both the (natural and human) environment and the economy.

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Being circular goes beyond sustainability

Regional initiatives

Circular shipbuilding is still in it's early stages. In Rotterdam, there are many ideas, collaborative projects, experiments, subsidies, supporting regulatory frameworks and tools being developed, but a continuous process incorporating the 10 Rs in practice has not yet been realized.

Of course, *some* of the Rs are being practiced on a larger scale than others, for example recycling steel maritime structures – although even there, it's more about offshore (wind) decommissioning than about ships.
Still, there are two interesting examples of end-of-life ship handling. One is recycling company EMR, which has a recycling yard in Rotterdam, where former offshore constructions are being processed, mostly in the service of steel manufacturers that can melt down and reuse part of that material. In the USA, however, they have taken a former US Navy aircraft carrier completely apart, recycling a lot of useful parts and materials. The other is Damen Shipyards, which has dismantled a small, 1927-built tug to see if circular shipbuilding does not only provide environmental benefits, but can also become a commercially viable option.

ROTTERDAM REGION AIMING FOR A MORE CIRCULAR FUTURE

To give you an impression of what's happening, here are 5 efforts in the greater Rotterdam region aiming for a more circular future:

1. **Waste-to-chemicals plant**
   This initiative involves converting 360,000 tonnes of non-recyclable waste into 270 million litres of sustainable methanol annually. Partners include Air Liquide, Enerkem, Nouryon, and Shell.
2. **Heat network**
   Residual heat generated in the port is used to supply heating to approximately 500,000 households, greenhouses, and industrial processes.
3. **Rotterdam Makers District**
   This port area hosts numerous circular companies, such as Umincorp, which focuses on chemical plastics recycling, and Royal 3D, which specializes in innovative recycling processes, a.o. in the breakbulk transport and shipping industries. These companies are at the forefront of creating new circular value chains.
4. **Research and Development initiatives**
   Projects like DigiPACT and PATH4ZERO focus on digital twins for ports and zero-emission, robust inland shipping, showcasing the region's commitment to integrating advanced digital solutions into circular practices.
5. **Recycling wind turbine blades**
   In a creative approach to reuse materials, Blade-Made repurposed discarded blades into playgrounds and noise barriers.

Circular opportunities

A recent report on circular maritime opportunities (in Dutch only) states that the maritime sector's heavy reliance on materials makes a strong case for a robust resource strategy that focuses on material and component conservation and reuse. This necessity is becoming more pressing due to emerging signs of material shortages and developments in global competition.

Currently, financial motivations dominate in 'going circular', except for a few pioneering companies, and modular design or retrofitting often fails to deliver sustainable benefits in terms of material conservation and significant reuse.

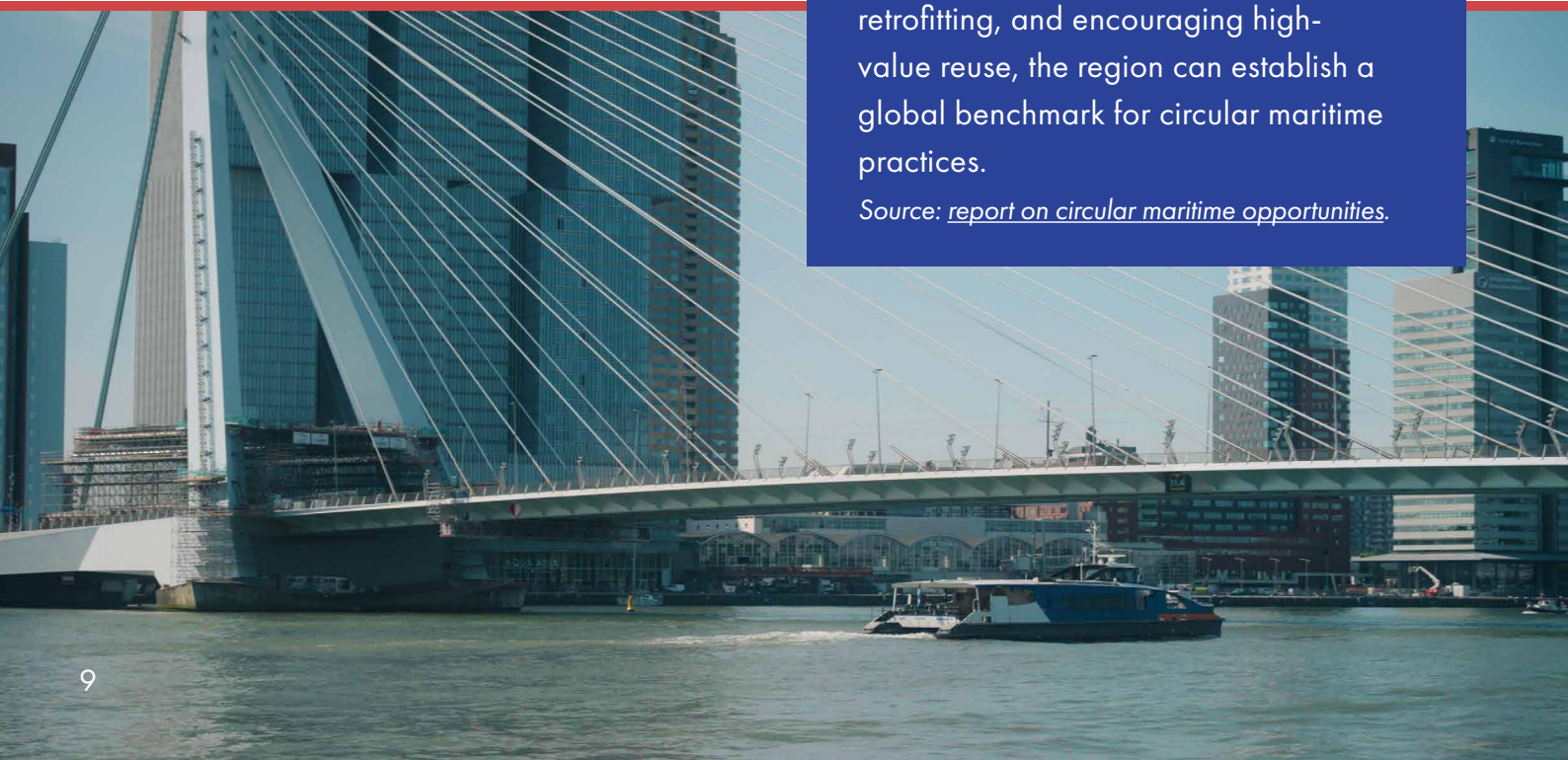
Regulations mainly emphasize energy efficiency and emission reductions. While this can lead the focus away from 'full-size' circularity, it does reflect the priorities of broad initiatives like the Maritime Masterplan, which aims to deploy 30 zero-emission ships by 2030 and provides opportunities for shipyards to take a step towards circular shipbuilding processes.

Projects like a Cradle-to-Cradle materials passport or 'Product as a Service' (where ownership remains with the manufacturer) are still being explored. However, the new generation is increasingly identifying and pursuing opportunities that align with both sustainability goals and economic benefits. Long-term sustainability can only be achieved by investing in true circular (re)manufacturing, while integrating societal and economic interests in the process.

RECOMMENDATIONS

The greater Rotterdam region has significant potential to become a leader in circular shipbuilding. By utilizing its existing strengths in modular construction, 'smart port & shipping' initiatives, prioritizing sustainable retrofitting, and encouraging high-value reuse, the region can establish a global benchmark for circular maritime practices.

Source: report on circular maritime opportunities.



Netherlands Maritime Technology

Netherlands Maritime Technology (NMT) is the trade association for Dutch shipbuilders and -suppliers. They provide their members with knowledge and training, organise trade missions and events around important topics, lobby in political circles and generally promote their members' interests.

Therefore, it's not so strange that NMT jumped on board one of the most promising circular projects, CirclesOfLife, where NMT is responsible for the dissemination and utilization of knowledge and research results and will develop trainings for manufacturing companies that want to start working according to the principles of circularity. Eventually these trainings will be available for all EU maritime suppliers and shipyards. So, what is the CirclesOfLife project?

CIRCLESOFLIFE

Rosanne van Houwelingen, NMT's Project Manager Innovation, explains: "CirclesOfLife is an EU-wide – and EU-financed - initiative focused on sustainable and circular shipbuilding. The three-year project unites 15, often competing, shipyards, universities, NGOs, and technology providers from across the European maritime supply chain to come up with innovative and collaborative solutions." "This project aims to revolutionize the current state of shipbuilding", says Rosanne.

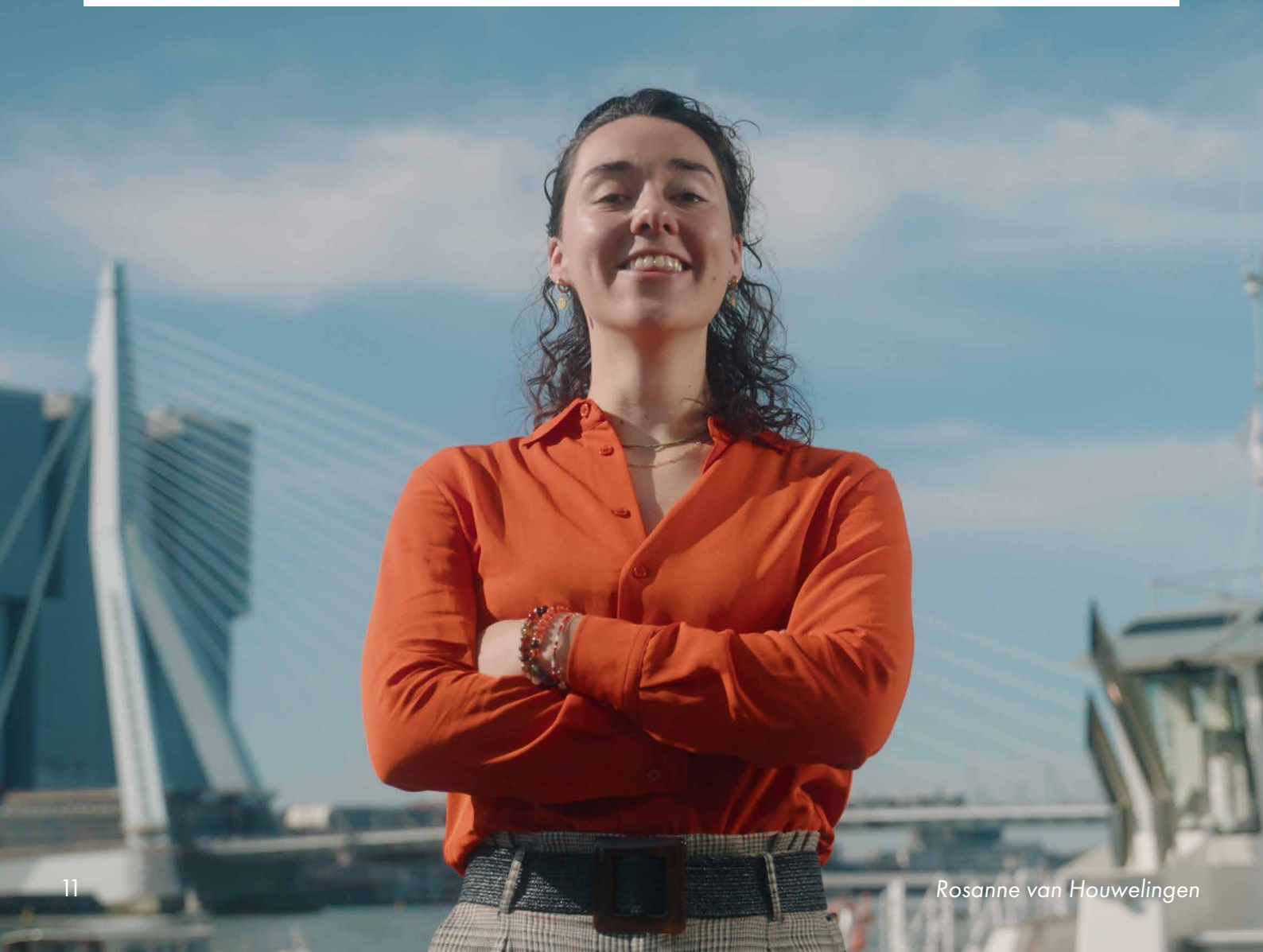
"How? By quantifying environmental performance of shipyards, identifying the impact of the used components and materials in a ship, and track their lifecycle. This provides valuable insights for predictive maintenance, recycling and zero-emission shipping."

To realise this objective,, CirclesOfLife will develop and test a methodology and tools that all European shipyards can use:

1. **SEPI: Shipyard Environmental Performance Index**
   The SEPI tool is there to help shipyards measure, assess, and improve their environmental footprints. SEPI will offer a standardized framework for enhancing sustainability in shipbuilding, repair, and recycling processes. Once finalized, SEPI will be made available for all European stakeholders.
2. **C2C Ship Passport**
   Together, the CirclesOfLife participants are developing the Cradle-to-Cradle (C2C) Ship Passport. This tool aims to reduce waste and promote a circular economy by documenting the lifecycle of materials used in shipbuilding, from design and production to repair and recycling. As with SEPI, this practical tool will be available for all stakeholders involved in ship creation, maintenance, and dismantling.

"With new legislation coming in, companies need to move in the direction of circularity. There's the Corporate Sustainability Reporting Directive, or CSRD, and that is a result of the ESRS, the European Sustainability Reporting Standards. This impacts large companies first, but as of 2025 all companies in the EU will be confronted with this. Hence our goal is to establish methods and monitoring systems that are aligned with the ESRS. The idea is that, when shipyards implement the tools we are now developing - SEPI and C2C Ship Passport – they automatically comply with the EU's new standards are helped with the compliance with the EU's new standards. With the support from the CirclesOfLife participants, and regulatory bodies, we facilitate faster market adoption of sustainable shipbuilding practices."
Finishing up, Rosanne says that "it's great that the region is deeply involved in this European project, from Delft, to Rotterdam, to Gorinchem. Both the public and private regional stakeholders want to be at the forefront of this development."

Rosanne van Houwelingen
Project Manager Innovation
Netherlands Maritime Technology



Rosanne van Houwelingen

European Metal Recycling (EMR)

In the middle of the Rotterdam port area EMR has its Dutch headquarters, although the originally UK company has expanded to a global industrial partner in sustainable materials with 150 locations worldwide. Recycling 10 million tons of waste materials annually, ranging from soda cans to entire former US Navy aircraft carriers, EMR plays a pivotal role as a supplier in the global chain of sustainable material use. In addition to the 200 new sustainable raw materials produced from the scrap intake, they are looking for ways to assist and advice the maritime industry in becoming more circular.

Tjeerd Jager, EMR's Director Ferro Netherlands, says: "If, often family-owned, companies want to continue building ships (or supply parts for ships) for generations to come, using the necessary materials – and keeping them affordable – then they must commit to recycling. Here, EMR can play its part. Not only can we advise shipyards and offshore (wind) operators on how to bring circularity into the design phase of their assets, but EMR itself also transports its sorted and high value metals via dry cargo vessels or coasters to smelting plants, like Tata Steel in the Netherlands."

"Shipbuilders and their suppliers need to take the next step in sustainability. Many residual materials can be transported to companies like EMR, where they can be made suitable for reuse. With our division EMR International Shipbreaking we already dismantle entire ships in the USA. We also want to do this in the Netherlands, but it's not easy to obtain permits - and space. However, if Europe aims for strategic autonomy and wants to keep valuable resources within its borders - resources that we now partly export - then Europe, including the Netherlands, needs steel mills and other heavy industry assets. Because of the surpluses of Western European scrap that are currently exported, additional steel mills are required in order to melt the surplus capacity within Europe."

"The good news is that we are already underway and have gained a lot of knowledge in the past years that we are willing to share. At our recycling yard, with its own heavy lift quay outfitted with hybrid and electric cranes, we are already handling decommissioned oil rigs and wind turbine materials. We cut these to the right length and supply them to companies who produce higher grades and qualities of steel. Those processes require the use of metals with a specific chemical specification, such as a low percentage of chromium, nickel and copper.

This recycling process touches upon many other environmental topics and industrial processes, such as energy consumption and

clean water, rig and vessel design, inland waterway transport and many other things that play a part in becoming a circular economy. Being in the port of Rotterdam means that you are close to all the other stakeholders with their own knowledge about these topics. When we all put our expertise together, we can make some big steps."

"Concrete, like EMR already does in the automotive sector, we can and want to be involved in the design phase of ships. For example: can the bulk of a ship's electronic hardware and circuit boards be installed in one location, in order to easily take it out again after 30 years? Or: how do you handle the various types of metals, which metals do you use and where do you obtain them? With the C2C passport, it would become easier to recycle a ship at the end of its lifecycle, but for that to happen shipyards should collaborate more, and that is still a sensitive issue."

"That's why the CirclesOfLife project is a great step forward: you see European competitors collaborating for the greater good – and EMR can play a part in this project."

Tjeerd Jager
Director Ferro Netherlands
EMR (European Metal Recycling)

WHERE DOES EMR SEE OPPORTUNITIES FOR CIRCULARITY?

According to Tjeerd, there is already quite a bit of low hanging fruit, such as:

1. **Decommissioning wind turbines**
   EMR tries to reuse as much material as possible.
   - The steel can go to foundries or be re-rolled, avoiding the need for melting.
   - Reusing electric motors instead of dismantling them.
   - Even the blades can now be granulated (the Port of Amsterdam is working on this). An obstacle is that manufacturers are unwilling to disclose their formulas.
2. **Sorting materials**
   EMR advises maritime companies on how to sort their materials better for higher homogeneity and quality in recycling, promoting the creation of materials passports for easier recycling during refits and end-of-life stages. As to metals, proper recycling ensures metals can be endlessly reused, generates minimal waste, and yields high-quality outputs ready for smelters.
3. **End-of-Waste certification**
   EMR initiated and obtained KIWA certification, allowing materials to be sold as secondary raw materials instead of waste.

Tjeerd comments: "Recycling is essential to prevent the earth's depletion of essential raw materials. And it can be done. The automotive sector is already quite advanced as to reintegrating recycled products into the often automated production process. The maritime industry is less refined and relies more on craftsmanship, but that also brings the benefit of material knowledge, which can be put to good use in thinking about sorting, recycling, reusing or repurposing materials that are now seen as waste."

Damen Shipyards Group

Dewi Wesselman, Damen Shipyards Group's Project Manager ESG & Digitalisation and its main circular economy specialist, is very clear: "We aim to be most sustainable maritime solutions provider in the world. We can only achieve this goal if we build our vessels with a cradle-to-cradle mindset, connect and monitor them throughout their lifecycle and operate them in a way that minimizes emissions."

"For us it was logical to participate in the CirclesOfLife project as we are already experimenting with, for example using circular materials for the interior of crew cabins, or the Damen Air Cavity System (DACS) which reduces water resistance. Furthermore, we're looking for ways to recover production materials, aim for products that are easy to maintain and repair, are seeking opportunities for the second life of batteries, and one of our major Rotterdam repair yards, Damen Shiprepair Verolme, is now certified for ship recycling."

OPERATIONAL INSIGHTS

"In addition, we have launched 'Damen Triton'. This is an IoT solution collecting data throughout the vessel. With these data we can make serious efficiency gains. For example, using Triton in two new ferries has led to the captains actually adjusting their sailing behaviour and a 20% decrease in fuel consumption and emissions. Another benefit is that we can also refit this system, enabling existing ships, in theory the entire global fleet, to get clear picture of their operating profile, which then can be used to increase efficiency and decarbonise their operation."

Dewi continues: "We also aim to gain circular insights through the recently establishes Damen Heritage Fleet. This is a group of six very old Damen designs, for example a tugboat from 1969 and a small motor yacht from 1949. We will try to keep these vessels in sailing condition forever, applying circular principles in their maintenance. We've also taken an old tug from 1927, taken it apart and defined all the waste streams and what can be done with them, an interesting exercise!" All in all, Damen is trying to come full circle by closing the gaps in the loop, as visualised below.

CLOSING THE LOOP

- Minimize the use of raw materials and design out waste and pollution
- Retain the value vessels, components and materials
- Recirculate materials and reuse products to eliminate waste

Image: Damen Shipyards Group

REGULATION: CSRD

"In general there's a big push towards sustainability for EU companies, as under the CSRD (Corporate Sustainability Reporting Directive) it is mandatory to report about it in conjunction with your financial reports. In the maritime industry, we see that more and more investors and banks also want to see these facts and figures before deciding whether or not to invest in new vessels. Concrete: to receive a green label we now have to show that the ship emits 20% less GHG emissions in order to get a lower premium on financing," says Dewi. "We've taken this fully on board and will take our 'cradle to cradle' responsibility."

According to Dewi, the maritime industry holds significant potential for circularity. Key factors are:

- **Valuable assets**: large and expensive vessels naturally benefit from extended lifecycles to maximize their value.
- **Material value**: the materials and components of ships are valuable and resources become more scarce, making it logical to reuse them rather than constantly producing new parts.
- **Sustainability vs. circularity**: there's a balance to be struck. For example, an older engine might emit more pollutants than a new one, but its material can be reused for a long time.

To reach this potential, however, several challenges have to be overcome.

- **Financial barriers**: to capitalize on this potential commercially, Damen plans to offer vessel recycling services to its clients, regardless of whether they built the vessel initially. Financing remains a challenge, as most owners see recycling as a cost. "One solution could be to offer them a discount on a new vessel in exchange for their old one", says Dewi. "Another solution is PaaS, or Product as a Service, where we, as builders, keep track of 'our' vessel throughout its lifetime."

PaaS This is a new lease-focused business model which can help retain customers and ensure better maintenance, leading to components lasting longer and reduced material consumption.

- **Material regulations and transparency**: complying with regulations, such as those for asbestos, which is used in many older vessels, can complicate material or component reuse.
- **Global production system**: recapturing materials and recycling or remanufacturing them presents significant difficulties within the current global vessel production, purchasing, sales and operations system, which wasn't designed with circularity in mind.

Despite these and other challenges, Damen believes that it is possible, the CirclesOfLife project being a step ahead. "The cooperation of suppliers is key. Currently, they are often still hesitant to dedicate time and attention to this, and don't have, for example, the traceability data of the materials they use. So, together we are looking for new ways of collaborating in a way that enables circular shipbuilding, such as having engine manufacturers remain responsible for the engine throughout its lifecycle - aligning with the concept of 'products as a service'."

> Dewi concludes: "Working together with various stakeholders, including competitors, we believe we can integrate circular practices throughout the entire ecosystem and supply chain."

Why Rotterdam?

Regarded as the Maritime Capital of Europe, the Rotterdam region stretches from Hook of Holland to Gorinchem and from Delft to Dordrecht. The area exudes a strong maritime presence and attitude. All essential services are available along the Maas and Merwede rivers (part of the Rhine delta).

Not only can you find terminals, shipping companies, manufacturers and shipyards, but also any type of service provider, such as marine lawyers, repair facilities, (technical and business) consultants, freight forwarders, insurance companies, investors, universities and more. In addition, the regional cities' and ports' ambition to provide existing and new companies with the chance to settle and grow has a positive impact on the entire supply chain.

WE CONNECT YOU TO RELEVANT SPECIALISTS IN THE ECOSYSTEM.

INTERESTED?
Want to be part of the circular or other maritime developments in the greater Rotterdam region? Please reach out to us via maritime@rotterdam.nl or visit www.rotterdammaritimecapital.com.

THE FUTURE OF MARITIME.

FURTHER READING

When it comes to circularity and circular manufacturing, there's more going on in the wider Rotterdam region than in the maritime industry alone. Some of these initiatives have a correlation to or overlap with port, shipping and shipbuilding activities, both on a practical and policy-making level. Here are 5 projects and innovations that can help you dive deeper into circular activities, reports and organisations:

- Circles-of-life.eu
- en.rotterdampartners.nl
- Hollandcircularhotspot.nl (a.o. this page)
- Kenniskaarten.hetgroenebrein.nl
- Portofrotterdam.com

More information

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