LOOP·Ports
Circular Economy Network of Ports

Climate-KIC
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LOOKING AT THE FUTURE OF EU PORTS

OPPORTUNITIES FOR INTERVENTION
INNOVATION RECOMMENDATIONS

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Content

Who this report is for and how to use it

A report for the port sector and its stakeholders

This is a report for Port Authorities and other port management bodies, as well as for port stakeholders - think of companies within and around the port, but also municipalities, cities, legislators, industry bodies, knowledge institutes and citizens.

The objective of this report was to identify key innovation recommendations that would enable ports to make subsequent steps in becoming more circular themselves, as well as to (better) enable them to actively facilitate circularity within societies and economies. This explains the wide range of stakeholders that feature in this report: many other actors besides ports have important roles in supporting and enabling ports in becoming more circular.

To enable a focus on both the individual levers as well as on the different stakeholder roles, the following was done. It was decided to first list the key innovation recommendations with the respective lever of change it applies to (see section *Lever of Change)*. However, at the end of the report a summary is provided that collects the key innovation recommendations per stakeholder group. It should be kept in mind, however, since the interviews this report is based on were conducted with a focus on port management bodies and port authorities that these lists are a starting point and they need further development and refinement through working with these respective stakeholder groups.

When reading this report please keep in mind

Levers of change can be - and often are - closely related. To avoid repetition in this report, levers of change other than discussed in a specific section are referred to using '> *Lever'* followed by the number of the relevant lever where applicable. The reader may therefore want to refer back to previous sections whilst reading.

Also keep in mind, that the case examples used in this report to illustrate both the port CE themes (see section *Ports & Circular Economy)* as well as relevant aspects of the 7 levers of change are drawn from the interviews, the case examples from other case study work conducted in the LOOP Ports project, the academic literature, and materials found through web searches. Furthermore, quotes may have been translated into English and edited to fit. Care has been taken, however, to keep the original meaning as closely as possible.

Executive summary

This report analyses the most important drivers with the potential to unlock system innovation in the port sector towards circular economy. The primary source of information was a series of interviews with ports and port stakeholders in Europe, conducted during May - October 2019.

The first key learning was that a more rich understanding of the CE concept needs to be disseminated more widely (*Lever 1*). That is: CE encompasses a wide range of circular strategies, of which recycling is only one. This applies in particular to newcomer ports - ports that are relatively new to CE - which seems to be the majority of the ports in Europe at the moment. Of course, several forerunner ports also exist - ports who are experienced with applying CE thinking.

In addition to this, collaboration and co-creation efforts are crucial: to understand the local potential for CE in a port, as well as for the development and implementation of CE initiatives (*Lever 6*).

One important area that should be focused on when engaging with newcomer ports is to show benefits from circular initiatives, whether they are financial, mitigate risk, or capture other types of value. It would be beneficial to provide examples of inspirational business models and business cases, and to adapt or develop these for the local contexts (*Lever 2*).

The second area of key importance is to design new processes and new ways of working together to capture the identified opportunities (*Lever 6*). Knowledge and skill development should therefore focus on these areas first (*Lever 7*). The remainder of the levers of change become more important when ports become more advanced in their approach to CE.

LOOP Ports project summary

As part of its continuous effort to transform Europe's economy into a more sustainable one, the European Commission launched in December 2015 the Circular Economy Action Plan [1]. A series of initiatives followed to bring the vision set out in this plan a reality. In this context, the port area is a crucial sector, as it serves as 'matchmaker' and crossing-point for all kinds of waste and industrial flows and acts as logistics hubs for the import and export of waste materials. This is why ports are ideal places to further assess and incorporate circular economy strategies. What's more: ports already accommodate industries that are active in the treatment, collection and shipment of waste. The LOOP Ports project aims to build on existing circular economy initiatives in ports, and look at how they can be improved, scaled up, and what other potential for increased circularity is currently left untapped. For this, the LOOP Ports project actively works with the ports to understand their needs, provide inspirational case examples, and to develop initiatives that will help ports to make the next step in their circular economy initiatives.

Where to focus interventions aimed at systems innovation

For newcomer ports - ports that are exploring CE potential

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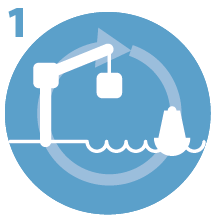
Ports & Circular Economy

'Refuse, reuse, recycle' is a familiar approach for waste management and resource efficiency. However, opportunities to preserve or extract more value from resources, as well as for saving costs are left untapped by not looking at resource use holistically. For example, think of strategies that support products through their life such as maintenance and repair, but also upgrading, refurbishment and remanufacturing. Likewise, for materials, think of cascading or industrial symbiosis, where materials are not simply recycled, but given a high-quality or high-value second application. Together, such approaches are referred to as a 'circular economy,' or CE.

Ports can become more circular in a variety of ways. These ways are covered by the three port CE themes described below: circular ports assets and equipment, circular flows within ports, and ports as part of circular markets. One or more of these themes can be deployed in different ways by port authorities, the companies within the port and even in collaboration with other companies and even cities near to the port, depending on the context. See for a short description of the themes and inspirational case examples below.

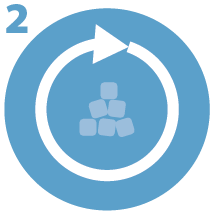
How ports can work with circular economy

3 themes:



Circular assets & equipment

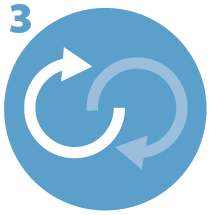
Optimisation of capacity and life-time extension of port assets and infrastructure, such as buildings, cranes, quays, buoys and other equipment through maintenance and smarter use (sharing, renting, etc). Incl. green procurement.



Circular flows within ports

(and between ports & surrounding area)

New uses for would-be wastes generated by port activities, such as ship waste and by-products of industries within ports and port (re)development activities (recycling, upcycling, cascading, etc).



Ports & circular markets

Ports enabling other industries – both on and offshore – to become more circular by developing new activities that connect supply and demand for circular resources targeted at the material moving through the port.

Case examples

- *Port of Haminakotka, Finland*
  Digitalisation through 3D operating system - this allows intensification of daily port operations, as well as effective maintenance and repair of port facilities.
- *Ramsgate, United Kingdom*
  A new light-weight and modular design enables quicker buoy maintenance, with less stock in reserve, and executed by smaller ships enables more cost-effective maintenance.
- *Cruise liner in port (DTU)*
  A cost-effective product/service system for reducing in-harbour emissions through onshore power supply.

- *Port of Aalborg, Denmark*
  Dredging has become a value adding activity - the sands are used as a raw material in the production of grey cement in the co-located cement plant.
- *Port of Boulogne-Sur-Mer, France*
  Fish by-products used as raw materials and ingredients for the nutraceutics, functional food, cosmetics and animal nutrition markets.
- *Port of Goroand Garibaldi, Italy*
  To ensure a sustainable production of seafood, a circular value chain is created aimed at prevention measures to limit lost nets, reporting of lost nets, and collection and recycling of collected nets. Lastly, biodegradable nets are being developed.
- *Port of Marseille, France*
  The VASCO project is using state-of-the-art green chemistry to transform industrial fumes, such as CO_2, from industry based at the port in the production of microalgae.

- *Port of Frederikshavn, Denmark*
  Full circle decommissioning of ships & rigs - a dedicated quay with specialist facilities is built that will support 100% repurposing of both machinery and materials.
- *Port of Antwerp, Belgium*
  The Carloop project - extending the life of car parts and recapturing valuable raw materials by providing logistical services that link locations where products are used, with locations where specialist knowledge is available for parts refurbishment and recycling.
- *Port of Moerdijk, Netherlands*
  Piloting return logistics to valorize waste tires through pyrolysis - replacing incineration to obtain gas, oil and biochar for producing new goods and generation of energy.

Approach

The primary source of information for this report was a series of interviews with ports and port stakeholders in Europe, conducted over the period May - October 2019. 'Port' is used here to indicate a port management body, in recognition of the fact that such bodies have a varied ownership and management structure across Europe. In addition to this, a targeted academic literature review was conducted. Finally, supplementary materials from the interviews were collected (websites, referenced documents), as well as relevant materials from web searches.

Interviews

In total 17 European ports participated and 2 (inter) national port industry bodies. 14 core ports were interviewed, 2 comprehensive ports, and one port management body represented a mix of these. Ports furthermore represented a mix of ownership and governance structures. Six interviews with other port stakeholders complement the dataset. These stakeholders represented the maritime industry, local authorities, environmental organisations, and port users such as cruise companies.

On average the interviews lasted 1hour and 20minutes, with the shortest taking 30 minutes, and the longest 3 hours. Nine of the interviews were conducted with 2 or more interviewees, with a maximum of 5 interviewees. Interviews were held in the interviewee's native language, or in English if the interviewee was comfortable with this. 11 of the interviews were conducted face-to-face, the remaining 14 through Skype or telephone.

Interviews were recorded wherever interviewees allowed this, and transcribed, summarised and aggregated in a common data-sheet used for analysis. Interviewees were provided with the transcript or summary, and asked to validate the reporting of the interview. Quotes used in this report are translated into English, and edited for legibility.

Interviews were conducted under the condition that the comments would be confidential, and that results would be presented in an aggregated and anonymised way. For this reason, quotes used in this report are anonymised. Despite this, some interviewees asked to remove what they considered sensitive information from the interview reporting (which was therefore not used in the analysis).

The interviewees

19 of the interviews involved an interviewee with seniority within their organisation: defined as having 'director,' 'head of department,' 'president,' or 'senior' in their job title, or their assistants.

6 interviews represented a technical, operations or general management perspective; 13 interviews represented an environmental, or security/ safety expertise; 6 interviews contained a mix of expertise.

Interview guide and materials

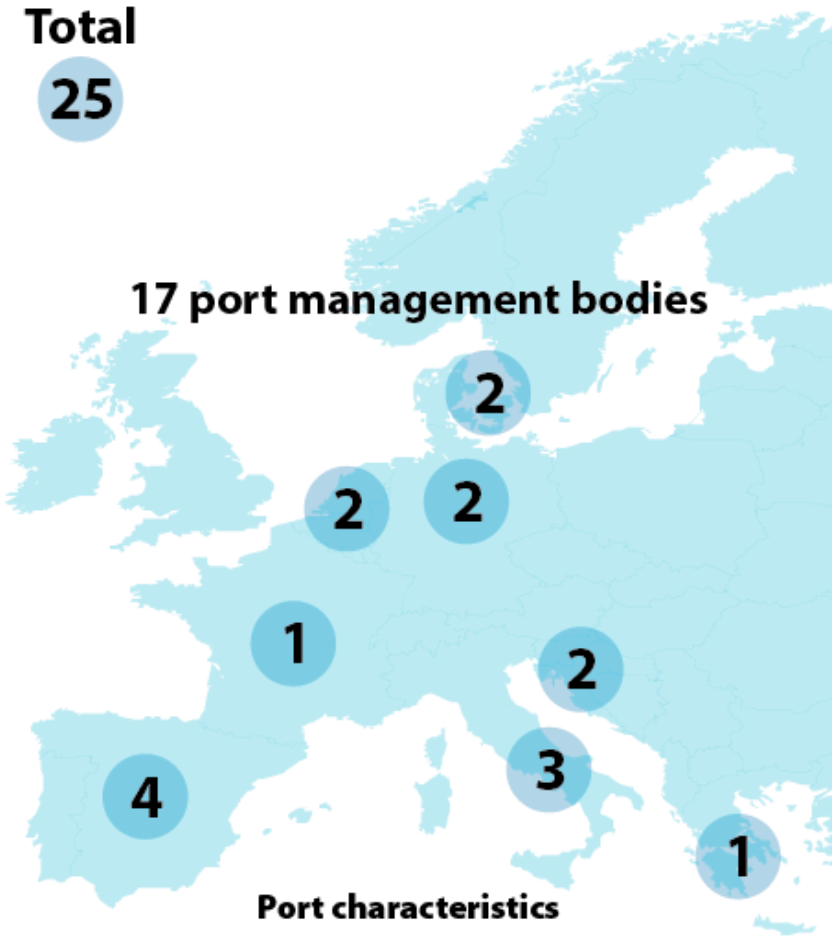
Three pilot interviews were conducted to test the interview guide. Minor adaptations were made to the interview guide, after which it was used in the remaining interviews. Other materials, such as six inspirational case examples (printed on A4) and a materials sheet (A4) were also provided to serve as boundary objects to discuss during the interview.

Literature search

A targeted literature search was conducted in Scopus and Web of Science: the two major repositories for academic papers. The search was conducted in April, and updated in October. The keyword 'port' or 'harbour' were used, in combination with various synonyms for 'circular economy.' In total 37 academic publications were found, and 20 were included based on relevance.

Analysis

Quotes or summaries of the discussions were placed in an Excel sheet that contained a space for each of the 7 levers examined in this report (see next page). A thematic analysis was performed on this, using the interviews from the 17 ports and 2 port bodies as the main starting point, and supplementing this with the other interviews and documents.



Port characteristics

Type		Ownership		Governance	
Core	14	Municipal	5	Tool port	2
Comprehensive	2	Regional	2	Corporatised	2
Mix	1	State	9	Landlord	11
		Private	1	Private service	2

+ 2 (inter)national port bodies

+ 6 other port stakeholders
(Maritime representatives, local authorities, environmental organisations)

+ relevant literature
(Academic and practitioner literature)

7 Levers of Change

Levers of change or system levers are system conditions that support or aid a change or transition. Having strong levers that point in the same direction can accelerate a transition and different levers can be important at different stages of a transition.

The levers of change used here, were developed by EIT Climate-KIC through a co-creation process with a range of stakeholders. Together, the 7 levers of change as described below, cover the key ingredients of a systems change. The descriptions below are adapted for use in the port sector and circular economy as described below.

7 levers of change
within scope for this report:

Lever #1
Awareness and information regarding CE potential
The first condition for change is awareness of the problems that CE can help address and areas where CE can create new opportunities (conceptual understanding of the CE concept). To make a clear link with the local situation in the port, insight into current resource streams and other improvement opportunities are needed. Next, technical and non-technical knowledge is necessary to effectively leverage CE to capture the associated business and enviromental benefits.

Lever #2
Business models & market structure
The second lever focuses on the formal and informal relationships between actors in the port sector. It can be split into two strongly related aspects: the way business is conducted (how ports create, deliver, and capture value, in economic, social, cultural or other contexts to other stakeholders) and market structure (competition and collaboration, information sharing, economies of scale, transparency, stability, and market shaping instruments such as fines, fees, contracting practices, rebates, etc).

Lever #3
Rules, policies, and regulatory instruments
This lever covers the legal, policy and regulatory instruments deployed by local, national or supranational governments, business and other organisations to influence decision making linked to the port sector that direct or determine what circular economy initiatives are viable. Think of strategies, targets, performance and technology standards; labelling and bans; spatial planning; monitoring and enforcement; and assessments and permits.

Lever #4
Fiscal instruments, investment and funding
Lever four examines the current situation and developments related to fiscal instruments and incentives. It asks what financial tools (fines, rebates, bonuses, procurement) are currently available to ports to stimulate CE initiatives. This lever furthermore explores the status of the investment climate, and the role of funding instruments such as grants and subsidies.

Lever #5
Technology, processes, design, standards and infrastructure
This lever revolves around the physical conditions that can help or hinder circular economy practices. It explores the current status of technology, designs and processes, and how new developments in these areas create new possibilities. In addition to this, this lever examines what standards or certification schemes are needed to capture these opportunities., as well as the enabling role infrastructure plays.

Lever #6
Collaboration inside the port and with other port stakeholders
This lever examines the status as well as the need for collaboration and co-creation processes between stakeholders. It focuses on both the engagement of the ports with its environment such as businesses based in the ports, solutions providers, legislators, etc. In addition to this, a spotlight is put on the relationship with the cities ports are often based in or near, and the need for a positive engagement with citizens that stems from this.

Lever #7
Technical and non-technical knowledge, skills and capabilities
This lever reviews the previous levers and looks at what knowledge, skills and capabilities are needed for ports to make the next step with circular economy. A distinction is made between newcomer ports - ports new to circular economy, and forerunner ports - ports who are experienced with applying CE thinking.

Awareness and information regading CE potential

The current situation

Although many circular initiatives are ongoing in ports - and have been for a long time - it appears that CE as a strategic concept is still largely unfamiliar. Generally, where the term "CE" is known, the primary interpretation revolves around waste management, whether this is ship waste or waste from fisheries, or waste resulting from cruising activities.

That is: when using these wastes to create circular flows within ports, the focus is on generating more high quality - and thus more valuable - outputs. This can involve working with waste management companies to increase the separate collection of waste flows, so they can receive special treatment. In addition to this, synergies between industries in the port area are explored and valorised. Examples of this are industrial symbiosis projects, which focus on the exchange of waste materials, heat, gases and slurry between production facilities. Similar synergies are also pursued between the port and neighbouring cities. Such activities are aimed at generating sufficient economies of scale for recycling and composting activities, when port wastes alone are insufficient.

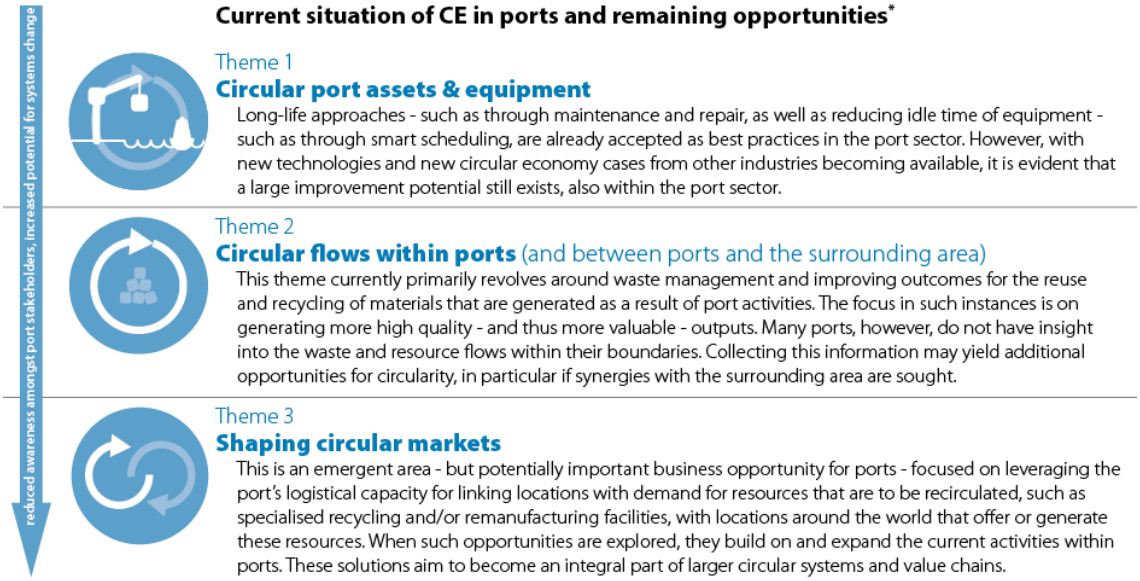
Preventative strategies are also seen, such as the EC regulation to report and retrieve fishing gear that gets lost in sea [2]. Projects are also underway to explore whether fishing nets can be made from bioplastics that can safely biodegrade [3].

Long-life approaches for port assets and equipment-through maintenance and repair, as well as reducing idle time of equipment - such as through smart scheduling, are already accepted as best practices in the port sector. However, with new technologies (> *Lever 5*) and new circular economy cases from other industries becoming available, it becomes evident that significant improvement potential still exists [4] [5]. In the heavy machinery industry, for example, digitalisation and predictive maintenance are increasingly important to keep equipment functioning well for longer. In certain types of product/service systems, furthermore, the end-user no longer owns the equipment, but merely buys access to it or the performance it delivers. In such cases the manufacturer has a clear incentive to maximise longevity and minimise downtime [6].

From the building and construction sector, likewise, examples have emerged that include modular designs, enabling moving or adapting a building as the needs change [7]. Buildings that use renewable materials such as wood in their construction is also a recent development in this area.

Circularity enabled by ports is an emergent area, focused on leveraging the port's logistical capacity for linking locations with demand for resources that are to be recirculated. Think of specialised recycling and/or remanufacturing facilities, with locations that offer or generate these resources. This development was already anticipated in earlier work exploring potential in this area [6]. When such opportunities are explored, they build on and expand the current activities within the port or region (also known as economic clusters [7]). For example, if the port serves as a distribution hub for particular goods, it is examined how additional activities or new types of businesses can add additional loops to these existing value chains.

Although this has the potential to create win-win situations where the port generates new businesses, and increased circularity is the result, interviewees have noted that it cannot be assumed that this is automatically more sustainable. As transport activities come at an environmental cost, Life Cycle Assessment or other such methods need to be applied for determining the environmental benefits.



What could support improving and scaling CE solutions?

Several factors currently hinder the further development of CE initiatives in ports. First, a more rich understanding of the potential of CE needs to be disseminated more widely. One of the interviewees put it thus:

> *"Sometimes you might hear people talk about the concept of CE, but what they mean is producing electricity from burning waste. Raising awareness about basic concepts of CE, is therefore an important topic. I'm not sure if all people involved in port operation are fully aware what CE really is: that the real purpose is to minimise waste production, and to maximise reuse and recycling."*

In other words, CE encompasses a wide range of circular strategies, of which recycling is only one. When communicating about CE it needs to be framed in a way that is relevant for the port sector [10]. This can be done, for example, through using the 3 themes, in combination with case examples (> *p. 6*).

Next, the local potential needs to be understood, so that a set of strategic initiatives can be developed. It is clear that this may involve a wide range of materials (> *section Materials)*, but which ones and under which of the 3 themes the circular activities would fit, strongly depends on the characteristics of a port and its environment. Therefore, the first step would be to collect data on this. Some ports already collect data about waste and flows, and others may be able to start doing so. For some, however, their ownership and governance structure limits or prevents the access to such data:

> *"Materials just pass through our ports, we don't do anything with it, we don't have any machinery. And therefore it's not really up to us to say "let's change it into something else."*

In these cases, it may be possible to work with stakeholders to collect the data. Knowledge institutes can support such efforts and collate publicly available data, or perform modelling. In addition to this, they can provide methodological support (e.g. Material Flow Analysis, Input/ Output Analysis, Spatial Analysis [e.g. 6]). However, stakeholders may consider this information confidential or proprietary, or be unwilling to share for legal or fiscal reasons (> *Lever 3*). In such cases, a third party can be used to conduct interviews under a non-disclosure agreement (NDA), so that synergies can be explored whilst assuring that only relevant information is used with permission.

*Building on [8], expanded and reframed through including the full range of circular strategies associated with CE [9].

For smaller ports the capacity for collecting data in this way may be prohibitive. To get around this, data could be generated through working with a smaller sample of larger ports or those ports whose ownership and governance structure allow for data collection. This could be used to create 'port profiles' or 'CE solution sets' linking specific port activities to matching CE case examples. One avenue that could be explored, is whether port terminals can be characterised in terms of the potential for CE. If this is made available as a self-assessment that ports can perform unaided, this may provide a means for the wider dissemination of how CE offers a different way of conduction port activities. This would be supported by the inclusion of inspirational case examples [11] and clear business cases, or a clear explanation of other drivers or benefits such as risk reduction and other means of capturing value [12][13][14]. That such benefits may not always be monetary, was helpfully highlighted by one of the interviewees, when discussing green certification and schemes:

> *"These schemes aimed at giving ports a good market reputation, so that their customers - retailers - can advertise that their products are sustainable, if you go to buy clothes, you can see, they put a tag, sustainable jumper. That means that this jumper has been transferred, from Asia to EU by a ship that is greening its operation."*

Encourage, assist, trigger.

Merely providing information, however, has proven insufficient to initiate green or sustainable change efforts in the past. Often, a trigger from the environment such as water scarcity [14] or some other incident is needed. However, encouragement and assistance can fulfil a similar role [14]. Think of facilitated workshops that help both the individual and the network of ports to identify initiatives.

Summary of Key Innovation Recommendations

1. Disseminate a more rich understanding of the potential of CE more widely

The 3 themes can be used as a framing to convey the broader relevance of CE to ports and to inspire with concrete examples.

2. Provide a means to understand the local potential for a port to work with CE

To generate a first picture of where potential lies, provide a simple and quick means to perform a self-assessment for ports.

This would be supported by the inclusion of clear business cases for inspirational examples, or a clear explanation of other drivers or benefits such as risk reduction.

To create an in-depth understanding of the local context when there is publicly available data to draw from, involve knowledge institutes to collate it and offer methodological support.

To create an in-depth understanding of the local context in cases where data is not (publicly) available, use neutral third parties under NDA to explore synergies in a safe environment.

3. Encourage, assist, trigger

Go beyond providing information: actively involve individual ports and other local stakeholders and encourage networking among ports.

2 Business models & market structure

The current situation

An area that is seen as an important enabler for CE is circular (public) procurement [15] > *Lever 4*. Through applying this practice, ports can enable circularity in other industries, whilst getting access to more resource efficient products and services. For example, when equipment needs to be acquired this can be done on the basis of availability instead of ownership, or have the results as the basis for contracts instead of a pre-defined solution.

Although not always bearing the label of circular economy examples can be found, for instance, in the heavy machinery sector. Product/service systems such as those on offer for cranes, can extend product life and reduce downtime [16].

Adding circular elements to port business models.

It was observed that ports add circular elements to their existing business models to enable circular port operations. Take, for example, waste valorisation activities such as the separate collection of waste. This can achieve better outcomes from a recycling or composting point of view, and does not necessarily have to cost more. Examples show that it is possible to turn such activities into value-adding activities, amongst those the Empty Depot - Area Workshop in the Port of Ravenna [17]. Likewise, the use of renewable energy is explored by many ports as a means to become more sustainable and more circular, whilst reducing running costs or to offer additional services, such as onshore power supply. For example, in Copenhagen-Malmö Ports it was explored to turn ship bio-waste into on-shore electricity [18].

These activities can involve enhancing business models of providers of circular services (such as waste handlers), or be added as circular elements to a port's own business model (e.g. additional revenue streams through waste valorisation).

Ports as part of circular industries, cities and markets

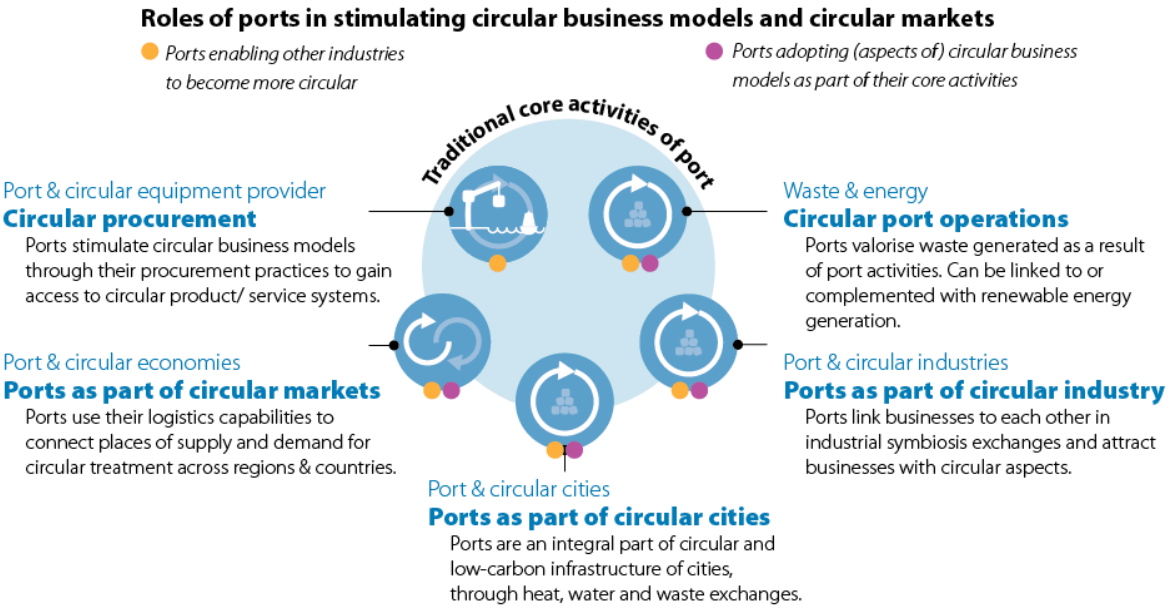
Ports have also been observed to take on roles as facilitators in circular industries. That is: ports actively investigate what flows go unused by the industries in or near them and find subsequent uses for these resources in industrial symbiosis schemes [11].

Similar synergies can also be seen when ports are part of circular cities. Ports can become an integral part of circular and low-carbon infrastructure of cities, through enabling heat, water and waste exchanges. Examples of this can be found in cities such as Amsterdam, Rotterdam, London, Antwerp, Hamburg, Marseille, Lisbon, and Porto [19].

In addition to this, ports can play an important role in circular markets. That is: through strategically leveraging their function as transport hubs, it is possible to find and exploit gaps that add new loops to existing value chains. Think, for instance, of the CarLoop project in Antwerp [20], or the Moerdijk project involving the pyrolysis of waste tyres [21]. In both cases, these ports already function as a hub for transporting these resources, and merely add a loop to existing activities in the market.

These efforts require that ports take on an active role as shapers or participants in circular industries, cities and markets in addition to loading and unloading ships. Even though ports are limited by the information available to them, they are in the unique position to connect stakeholders [6]. One interviewee observes that such activities are a natural extension of current activities within ports:

> *"Valorising flows, whether these are residual streams or virgin, is in the nature of most of the companies in the port. Hence, the CE is something that fits well within harbours: reusing streams and goods fits with conventional activities."*



What could support improving scaling CE solutions?

Circular business models

Many of the ways in which ports can contribute to circularity do not necessitate a change in port business models. For instance, circular procurement approaches primarily need new tendering and contracting practices within ports. Likewise, ports could continue to generate revenue through ship and handling fees, but influence whether the transported flow contributes to circularity. Empty freight capacity can be the starting point for exploring new circular business cases, as these two interviewees explain:

"Because ports have to grow in sectors that are generally not growing much; the CE provides new goods and (return) flows that can be valorised and marketed."

"The more sophisticated the way in which we will reuse waste, the more sense it makes that it's concentrated. And then it makes sense to ship it. I think this will be an enabler or opportunity for ports to develop and get this market."

However, developing such opportunities would require a different mindset, different activities and different skills and knowledge (*> Lever 7*):

"The [port] company missions have been very narrow: their main mission is to load and unload ships. If we start looking at what a port can actually do in the future: being a facilitator, being a spider in the web, connecting people. It's a completely different role for the port trying to make more business, trying to help the clients in a much earlier stage. Now, in order for companies to choose [a port], [ports] also need to import something, because you don't want the ships to be empty in one direction."

Other circular port operations of ports as part of circular industry and circular cities may necessitate the expansion of existing business models. Depending on the local context, this may even entail a shift in core activities of the port. Think, for example, of cases where ports actively develop opportunities related to circular port operations or to circular industry or circular cities, with the aim to generate additional revenue streams, such as becoming part of energy and heating value chains. A long term outlook or strategic plan supports this [13].

In some cases, taking on this role may require a change in the regulatory framework that

ports operate within (*> Lever 3*), as the governance and ownership structure of the port sets the scope for the tasks and responsibilities it can take on. Control over the land and onshore port functions by a public body, for example, can generate key political support for CE activities [22]. However, recapturing investments remains a concern in such cases (*> Lever 4*).

Market structure

In addition to existing instruments available to ports and port stakeholders to influence and shape (local) market structure - such as good practice agreements, tenders and waste fees and a long-term outlook and contracting - increased collaboration and sharing of information are frequently cited as enabling circularity. This can be between ports, such as this interviewee describes:

> *"For things such as biomass, maybe we should have an exchange with another port, and then it would be two ports doing the deal and not two clients to each port. And this would create enough scale or quantity to do something with the materials."*

Alternatively, it may also be between ports and other companies or between companies based in or near ports. Facilitating this, is where ports see themselves as playing an important role:

> *"Many parties that will have to cooperate to harvest circular business opportunities have never been business partners before. The port authority has to play a role in linking them and in finding the right ways to cooperate."*

The key take-away here, is to look at the industrial network as well as individual nodes, and to support both [11][23]. The aim should be to establish relevant connections and link problem owners with solution providers [24][23], and to create economies of scale that allow for viable business cases [14]. Third party facilitation or platforms are known to play an important role in this [11][24]. This can be enabled in different ways as already discussed in *> Lever 1*.

Summary of Key Innovation Recommendations

Business models

1. Many circular opportunities can be captured within existing port business models, provided the transported flow contributes to circularity.

Developing such opportunities, however, requires strategic support and new skills such as circular procurement, or market analysis capabilities.

2. Other circular activities may necessitate the expansion of existing business models or a shift in the core activities of the port.

Market structure

1. Establish good practice agreements, include circularity requirements in tender documents and contracting, use fees and rebates for good environmental practices, and choose (longer) concession times such that investment
2. Support both the industrial network as well as individual nodes.

Establish relevant connections and link problem owners with solution providers & create economies of scale that allow for viable business cases

3 Rules, policies, and regulatory instruments

The current situation

Current policies in the port sector

In the theme circular flows in ports, a much discussed topic was ship waste. An important role in this is played by the MARPOL directive*. This directive is the main international convention covering the prevention of pollution of the marine environment by ships from operational as well as accidental causes. Among other things, it deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of. Importantly, it imposes a complete ban on the disposal of all forms of plastic into the sea.

However, the implementation of this directive is problematic as enforcement is lacking, resulting in what one of the interviewees described as the "waste-gap" for plastic waste: a significant difference between the quantities that are expected to be delivered and those that actually are.

Nevertheless, increasingly stringent environmental policies are perceived as potential risks or as a liability by some ports [12]. At the same time, however, ports perceive discrepancies between international and national/ local rules when it comes to circularity [14]. For instance, ships have to deliver and separate waste based on the MARPOL rules [25], but due to misalignment with national rules, some ports have to collect and separate the waste again.

Despite being caught between good intensions and contradictory policies, ports still have a degree of influence, often in collaboration with local authorities. Think of local ordinances and by-laws. There is a sense that these instruments can be wielded in a more targeted way. That is, instead of having voluntary schemes, sustainable practices can be made a requirement for acquiring or maintaining a license to operate.

However, in many ways ports also perceive a lack of empowerment to act and implement circular solutions. For instance, for compliance reasons some ports cannot collaborate with specific individual stakeholders, as it is a requirement that all companies based in the port need to have equal access to the services of the port authority. This issue is faced, for example, by German ports. A lack of empowerment was also seen in Slovenia and Spain, due to the need to seek permission from either local or national authorities for undertaking projects.

The broader policy landscape on waste & circularity

In addition to sector specific policies, ports have to operate within the national and international directives for waste and circularity. At present, however, these are perceived as duplicitous, complex and, at times, contradictory. Take legal definitions: a premature definition as 'waste' - instead of 'by- or co-product' - can prevent further treatment and valorisation [12]. In Sweden, for instance, dredging sediments are automatically classified as 'waste,' without considering whether they are contaminated or not. However, the EU regulation allows for different types of processing, including as a commercially exploitable resource [26]. This also illustrates how flexibility in EU regulation is not capitalised on in national regulations. This leads to unjustly perceived limitations of CE opportunities.

Furthermore, there is the perception that environmental regulation and the regulation around energy generation - although well intended and suitable for when they were established - are in need of review and updating [13]. For instance, in Italy old rules aimed at preventing arsenic pollution now obstruct the discharge of potable water.

In the areas of circular port assets and equipment and ports and circular markets policy barriers are also present [27-29]. Circular solutions require producers of materials and products to take on increased responsibility for these wares, bringing with it increased risk, in the form of liability and

* The International Convention for the Prevention of Pollution from Ships and its six annexes, by the International Maritime Organization (IMO)).

warranty issues. At present, a clear policy framework for dealing with this increased risk is lacking [27-29].

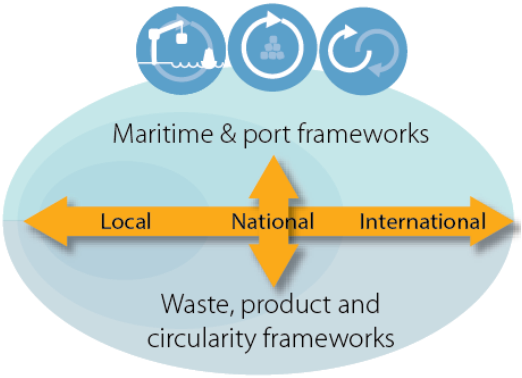
How the policy landscape is changing

With increased awareness around environmental issues, it is expected that policies and regulatory instruments - local, national, and supranational - will be pushing more strongly for stricter waste and pollution regulations - around the world [13]. With new laws aimed at creating a CE - stimulating recycling as well as reuse [1] new ways of thinking about resources are needed.

This is already affecting the port sector. For example, the provision for extended producer responsibility (EPR) schemes for fishing gear incentivises the delivery of fishing gear on shore [2].

In addition to this, there is an increasing interest in evidence-based policy making. Or: the use of evidence from interventions and other pilots or experiments to evaluate and scale initiatives [30][31]. Note that lever 3 is strongly linked to > *Lever 4*.

Rules, policies, and regulatory instruments



What could support improving and scaling CE solutions?

More space for circularity in policies

When it comes to ship waste, there are many possible intervention points to improve circularity. For one, regulations should be aligned such that when ship wastes are delivered on shore, they do not have to be resorted. For this, the discrepancies between international and national/ local rules have to be removed.

However, there are additional considerations. For instance: currently plastic waste contaminated with food waste has to be incinerated, as it cannot be identified when such food waste has originated from outside the EU, thus posing a potential biohazard. However, the new port reception facility directive [25], aims to make it clear when food contaminated plastic waste is generated within the EU, allowing waste handlers to wash and recycle it. Similarly, other ports highlight the need for frameworks around waste storage to achieve economies of scale.

When collecting and storing waste is facilitated, however, does not automatically mean that this provides opportunities for its valorisation. In particular, the removal of cumbersome and costly administrative procedures and prohibitive fee structures with a legal origin can pave the way for capturing opportunities by ports and other companies.

In summary: for circularising ship wastes effectively, policies along the entire chain from collection, to reception, and from storage to value capture needs to be aligned better. Policy interventions should be designed integrally with this in mind, taking a long term perspective [13] and be informed by technical and business knowledge within ports. Involving local authorities in CE projects helps local rules and regulations to be formulated as enablers [11].

This thinking also applies to further developing circular port assets and equipment and ports and circular markets, which likewise require an integral assessment of barriers and enablers along the value chain [29]. As well as collection, storage and treatment of these flows, policies should provide clear frameworks around risk and ownership [27-29] if viable business cases are to be developed and investment stimulated > *Lever 4*. (Although firms can address such risks through improving the monitoring of their products and services [32] > *Lever 5*.)

Relevant for all circular flows is the alignment of port policies with other waste and circularity regulations. This is a challenge for

circular economy in general, across sectors: to harmonise waste policies and enable both reuse and recycling. One key element of this would be to ensure that companies do not experience negative effects for sharing information with authorities.

Lack of empowerment

To address the perceived lack of empowerment, the following can be done. For one, policies could be designed that allow for pilots and experiments [13]. This can take the form of leniency or the suspension of fines for certain port functions affected by such a pilot, for the duration of the pilot. Other interventions may make it possible to partner more easily with suitable partners. In the example of German ports, the default could be reset to collaboration, unless other stakeholders have valid objections. Similarly, other structures such as spin-outs or other (temporary) entities could be used.

When policies have such flexibility, however, it is important to ensure that there is local capacity to adapt the policies. This means that knowledge and other resources have to be made available to ports for this. Without this, one interviewee comments, such policies can create delays and uncertainty:

"There may be a lot of flexibility possible from a national government perspective. But this often stalls at local government levels – either approval or implementation takes too long, or it is not accepted at all due to this"

In the interaction between ports and policymakers, it is furthermore helpful if technical and business knowledge from the sector is translated in a meaningful way for policy makers. The aim of this is to empower policy makers to align policies more closely with the reality as experienced by ports.

Summary of Key Innovation Recommendations

1. Integral assessment and development of policies and regulations, based on evidence

Address barriers along the value chain, from delivery to collection, and from storage to valorisation.

Prevent premature classifications of 'waste', and aim for 'co- or by-product' instead.

Seek alignment with other waste and circularity policies to prevent contradictions.

Update outdated policies.

Test and evaluate new policies before scaling.

2. Reduce risks of sharing information for companies

Design policies that do not penalise openness from a legal and fiscal perspective.

3. Design policies that allow for experimentation and that offer sufficient flexibility for local adaptation
4. Provide support for translating flexible policies into local action

Provide knowledge and other resources to capitalise on the provided flexibility.

5. Provide support for translating technical and business knowledge to policy makers
6. Empower ports

Take away legal barriers for ports to develop CE initiatives that stem from the ownership structure.

4 Fiscal instruments, investment and funding

The current situation

Fiscal instruments & incentives

Although ports can generally impose fines, provide rebates, and give bonuses, one tool within the control of ports that is currently underused is circular public procurement for circular assets and equipment [13]. One interviewee describes that the intention is there, although not yet the capacity and capabilities:

> *"Our municipality wants to change their procurement, and that will also apply to us as we are owned by the municipality. We have already discussed bringing in more sustainable materials into our procurement. For example, more sustainable woods in buildings. Also in regards to the next port extension: how we can use more recycled materials in the port structure, to reduce the use of cement. There's nothing that is stopping us from starting, except the time. We need to work on this and bring resources and competences into this area."*

Generally, the interviewed ports perceive the broader landscape of fiscal instruments - similar to the legal definitions (> *Lever 3*) - as duplicitous, complex and, at times, contradictory. For instance, in Denmark, fees for using waste heat are paid twice: both the company who delivers the energy pays, as well as the company using it. This makes the reuse of this energy in industrial symbiosis schemes prohibitively expensive. High taxes, such as on selling electricity in Croatia (25%), can likewise form economic barriers for viable business cases.

When it comes to collecting ship waste, a wide range of fiscal instruments is currently deployed. Some ports use flat fees per type of waste, and others ports are not allowed to charge any fees. In some countries, such as Italy and Germany, ships certified as 'green' (with ISO or ESI certification*) can obtain further fee reductions.

However, there does not seem to be a clear understanding of what is the most effective in terms of delivering the highest quantity and quality of materials - and under which conditions, whilst also reducing the discharge of waste at sea. In Italy a longitudinal study was done which led to the decision to increase the fixed fee for ships without a waste load in the port of Venice. This significantly increased the input and the quality of the plastic, paper, glass and not separated material. In parallel, a new initiative is in preparation in Europe, where mixed waste will be covered by a flat fee, independent of quantity. The guidance provided by the EU directive on port reception facilities, however, is that no disincentive is created for ships to use the port reception facilities [25]. This broad framing provides limited guidance, and a lack of understanding of what best practices to apply.

Investment climate

When it comes to the investment climate a number of considerations surfaced. For one, increased ambiguity from the side of governments that are implementing many new policies in a short period of time, means that policy is perceived as being in flux and this creates uncertainty for investment.

Ports perceive a lack of empowerment for other reasons, too. For example, some ports have previously found themselves in situations where it is not clear who should invest in the proposed CE solutions, and several stakeholders point to each other as the one who should invest. However, ports can be unable to take on this task, due to a lack of expertise or capacity. Alternatively, they can perceive it as outside their task remit, due to the ownership of governance structure, which poses legal limits on the activities a port can undertake. This is the case, for example, in Croatia. The size of ports plays a role in this: larger ports are able to bear some of financial risks more readily than smaller ports.

Especially for larger projects the possibility to co-finance these with multiple partners, possibly as public-private partnerships, comes up. Whether ports themselves take up the opportunities, or take on a role as facilitator to align investment, clear business cases are required (*> Lever 2*). The more robust the business case, the easier it will be for the ports themselves to take up the opportunity.

Dedicated investment funds for circular economy (infrastructure) also now exist to support circular investment [33][34].

Funding

There is the perception that funding organisations have increased their support for innovative projects in the area of circular economy over the last years. Ports find these mechanisms of key importance [14]:

"It's excellent that we can apply for EU and national funds for pilot studies. That's very important. Otherwise it's too big of a step if you're financing it completely by yourself."

The benefit of funding goes beyond the financial de-risking that it provides. Of particular value is the common framework that such mechanisms provide: the structure that they bring to collaborations aligns expectations and clarifies who pays which contributions. However, not all ports have resources to find and apply for funding.

It is noted, however, that funding should not be the sole incentive for projects: they should be done because there is a need and the social, economic or circular benefits they aim to create.

What could support improving and scaling CE solutions?

Fiscal instruments & incentives

To enable circular assets and equipment, capacity and capabilities for circular procurement practices should be developed. This can consist, for example, of case examples, training and forming consortia to be able to negotiate favourable terms with solution providers. Likewise, for circular flows in ports - think of industrial symbiosis schemes - case examples of costing and innovative financing schemes may stimulate other ports to follow suit, providing a starting point for adapting such models to the local context. If such materials were available, the following consideration by a port could then have a basis for the further exploration of possibilities:

"Do we do this as a voluntary agreement and every company who wants can chip in, or do we provide this infrastructure? You could do both, but we haven't found our feet."

Of particular importance, also, is a better understanding of best practices in the area of fiscal instruments and incentives. In this sense, the need for evidence based policy *> Lever 2*, also applies here.

What is furthermore similar to *> Lever 2*, is the need for an integral assessment and development of fiscal instruments, and to align both local, national and international practices, as well as align across port and maritime, and waste and circularity instruments. This may improve the consistency and coherence across policies and reduces uncertainty for investment.

As part of fiscal measures the 'polluter pays principle' is often applied [13]: pricing externalities such as pollution, so that market dynamics start working to minimise them. Although tried and tested in many ways, caution is advised with such instruments in the port sector, due to difficulties with enforcement.

Investment climate

To further reduce uncertainty in the investment climate, interviewees' stress that authorities should set clear frameworks and rules, and act accordingly. To bring investments into CE in line with each other, ports should take an active role as facilitator, for which additional knowledge and skills may be needed.

For situations where ambiguity exists with regards to who should invest, guidelines could be provided or case examples that give insight into innovative solutions for ownership of problems and solutions. Where possible, expansion of existing business models should be explored or a shift in the core activities of the port (> *Lever 2*). There may be legal aspects to this (> *Lever 3*). For example, when ports are classified as a not-for-profit organisation, they cannot develop circular initiatives that have this aim. For smaller ports in particular, external support can be helpful.

Funding

More can be done to help ports find appropriate funding, and to scope bids for the needs of ports. For one, an apparent tension exists between wanting to 'go green' and the uncertainty around whether this makes good business sense for ports and its stakeholders. On the one hand, the increased sustainability and circularity of ports could be beneficial for ports, as already shown in > *Lever 1*:

> *"These schemes aimed at giving ports a good market reputation, so that their customers - retailers - can advertise that their products are sustainable. If you buy a jumper you can see on the tag that it has been transferred from Asia to EU by a ship that is greening its operation."*

On the other hand, uncertainty exists with regards to what the precise value of this is, and how it influences the overall competitive position of a port:

> *"If we raise the prices for the companies using the port, maybe that will hit us on the competition with other ports. Maybe not, because you can say that if you use our port, you are using a green port. [But at the moment,] it is difficult for me to answer this."*

Bids could focus on facilitating experiments that support the articulation of clear business cases, aimed at providing insight into how the reputation as a 'green port' can be valorised (further).

In addition to this, pilot schemes could be developed aimed at stimulating local economic clusters through the addition of new loops, stimulating ports to actively pursue opportunities in the theme ports as part of circular markets.

Summary of Key Innovation Recommendations

1. Build (further) capacity with regards to fiscal instruments and incentives

For circular procurement, valorisation of waste and industrial symbiosis schemes.

Generate and share insights into 'best practices', in particular with regards to how to align investment across stakeholders. Included in this is also the question of ownership of problems and solutions.

2. 2. Integral assessment and development of fiscal instruments and incentives

Address barriers along the value chain, from delivery to collection, and from storage to valorisation.

Seek alignment with other waste and circularity instruments to prevent contradictions.

3. Provide support for ports to find funding
4. Scope funding bids such that they are in line with the circular economy needs of ports.

For instance: how can the reputation of 'green port' be valorised, or explore what other loops a port can facilitate in circular markets.

Climate-KIC is supported by the EIT, a body of the European Union

5 Technology, processes, design, standards and infrastructure

The current situation

Technology and innovative processes for CE

Ports are interested in - and actively experimenting with - new and emergent technologies. Highlighted in particular is Industry 4.0, or increased automation and connectivity through sensors and analytics. However, the developers of these new technologies do not necessarily consider the reality of ship and port processes. One port describes the unsuccessful project of developing an application for use on a smartphone to support waste management. But:

> *"The tool was made, it was paid for, but there was no one to feed it with information, so it finally stopped being used."*

It needs to be considered that ports are limited in their engagement with developing new technologies:

> *"We cannot run our own research and development. However, we can answer some of the practical questions: what can work and what cannot work in a port."*

Apart from their impact in port processes and operations, it also surfaced that technological development - the ubiquity of smart phones and the use of social media - is and will continue to cause increased exposure of different port operations. This is connected to the need to maintain good relationships with a port's environment (> *Lever 6*).

Eco-design practices to support circularity

As part of the Eco-Ports network, ESPO aims to disseminate eco-design best practices to ports related to air pollution and climate change. To a degree, CE practices are part of this. However, there is scope for improving these materials and making them more relevant to ports.

Circular port assets & equipment

Ports continue to look for ways to improve the efficiency of port operations, through the application of existing technologies in new ways. An example of this could be smart lighting, which can adjust its brightness to the time of day and the ferry timetable. Moreover, the use of more advanced software tools for monitoring as well as corrective, preventive and predictive maintenance, and in building information modelling (BIM) are already a common practice in many ports.

However, new technologies create new opportunities, too. For instance: Project 3D HydroMapper in Germany, [35], in which an innovative 3D scanner is tested to obtain an overview of all maintenance measures in order to optimise cost, planning and environmental safety in the long term. Similar activities are underway in the Finnish Port of Haminakotka, where a 3D operating systems is being developed, together with Finnish technology company VRT Finland Oy [36].

A number of ports already actively support companies based at their location with finding technological innovations. For instance, in the port of Moerdijk the port authority actively investigates opportunities for technological innovations that can be implemented by the companies in their harbour to become more sustainable.

Circular flows within ports

Over the last decades technological developments have increased the possibilities of processing waste tremendously. For example, processing the co-products from the fishing industry into high value ingredients for cosmetics and food supplements in the port of Boulogne-Sur-Mer would not have been possible without the development of new technologies in the late nineties - such as fractionation and peptides isolation.

Fuel and energy remain a recurring theme, also when it comes to technological

development. Experiments are ongoing with sourcing biofuel (in some cases from ship waste), providing shore-to-ship power, cold ironing [18], but also hydrogen and LNG. This is strongly linked to infrastructure considerations, as energy transmission and storage facilities in many cities do not have the added capacity to provide this. Shipping companies, however, are not inclined to make the necessary investments. A similar observation can be made for storing waste, where a lack of storage space can represent a major barrier to recycling [14].

Ports as part of circular markets

To capture the opportunity of ports as part of circular markets, tracking, tracing and information about product health are important parts of enabling circular markets. To be able to link the supply of resources with locations for their specialised treatment, it needs to be understood where flows come from, where they need to go and when they need to be shipped. For this, it is important that the information regarding the condition of resources is maintained throughout the logistics chain, through databases or blockchain technologies [37]. In addition to this, real-time information about the location of resources can be used for system optimisation [37].

What could support improving and scaling CE solutions?

Technology, processes, design

The sharing of best practices of the application of technology and eco-design practices for improving efficiency and circularity of port operations could be further supported. Specifically, enabling the flow of knowledge from bigger to smaller and medium-sized ports. This can be done by providing inspirational case examples such that ports can easily find relevant information, accompanied with sufficient actionable information - e.g. business cases that can be adapted to fit the local situation.
With regards to new technologies, one interviewee voiced the following illustrative comment:

"Technologies are always invented. The key is to identify them and see how they can fit into your port and then have the will to implement them."

This comment highlights two aspects. First, it points to a need to help ports identify relevant technologies and applications. For example, identifying new production technologies could lead to a change in the production technologies used by industries in ports or to attracting different companies in the industrial portfolio of a port [38]. In addition to this, such developments can lead to new applications for ports wastes, such as (partially) substituting virgin sand with dredging wastes in the production of paving blocks [39].

Another interesting development is the emergence of new analysis methods for determining the exact composition of wastes and by-products more easily. For example, new analysis methods for dredging materials allows for determining the exact composition of sediments, enabling the identification of suitable applications for these materials, such as use in building materials and plant growing substrates, possibly mixed with other by-products such as fly-ash [26][40].

Secondly, the above quote links to the need for connecting solution providers to ports in an early stage of development, so that new technologies and new processes fit the need of port stakeholders. Although ports are unlikely to be able to take-up research and development activities, ports can provide space for piloting and testing new technologies. In addition to this, ports can provide their expertise with regards to practicalities and operational processes.

Circular port assets & equipment

For the theme of circular port assets, specifically, insight into how remote monitoring technologies can be used to overcome current legislative barriers around ownership, risk and liability > *Lever 5* could stimulate the uptake of circular business models and circular procurement. Collecting such data allows for quantifying

costs and risks, such that they can be included in business models. Various eco-design and circular design practices can further improve the fit of products and services within circular systems [41][42].

Circular flows within ports

Technology and new processes could be used to improve the quality of data on waste and the monitoring of waste flows. It is speculated that the technologies used for the enforcement of waste regulations - e.g. identifying pollution sources with drones and satellites - could also be used for waste management purposes. In addition to this, big data may offer insights and streamline enforcement. Ships currently have to report the quantities and qualities of the waste they carry online [25]. If it was possible to aggregate and analyse this data, authorities would gain a cost-effective tool to verify compliance.

Such applications of technology are not just tools for authorities, however. One interviewed port describes its work on a platform to manage waste from different sources, as well as to keep updated and valuable data for waste management per port activity, area, etc. and to estimate the benefits of waste recycling. Such data helps establish KPIs and to set and track progress towards recycling goals. However, it should be taken into account that the recycling infrastructure of some EU member states, such as Croatia, is still under development.

Standards, indicators and certification

There is a call for a normalised manner to assess the degree of sustainability of a company, assessing both economic, social and environmental impacts [13]. This can build on existing processes such as those for due diligence, take the form of carbon footprinting or measure the degree of circularity, including dimensions of co-operations and synergies [19]. It is felt that waste should be one of the elements of such standards, both for ports and ships. This can be linked to financial incentives *> Lever 4*.

Summary of Key Innovation Recommendations

1. Share best practices for technology and eco-design practices in the areas of efficiency and circular economy
2. Support ports in identifying relevant new technologies and applications

Including monitoring of new technologies for increased efficiency and circularity

3. Connect solution providers to ports in an early stage of development of technology applications

Ports provide space for piloting and testing new technologies, and their expertise.

4. 4. Standards, indicators and certification

Develop standards for port circularity, or expand existing standards with circularity dimensions

6 Collaboration inside the port and with other port stakeholders

The current situation

Collaboration and co-creation

Starting new sustainability and circularity initiatives is not easy:

> *"There's a long first step to take, to get to know each other, do we have something in common. Then as soon as you find someone, and you find that you can have a good solution together, then it can move quite fast. Then you can see the economic profits from it as well. There is a lot of work to be done before your sign an agreement."*

Collaboration and co-creation, however, are frequently used to address this difficulty. One example of a collaborative approach is the Green City project, in Bremerhaven, Germany. The port, the municipality, and local industry work together to provide sustainable heating for houses [43]. Another example is the "Fishing for litter" project, in the region of Molfetta in Italy, where thanks to the collaboration with the municipal services company and the local fishery industry 14 tons of plastic waste was collected in ±10 months of activity.

In addition to this, as discussed in *> Lever 4*, a key part of co-creation may involve establishing a common framework for problem ownership and benefit sharing. One of the interviewed ports describes their experiences with an energy project:

> *"Everyone is saying: "You should do it, because you need the energy." But we say: "We are not an energy company." They say: "You own everything else in the city, so why don't you own this as well." We say: "If you can't deliver the energy to us, then you should invest in it." [...] And then it goes around, and there's a customer in the middle of it: should they pay for it? It becomes very complicated, very fast."*

Citizen engagement

Ninety percent of the EU ports are either within or very close to urban areas. This makes a good relationship with the city and its citizens an important condition for establishing and maintaining a 'license to operate.' This is also illustrated in the ESPO Environmental Reports, where the relationship with the local community is consistently part of the top 10 concerns for the last 6 years [44]. One interviewee highlights the visibility of the port as a factor in this:

> *"Ports are visible. The port is always there. [...] If the people see the pollution, see the smoke, or something in the water, they think about the port almost immediately."*

It is therefore no surprise that ports already do a lot to inform and create awareness of their activities. Ports strive to increase knowledge and cast their activities in a positive light, and are keen to highlight the value they provide. Printed and online media, television, radio, etc., are used to share information. Eco-ports, for instance, publish an environmental report every 3 years, containing an overview of the port's goals and the progress that has been made. Guided visits are organised, as well as other activities such as opening up the port for sport and street food events, or cultural events.

It is expected that the visibility of ports will only increase in the future, due to both increased environmental awareness, as well as social media and smart phones *> Lever 5.* In some sense this is seen as a positive development, as it encourages ships and ports to become more sustainable:

> *"A game changer in the sense that citizens become more and more involved, more and more aware. To my experience, it is a very positive engagement. For the citizens and the ports. [It has the result that], for example, incentive schemes are created [in this area], such as regional*

development through financial instruments."

However, ports also perceive a tension in this. With regards to their on-shore energy initiative one of the interviewed port's explanation is illustrative:

"We are more or less being forced to do this, we're not very keen on it. Of course, we are keen on improving the air quality, but from our perspective it could as well be somebody else [to supply this]. It's not a core business for us, to build onshore power and to sell electricity. It's just something that we're externally forced to do, it's become a 'license to operate.' But we would much rather outsource."

Highlighted in this is the role of the media, and how perceptions are shaped by emotions:

"Citizen concerns push us forward. But at the same time, sometimes the media and our neighbours have already figured out the best solution for us, without knowing whether it will work. And all of a sudden it is a 'truth' in public debate. Then we find ourselves in a corner where [...] we have to invest in something that we know is wrong. Because we can't convince otherwise: the debate has gone too far in the wrong direction and it's difficult to backtrack. At the same time they keep on providing numbers of CO_2 and kilos and tonnes, etc. They have no idea about how many tonnes is ok, and how many is not ok, but it sounds horrible. They are playing with emotions."

In other words, having a positive engagement with citizens around circular solutions in ports is not a given, but requires careful management.

What could support improving and scaling CE solutions?

Collaboration and co-creation

Collaboration and co-creation can address many of the levers covered so far: in order to see the potential for CE, it may be needed that various stakeholders engage in a dialogue as a means to uncover the opportunity (> *Lever 1*), and information needs to be shared and a level of trust established to capture the opportunity (> *Lever 2*) [11]. It may furthermore entail aligning local ordinances (> *Lever 3*), de-risking through scoping appropriate funding calls (> *Lever 4*), and bringing in a technology provider to create a solution fit for the context of the port and the processes of the stakeholders (> *Lever 5*). A wide range of stakeholder thus needs to be involved: the port, the companies in the port, companies providing services to the port, local authorities, funding bodies, technology providers and citizens. Knowledge institutes such as universities can - and do - support these processes.

Therefore, where no or only weak prior relationships between stakeholder exist, efforts should first aim at establishing contact, and an atmosphere of familiarity and trust. Think of local conferences, networking events, round tables, etc. which would provide an opportunity to share experiences and knowledge. Alongside or following this, activities that match problem owners with solution providers can take place. This can be in the form of matching industries through understanding which co-products produced by one facility can be used by other facilities [11].

"In order to be able to connect parties it is important to listen carefully and combine that with the knowledge of input and output flows. If you hear one company talk that matches the desires or ideas of another party, you can connect them and foster collaboration."

A focus on reducing costs whilst also creating environmental benefits, has proven an effective approach [14]. Where the costs for

getting access to expertise or skilled facilitation is prohibitive for smaller ports, a collaboration or network of ports could be established. Perhaps the most salient lesson of all, is to simply start. Accept (and communicate) that progressing towards circularity is a journey with many steps [14] [45] [46].

Citizen engagement

In addition to informing and creating awareness, some ports are seeking to involve citizens in more active ways. For example, when addressing plastic waste, it is important to not only involve fishermen, but also vacationers, bathers and boaters to address littering. Other examples from other CE initiatives both inside and outside of ports could provide additional ideas. The French start-up Yoyo, for example, engages citizens in the collection and sorting of plastics in return for participation in a reward scheme [47]. In the redevelopment of Stockholm Royal Sea Port, citizens were actively involved in a co-creation process which served to generate a greater understanding of circular potential and increased local support for proposed initiatives [22].

Emotion versus impact

When it comes to stakeholder engagement, it should be kept in mind that some issues are more easily communicated to some audiences than others. One interviewee describes this as follows:

> *"Plastics are so visible and on everybody's lips, so if you can do plastic projects that's really good. And then there's energy from our perspective, due to the increasing demand for electrification on the port side. [...] So if together with these companies you can provide green energy, it will make a good story. And easy to communicate."*

However, to prevent that the kind and scope of projects being undertaken is driven by emotions, it is recommended that projects are assessed based on their expected impact. In this, circular rebound effects [34] need to be taken into account. That is: circular solutions are valid when they contribute to a reduction in resource use, and less so if they create more demand for resources.

This means that it may be in the interest of ports to be both proactive and self-critical when it comes to assessing projects. Ports could benefit from sharing best practices for assessing and communicating about CE projects. Complicated cases, for instance, may want to communicate the steps and progress that is being made, and what is learned along the journey. This, as opposed to committing to a quantified impact up-front. Such approaches, however, benefit from good relationships with the media.

Summary of Key Innovation Recommendations

1. Start!

Accept and communicate that progressing towards circular economy is a journey.

2. Co-create solutions with stakeholders within the port, as well as communities around ports.

Ensure that the needs of key stakeholders are addressed.

Gain information and trust, and generate mutually beneficial business cases. Establish working groups and joint projects.

3. Explore ways to actively engage citizens.

Learn from other examples from other CE initiatives both inside and outside of ports.

4. Share best practices for assessing and communicating about CE projects.

Maintain good relationships with the media.

Technical and non-technical knowledge, skills and capabilities

The current situation

Background

For the purposes of Lever 7 a distinction is made between newcomer ports - ports new to circular economy, and forerunner ports - ports who are experienced with applying CE thinking. Many ports of all sizes and experience levels offer trainings in the areas of health and safety, and environmental best practice. However, no purpose-designed training programme on CE was uncovered.

Newcomer ports

Newcomer ports primarily speak of a lack of knowledge on CE - within their own organisation as well as among other relevant stakeholders. Illustrative comments in this regard:

"Disseminating and addressing key misconceptions about the concept of CE is needed. And dissemination of good practices."

"Introductory training would be important, but also workshops to disseminate best practices."

"Everyone sorts their plastic. And I'm not sure when I sort the plastic, is this actually doing something good? Or is it better just to burn it? The lack of knowledge does not help on the motivation to do it. This also goes for paper and carton."

"Step 1 is seeing: what is circular?"

"Examples of competences would be innovation, also project management. How to drive projects through. The few resources [companies based in the port] have they will put on the core activities of their own business or compliance. Also, co-creation is an important area to train."

These comments illustrate that there is a need to explain what CE is [23], and what benefits can be created through applying it. Moreover, there is a high need for this to be supported by inspirational and practical (business) cases with local relevance. An emphasis is furthermore put on collaboration and co-creation, including how to design new ways of working that allow for capturing the identified CE opportunity:

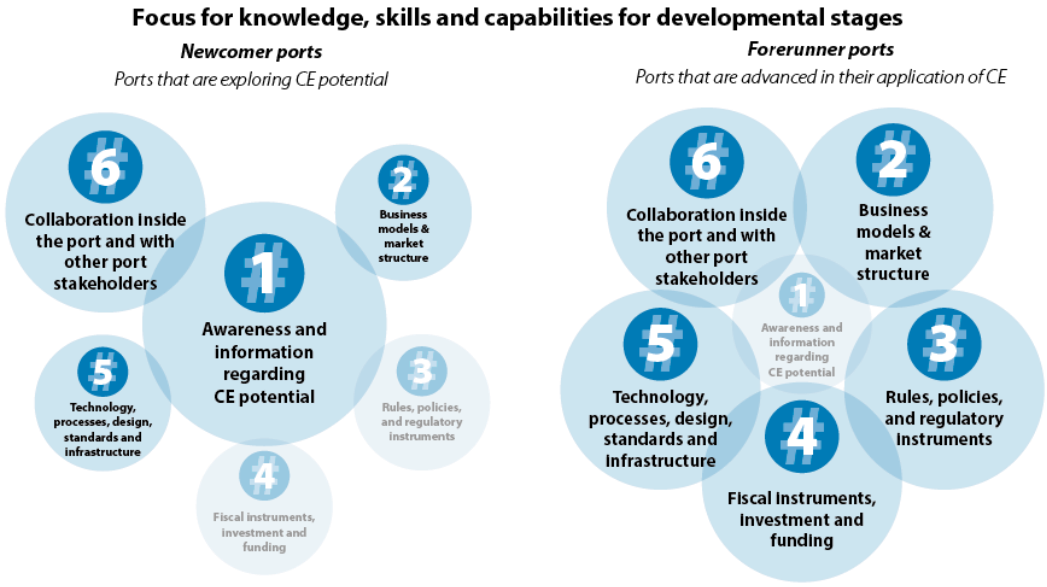
"Bringing as many stakeholders as possible together, exchange best practices, exchange information, in the end it is all about engagement."

Forerunner ports

Compared to the newcomer ports, collaboration and co-creation activities remain important for forerunner ports. However, for these ports the emphasis shifts to activities related to further advancing and developing more advanced applications of CE. These activities are more likely to venture into unfamiliar terrain, and therefore require additional knowledge and skills, such as on alternative business models, relevant policies and funding mechanisms, and supporting technology.

As such, the needed knowledge and skills - and the depth of knowledge and skills proficiency levels - are somewhat different for ports at different developmental stages. However, when asked about their interest to develop more knowledge and skills in CE, there seems to be a high interest level.

It is emphasised that the local context should be taken into account, as well as the size of the port, and its ownership and governance structure.



What could support improving and scaling CE solutions?

Suitable knowledge and skills are indicated as of major importance in progressing with sustainable and CE initiatives [13].

Newcomer ports - What training is needed

"Maybe we don't know what some stakeholders are planning, and they don't know what is possible in the port."

As part of the first step in trainings, an inventory should be done of what CE activities are already underway. Next, it should be detected what other possibilities there are. For port authorities, this allows for creating a strategic CE agenda [48], identifying which of the 3 themes are of interest, and what activities can be developed within each theme.

For new possibilities, the ideas should be further detailed with regards to the benefits they bring and what processes are needed to capture these benefits. It should be examined what stakeholders are needed to make it a success, and who is willing and able to take charge.

As supporting or following activities it is suggested to conduct case studies, and to visit other ports and CE projects to see other experiences. The aim of these activities is not only to inspire and educate, but also for stakeholders to get to know each other and to establish good working relationships.

Specific follow-up trainings are envisioned, depending on the needs of the identified project.

Newcomer ports - Who to involve *

The type of stakeholders that need to be involved in CE projects depends on which of the 3 themes the activities focus on. For instance, theme circular port assets, technical personnel and facilities management of the port needs to be involved, as well as suppliers of equipment and/or builders and contractors.

When pursuing circular flows within ports, stakeholders dealing with (hazardous) waste treatment and sewage are needed. From the port authority this requires those responsible for the waste, as well as for sustainability to be involved. Also think of various waste concessionaires, energy companies and municipalities. Of course, if industrial waste from companies based in or near the ports are involved, they also need to be present.

For exploring ports and circular markets, ports need to work with their customers, or with a cluster of companies if the port is a hub for particular goods.

Also mentioned as potentially relevant are city, municipality or regional officials, environmental experts, circular economy

practitioners and knowledge institutes such as universities and research centres. Of course, a combination of the above is possible. It is also expected that as initiatives progress and mature, a wider group of stakeholders will be involved.

Newcomer ports – Format

Although some parts of collaborative and co-creation processes can be facilitated online, such as introductory webinars or making available case study documents, interviewees indicate a preference for workshops and peer-to-peer learning. This is in line with the importance attached to collaboration and co-creation, and the need for establishing good working relationships.

For an introductory webinar or seminar a maximum of 1 day is indicated. For the duration of actual training sessions interviewees indicate between 1-2 days. Participants would be willing to travel to events, only if events involved many of their colleagues, or one or more esteemed speakers. Willingness-to-pay is estimated as low.

Forerunner ports - What, who and format

Trainings for forerunner ports are expected to be more tailor-made depending on the needs of the identified project, and requiring more in-depth knowledge and capabilities in relevant areas [24].

Unlearn

Highlighted as an important skill to (partially) 'unlearn,' are routines that focus solely on individual companies [23]. Think of directives or instructions that come from headquarters, which limit the space for local or regional experimentation. Unlearning such views could potentially facilitate a mindset change and increase the number of circular initiatives within the companies working at the port.

Summary of Key Innovation Recommendations

For newcomer ports

1. Develop trainings aimed at knowledge and skills in Lever 1 and 6, combined with knowledge and skills in Lever 2 and 5

Ensure relevance for the local context, size of the port, and its ownership/ governance structure.

For forerunner ports

1. Tailor trainings for the needs of specific projects

Ensure relevance for the local context, size of the port, and its ownership/ governance structure.

2. Use the lens of circularity within all business development activities.

Summary

This section summarises the lessons learned from across the 7 Levers of Change. Bringing together and synthesising the key innovation recommendations, they are organised according to the stakeholder that they have the most relevance to. When recommendations apply to multiple stakeholders, they are repeated to enable a complete overview per stakeholder. In this, special attention was paid in drawing out the activities a Circular Economy Network of Ports could perform, as to provide input for the development of such network and its stakeholder interaction within the LOOP Ports project.

Please note that this list does not aim to be comprehensive or complete, as the primary source of information for this report were port authorities. However, these lists can serve as a basis for further development and discussion.

PORT MANAGEMENT or port authorities

With their varied ownership and management structure across Europe

1. Start!

Accept and communicate that progressing towards circular economy is a journey.

2. Provide a means to understand the local potential for a port to work with CE.

To create an in-depth understanding of the local context when there is publicly available data to draw from, involve knowledge institutes to collate it and offer methodological support.

To create an in-depth understanding of the local context in cases where data is not (publicly) available, use neutral third parties under NDA to explore synergies in a safe environment.

3. Encourage, assist, trigger, and co-create.

Go beyond providing information: actively involve local stakeholders. Co-create solutions with stakeholders within the port, as well as communities around the port.

Ensure that the needs of key stakeholders are addressed.

Gain information and trust, and generate mutually beneficial business cases. Establish working groups and joint projects, and work with solution providers in a collaborative approach.

4. Many circular opportunities can be captured within existing port business models, provided the transported flow contributes to circularity.

Developing such opportunities requires strategic support and new skills such as circular procurement, or market analysis capabilities.

5. Other circular activities may necessitate the expansion of existing business models or a shift in the core activities of the port.
6. Establish good practice agreements, include circularity requirements in tender documents and contracting, use fees and rebates for good environmental practices, and choose (longer) concession times such that investment in CE is stimulated and legally ensured.
7. Build (further) capacity with regards to fiscal instruments and incentives

For circular procurement, valorisation of waste and industrial symbiosis schemes.

8. Maintain good relationships with the media.

COMPANIES WITHIN/ AROUND PORTS

Port users such as logistics and shipping companies, but also industry based in and around the port.

1. Actively participate in collaboration and co-creation efforts.

Share information where possible.

2. Test new technology solutions for ports in the early stage of development within ports

Ports can provide space for piloting and testing new technologies, as well as their expertise.

KNOWLEDGE INSTITUTES

Universities, research institutes, knowledge experts. Actively participate in collaboration and co-creation efforts.

1. Provide a means to understand the local potential for a port to work with CE.

To create an in-depth understanding of the local context and there is publicly available data to draw from, knowledge institutes can collate publicly available data, as well as provide methodological support. Alternatively, modelling approaches can be applied.

2. Develop standards, indicators and certification.

Develop standards for port circularity, or expand existing standards with circularity dimensions.

AUTHORITIES & LEGISLATORS

Local, municipal, regional, national and international legislators and policy makers.

1. Encourage, assist, trigger, and co-create.

Go beyond providing information: actively involve individual ports and other local stakeholders and encourage networking among ports.

2. Integral assessment and development of policies, regulations and fiscal instruments, test and evaluate before scaling interventions

Address barriers along the value chain, from delivery to collection, and from storage to valorisation.

Prevent premature classifications of 'waste', and aim for 'co- or by-products' instead.

Seek alignment with other waste and circularity policies to prevent contradictions and update outdated policies.

Test and evaluate new policies before scaling.

3. Reduce risks of sharing information for companies

Design policies that do not penalise openness from a legal and fiscal perspective.

4. Design policies that allow for experimentation and that offer sufficient flexibility for local adaptation
5. Provide support for translating flexible policies into local action

Provide knowledge and other resources to capitalise on the provided flexibility.

6. Empower ports

Take away legal barriers for ports to develop CE initiatives that stem from the ownership structure.

7. Provide support for ports to find funding
8. Scope funding bids such that they are in line with the circular economy needs of ports.

For instance: how can the reputation of 'green port' be valorised, or explore what other loops a port can facilitate in circular markets.

9. Develop standards, indicators and certification

Develop standards for port circularity, or expand existing standard with circularity dimensions

CIRCULAR ECONOMY NETWORK OF PORTS

A network of ports, collaborating and sharing knowledge to further their CE approaches (formal or informally organised - tbc).

1. Disseminate a more rich understanding of the potential of CE more widely

The 3 themes can be used as a framing to convey the broader relevance of CE to ports and to inspire with concrete examples.

2. Provide a means to understand the local potential for a port to work with CE

To generate a first picture of where potential lies, provide a simple and quick means to perform a self-assessment for ports. This can be based on in-depth information from cases to generate 'port profiles' or 'CE solution sets' linked to port or terminal type and the 3 themes.

Clear business cases

3. Encourage, assist, trigger, co-create

Go beyond providing information: actively involve individual ports and other local stakeholders and encourage networking among ports.

4. Support both the industrial network as well as individual nodes

Establish relevant connections and link problem owners with solution providers & create economies of scale that allow for viable business cases.

5. Provide support for translating flexible policies into local action

Provide knowledge and support to capitalise on flexibility in policies appropriately.

6. Provide support for translating technical and business knowledge to policy makers
7. Build (further) capacity with regards to fiscal instruments and incentives

For circular procurement, valorisation of waste and industrial symbiosis schemes.

Generate and share insights into 'best practices', in particular with regards to how to align investment across stakeholders. Included in this is also the question of ownership of problems and solutions.

8. Provide support for ports to find funding
9. Support bid development such that they are in line with the circular economy needs of ports.

For instance: how can the reputation of 'green port' be valorised, or explore what other loops a port can facilitate in circular markets.

10. Share best practices

For technology and eco-design practices in the areas of efficiency and circular economy.

For assessing and communicating about CE projects

For actively engaging citizens in CE initiatives from CE initiatives both inside and outside of ports

11. Support ports in identifying relevant new technologies and applications Including monitoring of new technologies for increased efficiency and circularity

Limitations & recommendations for further work

When using this report, please keep the following key limitations in mind. This report relies heavily on a set of interviews conducted with port authorities and port management bodies. As such, the views of other port stakeholders may be underrepresented in this report. Further work can and should be undertaken when circular initiatives are designed that involve or affect other port stakeholders.

Furthermore, keep in mind that the interviewed ports were all based in Europe. As such, the outcomes may pertain to specifics of the European context and cannot be said to apply to ports elsewhere.

Also, the port ownership and management structure were identified as important boundary conditions determining the potential for port authorities to develop circular initiatives. Further work can be undertaken to understand the scope of solutions available within these different contexts.

Moreover, it may provide valuable to involve the maritime industry, as many issues such as ship waste and ocean plastics also affect this sector.

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