- **The development towards a circular economy will strengthen the competitive position of Rotterdam's port area. Stronger circularity is also a necessary step in realising the current energy transition and will improve the supply reliability of raw materials.**
- **A large volume of raw materials and residual flows come together in Rotterdam's regional port and industrial area. Combined with the region's good accessibility, this presents an excellent point of departure for the large-scale introduction of circular production and consumption.**
- **The Port of Rotterdam has a strong international position as a Waste-to Value Port with numerous existing circular companies and new projects, with a focus on innovation and scaling-up, sorting and recycling, industrial symbiosis and CCU.**

International position as Waste-to-Value Port

Rotterdam circular hub for raw materials transition

A – From linear to circular

Our society is primarily powered by what our planet provides. Agriculture, industrial manufacturing, digitalisation and even artificial intelligence are possible thanks to the existence of raw materials. In the 20th century, we saw an eightfold increase in the consumption of these materials, as a result of on-going industrial development, population growth and increased prosperity.

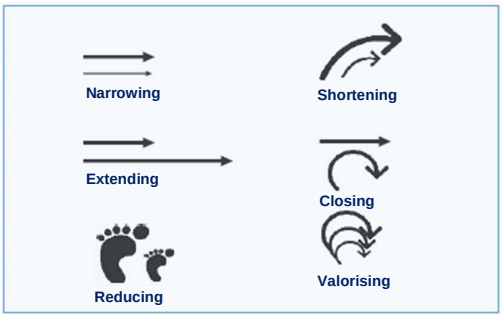
And this trend shows no signs of topping off. Increasing consumption by an ever-growing global population continues to drive up our demand for raw materials.

And not without consequences. Global warming, declining biodiversity and hitches in the nitrogen cycle are but a few issues that make it clear that we need to make fundamental changes to our economy and lifestyles.

The current economy is a linear system: we extract raw materials, turn them into products and treat whatever remains as waste. And while recycling efforts in our country are relatively widespread, substantial volumes of raw materials still end up in a landfill or waste incinerator or are released in the air.

This will be fundamentally changed by a circular economy. In a circular economy, the focus will be on generating maximum value from the smallest possible quantity of raw materials. This primarily calls for the optimal use of raw materials within the production chain. We believe optimal use takes advantage of one or more of the following strategies:

- *Narrowing* raw materials flows through prevention and increased raw materials efficiency.
- *Extending* raw materials flows by lengthening the lifecycle of a product or asset with targeted design and maintenance (*long lives*).
- *Shortening* raw materials flows by bringing production and consumption closer together (*short cycles, local for local*).



- *Closing* chains by re-using and recycling products and materials after use (re-use, recycling and other re-s).
- *Reducing* the impact of our raw materials consumption by opting for sustainable and renewable raw materials *(footprint)*.
- *Valorising* raw materials by investing in both high-grade and repeated use *(cascading & multiple lives)*

A FEW REAL-LIFE EXAMPLES:

Narrowing
During the construction of the Prinses Amalia overpass at Maasvlakte 2, the contractor Boskalis used Beaumix: a sustainable construction material that is made using decontaminated residuals from waste incineration plants in Amsterdam and Alkmaar.

Extending
RDM Rotterdam is the premier innovation hotspot in the port. This former Rotterdamsche Droogdok Maatschappij (RDM) shipyard, which used to launch famous vessels like the SS Rotterdam, has been given a new life as a centre of enterprise, education and research.

Shortening
Together with MerweVierhavens (M4H), RDM Rotterdam forms the Rotterdam Makers District. The two areas are the region's leading innovative manufacturing hub. Another example is Blue City, a 'breeding ground' for innovative companies that work to connect their residual flows. One business's output can serve as another business's input.

Closing
Here, we can offer a range of examples – like the Waste-to-Chemicals project, in which a private sector consortium of companies is developing a new plant that can convert residual flows into clean methanol. The firm REKO has started construction on a new thermal decontamination plant that will be able to convert an annual total of 1.2 million tonnes of residuals into base materials, electricity and heat. LyondellBasell and Covestro are jointly investing € 150 million in new systems that will reduce CO_2 emissions at their Maasvlakte plant by some 140,000 tonnes per year.

Reducing
In the near future, we can expect widespread use of residual heat generated in the port to heat homes, greenhouses and offices. The Zuid-Holland Heat Alliance, made up of the Province of Zuid-Holland, the Port of Rotterdam Authority, Gasunie, Eneco, Warmtebedrijf Rotterdam and the municipality, is focusing on the realisation of a main infrastructure for heat in the region.

Valorising
Alta Innovation Support does not see CO_2 as a greenhouse gas but as a valuable feedstock for industry, and chemical production in particular.

The optimal implementation of these strategies calls for an integrated approach and collaboration between parties across the production chain, involved in everything from the extraction of raw materials, product design, production processes and repairs to re-use and recycling.

And along the way, we can still achieve a lot of wins. Although when it comes to generating maximal value from the smallest possible volume of raw materials, the Netherlands is pretty successful as it is. This ability can be expressed through a so-called *raw materials productivity* score – in other words, the added value in euro per kilogram of raw materials.

According to figures published by Eurostat, the Netherlands adds more value to natural resources like oil, gas, ores and metals than any other EU member state. In 2017, the Netherlands was able to create nearly € 4.50 in value per kilogram of raw material after processing. Average raw materials productivity in the EU was € 2.20.

Inextricably linked to the energy transition

The circular economy is inextricably linked to the present energy transition. Through both recycling and reuse and by promoting the replacement of fossil-based raw materials with non-fossil based materials, the circular economy can help to reduce the volume of greenhouse emissions released into our atmosphere.

Apart from improving our environmental footprint, the circular economy can also yield economic benefits. According to PBL Netherlands Environmental Assessment Agency, the circular economy could potentially create € 7 billion of added value for the Dutch economy alone, in the shape of 50,000 new jobs, a 20% reduction in industrial water consumption and a 25% reduction in the import of base materials.

In short, the transition towards a more circular economy will strengthen the competitive position of Rotterdam's port and industrial area – and of the Netherlands as a whole – contribute to a cleaner environment and improve the supply reliability of raw materials.

B - Rotterdam as the perfect Waste-to-Value hub

Rotterdam's port area – and the associated port and industrial area found in nearby Moerdijk – is an attractive location for giving further shape to the circular economy. The region's extensive network of hinterland connections offers an excellent point of departure for bundling circular activities. And Europe's largest sea port is not only a major hub for international cargo flows; it is also one of the world's foremost centres of refining and chemical production.

This concentration of frequently interwoven industrial activities provides excellent opportunities for the valorisation and utilisation of a wide range of residual flows that can be found (or imported) in the greater Rotterdam area. Parties in the region are working to realise a smart infrastructure for the transport of various flows, including steam, heat, CO_2 and hydrogen, as well as a joint system for wastewater treatment, sludge processing and bleaching earth that links together a variety of companies.

The region is home to a range of residual flows:

- *Plastics and rubber* – Comprising a variety of plastic and rubber waste categories that derive from e.g. packaging and industrial components.
- *Biomass* – Comprising scrap paper and pulp, as well as wood, organic sludge and other biomass-related flows from food, cooking oils and other organic waste.
- *Metals* – Comprising both ferro and non-ferro metals.
- *Minerals* – Comprising building and construction waste including concrete, gypsum, ceramics as well as sand, gravel and glass.
- *Chemical* – Comprising all residual flows generated by the chemical sector.
- *Other industrial and shipping flows* – All flows that do not belong to the Chemical category. Examples include industrial oils, bitumen, tar and other residues.
- *Remaining flows* – Residual flows from manufacturing, household waste and production chains.

Change of course

To step up the transition towards a circular economy, the Dutch government has formulated a road map document, 'A Circular Netherlands by 2050'. This road map sets out how the Netherlands can re-route its economic development towards a circular economy.

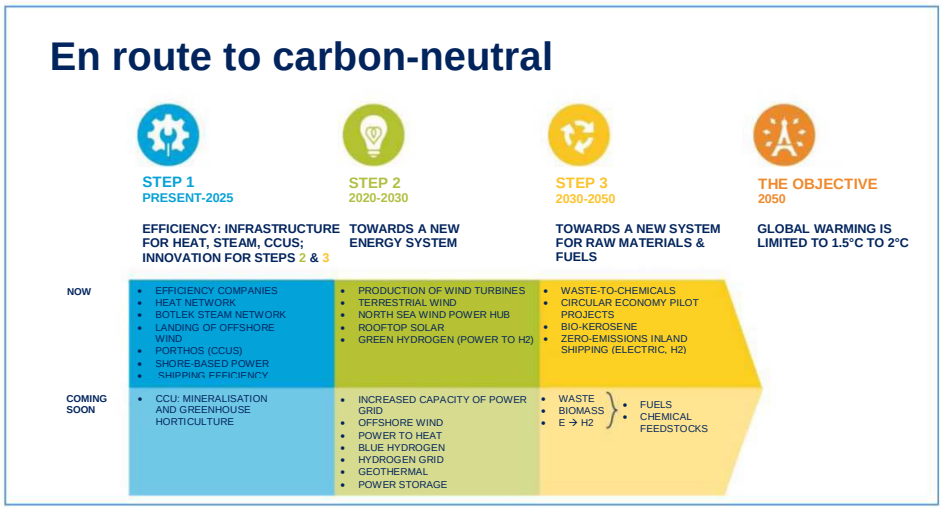
The government's ambition is that by 2050, all economic processes in the Netherlands will be based on renewable raw materials. To realise this objective, the government will be working together with the private sector to draw up transition agendas for five distinct sectors and chains: biomass and food, plastics, construction, manufacturing and consumer goods.

As mentioned earlier, a circular economy can make an important contribution to a successful energy transition. To gain a more detailed picture of its expected impact, in early 2017 the government set up the Rotterdam-Moerdijk Industrial Cluster working group. This group serves as one of the regional

roundtables in consultations across the Netherlands en route to a national Climate Agreement.

The most important conclusion reached by this working group is that the region's industrial area will be able to satisfy the climate requirements set by national government – initially mainly on the basis of efficiency, innovation and a joint infrastructure. Achieving the government's ultimate objective for 2050 (a 95% reduction in greenhouse gas emissions compared to 1990) however requires the creation of a new energy system, followed by a new raw materials and fuels system. The following chart shows that without a fundamental transition in our reliance on raw materials, the established climate objectives will remain beyond our reach.

The Port of Rotterdam Authority is playing an active role in this development, based on the philosophy that a process of this kind can only take shape in collaboration with a wide range of parties and that to successfully change course, we will need to continue supporting existing industrial players.



C – How to give shape to the circular economy

The Port Authority acknowledges that fundamentally changing our energy and raw materials systems promises to be a challenge. At the same time, it creates new opportunities to position the port as a leading example of how to make this transition. And this in turn will contribute to Rotterdam's appeal as a business location.

We can only succeed in the energy transition if we see it as the beginning of a new and circular economy – rather than as the end of the industrial age.

Scale, capacity, technology, innovation and entrepreneurship are important focus areas for a special Port Authority energy transition team that can build coalitions that help existing industries to innovate and welcome new sustainable start-ups and businesses.

Against this background, the Port Authority has formulated the following vision, describing the circular economy that has taken shape in Rotterdam by 2050:

Vision of a Circular Economy in 2050:

In 2050, Rotterdam will offer a port area that has circular processes and systems in place for industrial and logistics activities. This will help us to achieve the set climate goals and allow the region to deal more effectively with geopolitical and economic fluctuations and serve as a magnet for innovation and new enterprise. A port area like this can create both economic and social value.

We believe a vision of this kind should be linked to an ambition. This ambition has been formulated as follows:

Ambition:

Strengthen Rotterdam's position as the premier international Waste-to-Value Port, with a leading position in the area of raw materials productivity for low carbon, circular production.

The advance of the circular economy depends to a large extent on technological breakthroughs, scaling-up and the financial aspects of different solutions. The Port Authority supports this development as a driver, matchmaker and investor.

At which pace the transition will unfurl, and with which intensity, depends on numerous factors. While we have already gathered a mass of knowledge in this area, we still lack a basic blueprint to work from.

The Port Authority has chosen to follow four key *circular pathways*. It is actively advancing along these four routes in collaboration with a range of partners. While in virtually every case, the Port Authority has neither the mandate nor the financial clout to drive forward the entire project single-handedly, it is able to do so according to its principles in a variety of coalitions.

Circular pathways:

1. ***Innovation focused on attracting new activities and helping start-ups to develop into scale-ups that can be widely implemented within their respective industries.***
   - The circular economy is still in its infancy. This is the main reason why the Port Authority recognises that the first pathway is innovation. The Port Authority believes that developing start-ups into scale-ups and beyond plays a crucial part in the introduction in the longer term of new methods and technologies that can be successfully applied to the large volumes found in the Rotterdam region. In this context, the Port Authority is also paying attention to the logistics aspects of flows in the port area – the added value of blockchain technology in the field of efficiency, for example.

2. ***Sorting and recycling (with a particular focus on 'closing' the chain)***
   - As one of the world's foremost ports and logistics centres, Rotterdam has the potential to develop into a key international hub for the processing of plastic residuals into secondary chemicals and fuels with a smaller carbon footprint. Every link in the chain can be found in Rotterdam: from primary plastics manufacturers, transport firms, sorting facilities, recycling plants to consumers of a wide range of secondary products. The arrival of novel, promising mechanical and chemical recycling technologies has created new opportunities for the production of secondary plastics and other products that can contribute to the decarbonisation of various sectors, including packaging, chemical, refineries, shipping and aviation. This further expands the existing foundations for the local bio-based cluster.

3. ***Industrial symbiosis – smart infrastructure (with a particular focus on 'extending, shortening and narrowing' the chain)***
   - The high concentration of industrial and logistics activities in the Rotterdam-Moerdijk region makes it relatively easy for local companies to exchange products and residual flows, as well as take advantage of shared facilities. Rotterdam is mainly investing in the latter prospect. The Port Authority works to take work off businesses' hands by investing with its partners in a joint infrastructure (initially for steam and residual heat, among other things, but there are also plans to include CO_2 and hydrogen) that would be cost-prohibitive for individual companies. The partners are making steady progress in this form of industrial symbiosis. For example, CO_2 has been captured and supplied to local greenhouses since 2005, and six years ago, various steam and heat networks were taken into use that allow local companies to exchange steam and feed heat into regional district heating networks. One example is the Vondelingenwarmte project, within which Shell Pernis supplies residual heat to around 16,000 homes in South Rotterdam.

4. ***Carbon Capture & Utilisation (CCU, with a particular focus on 'closing' the chain and 'valorising')***

   - In CCU, CO_2 is captured at the source and re-used as a feedstock in various production processes – reducing the volume that is released into the atmosphere. There are a number of sectors where this technology can be implemented, including Chemical (low carbon chemicals) and Construction (mineralisation). In Rotterdam, partners are working on the further development of CCU implementations in a number of ventures, including the Smart CO_2 Network, which focuses on projects that supply new base materials to the industrial sector.

D – Conditions for success

In some cases we need changes to existing legislation – particularly when it comes to valorisation of residual flows and recycling. The point of departure for current waste legislation is protecting people and the ecology. Moreover, when this legislation was drafted, it was still difficult to identify the positive aspects of reusing waste.

We can no longer make do with a simple distinction between either waste or raw materials. The Port Authority is in favour of an approach whereby residuals are not – or not yet – designated as waste if it is still possible to upgrade them through one or more steps that can be accommodated within a single geographic area – Rotterdam's port area, for example.

Furthermore, the Port of Rotterdam Authority believes we should support pilot projects and demonstrations that will allow us to continue injecting new knowhow into the development of a circular economy.

January 2019