PlasticsToBio

an affordable, economically viable concept and initiative to decouple plastics from fossils

AFRY
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The world's plastics and waste issue can be solved in an economically viable way

PLASTICSTOBIO – AN AFFORDABLE, ECONOMICALLY VIABLE CONCEPT AND INITIATIVE TO DECOUPLE PLASTICS FROM FOSSILS

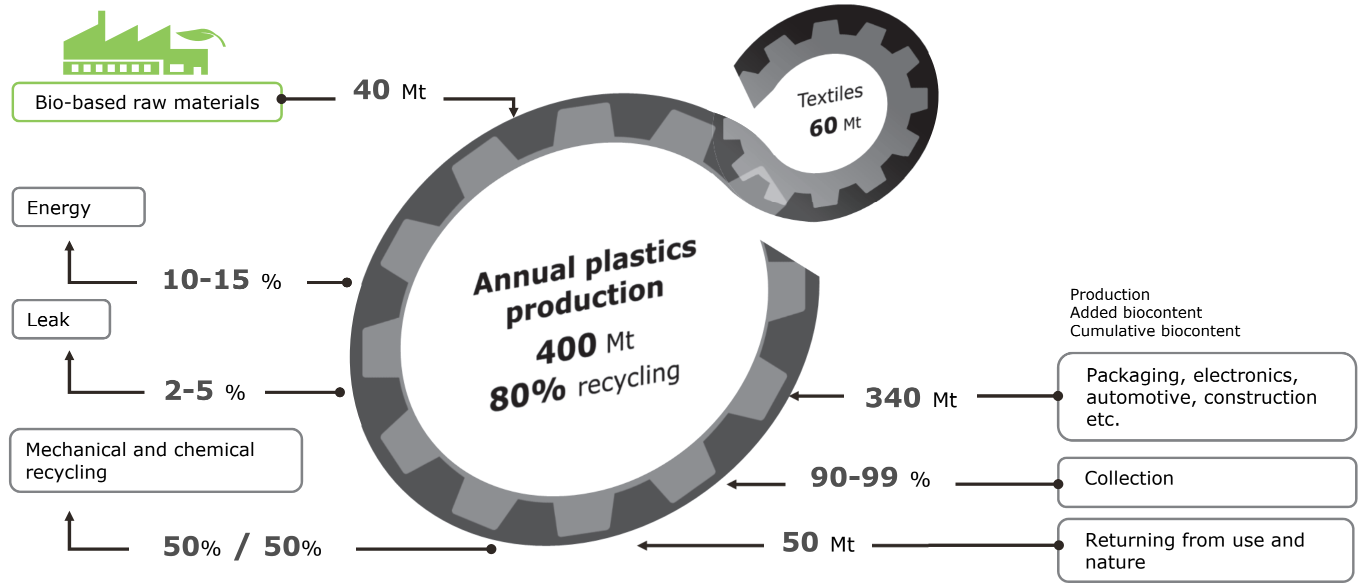
Production of plastics will soon reach 400 million tons per annum. Unless we react we will produce over 1 billion tons in 2050 – and even if we take all the currently known possible mitigation measures, growth will still be immense and we will reach a level of 700-800 million tons of plastics produced annually. This growth is driven not only by population growth, expected to be 50% in the next 30 years, but also by the growth of the middle class. The number of middle class citizens, living in highly urban areas, is set to increase by 2 billion in the same period. The global plastics problem is crying out for a solution. Unless mankind starts to take responsibility for its waste, we will soon drown in plastics – and all other sorts of waste.

The plastics problem can be solved. Technologies are available, it is just a matter of will. Besides solving the problems related to plastics, we can make the conversion to bio-based materials in an affordable, economically viable manner. An unconventional way of thinking, frustration and interest to learn combined with deep understanding and knowhow can lead to a complete restructuring of value-chains and industries. Three things are needed: collection of all plastics after use, no matter how long the use period has been; recycling of all plastic types and qualities; and enough bio-based feedstock to replace fossil feedstock.

PlasticsToBio will enable 1 Gt CO_2 savings per year when implemented.

PlasticsToBio is a pre-competitive taskforce of companies solving the plastics issue

ANNUAL PRODUCTION
400 million tons

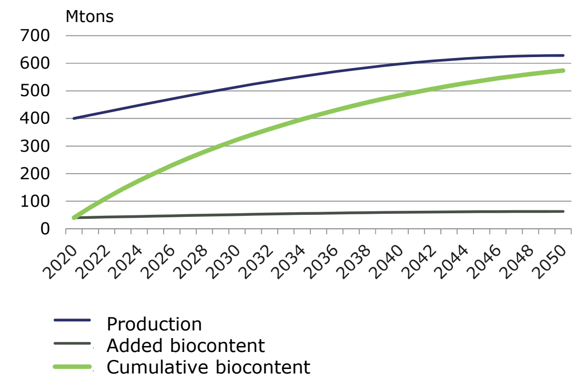


Task forces are required to turn discussions into actions
Companies need to join forces to implement in large scale the collection and recycling of plastics. Under the PlasticsToBio initiative companies with non-competitive interest to recycle plastics and start the use of bio-based materials as raw material can collaborate to optimize solutions for each type of recyclable material available.

Plastic waste incineration - an interim solution
The good news is that societies and consumers have in recent times become more and more aware of the huge magnitude of the plastics waste problem. Many countries have invested in waste incineration. This has led to investment in sites that collect waste from surrounding areas and turn it into heat, electricity, CO_2 and ash. While it is better to burn the waste to energy than dump the waste to landfill and leave it in nature, it is not a perfect solution. Only about a third of the heat can be turned into electricity. The rest needs to be distributed as heat. Burning the waste also generates carbon dioxide. One ton of incinerated plastic waste can generate almost four tons of CO_2. The ash produced may be a third of the initial mass of burned waste and may contain metals and minerals which could have been sorted out from the waste prior to incineration and at least partially recycled. Consequently, incineration should be seen as an interim alternative while we are discovering and implementing other ways to recycle the valuable materials that are contained in this waste.

Scheme for collecting up plastics
Let's take a closer look at the production of plastics and the plastics market - what are those 400 million tons of plastics used for? Roughly 60 million tons are used in PET (polyethylene terephthalate fibre) textiles, partially based on virgin material and partially already recycled material. This leaves roughly 340 million tons for other plastics applications, including packaging, building and construction, automotives, composites etc.

Now let's imagine we can set up a scheme that ensures that all the plastic that is sold to the market, in any form, comes back. Today in the Nordic countries and Germany as much as 97% of beverage bottles are returned and collected after use for recycling. This is largely due to an efficient deposit scheme and organized equipment infrastructure and logistics.



The biobased plastics, when collected and recycled will lead to a gradual accumulation of bio-content and in just over 10 years we have only about 10% fossil content left.

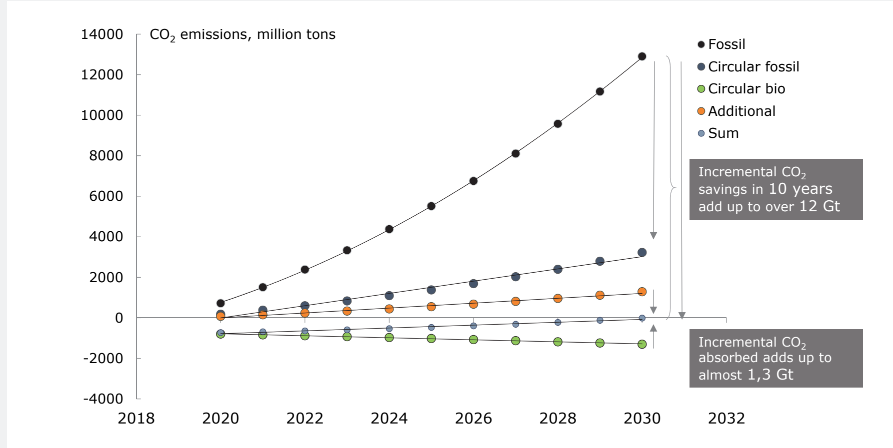
In order to decouple, the rate of investments for recycling capacity must be more than double the fossil production growth

How does a deposit scheme work in practice?

A partnership and value chain is set up between retailers and recyclers so that when a consumer buys a product from a store, a deposit value of, say, 10 US cents is charged to the consumer for the packaging. When returning the used packaging to the allocated shops, the bar code is read by a collection machine, which then returns either money or a receipt indicating the deposited value. This money can then be discounted from the next purchase in the same store. The returned plastic packaging is then regularly collected, transported and sorted for recycling and material reuse. In this way, the scheme demonstrates to consumers that plastic packaging has a value and should not be discarded, but instead returned to the shop for recycling.

12 Gt of CO_2 emissions can be cut from plastics production in 10 years

The fossil curve shows emissions caused by the production of 400 million tons of plastics based on GWP (Global Warming Potential) of polyethylene, and assuming an annual market growth of 5%.
When plants grow, they absorb CO2 in a process called photosynthesis. These plants are then used as raw materials for feedstock and the carbon dioxide eventually gets stored in the bio-based plastics. When continuously recycled, the entire plastic pool then becomes a storage for bio-based carbon.



How can we make the same happen for plastics and collect them after use with the same intensity? Take ketchup bottles, meat packaging, 20-year old car bumpers and dashboards, plastics films and pipes from demolished buildings. They all contain valuable plastic raw materials that should be collected up and recycled. Around the world there is almost 8 billion tons of plastics in the environment – being used, in landfills, and (sadly) dumped in nature – such as in the sea and at the bottom of rivers (~80% of plastics do not float!).

With not much effort we can collect, say, 50 million tons of this plastic every year. Maybe a #plasticsstrike type of campaign like the #climatestrike would be required to wake up people to realize that every bit of plastic they leave behind is money, cash, valuable raw material that must be collected.

Today, people discard a majority of the plastics they use, but we should target a low, single-digit number in terms of leakage to the environment. We cannot, unfortunately, avoid mistakes and accidents which will cause leakage to the environment but even those plastics could eventually be recovered later.

Improved quality thanks to developing recycling techniques

Today we are aware of some, mostly grey, recycled plastics products. The quality of recycled materials is set to improve as technologies develop. Mechanical recycling requires intense sorting according to plastic type followed by washing and regranulation. Sorting is typically done by near infrared, middle range infrared or magnetic flotation techniques. In practice, all plastics can be recycled mechanically, yet plastics like polyethylene, polypropylene and PET are the most convenient. In the recycling of industrial, clean grades, the final recycled plastic is very close to the original due to minimal contamination. In post-consumer resins (PCR) the collected plastics contain remainders of food, soil and chemicals and so the quality is not uniform, leaving the end product grey and often with an odour.

The limitations of mechanical recycling have led to the development of physical and chemical recycling techniques, many of which exist already today. For example, for PET recycling techniques include the disintegration of the polymer back to monomers or oligomers that can be polymerized again to plastics. Other techniques include delamination and selective solvent-extradction hydro-pyrolysis, pyrolysis followed by catalytic hydrotreatment, thermal (catalytic) cracking, gasification, Fischer-Tropsch and so on. Some of these technologies are also suitable for turning mixed waste, biowaste and waste from agriculture and forestry into hydrocarbons which can be used as feedstock for plastic production.

We estimate that in large scale 50% of plastics can be recycled mechanically and 50% would need chemical recycling. Mechanical recycling also leads to the gradual degradation of the polymers as the chains are cut shorter. Chemical recycling, however, going back to the hydrocarbons and monomers, is capable of recovering all the properties of the virgin plastic.

Recycling processes require a lot of energy and we can estimate 10-20% consumption of the plastics as energy. These may be fractions challenging to recycle or for example methane produced in chemical recycling. Methane itself, cannot be directly polymerized into plastic, but could be used as a feedstock for methane-to-olefins processes eventually yielding in plastics or alternatively in e.g. PHA (polyhydroxyalkanoate) production.

Bioplastics can become competitive and even cheaper than fossil plastics today

How do we use bio-based materials today?
Now that we've discussed the scheme for collecting and recycling plastics - key elements of PlasticsToBio - what about the other important aspect, namely bio-based feedstock? What materials are available and what are the competing end-uses for these raw materials?

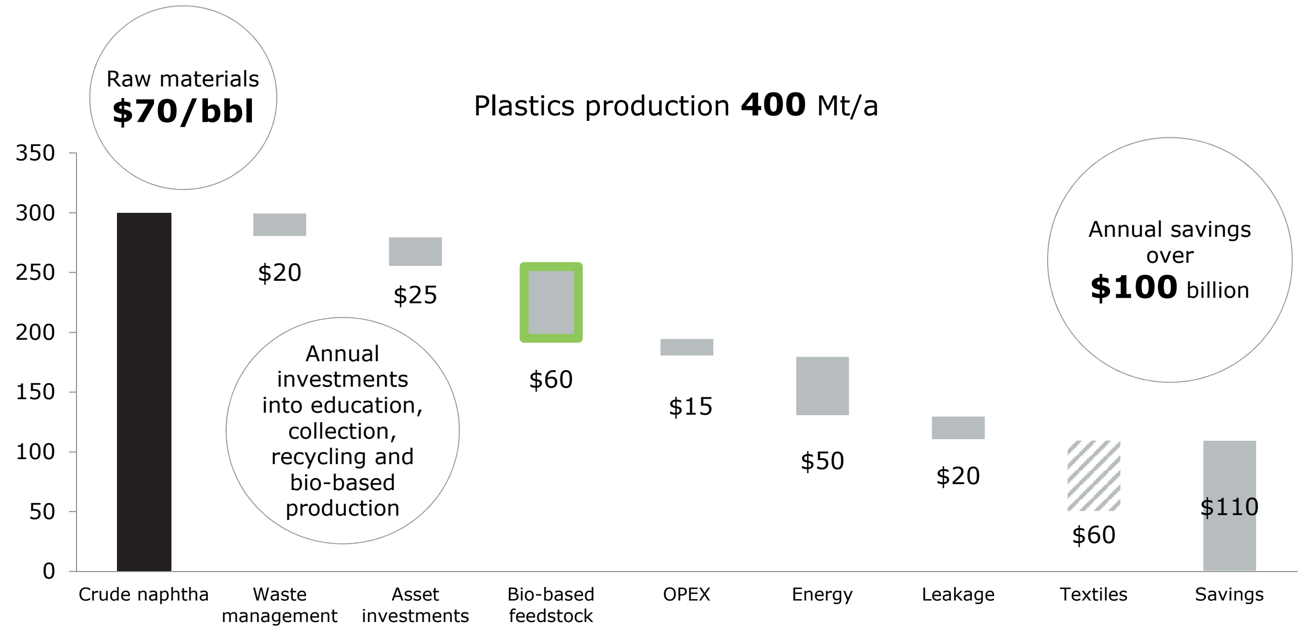
Although not as plentiful as non-renewable fossil resources (oil, gas and coal) there are many bio-based raw materials available in the world but today only 500-600 million tons of bio-based raw materials are used every year. Roughly one third of this volume is vegetable oils and animal fats, the largest single product types being palm oil, soy bean oil and rapeseed/canola oils. The vast majority is used for food although an increasing amount is ending up in second use, for example as fuels for heating, in biodiesel and renewable diesel. Even though palm oil is not very healthy, it is still very widely used in chocolates, cookies, ice creams, spreads, cooking oils and so on. In addition, large amounts of sugar and cellulose are grown. Sugar is used for food, fuels, plastics and chemicals and cellulose primarily for paper and board purposes. Other streams of the pulp and paper industry, hemicellulose and lignin, are starting to find their mass uses in chemicals, resins and composites sectors.

In discussing whether bio-based raw materials should be used for food or fuel, we must again take a holistic approach. Traffic and energy sectors are undergoing major restructuring and although the growing population will need more food in the future, it may still be that 10% of the production of natural oils and sugars can be made available for plastics applications. Today, for example, 70% of rape seed oil is used for traffic fuels in Europe. Does it make sense to burn this virgin natural oil based fuel once, or should we convert it first into plastics, which are then recycled mechanically 5-7 times and chemically 3-5 times before the molecules are converted into energy and only then let it escape the circular system? It is obvious that keeping the material recirculating as many times as possible makes sense and incineration is just the ultimate recourse in cases when plastics can no longer be recycled.

The path from fossil to bio-based plastics
Now we need to put these two key elements – collecting/recycling of materials and bio-based feedstock - into practice. Let's do the maths and define a theoretic timeline for this. Today the amount of plastics production that is 100% bio-based is roughly 1 million tons per annum and total production with any bio-based content is only about 2-3 million tons per year. Just imagine if we could scale up the bio-based feedstock to a level that would result in 40 million tons of bio-based plastics. This would mean that every year 10% of all plastics produced would be bio-based.

Then, if we are absolutely meticulous in collecting and recycling the plastics back from the market after use, this 10% will start to circulate. Next year, we again add another 40 million tons and the 10% starts to accumulate gradually. If the overall production of plastics remains stable, in 10 years fossil plastics would account for only 13% of all plastics produced. With a 5% market growth in plastics production, it would take 12 years to reach a similar level.

So we have shown how we can decouple plastics from fossil feedstock practically in 10 years. Why is this not being done yet? Many refer to the cost as the reason, but that may not ultimately be the right argument.



A global deposit scheme must be set to encourage collection of all plastics

It's all about the money

Let's forget about plastic as material and think about money. If a piece of plastic litter is on the street, over 90% of the people walk past. If a dollar note is on the street, 100% will pick it up. The misconception that a used packaging, a piece of plastic, is not valuable is very strong in our minds. We need to educate everyone that each single piece of plastic, no matter how small or dirty, is worth picking up, collecting and returning to recycling – because it is in fact our money that is lying around neglected!

A transformational investment CASE

What is the investment need required to do all of the above? Investment into new, alternative capacities must be more than double the current growth of the fossil plastic market for a sufficiently large decoupling effect to take place. Addressing the plastics challenge naturally requires recycling sites. These can be established by converting existing oil refining assets for the use of mechanical and chemical recycling processes and in new recycling assets. As we include more and more bio-based feedstock into plastics production, we gradually reduce the amount of crude oil derived feedstock such as naphtha and shale ethane required for plastics production. Instead of them becoming obsolete we could, say, convert 20-30 oil refineries into recycling sites.

We can invest for example US$ 20 billion in collection and waste management. We need to educate people, build new infrastructure for collection, sorting and logistics. This is an interesting area as today in various countries, companies receive a 'gate fee' to accept waste from the market. In the future, this waste raw material will turn into valuable feedstock and companies will start to pay to receive it at their site, just like they pay today for crude oil. The estimated value should, however, remain lower than that of crude oil.

Let's say we invest US$ 25 billion per year, of which US$ 20 billion is in mechanical, physical and chemical recycling assets and the remaining US$ 5 billion in bio-based feedstock, hydrocarbons from oils, sugars, cellulose, and wastes and residues. This is the magnitude of investment that is needed to keep up with the pace at which plastics demand is currently growing if we want to decouple plastics from fossil crude oil.

New and converted sites may be more complex compared to the old operations at least to begin with, which may result in the need to invest in more people to operate the sites and run sales and logistics operations. This may require an investment growing gradually from a few billion to even US$ 15 billion until the new system becomes established, the level of automation starts to support advanced production and costs are stabilized.

The textile market will be decoupled from fossil products partly as material gets sold into that market from the same pool. The textile market can pay US$ 55-80 billion depending on the price of e.g. polyester for fibres. After use, also the synthetic textile polymers return to the system for recycling.

The investment into additional energy, in new renewable energy production and incineration of difficult-to-recycle plastics and methane from chemical recycling may consume even up to US$ 50 billion from the system. Negligence and accidents leading to environmental leakage of plastics may cause a loss of US$ 20 billion – which again, can later be at least partially recovered back into the system.

Summing up all the above costs and investments required to replace fossil with bio-based plastics in this very simplified top-down model, we end up with a sum of US$ 190 billion per year. If we take a crude oil price level typically used in various scenarios at $70/barrel, with fossil naphtha price of US$ 600-700/mt and shale ethane at 35 cents/gallon, we pay $300 billion per year today.

At some stage, in 10 years or more, the new assets will be ready, new processes running to collect and recycle all plastics and no further capital expenditure will be required to convert and construct new production sites. This will reduce the annual amount needed for investments by $ 40-45 billion.

Ultimately the society can save over $ 100 billion every year by creating a circular economy and a bio-based feedstock in a well-managed manner and recycled bio-based plastics could become cheaper than the fossil plastics we use today.

Deposit scheme

In order to collect all global plastics after use a deposit scheme must be set up to ensure that firstly, everything is collected and secondly the recycled material has a value.

AFRY has designed an icon for a global deposit scheme that is available for open use everywhere, free of charge. This icon enables all plastic products to be labelled to have a value of either 0,10 or 0,20 euros/dollars/pounds etc. per piece or to have a value of 0,10 (currency) per kilogram collected and returned.

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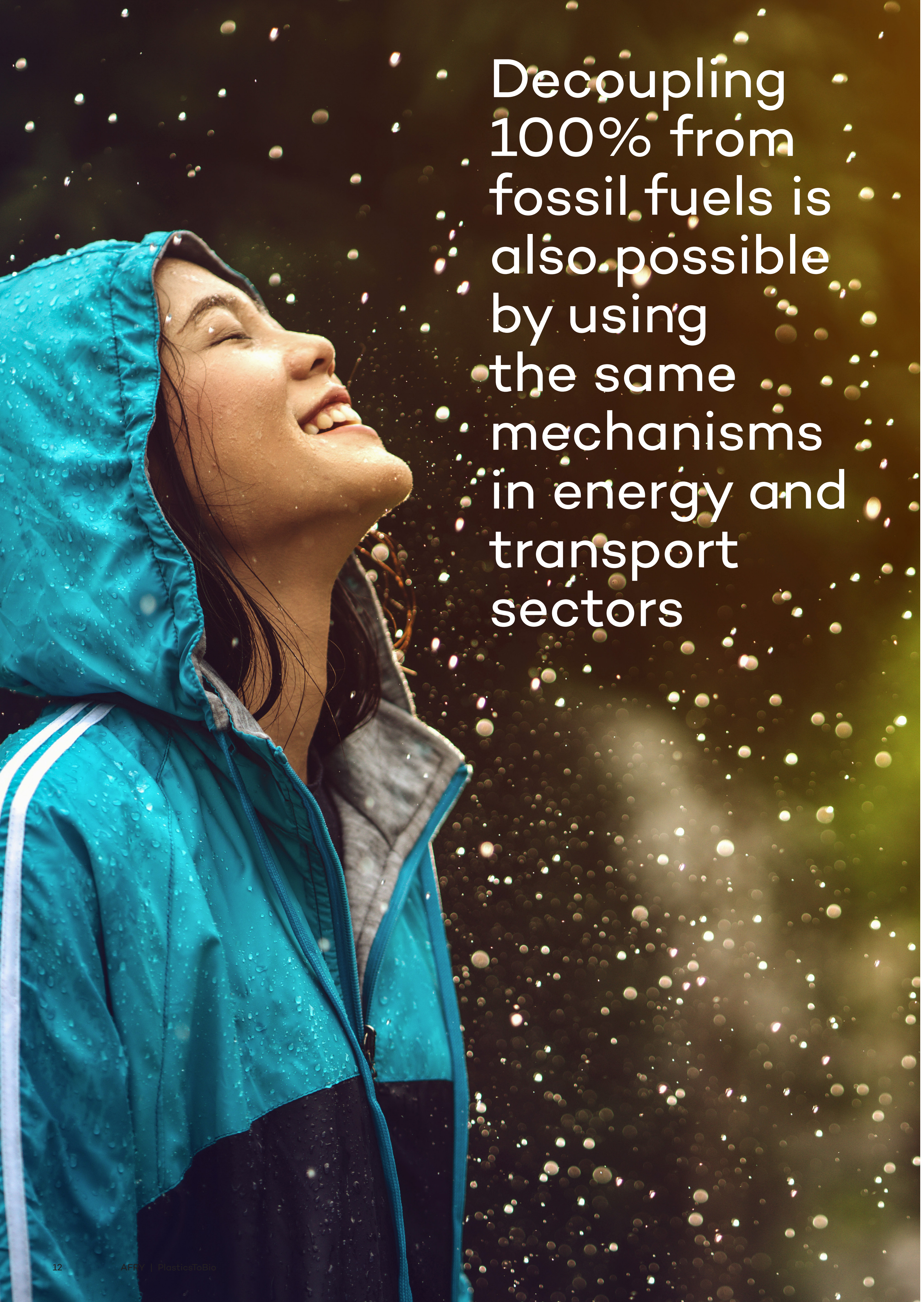
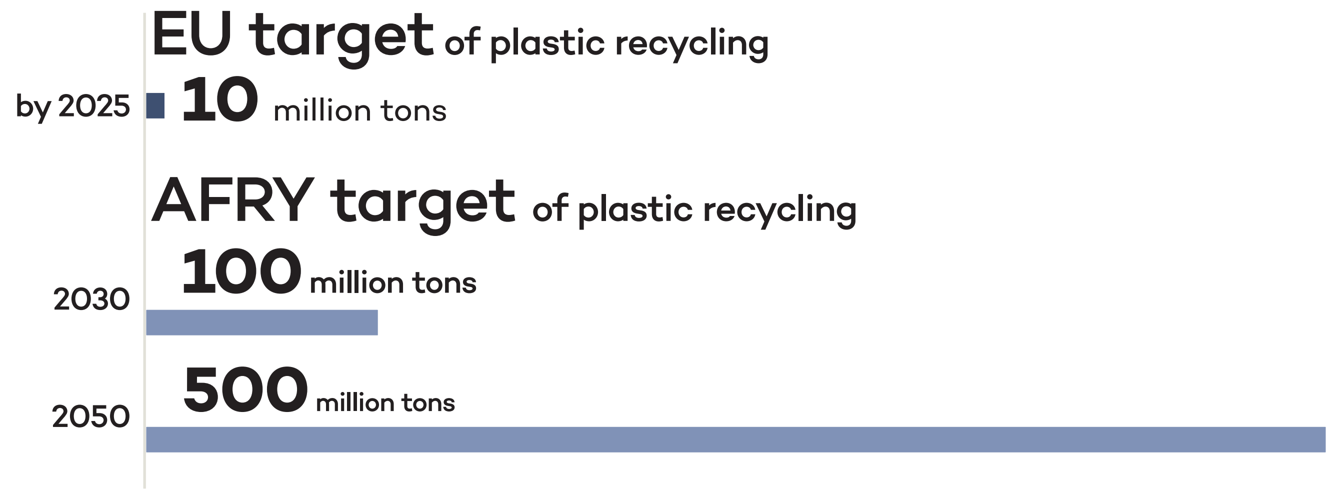
In years, 20-30 oil refineries will no longer use crude oil as feedstock

Recyclable bio-based plastics and feedstock for the producton of bio-based plastics required is

40-60 Mt/a



Decoupling 100% from fossil fuels is also possible by using the same mechanisms in energy and transport sectors



Summary:

Plasticstobio is possible but requires co-operation

AFRY has a clear view on how this can be implemented and with what investment and timetable. Companies around the world are keen to begin this task of solving the world's plastics problems and preventing us from drowning in plastics. AFRY is approaching companies active in oil refining and plastics production, bio-based feedstock and bio-plastic producers, waste management companies, technology providers, mechanical physical and chemical recyclers for plastics, retailers and brand-owners. Our ambitions must be high if we are to achieve these challenging objectives.

In a matter of a decade, we should recycle already more than 100 million tons of plastics and by 2050 the amount must exceed 500 million tons. Currently, less than 10% of all plastics end up recycled.

This PlasticsToBio concept will lead to the largest transformation in the history of petrochemicals and the restructuring of businesses and redistribution of value. In a new circular economy, the ownership of raw materilas and goods is no longer obvious and each stakeholder needs to figure out their position on material ownership. It may be more efficient and economical just to lease the material. Many companies are now considering these options and it may lead to a fight over the valuable waste raw material assets. During the transformation, it is however obvious that unless everyone works together, the problem will not be solved. No one party can solve the issue by itself, it will require a lot of horizontal and vertical cooperation among suppliers, clients and competitors.

Non-competition laws state very clearly what is possible and what can be done during an interim transition period. All relevant tools will be required to make this happen. The amount of work, engineering, plant design, construction, agricultural adjustments and development, process development, logistics, sales and marketing are immense and tens of thousands of hours of work will be needed to reach completion.

Let's start making future together!

AFRY is an international engineering, design and advisory company.
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Making Future

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