MATERIAL ECONOMICS

A NET-ZERO TRANSITION FOR EU INDUSTRY

What does it mean for the pulp & paper industry?

This discussion paper presents a short summary of the conclusions from a study carried out by Material Economics in 2019, 'Industrial Transformation 2050 – Pathways to Net Zero Emissions from Heavy Industry', and draws out the main implications for the pulp and paper industry. It has been written by Material Economics on behalf of the Finnish Innovation Fund Sitra and the Cambridge Institute for Sustainability Leadership, CISL.

SITRA

UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

EXECUTIVE SUMMARY

We argue that the pulp and paper (P&P) industry will be profoundly affected by the broader industrial transformation to net zero emissions of CO_2. The traditional challenge has been to provide an answer to how the remaining fossil CO_2 emissions will be eliminated. This remains critical, and the industry could perhaps do even more to answer it. Nonetheless, we find it may not be the most important issue.

The main impact of a net-zero transition on P&P companies may instead be through entirely different channels, presenting both challenges and opportunities. In a net-zero transition, P&P companies will operate in changed input markets, with electricity demand increased to the tune of thousands of TWh in the EU alone, and large new claims on forest resources that put pressure on companies' access to raw materials. Demands on products will change too, with expectations on a more circular economy. More positively, there could be large potential upside for those who can provide attractive and renewable materials to replace today's hard-to-abate, fossil options. This could extend further, with entirely new business opportunities in 'carbon management'.

These changes raise deep questions for P&P companies. Practically all areas of company strategy are affected, from raw materials and energy sourcing, through to R&D and product portfolio choices. Understanding a complex external landscape is an essential first step.

1. INTRODUCTION: ADJUSTING TO AN EMERGING INDUSTRIAL TRANSITION

There is intense debate about how to close the gap between current climate policy and the aim of the Paris Agreement to achieve close to net-zero emissions by mid-century. Energy intensive industry holds a central place in these discussions. The materials and chemicals it produces are essential inputs to major value chains: transportation, infrastructure, construction, consumer goods, packaging, agriculture, and more. Yet, their production also releases large amounts of CO_2 emissions. Policymakers and companies thus have a major task ahead.

EU debates are now starting to engage with these questions in earnest. A new Commission has signalled a strong focus on industrial strategy, circular economy, and new climate policy initiatives. The task is daunting: to reconcile a prosperous industrial base with net-zero emissions, and how to get there in the 30 remaining years to 2050. The journey starts from a point of often challenging market conditions, and the EU and its companies rightly are asking how climate and wider industrial strategy can be joined. There is no doubt that significant innovation and entrepreneurship will be required, by companies, policymakers, cities, and a range of other actors.

In a recent study, *Industrial Transformation 2050 (IT50)*, Material Economics investigated what this transition would entail for the steel, chemicals, and cement industries. These sectors jointly account for more than 500 Mt CO_2, and the emissions are some of the 'hardest to abate' in the entire economy. The study nonetheless found that net-zero is possible, but only with deep transformation and major changes to policy, infrastructure, energy use, and technology.

As these industries change, they in turn will affect others drastically. A net zero transition will impact both input markets (especially with claims on electricity and biomass) and those who rely on their products (with prices of basic materials and chemicals significantly higher than today).

Companies in the pulp and paper (P&P) industry are among those who could be strongly affected. In this discussion paper we draw out some of the main themes to watch.

2. COMPANIES NEED A GOOD ANSWER TO THE EXPECTATION OF CLIMATE NEUTRALITY

The IT50 study found that deep emission reductions from steel, chemicals and cement will require significant change. Carbon is deeply ingrained into the production of these materials, either as the feedstock itself (plastics), in the process chemistry of the production (ammonia, cement, steel), or in the production of high temperature heat of more than 1000°C. As much as 84% of emissions are in these 'hard to abate' categories, which cannot be addressed with energy efficiency or by using zero-carbon energy alone.

The good news is that, for all these challenges, net-zero emissions is, in fact, possible. Even for these tricky CO_2 emissions, the solutions required are available or in development. In the steel sector, hydrogen-based steelmaking and carbon capture and utilisation (CCU) offer possibilities. In chemicals, new production routes and platform chemicals, and new feedstocks such as biomass and end-of-life plastics can be used. Cement can look towards new cementitious materials. Across all of these, some amount of carbon capture and storage can be deployed, but the amounts required vary as widely as 40-200 Mt per year in Europe depending on the chosen route.

While possible, these are profound changes to industrial production systems. Some of the most basic industrial processes need to be replaced wholesale or substantially modified. Despite the size of the challenge, several EU companies are now showing their willingness to embark on this journey. For example, the three largest steel companies have announced targets of zero GHG emissions from their European operations, while the largest cement producer also has set such a target.

In this context, how does the pulp and paper industry compare? In emissions terms, it's much smaller. In 2016, direct energy use stood at 324 TWh, of which 60% was from bioenergy. As a result, only some 32 Mt out of the total c. 100 Mt of CO_2 emissions were fossil. Seen in this light, the industry could argue that more than two-thirds of emissions already have been addressed.

Moreover, the remaining fossil emissions are *technically* relatively easy to cut. Unlike the tricky emissions from chemical processes or high-temperature heat in the steel, chemical, or cement industries, CO_2 emissions in the P&P industry arise mostly in the production of steam or low- to medium-temperature heat (with lime kilns the clearest counterexample). Several P&P companies are investigating solutions: direct electric heating, hybrid boilers, CHP based on biomass gasification, heat pumps, hydrogen combustion, and other solutions. In addition, the industry has well-documented potentials for energy efficiency improvement, albeit with at times challenging investment requirements. The technical potential thus is there for cuts to practically zero emissions. The roadblocks instead are making the technical solutions commercially viable, given the heavy investments and often higher operating costs. Nonetheless, by most estimates, both the technical challenge and cost of cutting CO_2 deeply from P&P production is far lower than from cement or chemicals (see following section).

The P&P industry was early in articulating a joint sector view of deep emissions cuts. A 2015 CEPI roadmap traced paths to reductions by 80% by 2050. While pioneering at the time, in 2020 it risks being seen as dragging its feet; suggesting that 20% of emissions be left in place in 2050 is not an answer in tune with the current debate or policy targets. At a point where discussion has moved to net-zero production of something as hard-to-abate as steel, and companies are setting net-zero targets, policymakers will expect a full net-zero answer from the P&P industry, too.

More importantly, we would argue that the P&P industry should continue to look beyond 'switching out' fossil fuels. A transition to net-zero emissions in the EU economy will involve profound change to the overall industrial and energy landscape. Electricity demand will increase to the tune of thousands of TWh in the EU alone. New claims on bio resources will put pressure on companies dependent on forest products. It will involve new demands on fitting into a more circular economy. More positively, we should expect large shifts in how materials are used, with large potential upside for those who can provide attractive and renewable materials to replace today's hard-to-abate, fossil options. This could extend further, with entirely new business opportunities in 'carbon management'.

These changes raise deep strategy issues for P&P companies, affecting raw materials sourcing, energy strategy, product portfolio, and investment choices. We turn to these topics next.

3. LOW-CARBON UPSIDE? WINNING NEW MARKETS FOR FIBRE-BASED PRODUCTS

One lesson from *IT50* was that net-zero materials and chemicals will have substantially higher production cost. Zero-carbon production routes cost 20-30% more for steel, up to 60% for chemicals and 80% for cement – and more than 100% for some of the very 'last tonnes' that must be cut (Exhibit 1).

This has two key implications for the P&P industry as well. First, companies should expect new policy approaches to industrial emissions. Cost differentials of these magnitudes simply cannot be borne by companies facing both internal EU and international competition, often in commodity markets. Moreover, *IT50* found that investment would need to increase by half, both to replace some existing capacity and to switch to more capital intensive, low-CO_2 production routes. Climate policy will need to mesh with industrial policy to solve this conundrum. And of course, any such new industrial policy will affect the P&P industry, too.

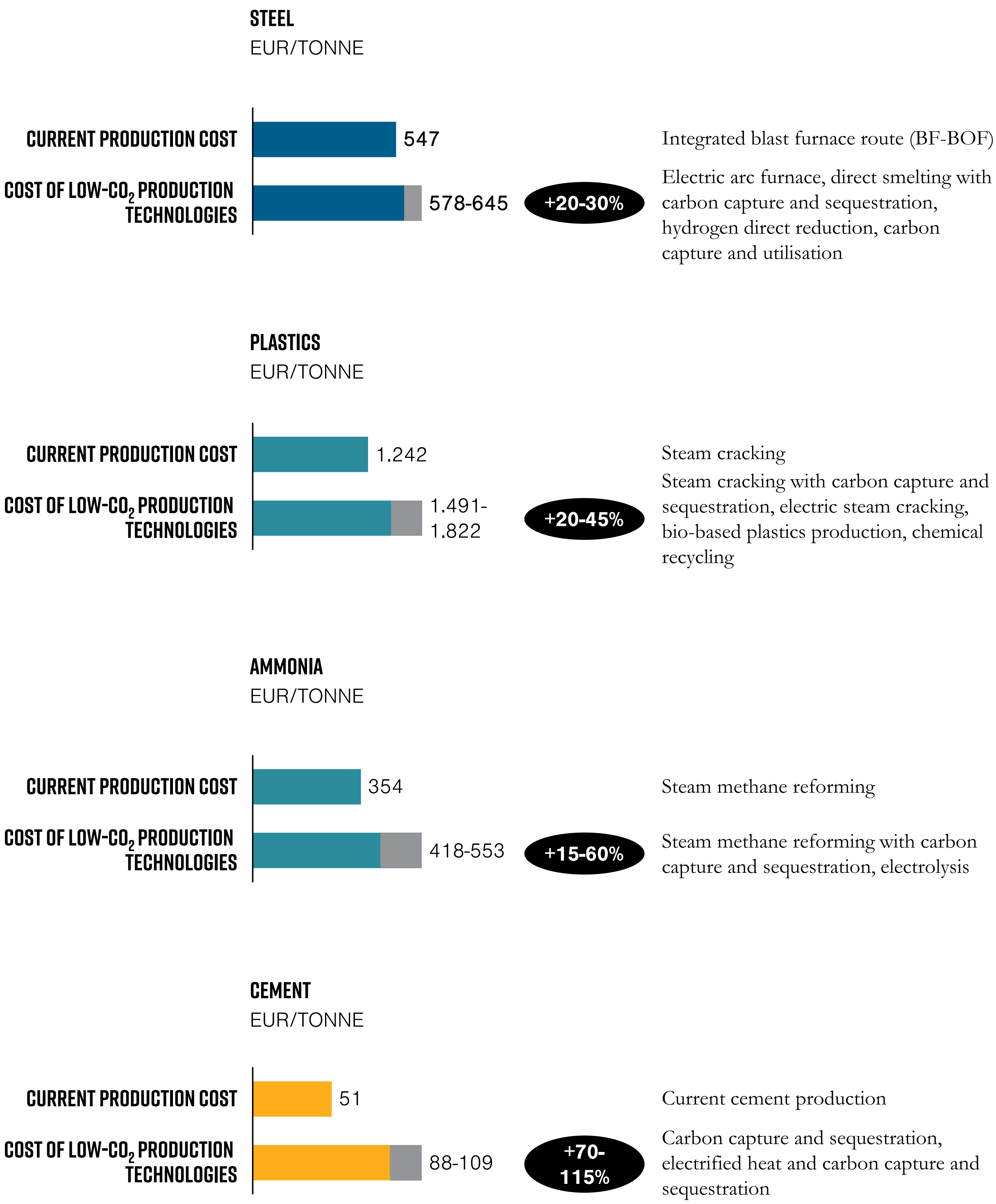
Second, increasing costs of other materials could provide an opportunity for pulp and paper companies. If net-zero plastic or cement not only depend on developing entirely new technologies and infrastructure, but also need to become 40-80% more expensive, it will be natural to ask what alternatives are available. Add to this the uncertainty about whether and when truly zero-carbon plastics or cement will be available, and the case for substitution to other materials will only be stronger.

Based on a preliminary analysis, the costs of deep cuts to CO_2 in P&P would be lower than for any other sectors. Much depends on the future cost of electricity, but by our estimate many of the levers required lead to cost increases for final paper products of no more than 15-20% (as compared to 20-115% for plastics and cement). Moreover, low-CO_2 production of fibre products depends much less on major transformations of production, so P&P could, in principle, have a head start in low-carbon offerings.

Plastics packaging substitution provides an illustration of the potential available. There is widespread concern about plastics packaging from a number of angles, and consumers as well as FMCG companies are actively seeking new solutions to waste as well as climate demands.

A detailed investigation of all major packaging segments showed that up to 25% of current plastics used in packaging could, in principle, be substituted with fibre-based alternatives without compromising on the unique properties of plastics (barrier properties, formability, transparency, etc.) (Exhibit 2). This implies a new market potential of close to 10 million tonnes of fibre-based packaging per year in the EU (assuming a substitution ratio of 2:1). The value to customers would be a solution that is 'future-proof', in that it can be rendered essentially climate neutral.

EXHIBIT 1: COSTS OF MATERIALS PRODUCTION INCREASE IN A LOW-CO_2 TRANSITION



SOURCE: MATERIAL ECONOMICS (2019).

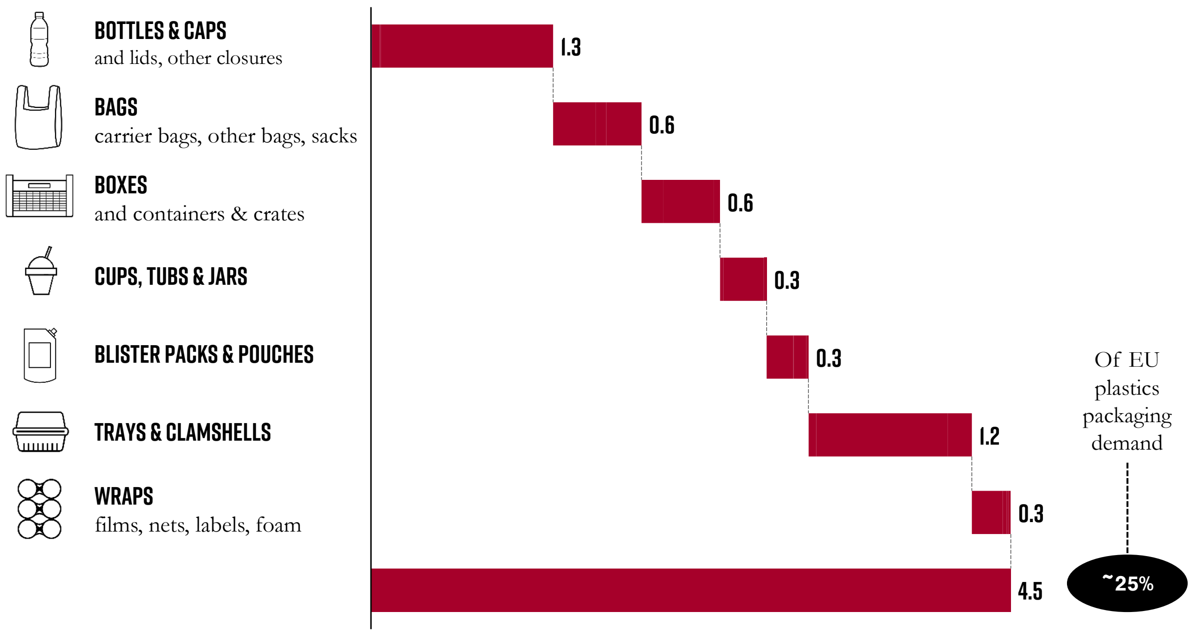
Of course, P&P offerings would have to score well on many dimensions: the total cost of ownership, impact on other objectives such as recyclability, the value of fibre used for packaging vs. other opportunities, and the feasible pace of transition given existing logistics systems and installed machine base. The real commercial potential will differ markedly between different packaging applications. For all that, with increased costs of zero-CO_2 plastics of up to 50%, our analysis is that fibre should have a growing advantage over time in a transition to net-zero emissions.

Packaging offers a 'here and now' opportunity, but there are many other possibilities. The around 80% higher cost of achieving zero-carbon cement makes engineered timber construction a still more promising opportunity. Likewise, the need for and high cost of alternatives to fossil-based basic chemicals expands the set of potentially competitive offerings from pulp and paper players. And of course, there is a strong pipeline of ongoing innovation ranging from cellulose-based textile, numerous applications for microfibrillated cellulose, new biocomposites, advanced materials such as graphene, etc.

To seize these opportunities, P&P companies have a major innovation journey ahead. Adjusting product portfolios takes time. But before embarking on this, there is a need for the industry to demonstrate a credible, zero-carbon future for its own products.

EXHIBIT 2: SUBSTITUTING PLASTIC PACKAGING WITH FIBRE-BASED ALTERNATIVES

EU PLASTIC PACKAGING SUBSTITUTION POTENTIAL
Mt PLASTICS PACKAGING, NET POTENTIAL



SOURCE: MATERIAL ECONOMICS (2018).

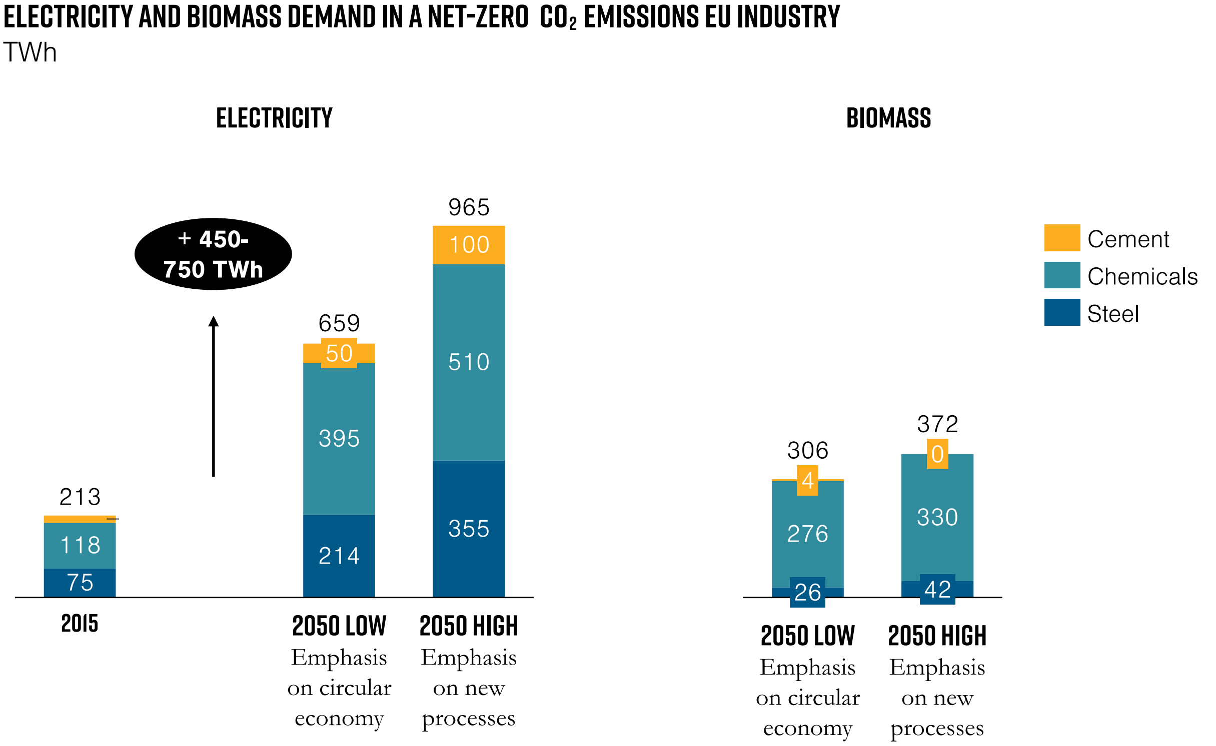
4. LOW-CARBON DOWNSIDE? BIOMASS AS AN OVERSUBSCRIBED RESOURCE

The opportunity presented by the challenge to decarbonise other materials has a sting in its tail: an industrial transition to net-zero likely will lead to large new claims on some of the key resources the P&P industry depends on for its own production. Both wood and electricity markets could see major disruption if other industries start transitioning to net-zero CO_2 in earnest.

Today, steel, cement, plastics, and ammonia production together use 8.4 EJ of energy inputs, largely from fossil sources. In a net-zero system, these inputs are substantially replaced by low-carbon electricity and biomass. A more circular economy helps take the pressure off, both by reducing materials demand and by mobilising inputs such as end-of-life plastics for chemical recycling. But nonetheless, we see another 450-750 TWh of electricity and around 350 TWh equivalents of biomass required (Exhibit 3).

The need for biomass is particularly important for the P&P industry. In these scenarios, the key new claim is on biomass not as an energy source, but as feedstock: providing a source of non-fossil carbon for the production of petrochemicals and plastics, and potentially as a reducing agent in steel production. This adds to more familiar potential claims in other sectors, such as biofuels in transportation. And as noted, the amounts required could be large. To date, these new claims have been all but overlooked in a debate focussed on bio-energy, as opposed to bio-feedstock. Pulp and paper companies therefore would do well to understand how the low-CO_2 transition could unfold in sectors such as chemicals and steel production.

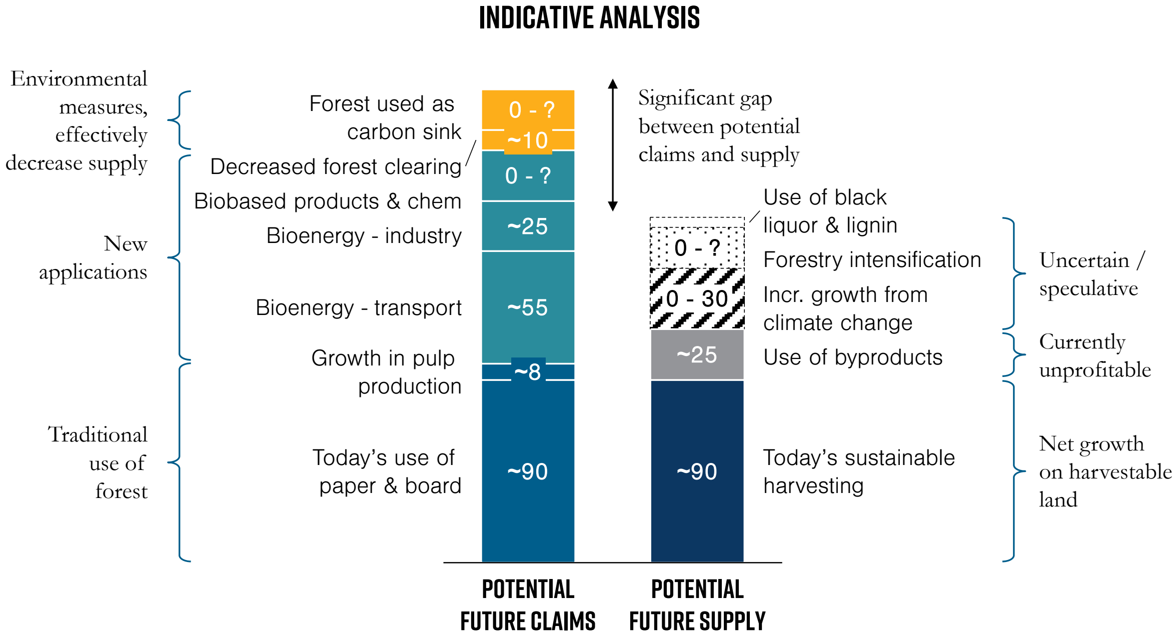
EXHIBIT 3: ACHIEVING NET-ZERO STEEL, CHEMICALS, AND CEMENT BY 2050 COULD REQUIRE AN ADDITIONAL 450-750 TWH OF ELECTRICITY AND 300+ TWH OF BIOMASS



SOURCE: MATERIAL ECONOMICS (2019).

EXHIBIT 4: THE FUTURE CLAIMS ON BIOPRODUCTS FAR EXCEED THE SUPPLY

POTENTIAL SWEDISH DEMAND-SUPPLY BALANCE
MILLION CUBIC METRE STRANDING VOLUME (m^3sk)



SOURCE: MATERIAL ECONOMICS ANALYSIS.

This only adds to a picture where biomass is an increasingly oversubscribed resource. An illustration of the high-level numbers in Sweden provides a snapshot of a dynamic that will strongly affect the wider European forest biomass market. Current forest harvesting is very close to net growth on realistically harvestable land, at around 90 Mm^3 per year. There are other sources that could be mobilised, notably some 25 Mm^3 of by-products that are not currently profitable to collect. Other additional sources of supply are much more speculative: some analyses suggest that climate change could lead to increased forest growth (perhaps as much as 30 Mm^3 per year), but this is uncertain (indeed, to date the main risk of unusual weather conditions has been to restrict harvesting volumes). There is technical potential for intensification of forestry, but this remains controversial and is far from the current political agenda.

Meanwhile, numerous claims are emerging on the demand side. Increased pulping capacity already is in the works, claiming up to 8 Mm^3. Current 'roadmaps' for the transport sector envisage a very large expansion of biofuels, equivalent to 55 Mm^3. Industry roadmaps also tend to propose heavy use of bioenergy, requiring up to 25 Mm^3. New forest-based products would require access to additional volumes of fibre. On top of this, environmental NGOs would like to see changed harvesting practices, away from clear-cutting and towards continuous harvesting, equivalent to reduced net harvesting of around 10 Mm^3 per year (Exhibit 4).

There also are proposals to use some of the forest growth not for harvesting, but as a 'carbon sink' for near-term net CO_2 emissions reductions, it is unclear how much. Putting this picture together it's clear that a large gap between claims and available resource is opening up. Something will have to give — or there risks being a drastic reduction in forest resource available for pulp and paper production.

We emphasise that these numbers are indicative and top-down – each number could develop somewhat differently. In particular, our view is that the large bio-energy claims in current 'roadmaps' are overdone, given the large potential for electrification that is now emerging. Nonetheless, they show the magnitudes involved, and the same dynamic would play out at the wider EU level. European forests are growing overall. One study suggests that it would be possible to increase removals to at least 650 Mm^3 (including bark) from today's 522 Mm^3 while keeping net outtake smaller than net growth.

However, this would require very major change to forestry practices in some countries, and the truth is that there is no good analysis of the supply-demand balance overall. Moreover, claims to fibre are of course not limited to the EU. For example, consumption of hygiene products in many growing Asian economies stands at just one-third of European levels, indicating a huge latent source of future demand.

Crucially many of the potential claims on forest biomass in the EU will be driven by climate policy, which therefore becomes a major determinant of P&P industry access to raw materials. Just as it can be an opportunity in creating new market opportunities on the output side, climate policy can become a threat on the input side. The risk is that policy does not keep up with developments. For example, recent analyses show a much greater potential for heavy transport electrification than was thought possible even a few years ago.

There is an obvious risk that policy interventions steer developments in the wrong direction, as arguably has been the case within the power sector, where subsidies resulted in large quantities of biomass being burned for electricity generation, even as wind- and solar power were significantly cheaper options.

Pulp and paper companies thus will need to navigate a very tricky landscape. Some already are branching out to look at entirely new sources of fibre. We would argue that more is required, including a reset of the policy debate to fully account for the many competing claims on forest resources. A first step to address the current risk would be to create an up-to-date evidence base on the realistically available resource, and then to take a hard look at the economically most advantageous uses, accounting for the potential for electrification and technological developments. At a minimum, understanding the evolving and complex landscape of claims on forests is a key element of company strategy.

5. FITTING INTO A MORE CIRCULAR ECONOMY

Policy for industrial emissions has traditionally looked primarily on the *supply side*: ways to achieve low-CO_2 production of materials and chemicals. A major finding from IT50 is that the *demand side* also holds significant potential. By better using and reusing the materials we already have, emissions could be cut by as much half:

- **Materials efficiency** strategies can reduce the total amount of materials required to serve the economy.
- **Materials recirculation** can replace high-emitting virgin materials with lower-impact recycled materials.
- **Substitution** from high-emitting or hard-to-abate materials to lower-emitting alternatives can achieve significant emissions cuts.
- **Finally, new business models** linked to the circular economy, such as car sharing, can substantially reduce the materials intensity of major subsectors of the economy.

In the *IT50* scenarios, these demand-side strategies account for as much as half of the emissions cuts required for a net-zero materials system: up to 350 Mt of CO_2 reduction, through a fundamental reshaping of how materials are used and handled at end of life. This is an astounding number, given that debates historically have been almost exclusively focussed on supply-side opportunities.

In addition to CO_2 concerns, the push for a circular economy is of course motivated by many other factors. Perhaps the most powerful in recent years has been that of concern about waste, and especially leakage of plastics to the natural environment. This is gradually motivating a major rethink and policy push in the area of packaging, in particular. Increasingly, companies are expected to have an answer to how they fit into a more circular economy. Policymakers are proving themselves increasingly assertive in answering to widespread public concern, and willing to enter into new regulatory approaches and areas.

In principle, P&P has a good starting point. Official collection rates for recycling are high, with 72% of raw materials from recycled fibre, and the recycling rate for packaging paper and board reported at more than 80%. This beats not just plastics, with far lower rates, but also materials such as aluminium or glass.

However, our view is that companies should not expect the debate to stay at this. There is a gradual realisation that single-cycle collection volumes tell us only a small part of the answer: quality, long-term materials balance, and the actual achieved energy and climate benefits matter, too.

First, it matters how many times a material can be cycled. Here fibre performs less well than metals or glass, but also less well than it theoretically could. While high-quality paper in principle can be cycled five to seven times (a number that likely could be increased), estimates of actual cycles for fibre in the EU are just two to three (for newsprint, graphic paper, and packaging board; higher for case materials). Improving on this is an important part of the answer for expectations about a more circular product offering.

Second, while pure fibre can be recycled, paper and board are often used in mixes with other materials, particularly plastics and aluminium. While many such mixed packaging products are recyclable in principle, actual recovery rates are much lower than they could be. More worryingly, if the companion materials (e.g., aluminium or plastics barriers) are not considered recyclable, policymakers may take a dim view of the entire solution, and thus also of fibre.

Third, it also matters whether the recycling process is 'clean'. Recycling is motivated in large part by the energy (and CO_2) savings it can produce relative to new production. Remelting and reprocessing metals or plastics uses only 5-10% of the energy required to make new materials. For fibre, the situation is more complex; while there are energy savings from avoided pulp production, 65-75% of the energy inputs of new production are nonetheless required.

Moreover, today recycling is generally more CO_2 intensive, lacking access to the renewable energy flows of an integrated pulp and paper mill and typically using fossil fuels instead.

On all counts, industry should expect tough questions in years to come. EU legislation is already changing to measure 'real' rather than theoretical recycling. Other industries are lobbying hard for branding that could easily end up a disadvantage to fibre-based products. In this area, too, pulp & paper companies therefore are better off taking a leadership role in articulating a good and early answer.

6. 'CARBON MANAGEMENT' AS A NEW ARENA OF POSSIBILITY AND RISK

The *IT50* study shows that even some of the hardest emissions in the economy can, in principle, be addressed. Yet it also shows that addressing the 'last tonnes' is a daunting prospect. For example, a sceptic might ask whether it really is possible to fit carbon capture on every last cement kiln, or ensure such complete recovery of every last fossil by-product flow in petrochemical industry.

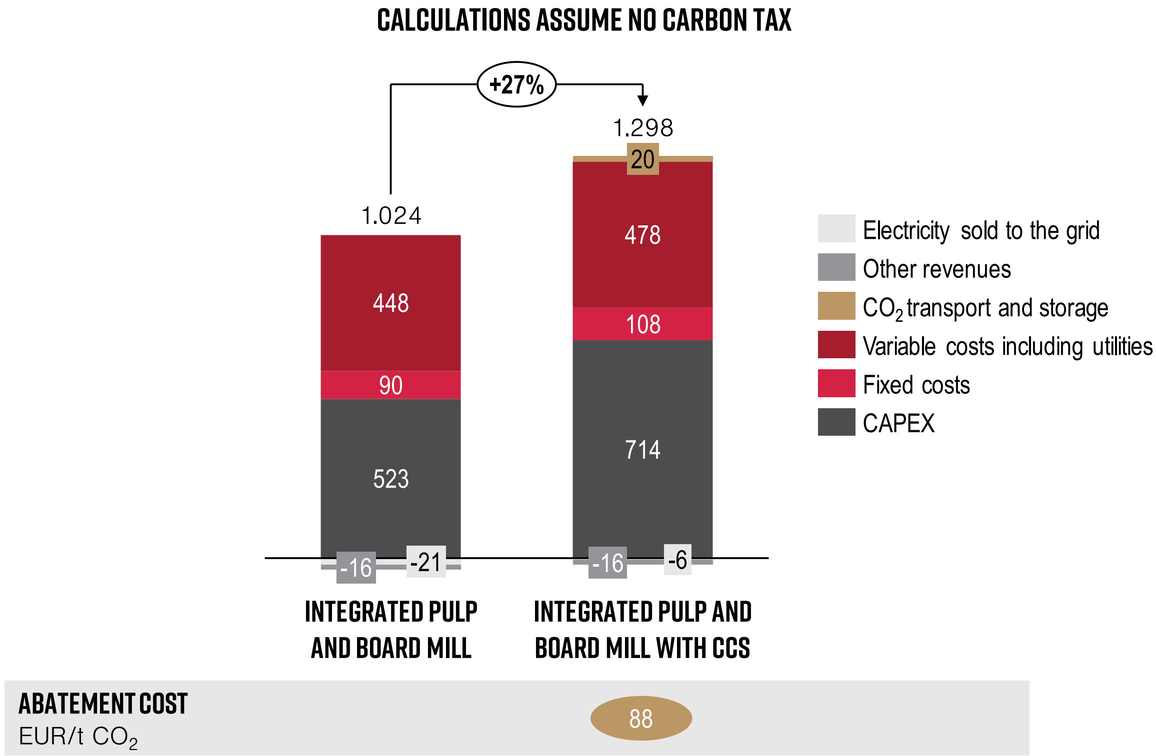
If all fossil CO_2 emissions cannot be avoided, climate neutrality requires an offsetting mechanism: 'negative' emissions, through systems activities that reduce the net CO_2 content of the atmosphere. Negative emissions could come through changes to carbon sinks, but also through explicitly designed systems. The largest potential may be through carbon capture and sequestration (CCS) on the CO_2 produced from bioenergy. Such bioenergy + CCS (or 'BECCS') features heavily in all climate scenarios that achieve two degrees or less of warming.

Other solutions also are emerging. For example, some studies suggest that it might be possible to directly capture CO_2 from the air at costs of less than 100 USD per tonne, with another 30-40 or so USD per tonne to then store it underground permanently. If these cost levels are realised, this would put these abatement options on a par with many that are required for the production of zero-CO_2 chemicals and materials.

For now, both BECCS and direct air capture exist only on the drawing board. However, virtually every modelled climate scenario that achieves a 2 degrees C target (let alone 1.5 degrees) relies heavily on negative emissions in the latter half the century. Negative emissions are also starting to creep into real-world policymaking. For example, Switzerland recently was one of the first countries to acknowledge that its climate targets will require that it relies on some form of negative emissions.

EXHIBIT 5: THE ABATEMENT COST INTEGRATED PULP MILLS IS ~80-90 EUR PER TONNE CO_2

PRODUCTION COST OF PULP AND BOARD WITH AND WITHOUT CCS
EUR PER AIR DRIED TONNE PULP



NOTE: THE PRODUCTION COSTS ARE FOR A CASE WITH SIMOULTANEOUS CAPTURE OF CO_2 FROM THE RECOVERY BOILER, MULTI-FUEL BOILER, AND LIME KILN, IN A SCENARIO WITH NO CARBON TAX.
SOURCES: MATERIAL ECONOMICS ANALYSIS BASED ON ONARHEIM ET AL. (2017).

This offers an intriguing prospect for P&P companies. With large emissions of biogenic CO_2 from pulp mills, it would be possible to fit mills with CCS. Production could then be carbon *positive*: consumers would buy not only paper or board, but emissions reductions, too. Viewed differently, in addition to making paper and board (or other fibre-based products), P&P companies would provide a service of emissions reductions.

The road to this is still long. CCS is proven at the R&D stage, but is only just being demonstrated at scale. Availability and public acceptance of CO_2 storage also is a major obstacle. And of course, CCS is costly (Exhibit 5). Existing studies of potential solutions for pulp mills suggest investment costs in the regions of 410-490 Mn EUR for a medium-sized plant, and a CO_2 abatement cost of around 60-90 EUR per tonne CO_2. This is far higher than any CO_2 prices in operation today, but may not be outlandish: it is no higher than cost estimates for other sectors (such as cement), or for that matter many other abatement options that *IT50* shows will be necessary to reach climate targets. All that said, companies will be wary of a solution that adds on the order of 250 EUR to the cost of producing one tonne of pulp and board.

CCS is only one aspect of the topic of 'CO_2 management' that is now emerging in EU debates. Others point to the potential for carbon capture and utilisation ('CCU') as an alternative approach. In particular, several chemical companies now are looking at using CO_2 as feedstock, either for fuel or for basic chemicals. The energy intensity of such processes arguably raises a still higher bar than the already formidable obstacles to CCS, but with the deep CO_2 reductions required, may nonetheless need to be part of the solution. If so, the biogenic CO_2 from pulp and paper production could become a feedstock for other sectors. Such 'industrial symbiosis' would depend strongly on local circumstances and co-location of the relevant industries.

CCS and CCU might seem far from today's business reality. Certainly, policymakers need to make major changes to policy for solutions of this type to be viable. However, our view is that they should not be discounted. The EU is only now starting to assemble on the type of policy frameworks that will be required for deep CO_2 cuts in industry. CCS will, in all likelihood, be part of this push. If the opportunity is right, P&P companies would do well to stay abreast of developments.

A final aspect of CO_2 management is of key importance to P&P companies. A major discussion is brewing about the true CO_2 footprint of products. Its first round is being fought on bioenergy, where many now argue that bioenergy is in fact far from as CO_2 neutral as current methods of emissions accounting make out. Round two will matter still more for P&P companies, as it is directly concerned with forests, and how their management affects the climate.

One part of this is the debate about whether an actively managed forest is better for the climate than one that is left standing. In many EU countries, the instinctive answer is that cutting down trees must be a climate problem rather than a solution. As P&P companies long have argued, the actual impact is much more nuanced, given the much higher growth and carbon sequestration potential of a managed forest. However, companies should not count on this playing out their way in the debate.

The other part is whether more permanent forest-derived products (whether timber, bio-composites, or other emerging and long-lasting wood-derived materials) provide 'carbon sinks' for their duration of use in the economy. The CO_2 benefits of wood construction, for example, differ sharply depending on how this question is answered. Here, too, debates are in danger of getting stuck. Our view is that P&P have a strong potential case on their side, but still have significant legwork left in order to translate this to favourable policy or acceptance by customers.

All in all, P&P companies will find themselves embroiled in important debates about how CO_2 can be managed, sometimes taking them far from their current core business.

7. CONCLUSION: HOW SHOULD COMPANIES AND POLICYMAKERS RESPOND?

The sheer breadth of issues arising from a low-CO_2 transition may seem daunting. We see four areas where companies have a particularly urgent task to develop new answers:

- **Develop the capability to develop and sell sustainable products.** Sustainability concerns could be a major driver of growth for new fibre-based products. The pulp & paper industry has major potential advantages both in providing low-CO_2 materials even as other industries struggle to do so, and in answering to concerns about waste management of plastics. To date, however, we see more confusion than clarity. One challenge is 'betting on the right horses', and sorting through which products are safe bets versus at risk is far from trivial. Likewise, for an industry traditionally based largely on volume-based selling, articulating the value of a more sustainable product and embedding it in the salesforce can be a major task.
- **'Put the own house in order' with a good answer to CO_2 and plastics.** Capturing sustainability-driven growth also depends on having a credible answer to one's own sustainability impact. Three areas stand out. First, many companies have set 'science-based targets' for CO_2, but in P&P these are at risk of being less ambitious than policymakers and customers in the EU expect. Within years, we would expect a net-zero answer to be firmly on the agenda.

Second, companies will need a good answer to plastics. As illustrated above, fibre could replace plastics in many applications. However, many P&P companies are themselves major users of plastics (or sell to customers who are), and arguably will become producers of plastics as some of the bio-based polymers now in the pipeline are developed. Third, there is much to do within the area of circular economy.

- **Revisit raw materials strategies.** In tandem with managing the potential upsides, companies need to face the new pressures on forest resources. The last several years has seen a very tight wood market in the Baltic region. If the discussion here is right, this may be far from an exception but rather the new norm. Companies are already responding by adjusting their forest ownership positions, considering new sources of fibre, etc. Such supply-side measures must now be combined with an increasingly sophisticated understanding of the new, emerging demand-side of rival claims on wood resources. Over time, ensuring a favourable policy framework may be as important as any other measure companies can take. The P&P industry may very well have the facts on it side, but it needs to show why this is, and avoid a situation where either sheer inertia or lack of understanding imperils future raw materials supply.
- **Consider new energy opportunities.** Given the importance of energy in P&P cost base, it is no surprise that this, too, is a major area of adjustment in a low-CO_2 transition. One part of this is to consider early electrification and novel sourcing. As one company representative put it, 'the simplest possible power-to-X is where X is steam'. This may have looked far from commercially viable only a few years ago, but with new, long-term renewable energy power-purchase agreements available at 30 EUR / MWh or less, early electrification may rapidly become much more attractive than it once was. And of course, this opens up the whole debate about how to valorise any bio-energy flows that are then released for other uses.

There is no question that the P&P industry could make a major contribution towards an economy with net zero CO_2 emissions. However, capturing this potential will depend on policy that has yet to be developed. The big debate is highly generic: if not just CO_2 prices, then what? But at a more granular level, we see five large areas where policymakers need to reconsider current policy frameworks:

- **Create lead markets for low-CO_2 solutions in industry.** There is no question that real progress on low-CO_2 materials will require much stronger policy support, and a resolution to the problem of international competitiveness. Many new proposals are now being floated, ranging from a revival of proposals for border tax adjustments, to quotas for low-CO_2 materials or 'contracts for difference' or other subsidy approaches. These are still far from implementation, and a lot of work would be needed to design such policies. Pulp and paper gives rise to unique considerations. Not least, as the discussion in this paper makes clear, the contribution of the sector could go far beyond just phasing out current CO_2 emissions in production.
- **Account for materials *substitution*.** The innovation in bio-materials is creating an entire new set of opportunities to cut CO_2. Policy has yet to catch up with this: the principle of renewable energy is well established, but that of renewable materials has barely been investigated. Some of this is due to well-founded concern not to distort competition by favouring one material over another. But increasingly climate policy is in any case introducing significant incentives to reconsider

how materials are produced and used. Omitting the potential for substitution entirely then becomes a distortion in its own right. One way or another, policy will have to handle the potential for materials substitution.

- **Comprehensively review the impact of climate policy on bio resources.** Climate policy already has become a major influence on the use of bio-resources. Many 'first generation' measures (such as wood combustion for power generation, or blending of corn-derived ethanol to transportation fuels) are already looking out of tune with today's technology possibilities – yet they continue to be encouraged by existing policy frameworks. As pressure on bio resources increases, the risk of misalignment only increases. There is an urgent need to review the full impact of policy on bio resource use, accounting both for new potential use-areas (substitution to renewable materials, bio-derived products as carbon sinks, new uses of biomass as feedstock, natural carbon sinks, etc.) and for the rapid developments in alternatives to bio-energy in sectors such as heavy transport or industry.

- **Develop a policy framework for negative emissions and sinks.** Much of the peril and promise of using bio resources depends on one unique property: that plants capture CO_2 when growing, which then is released on a variety of timescales depending on use. Today's policy approaches have not yet handled this issues but kept energy-system and land-use accounting largely separate, (often by simply zero-rating bio-based CO_2). This will no longer be adequate with more systemic shifts towards a bioeconomy: it neither gives a full account of actual near-term emissions impacts, nor does it capture the potential of carbon sinks (whether in nature or in wood-based products). Likewise, policy still has work to do in enabling bio-based CCS and other negative emissions approaches.

- **Consider life-cycle analysis carefully.** Recent policy proposals have given an increasingly prominent role to life-cycle analysis (LCA) as a tool to design policy. The underlying thought of LCA is sound: after all, who could object to a comprehensive consideration of CO_2 impacts? However, the implementation in practice is far murkier. One major risk is that LCA is based on backwards-looking information, assessing future solutions based on today's fossil-based energy and transportation systems. To name but a few examples, the thermal insulation benefits of cement in buildings may be less valuable in a future where low-carbon energy is used for heating; the lightweighting benefits of plastics are lower if logistics is electrified; electricity-based processes that are essential in the future may look bad in today's still high-carbon power mix; and fossil CO_2 emissions from end-of-life incineration become a much greater concern as landfilling is phased out to meet future waste policy targets. In general, the pulp and paper industry has more to lose from such inconsistencies than do other industries. At worst, LCA risks becoming an obstacle to the more systemic changes involved in a switch to a much more bio-based economy.

Material Economics Sverige AB
www.materialeconomics.com
Stockholm, Sweden
June 2020