Brightsite

Transforming industry

A radical new way of thinking

SCIAR model: the first roadmap from source materials to recycling

The chemical industry is facing major changes, with its future being shaped by electrification and the greening of raw materials. To achieve large-scale industrial application of alternative, circular raw materials and related disruptive electrical processes by 2050, it is crucial that we start scaling up innovations now. But how do you know which path to choose? How do we make the right choices? Brightsite's SCIAR model can help, by providing a rational basis for making these choices. This 'roadmap' clarifies the routes to the future and shows the transition paths to climate neutrality.

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The chemical industry is currently focusing primarily on greening and optimizing existing processes, and on capturing and storing CO_2 to meet the 2030 climate targets. If we also want to achieve the long-term goals, we will need renewable resources such as biomass (e.g. wood and sugar) and waste (recycling stream plastic), as well as innovative green electricity-based processes. "Scaling up these types of solutions will require a systemic transition, which requires us to formulate comprehensive transition paths. We need to know where to invest our scarce resources. This requires us to think in terms of the source (of new raw materials, for example) and to know what is available and what the potential volume is before we start working on the technology. If we want to use sugar from sugar beets and wood as bioresources for materials, we need to know how much of these resources will be available in the future, and how much plastic we can collect, and how, in order to optimize the recycling process. Other waste, in many different forms, is also becoming an important source of raw materials for products. During this time of transition in the chemical industry, we need to think rationally and weigh up each of the various options. This will provide us with insight into the potential impact and costs of different transition paths that can be used to realistically map the transition from a fossil-based to a sustainable industry," says Brightsite Director Arnold Stokking.

How does SCIAR work?

In order to make informed choices, we need to be able to compare the various sources and processing routes. SCIAR – Source, Commodity, Intermediate, Application and Resource – can help with this. It helps shape the transition paths and models both the influence of specific technological innovations and other – in some cases non-technical – factors in the system as a whole. "SCIAR is a way of depicting the complex system transition in the same way that roadmaps depict the road network. We map the entire spectrum and can zoom in or out to the desired level. We can then map a new technological innovation onto this flexible concept for shaping a transition and see what happens, or what needs to happen to make it a success. This modeling can be based either on the current situation or the future," says Paul Brandts, Intelligence Officer at Brightsite. "It works circularly: from raw material to use, and back again from waste to raw material. It also deals with entirely new intermediates and new applications, and lets us compare SCIAR routes with each other. This allows us to consider questions such as: Can we replace nylon with recycled nylon to make clothing? Can we torrefy wood into a useful product to make hydrogen? The result is similar to what navigation systems manage in traffic: finding the right way through all the complexity, while we at the Brightsite knowledge center remain behind the wheel."

Paul Brandts, *Intelligence Officer Brightsite:*

"SCIAR helps us make the right choices for the next generation."

The SCIAR model consists of five pillars (see Figure 1):

1. Source material: in today's chemical industry, our own planet is the main supplier, providing us with oil and coal. But cultivated land, forests, waste, water and air can also be sources for chemical processes and building blocks.
2. Commodities: specified substances from the above sources, which are suitable for multifunctional use and can be made available in high volumes, such as sugar or pyrolysis oil.
3. Intermediates: familiar or new chemical products such as methanol, hydrogen and polymers that can be processed into an application from these commodities.
4. Application: finished products such as packaging for food or lightweight materials for cars.
5. Resource: used products, which we currently negatively label as waste, can in many cases be fed back into the cycle. This creates a new cycle by returning to the application, intermediate, commodity or source material stages.

The whole portfolio of activities in the Netherlands in the field of green chemistry and circularity can be plotted in the SCIAR model. "The model currently covers 95-99% of those activities, allowing us to see relatively easily where there is a surplus or a gap," explains Herman Wories of Maastricht University, Project Director at Brightlands Institute for Supply Chain Innovation (BISCI). BISCI leverages computing power to highlight the potential for industry from source to application – a huge supply chain challenge.

Arnold Stokking, *Managing Director Brightsite:*

"During this time of transition in the chemical industry, we need to think rationally and weigh up each of the various options."

Work to be done

Figure 2, which includes a more realistic semi-quantitative relationship between fossil and non-fossil raw materials, shows that there is still much work to be done. Fossil resources are still dominant. "Plastic recycling is the obvious way to provide raw materials for the chemical industry. However, this has yet to really take off, and we need to think about redesigning products to make them more sustainable. It is not feasible for us to recycle 100% of what we produce; losses are inevitable and, aside from this, economic growth worldwide will lead to increased demand. All this translates into an increasing demand for familiar and new intermediates and applications – the I and A of SCIAR. This means that top-ups from, for example, agriculture and forestry will be necessary. The proportion of agricultural land, and waste, currently used is limited, but the transition will force us to consider how to use these resources in the future. This should include consideration of the broader impact. After all, there are also many social issues that play a role when determining the various transition paths. In the SCIAR model, we first summarize the facts about plastic and bioroutes from technology and science. The next step is to see what is and is not feasible. To help us do that, we can also literally put all the relevant parties on the SCIAR map. The SCIAR model thus provides an integral overview of the various intersecting or complementary opportunities. The results then need to be assessed against the social yardstick," Brandts explains. Next, the (new) players involved need to form a chain together, and appropriate business models should be created to govern and distribute the value in that chain. Sectors that were previously unconnected are now learning to work together, for example the waste industry and the chemical industry.

"Applying this model to bioresources, we can highlight the circumstances in which it is not – contrary to prevailing opinion – wrong to use land for the sake of the chemical industry. The model lists the alternatives and contrasts them with the fossil standard. It also shows how we can combine different raw materials and technologies. For example, it allows us to calculate how much agricultural land is needed for each source material, and to quantify what this means in relation to other activities. How many acres of farmland are needed for sugar? How many acres of forests for hydrogen and methanol? How much municipal waste is needed for recycling? Because of course we also want land for recreation and food production, and burning waste produces CO_2 emissions. The fact is that we can't manage this with waste streams alone. If we want to go green, we will also need to use agricultural land to ensure a continuous flow of raw materials. This transition to agriculture as a source of raw materials will have an impact on many areas, including farmers, transport flows and logistics, new business locations for reprocessing, and training and employment," Wories emphasizes.

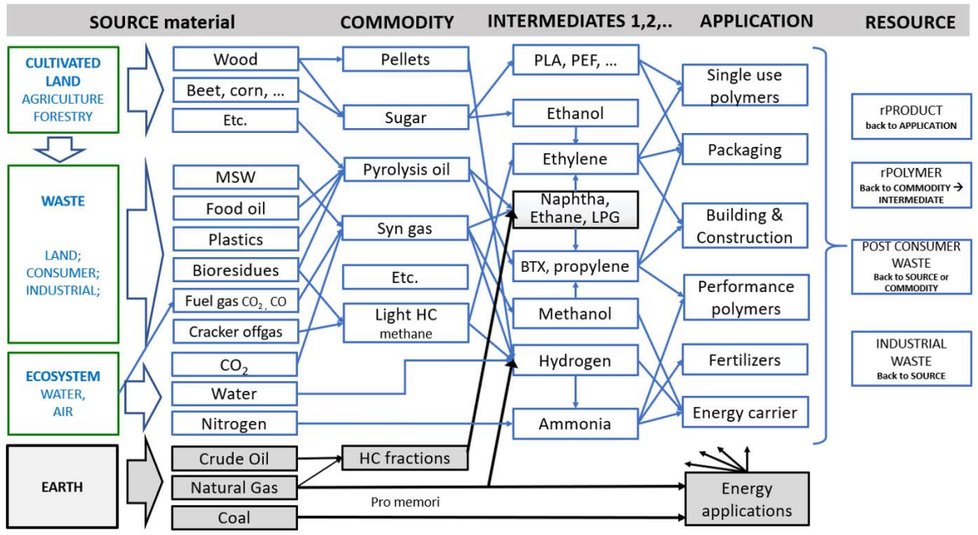


Figure 1: The SCIAR model based on the five pillars Source, Commodity, Intermediate, Application, Resource

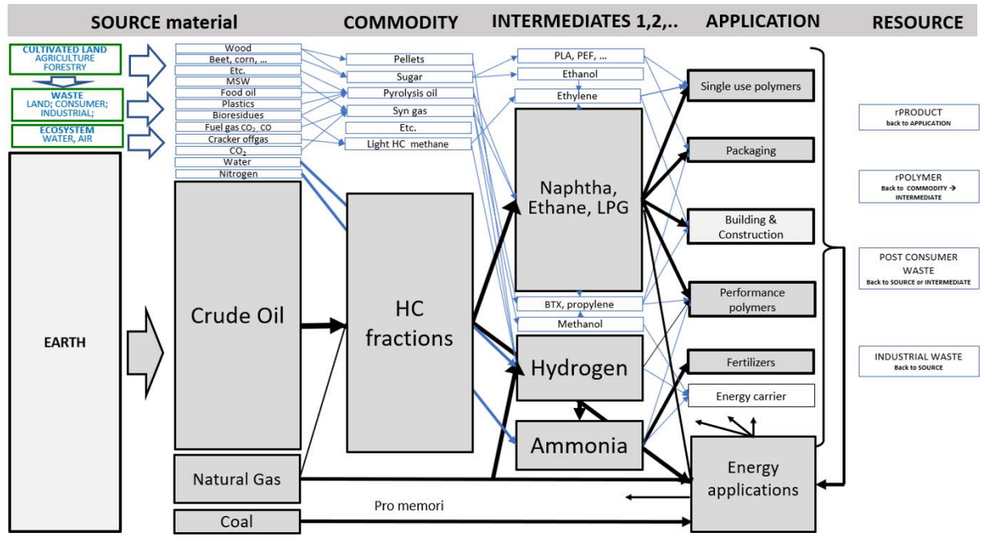


Figure 2: A more realistic semi-quantitative ratio between fossil and non-fossil raw materials in 2021

Sugar beet example

When it comes to cultivated land, sugar beet and grains, among others, offer opportunities for a new processing chain to provide bioresources for chemistry (see Figure 3). “Growing sugar beet of course involves using land. We need to think about this in relation to how that land is currently used, and weigh up agriculture against livestock and cattle feed, for example. Using SCIAR, we can bring the entire value chain into focus and see its implications, including in comparison with alternatives. We can also use it to consider aspects such as: What conditions does the chemical industry impose on the raw material to be supplied? Which route will provide year-round security of supply? What about scaling up cultivation, crop rotation to prevent depletion, logistics, storage and applying the technology to create intermediates (in this case bio-based plastics like PLA or ethanol)? In the case of sugar beet, cultivation is well developed in the Netherlands and the acreage can be expanded significantly without competing with food production,” says Brandts.

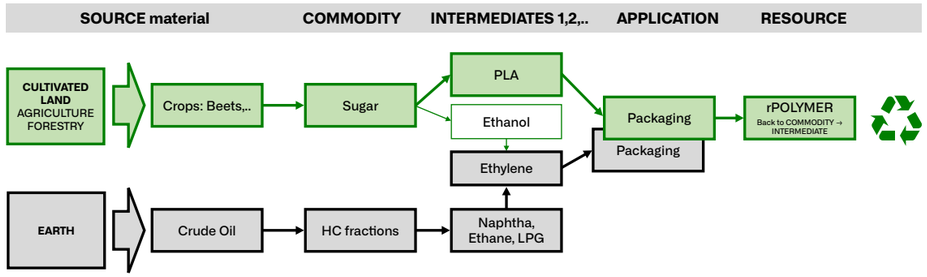
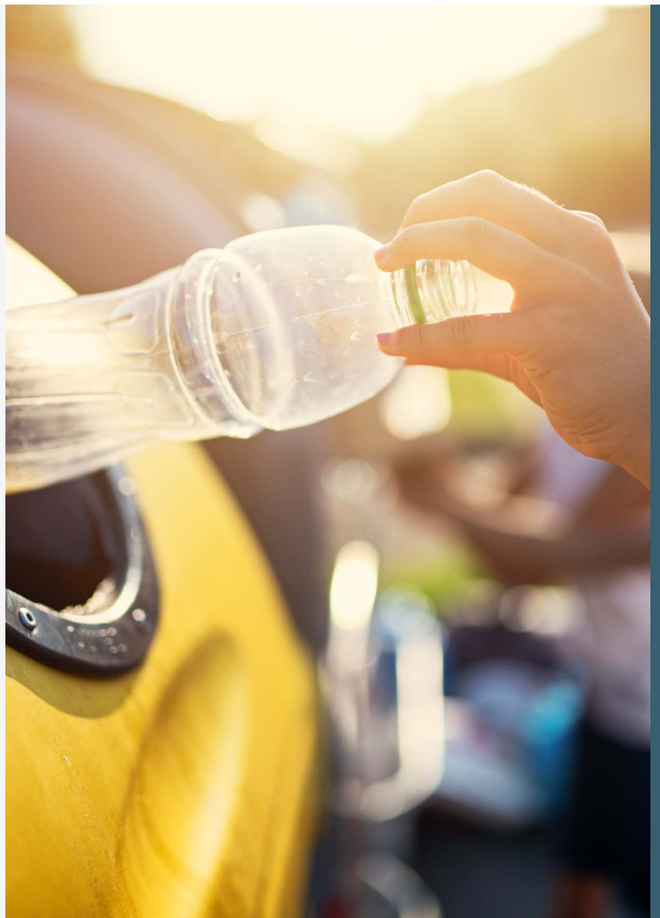


Figure 3: Opportunities for a new processing chain to supply the chemical industry with bio-based materials

Joining forces

The SCIAR model can be linked to policy. “There need to be policy incentives to ensure that source materials are more accessible for product redesign and, vice versa, that product redesign leads to better source materials,” says Brandts. “This will mean that product streams are easier to recycle, so that we are much more efficient in terms of source materials. We need to make closing the recycling loop as easy as possible.”

In terms of the short-term goals up to 2030, the focus is mainly on reducing CO_2 emissions and the energy transition. “However, it is not possible to separate the energy transition from the raw materials transition – they are intrinsically linked. Oil is used as a fuel, but also as a raw material. Therefore, in order to reduce fossil CO_2 emissions in the long run, it is also necessary to make the raw materials greener. The chemical industry uses a vast amount of energy and raw materials, so it will play a crucial role within the Dutch economy in achieving this combined transition. If we are to succeed, all stakeholders at all levels – involving all the pillars of the SCIAR model – will have to join in, otherwise this will not work,” concludes Wories.



Transition scenarios and systems thinking

At Brightsite, we have a comprehensive overview and can help companies at Chemelot make the right choice when it comes to innovative technologies. It is crucial that we use processes that meet the needs of the site as a whole as well as tying in with future developments in the Netherlands: we call this system integration, a prerequisite for making sensible decisions. We will need to devise and implement a strategy together as a site, but also as the Netherlands and Europe. Changes in processes, new technologies and products will influence each other; we can and must take this into account. This is what we are focusing on in Brightsite’s program line 5: ‘Transition scenarios and system integration’. We are looking at how to tie together the different opportunities and processes for greening. Although this is a complex area, given its dependence on a variety of rapidly changing (external) factors such as energy and CO_2 price developments, this complexity lends itself to rational thinking more than you might expect. Using systems thinking and careful modeling, we can cope with any uncertainty in well-considered scenarios, thereby achieving our goals. The SCIAR method helps us with this. It is an important concept, because it starts with the availability of source materials and works its way from there to the end product and recycling.

Herman Wories, *Maastricht University and Project Director BISCI:*

“It is not possible to separate the energy transition from the raw materials transition – they are intrinsically linked.”

Does your company recognize itself in the working method of Brightsite?

Brightsite’s SCIAR model offers help by providing a rational basis for choices. This ‘roadmap’ clarifies the routes to the future and shows the transition paths to climate neutrality. Would you like to know more about the SCIAR model, or would you like to use our services? Please contact us.

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