1 AKZONOBEL: BIOBASED RAW MATERIALS

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1.1 AKZONOBEL’S BIOBASED RAW MATERIALS STRATEGY IN CONTEXT

This chapter sets out AKZONOBEL as a company, its position in the value chain, and sustainability approach and describes how the company has responded to recent
developments in biobased materials. AKZONOBEL has developed and implemented a white biotechnology strategy to help respond to the sustainability challenges of its customers and to contribute toward its corporate sustainability goals. Guided by this strategy the company is now partnering with innovators and leading companies in the rapidly developing field of industrial biotechnology and biobased raw materials to bring economic competitive developments delivering meaningful sustainability improvements to our markets.

AKZONOBEL is a committed and recognized leader in chemical industry sustainability and our proactive effort has been recognized through our presence in the top three of the Materials Industry group of Dow Jones sustainability index (DJSI) for each of the last 5 years. We have even been Materials Industry group leader for each of the last three years. The DJSI benchmarks the sustainability performance of leading companies based on environmental, social, and economic performance, including forward-looking indicators, and is regarded as the world’s foremost sustainability index. It assesses various criteria, including supply chain management, operational eco-efficiency, product stewardship, human capital development, and occupational health and safety. AKZONOBEL is building on the basis of active health, safety, and environment (HSE) programs internally and through supplier support visits (SSV) and works with our key suppliers to improve HSE performance though our value chain. AKZONOBEL also takes a leading position in cross-sectoral initiatives such as the World Business Council for Sustainable Development and Together for Sustainability.

We are further building on this base with eco-premium solutions (EPS) and our Carbon Strategy. As part of our sustainability effort, AKZONOBEL is helping its customers to address their sustainability challenges by offering products that enable them to reduce their environmental footprint at competitive price points. To add impetus to this effort, we developed the concept of EPS in 2007 to translate the eco-innovation challenge into an operational target for our company. This eco-innovation challenge was defined by the World Business Council for Sustainable Development as the introduction of any new or significantly improved product—which can be either goods or services—process, organizational change, or marketing solution that reduces the use of natural resources (including materials, energy, water, and land) and decreases the release of harmful substances across the whole life cycle.

EPS are measured using a quantitative analysis or a qualitative assessment of performance in seven categories: toxicity, energy efficiency, use of natural resources/raw materials, emissions and waste, land use, and risks (e.g., accidents) and health and well-being (added in 2013) against the most commonly available equivalent commercial products or industrial processes (mainstream solutions) from a life cycle (value chain) perspective. The EPS must be significantly better with respect to at least one criterion and have no significant adverse effects with respect to any of the other criteria. The assessment is carried out by an experienced cross-functional group, including experts in R&D, marketing and sales, purchasing, manufacturing, and eco-efficiency. Since 2008, the EPS assessment has been audited as part of a broader sustainability audit.

Our 2020 target is to achieve 20% of revenue from products and services that provide customers and consumers in our downstream value chain with a significant
sustainability advantage. This is in addition to our target of increasing revenue share from EPS (with benefits at any stage of the value chain) to 30% by 2015. Both are challenging goals because the assessments are made against equivalent mainstream or standard commercial products and as such are an upward moving target, as both we and our competitors introduce new and more sustainable products into the market.

Addressing concerns about contribution to and the impact of climate change prompted AKZONOBEL to establish a Carbon Policy in 2009. In this we recognize the need to move beyond controlling emissions from our own operations toward—throughout our product chain—identifying and addressing both the opportunities for more sustainable sources of materials and the strategic risks arising from dependence on fossil fuels and fossil-based raw materials. In line with our commitment to develop eco-efficient solutions for customers, the company acknowledges that managing our carbon footprint through innovative products, technology, and energy management constitutes both a business opportunity and a social imperative. Our target is to reduce our cradle-to-grave carbon footprint by 25–30% per ton of sales between 2012 and 2020. The cradle-to-grave footprint adds the impact from our customer applications and end of life of our products to the cradle-to-gate measure we have used since 2009. Since 2007, we publicly disclose our Policy, Management and Performance on Energy Efficiency and Carbon Footprint by our annual reporting to the Carbon Disclosure Project (CDP).

To support these sustainability efforts, AKZONOBEL set out a biobased strategy that identified opportunities in biobased materials where these might be delivered economically and maximize the environmental impact reduction. This strategy aims to forge supply chain relationships that connect these innovations and opportunities to our markets and application areas.

We have meanwhile struck a number of partnerships as a result of this strategy and are working through our value chains to bring these to market. Developing and implementing this strategy have required considerable thought on selection of the target molecules, engagement with current and emerging suppliers in new ways, and significant attention on how to address sustainable sourcing and integrating these materials into existing value chains.

### 1.2 AKZONOBEL IN THE VALUE CHAIN

AKZONOBEL is a leading global paints and coatings company and a major producer of specialty chemicals that holds leadership positions in many markets. In 2013 the company employed approximately 50,000 people and reported revenue of €14.6B with high-growth markets in Latin America and Asia Pacific representing 44% of this revenue.

The company is divided into three business areas, each of which represents approximately one third of our revenue:

- **Performance coatings.** Performance coatings are used predominantly for protection, mainly to industrial consumers having hundreds of uses across a wide
range of industries and sectors including automotive, consumer electronics, aviation, shipping and leisure craft, sport equipment, construction, furniture, and food and beverage.

• **Decorative paints.** Our decorative paints business is the world’s leading decorative architectural paints company supplying a full range of interior and exterior decoration and protection products for both the professional and the do-it-yourself markets. The product range includes paints, lacquers, and varnishes as well as products for surface preparation (predeco products). We also supply building adhesives and floor leveling compounds for tile, floor, and parquet layers.

• **Specialty chemicals.** AKZONOBEL is a major supplier of specialty chemicals with leading positions in selected market segments. Our products are used in a wide variety of everyday products such as ice cream, soups, disinfectants, plastics, soaps, detergents, cosmetics, paper, and asphalt.

AKZONOBEL by and large is not vertically integrated back to the primary extraction of resources but occupies a position in the value chain as a formulator and converter of chemicals. While AKZONOBEL as the corporation is not widely known, many of our brands are household names, trusted by customers to brighten, protect, and preserve their homes, buildings, offices, and factories. These brands include Sikkens, Dulux, Jozo, International Paints, and Interpon, among others.

1.3 DRIVERS BEHIND DEVELOPMENT OF THE BIOBASED RAW MATERIAL STRATEGY

1.3.1 Background

AKZONOBEL has, for some years, been actively monitoring progress in the field of industrial biotechnology, white biotechnology, and biobased raw materials and recognized the advances being made in both industry and academia. Considerable progress has been made in developing fermentation, catalytic, and thermochemical technologies that could convert biomass from a variety of sources into both energy/fuels and materials useful to the chemical industry. These new developments have opened up new ways to produce drop-in replacements for existing and interesting novel materials from biomass.

Notable examples of progress in existing or drop-in materials we have noted include exploration of several routes to production of acrylic acid (e.g., through thermochemical conversion of glycerol or fermentation of sugars to 3-hydroxypropionic acid and subsequent dehydration) and a number of other routes and n-butanol (revisiting the acetone/butanol/ethanol (ABE) fermentation applied some 50–100 years ago applying new knowledge to improve yield, process, and product mix). Examples in novel materials include such 2,5-furandicarboxylic acid (FDCA) produced
from sugars and proposed as an alternative to terephthalic acid in resins and PET packaging and polylactic acid proposed as an alternative to packaging and wrapping material (e.g., polyethylene/polypropylene).

1.3.2 Existing Use of Biobased Raw Materials

In assessing how to address and respond to these and other developments, our first step was to better understand what use AKZONOBEL already makes of biobased materials. Doing so it was found that biobased materials represented a considerably higher proportion of our raw material base than we expected, wherein 9% by value of spend raw material has a renewable element (Figure 1.1). We believe that this compares favorably against our estimate of a chemical industry average of $\sim$3%, of which most are traditional biobased materials with only 0.3% coming from recent developments.

This use of biobased materials is in part ascribable to the long history in coatings and surfactants, using materials such as tallow, natural oils, rosins, natural waxes, gums, polysaccharides, etc. These still represent the main use within AKZONOBEL of biobased materials. In addition, while looking at our use of biobased materials, we found that we had more knowledge and experience represented inside the company than we expected and through this traditional base and the efforts of our R&D teams we held a significant but dispersed body of knowledge. Bringing these experts and knowledge base together was a significant step in allowing us to recognize and build on the potential.

![Biobased chemicals (%)](image)

**Figure 1.1** Wider chemical industry and AKZONOBEL use of renewable raw materials.
1.3.3 Emerging Products from Biobased Raw Materials

Building on this strong base, AKZONOBEL has also been active in developing and delivering to our markets a number of new biobased products and materials. These include examples such as Dissolvine GL chelating agent and our hybrid polymer technologies for formulation of cleansers and detergents. Dissolvine GL is part of our range of chelating agents wherein the majority of the molecule originates from a natural, renewable source. It is a safe and readily biodegradable alternative for phosphates, NTA, and EDTA and can be used in a number of applications, such as detergents, personal care and cosmetics, hard surface cleaning, automatic and mechanical dishwashing, oilfield chemicals, etc. Hybrid polymer technology is used in cleansers and detergents replacing the typically used synthetic water-soluble polymers. AKZONOBEL has developed a way to modify a natural polysaccharide “backbone” to make hybridized polymers that incorporate over 60% renewable ingredients and are nontoxic and readily biodegradable yet match or surpass the performance of the wholly synthetic alternatives.

1.3.4 Triggers to Developing an AKZONOBEL Biobased Strategy

As we monitored the sector, we noted three significant developments that triggered a more detailed assessment on whether to engage and respond and if so how:

- **Supply.** The supply of biobased materials is growing rapidly and many useful materials are becoming cost competitive.
- **Demand.** There is a growing customer interest and business drive for greener products.
- **Carbon footprint.** There is an increasing focus on reduction of greenhouse gas emissions.

Furthermore, three possible drivers were identified for our company to more actively address this area:

- **Security of supply.** Can renewable raw materials create alternative sources of supply addressing current or future bottlenecks in our value chain?
- **Market position.** Can renewable raw materials strengthen our position as world’s leading coatings and specialty chemicals company?
- **Sustainability.** Can renewable raw materials contribute toward realizing our sustainability targets?

It is worth noting that we did not base our analysis on the assumption of a green premium or niche market segments. It was, and still is, our clear belief that to be meaningful and make a genuine difference in sustainability, biobased materials will have to achieve economics and volume that allow them to compete on level terms with the incumbent petrochemicals and in mainstream markets.

Biobased raw materials do not sit isolated from the wider chemical market. Petrochemicals are primarily utilized for the production of energy and changes in supply
or demand through resource or technology developments in energy will have a significant knock-on effect on the chemical sector including biobased materials. This can already be seen with the emergence of shale gas in the United States both as an energy source and petrochemical feedstock, since this has had the effect of reducing the prices of C1 and C2 molecules, for example, methanol, acetic acid, and ethylene, while reduced use of naphtha as a refinery input has created pressures on propylene and aromatic value chains. This also creates significant intraregion market differences and is reshaping the political discourse. The full impact of disruptive developments of shale gas is still to be seen, but one could imagine that further fossil fuel developments, for example, shale development in other regions, fuel cell, solar, or battery technologies, or even significant shift in regulatory environments, would have considerable impact on the chemical markets. This would, of course, also impact development of the market for biobased materials possibly to the extent of quashing the sector outright.

1.3.5 Developing the Biobased Chemicals Strategy

In developing our white biotechnology strategy, we first looked at our existing value chains, formulations, and ingredients to identify those areas where biobased materials could make most meaningful impact and then address these allowing us to direct our efforts appropriately. Building on the work carried out to examine AKZONOBEL’s carbon footprint, we see that of the 16 million tons per year cradle-to-gate carbon footprint total less than one third of the cradle to gate is determined by our processes and operations, while approximately 11 million tons is upstream from our operations and embedded in the material and chemicals we buy. This emphasizes the importance of working with our value chain if we are to achieve our sustainability ambitions.

We focused on organic raw materials in spend areas that cover ~35% of our purchase volume, excluding materials not amenable to renewable replacement such as pigments, additives, salt, and sulfur. We mapped out these organic raw materials in our value chain and then assessed each material both its direct use and indirect through its derivatives in terms of volume, value, and environmental impact. For example, we looked at n-butanol not just for its use as a solvent but also as butyl acetate solvent, butyl acrylate monomer, and acrylic resins and latexes that contain butyl acrylate. We then worked backward through the chemical value chain step-by-step till we had an overall picture back to the primary fossil and biobased feedstocks. Mapping our value chain and calculating the indirect uses were also valuable in highlighting those materials, value chains, and businesses most exposed to disruptive developments in petrochemical sector (e.g., aromatic and C3/4 naphtha fractions). Having identified the ~50 key building blocks and chemical conversions that make up our value chain, we assessed the possibilities for biobased processes and materials in three streams (Figure 1.2):

- **Drop-in materials.** Wherein a like-for-like replacement is possible (e.g., n-butanol produced in fermentation rather than derived from propylene).
- **Novel formulation materials and products.** Where we find a material that offers similar or better functionality than an existing material (e.g., replacing synthetic adipic acid with a similar bioderived material such as succinic acid).

- **Chemical conversions.** In which we looked at the chemical reactions, conversions, and processes we use and tried to find examples of these conversions being achieved more efficiently or effectively using bioprocesses (e.g., esterification reactions utilizing lipase enzymes).

Looking at this map and with the support of RD&I chemists and chemical engineers in our business units, we were able to identify some 50 materials with potential drop-in opportunities from renewable raw materials, 50 novel renewable materials with potential relevance in our applications and markets, and 20 chemical conversions with some analogue in biochemistry.

Plotting our 50 drop-in, 50 novel, and process opportunities on matrices (Figure 1.3) and giving these a qualitative rating on technical and economic viability and potential impact – economic, volume, and sustainability – allowed us to prioritize and draw up a long list of materials and processes of interest. This rating was based on discussions with prospective suppliers, industry analysis, and patent/academic literature.

Based on this long list, the most viable and impactful of these opportunities were then examined in more detail. Each opportunity was assessed on common criteria basis, asking five questions:

- Could this material be cost competitive within five years (or provide a cost advantage)?
Could the material help address security of supply concerns for fossil material subject to current or anticipated disruption or uncertainty?

Can the material help market AKZONOBEL’s products and brand?

How much could the material help reduce AKZONOBEL’s carbon footprint and support its sustainability goals?

Are there other drivers for adopting this material (e.g., HSE impacts with the fossil material)?

This long list was further refined and detail added working with potential suppliers and academic experts. Information was gathered on price both now and long-term expectation, life cycle analysis compared to the incumbent technology and current and anticipated use of that technology, both direct and through derivatives. This detailing then allowed opportunities to be scored on a standard template against consistent criteria (Figure 1.4).

- **Potential for CO₂ savings.** Potential annual CO₂ savings obtainable by replacing total volume (direct and indirect spend) of fossil-based material with biobased product.
- **Strategic supply issues.** Will biotech material help alleviate a strategic supply issue associated with the fossil material?
- **Marketing potential.** Is there any evidence that customers will value the use of this material from a renewable source?
- **Other.** Does the biotech material have any other drivers for action?
In parallel with these assessments of materials, the social, moral, and economic considerations around biobased materials were debated and their impact on any actions in this area was weighed.

1.4 CONCLUSIONS OF THE BIOBASED CHEMICALS STRATEGY

After consideration a strategy was approved that AKZONOBEL would make “A proactive effort to lead the deployment of selected, relevant biobased chemicals in our core markets and applications”; that is, AKZONOBEL will connect and work with innovators in the value chain rather than try to compete and would use its size, experience, and expertise in formulations to help provide a route to market for biobased chemicals.

Supporting this conclusion four guiding principles were defined:

1. Leverage market innovation and focus on development of applications for renewables. Rather than attempting in-house development of biotech processes and products ourselves, we will work with innovative suppliers (both new and established) and work with them bringing our expertise and insight in conversion, formulation, and application.

2. Focus on cost competitive, high impact. We believe that the greatest chance of success and opportunity to maximize our impact is to direct our efforts to a relatively few areas guided by supply issues, sustainability, and customer...
insight. Where correctly chosen these will have more effect than many piecemal efforts and make a meaningful contribution toward our sustainability goals.

3. *Work across the supply chain.* We will work together with multiple value chain partners to remove barriers and integrate renewable raw materials not just to utilize renewable raw materials as simple drop-ins but to look more broadly at possible derivatives and polymers wherein we can find larger volumes and markets, thereby maximizing impact and quickly building toward efficiencies of scale.

4. AKZONOBEL will utilize biobased materials utilizing first-generation feedstocks as a stepping stone but insist suppliers work toward second generation. We acknowledge the issues and concerns around first-generation renewable raw materials that could adversely impact food availability and prices and have recognize that there are significant environmental impacts associated with agriculture through land, irrigation water, and fertilizer use. We believe that for renewable raw materials to be accepted by the public without accusations of greenwashing, we will need to work toward the use of second-generation cellulosic feedstocks derived from municipal wastes, agricultural by-products, and other underutilized resources. We, however, also believe that to build capacity and develop the industry a direct leap to second-generation feedstocks might prove a significant technical or economic barrier.

Scoring against our five criteria, we prioritized materials and assigned actions for each. These actions covered a range of options ranging from more proactive efforts to a watch-list monitoring future technical or economic developments.

Those drop-in materials we prioritized included (in alphabetical order) and a nonexhaustive selection of the biobased routes we considered:

- **Acetic acid.** This is used by AKZONOBEL both for use in production of monochloroacetic acid and through acetate solvents, vinyl acetate monomer, and latexes. Acetic acid could be produced from biomass by feeding anaerobic digestion or syngas-derived methanol into an existing carbonylation process or by fermentation of sugars with an aceticogenic organism.
- **Acetone.** We use this as a solvent but also see it in our value chain as a precursor to methyl methacrylate, bisphenol A, and a number of other chemicals. This is expected to be a by-product of ABE fermentation.
- **Adipic acid.** While not a high-volume constituent of our coating polyester resins we understand it has a relatively high carbon footprint per kg. Some routes by fermentation or production by catalytic conversion of natural fatty acids have been proposed.
- **Acrylic acid.** This is used to some extent in surface chemistry products and also a key precursor to acrylate monomers and acrylic resins and latexes. A number of potential routes from biomass have been proposed including catalytic conversion of glycerol and routes fermenting sugars to either 3- or 2-hydroxypropionic acid and then dehydrating.
• **Ammonia.** Our use of ammonia is mainly through the production of ethylene amines and fatty amines. Although not a carbon-containing molecule (and therefore not meeting any current or proposed standard for biobased certification), it has been proposed that ammonia might be produced from biobased syngas.

• **n-Butanol.** AKZONOBEL uses this as a solvent both directly and through butyl acetate. Indirect volumes also include substantial quantities through butyl acrylate monomer and containing resins. The principal biobased route is through the fermentation of sugars in ABE fermentation, but other routes have also been proposed.

• **Ethylene.** This is used by AKZONOBEL directly for ethylene oxide and ethylene amines but is also a precursor to many chemicals including vinyl acetate monomer and latexes. Biobased routes include dehydration of fermentation-derived bioethanol.

• **Epichlorohydrin.** AKZONOBEL used this material directly in some pulp and performance chemicals applications, but by far our largest use is as a precursor to epoxy resins. Production based on glycerol rather than propylene is now commercial and cost competitive.

• **Methyl methacrylate.** MMA is an important monomer and constituent of acrylic resins and latexes. While we believe that this is probably difficult to produce by a biobased route, some initial work has been reported both in incorporating renewable precursors into existing processes and in novel routes.

• **Terephthalic acid (and other aromatic diacids).** These diacids are key monomers in coating polyester resins. Driven primarily by actors in PET packaging, some routes have been developed including hydrothermal reforming of sugars or conversion of fermentation-derived isobutanol.

• **Xylenes.** These aromatic molecules are both important as solvents but are also a potential precursor to the aromatic acids described above. Main routes from biomass suggested have been the hydrothermal reforming of sugars or catalytic conversion of syngas.

In these areas we had seen some external research and activity which we judged as having some potential to change the palette of chemical building blocks. Of this list for action acetone, *n*-butanol and epichlorohydrin were expected to be well developed, close to commercialization and cost competitive (or close to). On these materials we are working toward supply agreements and integration into our supply chain. Ethylene, ammonia, and acetic acid as high-volume commodities available at relatively low-cost form natural gas were expected to be technically possible but facing considerable economic hurdles. We would explore these materials with suppliers and look closely at economic viability and if feasible work toward supply agreements and integration into our supply chain over the longer term. Adipic acid, acrylic acid, methyl methacrylate, aromatic diacids, and xylenes were all expected to be in development but to still be some time away from reaching market. In these we would have open discussions with potential suppliers and explore the options on an ongoing basis.
Excluded were materials that were too fragmented or low volume for substitution to make a real impact or those where the petrochemical material is so cheap as to make the biobased route uncompetitive regardless of potential impact.

Moreover, we also identified some areas for potential substitution by novel monomers or resins:

- Novel monomers for polyester resins
- Alternatives to epoxy resins
- Monomers for acrylic resins and latexes

Finally, some areas for further RD&I attention were defined. One area identified of particular potential interest is around the concept of the integrated biorefinery. There are a number of competing and complementary definitions of biorefinery, but by this we mean a facility designed and integrated for maximum valorization and utilization of biomass perhaps in combination or tandem with food, forestry, or waste processing. We believe that a biorefinery might offer both new raw material sources where integration offers the most competitive economics for all products but also find new applications for our BU knowledge in pulping chemistry, chlorine products, peroxides, process engineering, and optimization. Both thermochemical and fermentation-based process infrastructure might also find benefit from our knowledge in protecting chemical, oil, and gas installations through our coating products.

1.5 IMPLEMENTING THE STRATEGY: STRIKING PARTNERSHIPS

To implement the strategy we are bringing together cross-functional expertise in RD&I, sourcing, sustainability, and our value chain partners in derivatives to assemble the necessary technoeconomic assessment, validation, and life cycle analysis for biobased materials and to connect new companies into our supply chain. To this end we assembled a small team with responsibility for implementing the strategy reporting into our corporate directors of future proof supply chains and open innovation. This team is charged with connecting the right business units and responsible persons within AKZONOBEL with the selected opportunities in biobased materials either with new companies or established suppliers. These opportunities are then assessed (as far as is possible) for technical and economic feasibility and working with business and spend area managers we work on such sampling and testing as is necessary to validate the materials and work toward a definitive commercial agreement.

This process is generally supported by a nondisclosure agreement (NDA) and project memorandum of understanding (PMU), which sets out a project structure and timetable to allow both parties to be clear on steps necessary to achieve a commercial supply relationship. While nonbinding in nature this structure allows both parties clarity and mechanisms for building confidence. This process, while supported from a central team, is not a discrete activity and has to work in concert with the business units and spend area managers who drive the sourcing decisions of the company.
Spend areas coordinate across AKZONOBEL on material categories such as solvents, solid resins, colored pigments, etc.

Since establishing the strategy we have been able to announce several partnerships in succession:

- **Biobased solvents in Latin America.** This is a partnership with Solvay–Rhodia, which will target volumes of up to 10 ktpa of biobased solvents by 2017, through:
  - Joint reformulation of coatings to incorporate a novel glycerol-derived solvent into our coatings matching existing formulations both in performance and economically
  - Incorporation of drop-in n-biobutanol and acetone
- **Algae-derived fatty acids.** We have signed a joint development agreement with Solazyme to develop novel algae-derived fatty acids, which offer novel tailored compositions.
- **Biobased epichlorohydrin.** We are working in partnership with Solvay to develop a “chain of custody” methodology to integrate biobased epichlorohydrin used in AKZONOBEL’s epoxies working through supply chain epoxy producers with Ernst & Young (EY) acting as an independent party for data handling, addressing the validation of evolving volumes. This effort has the target to increase the proportion of biobased ECH in AKZONOBEL’s indirect use through epoxy resins to 20% by 2016.
- **Cellulose-derived acetic acid.** We are working with ZeaChem to explore the potential for acetogenic organisms to ferment cellulosic sugars to acetic acid and connect with other complementary users to growth volume and possibly obtain derivatives.

In theory all current petrochemicals could be derived from biomass, but in practice this would be inefficient and uneconomic. In practice a few drop-ins are being studied or applied where these are competitive. In fact with our activities and partnerships, we can start to see a path over time to significantly improve the sustainability of our supply chain (Figure 1.5).

In addition, we expect shortly to be able to announce several further partnerships addressing more of our target materials. This has not, however, been a straightforward process.

### 1.6 EXPERIENCE TO DATE

Particular experiences that we have identified over the 18 months since we launched this strategy include:

- **This incorporation of biobased materials needs considerable commitment to be seen through.** This is a long-term effort. Many technologies are only at demonstration scale. While first facilities are being planned, it may take years before
Figure 1.5 Potential green supply chain.
more than test samples will be available. Patience and long-term planning from both supplier and user need to come together.

- **A clear internal strategy is vital to move from analysis to action.** With all of the hype and rapid advances in the field, it would be easy but ineffectual to fall into the trap of trying to cover everything and be involved somehow in every consortium. Identifying a few addressable but impactful actions and seeing these through are critical.

- **Even with the best efforts of all parties surprises can come up,** which cause issues both technical and operational, and these need to be addressed by both parties in an open and honest fashion. Internally these also need to be communicated in such a fashion that these are put in context and build trust in a robust and responsive process rather than tarnishing all efforts.

- **We do not see a willingness from the broad market end users to pay a “green premium,”** but partners can frequently be found who can compete. A small segment of the market especially in brands or consumer products/marketing may find a willingness to pay a premium for a “green” image, but this is a limited segment of the market and likely temporary. For biobased materials development/producers, it is vital to be cost competitive at a mature stage. Although definitely not all will be competitive, numerous can or could be.

- **Feedstock availability, pricing, government support with investments, and integration will be critical.** Paramount aspects to success are to decide where these technologies are applied. There is little point in public investments and drive toward biotech and biobased materials if regional economics (either scarcity of raw materials or very low-cost petrochemical feedstock) prevent this from becoming feasible.

- **Attention needs to be paid to the logistical and business models,** which will eventually bring these materials and technologies to market. While petrochemicals are well defined, are energy dense, and have an established infrastructure, biomass is locally and seasonally variable, is geographically dispersed, and contains a lot of water, so aggregation, drying, and transport will play a large part in determining economic success.

- **Participants need to be clear about what they bring to a partnership.** AKZONOBEL can be a channel to market, guarantee of offtake, and bring considerable strength in downstream and formulation chemistry but is generally not aiming to make equity investments or to license technology to integrate upstream into biobased materials. Many small firms develop technology and are looking for either investors or eventual licensors—if there is not a clear understanding of what each party wants from a discussion and the eventual path to commercialization, then frustrations are inevitable.

- **Win-win opportunities do exist.** Increasingly these biobased materials are becoming economic alternatives to petrochemicals. Improved fermentation yields, separation processes, and integration are making these real. There is still no evidence for a broad market green premium, but partners can be found where this is not needed.
- **Genuine interest to make it work for both parties.** There is no one-size-fits-all model—every opportunity and partner requires a different approach. As in real life, partner choice is a high-stakes matter. It is not always easy—no partner is perfect right away—the strategy sees you through. Each situation and partnership is unique—this can be due to the challenges of working with new processes and materials but also the complexities of a value chain. Indirect use might be a bigger absolute volume but extremely challenging to achieve substitution. For both participants in a partnership, making the right choice is an important decision. You need a robust process to see the work through to conclusion.

### 1.7 MEASURING, REPORTING, AND ENSURING SUSTAINABLE SOURCING OF BIOMASS

In developing a strategy we also had to consider how best to measure, report, and communicate this effort. Setting a strategy is one thing, and quantitatively monitoring progress another one. We had to define internally the language and terminology, that is, what we mean by biobased, renewable, etc., as these might be interpreted differently as questions arise over materials such as water, inorganic materials that might contain carbon (e.g., carbonate minerals), and materials that are derived from fossil resources but do not contain carbon (e.g., ammonia or hydrogen). The terms green and sustainable were also examined and discarded for internal reference to biobased or renewable raw materials. With agricultural land, materials, and energy use, it was recognized that it was possible for material to be biobased but to have a higher environmental impact than the fossil alternative.

For clarity and reporting we have defined biobased materials as raw materials that are wholly or partly derived from a biomass source that is continually replenished (typically well within 100 years). The biomass can have undergone physical, chemical, or biological treatment(s). Peat and natural forest are not defined as renewable raw materials due to the fact that these materials cannot be continually replenished well within 100 years. Definition includes materials derived from trees, crops, fats, etc. and excludes peat and natural forest.

Having measured our baseline use of biobased raw materials, we then considered how we should measure this for the future. A line-by-line interrogation of sourcing volumes is not an efficient approach. AKZONOBEL has implemented the following working procedure to ensure that the reporting is more easily and reproducibly done in the future. A report of spend by weight and value is generated from our purchasing database—this is then matched with material listings of biobased and organic raw materials. The spend report can be generated on several levels: AKZONOBEL, business unit, and region. The business units receive their report with the draft biobased volumes for review and sign-off. This setup ensures that each business unit owns and is responsible for this measure with support from the sourcing community. In a nutshell, business units are data owners and accountable for the material listings and sign of procedure in place with checks and balances. Central support is given in setting up and identifying renewable and organic materials and in regularly
providing the results. This procedure should ensure cross-AKZONOBEL consistency as well as accuracy.

A number of ways to measure biobased materials were reviewed each approach with its pros and cons:

- **Biobased materials reported as a fraction of organics.** This is used by some peers, provides a bigger number, gives the opportunity for 100% biobased to be theoretically possible, and is not impacted by variation in inorganics. It does however raise some concerns over potential to be accused of “greenwashing” and could be cumbersome to determine/maintain.

- **Biobased materials as a proportion of all raw materials.** This is used by most other organizations and easiest to determine and maintain. This is absolutely the easiest to communicate externally requiring no caveats or explanation. On the downside it is impossible to reach 100% substitution and will be impacted by changes in inorganic product value chains, which are not affected by biobased programs (e.g., salt chain, clays).

- **Biobased plus abundant materials as a proportion of all raw materials.** This provides a bigger number and stimulates the use of abundant materials. On the downside it is cumbersome to determine and explain the definition of abundant materials (e.g., salt, calcium carbonate, etc). It also loses the focus on biobased materials.

- **Spend fluctuation in raw material pricing.** Advantages more expensive materials.

While a case can be made for excluding all inorganic materials and reporting biobased as a fraction of carbon-containing (organic) materials, we decided that it was more transparent and easily communicated externally to report as a fraction of all of our raw materials:

- **External reporting.** Report renewable raw materials as % total purchased materials alongside the AKZONOBEL KPI for comparability in the industry:
  \[
  \frac{\text{mass (renewable RMs)}}{\text{mass (total RMs)}} = \% \text{ Renewables of total}
  \]

- **AKZONOBEL KPI.** Renewable raw materials as % organic materials is the internal measure to drive improvement:
  \[
  \frac{\text{mass (renewable RMs)}}{\text{mass (organic RMs)}} = \% \text{ Renewables of organics}
  \]

### 1.8 BOOK AND CLAIM

While it would be desirable for transparency biobased materials to be separated and incorporated into products as wholly biobased, this is in many cases unrealistic.
A fatty acid or carbohydrate will be 100% biobased from the start of the value chain to final formulated product and be traceable by carbon isotope measurement in keeping with standards such as the US BioPreferred program, but dogmatic adherence to this approach will present a significant barrier for future growth of the sector.

Dedicated supply chains would be very inefficient. If a supplier needs to specially segregate batches or set up separate storage and production lines, for example, keeping biobased n-butanol from petrochemical in the production of butyl acrylate or derived resins, then we believe that this will create an impassable hurdle for acceptance.

In order to see this sector grow, we should take some cue from the energy sector wherein renewable electricity or gas is fed into the general grid system and the customer can choose supplier but not require separate supply (e.g., book and claim). A comparable book and claim approach would be desirable and we are in the process of discussing mechanisms with value chain partners and an independent auditor who could verify volume and ensure that competitive information is not shared inappropriately.

1.9 SUSTAINABILITY IN THE VALUE CHAIN: LCA

AKZONOBEL ensures that suppliers endorse our environmental and social standards as formulated in our code of conduct by asking suppliers to sign a vendor policy declaration. This procedure applies also to suppliers of biobased RMs. Biobased RMs often have a lower carbon footprint than the fossil alternative but that is not always the case. Renewable raw materials are often connected to use of fossil fuels due to harvesting, handling, transport, processing, etc., which also need to be included when compared to the fossil alternative.

There are also a number of potential concerns that should be addressed in assessing whether renewable RMs offer a genuine sustainability advantage:

- **Land transformation and biodiversity.** Cultivation replaces natural forests (land transformation, biodiversity, ecosystem values).
- **Food competition and indirect land use change (ILUC).** Competitive uses of the land (food security in region, rights of indigenous peoples) and the environmental impact connected to that other land use interest are moved to other regions (ILUC).
- **Poor land management practices.** Cultivation without good land management practices (pesticide use, soil degradation, direct land use change leading to emission of greenhouse gases, conservation of rare, threatened, or endangered species, and other high conservation value habitats, etc.).
- **Water stress.** Cultivation takes place in area with serious water issues.
- **Social issues.** For example, not allowing unions, child labor, etc.

These concerns have already been raised due to the growth in biofuels using first-generation technologies like corn ethanol and palm oil biodiesel, which have
both seen significant negative attention. It is, however, important to note that still by far the biggest demand for materials of concern such as palm oil comes from consumer use as cheap oils and fats for soaps and foodstuffs. This is a nuanced area and in some cases the answer will not be clear – it might seem unsustainable to grow more sugarcane land in Brazil to expand in biobased materials, but if the main sugarcane-growing areas are a long way from rainforest and can make fresh use of land, which was degraded by pasture and abandoned, this can provide new income and fresh opportunities for local farmers. Consequently in addition to our existing sourcing standards, we are reviewing what additional standards/assessments will be appropriate for the future.