Lectio Magistralis by Catia Bastioli

Renewable raw materials and the transition from a product-based economy to a system-based economy

on the occasion of conferral
of her Honorary Degree
in Industrial Chemistry by
the University of Genoa,
Faculty of Mathematics,
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"I am personally highly honoured to receive this precious, most unexpected award from Genoa University and I would like to extend my sincere thanks to the rector, the chairman of the Mathematics, Physics and Natural Sciences Faculty, Maurizio Martelli, Professor Saverio Russo, Chairman of the Industrial Chemistry Course Board as well as the entire academic Senate. Heartfelt thanks also go to all my colleagues to whom I owe so much and who proudly share this award with me. Our Novamont adventure would not have been possible without the contribution of our group of researchers; men and women who have made great personal sacrifices and who are blessed with exceptional technical and human skills; they are freethinkers who not only chose to support me during the most difficult stages of this adventure, but who also had the skills to do so. I would also like to thank all the people who represent Novamont today because I truly believe that they are the greatest asset which we have built up over these years. My dissertation will focus on areas which are particularly significant for me, and which I have reflected on and analysed over the last few years. These areas are the bedrock on which Novamont is built. I have endeavoured to focus on renewable raw materials, considering the risks and the opportunities afforded by this sector, a sector which is crucial to the future of our planet, in light of the ever-changing relations between science and society and the role played by the chemical industry in Italy. Through my description of Novamont's development, as a case study in the renewable raw materials sector, I have endeavoured to present my vision as to how academia and local businesses can tackle wide-ranging, ambitious projects, projects capable of moulding the local region, rendering it once more competitive, stimulating trust and raising the cultural level."

Products and systems

The scarcity of energy resources, climate change and agricultural problems, are all phenomena which in large part can be attributed to the consequences of a way of life distinguished by wastefulness; one which encourages all of us to squander the planet's resources over a shorter and shorter timeframe and in increasing quantities, interested only in short-term profits, and caring nothing for the catastrophic effects of our actions on a global level. The risks we run with this type of model are enormous and the alarm which has been raised as to the conflict between bio-fuels and agricultural food resources is just one example.

Therefore there can be no doubt that the main challenge facing the new millennium is to find innovative development models which are capable of preserving the planet's resources, whilst maintaining and improving the quality of the lives of its inhabitants.

We need to encourage the transition from a product-based economy to a system-based economy, making a cultural leap in the direction of economic and environmental sustainability which must involve the whole of society. We must start by enhancing the value of our local areas and co-operating with all the players involved.

Only by counting on greater cultural awareness and critical capacity can we hope to obtain a more mature society, one which is capable of finding the right balance between change and tradition in the local area, fostering economic competition and environmental quality together with tolerance and democracy.

The increasingly wasteful development model which we have adopted obviously traces its roots back to the changes that took place in the relationship between science and society with the Second World War, when the dangers endured by the planet encouraged governments to fund important military projects, dedicating enormous economic resources to applied research.

Forty years of Cold War continued to have a profound effect on research, rendering it increasingly dependent on governments and increasingly tied to defence requirements and the associated industrial system.

In this way the concept of competition based on innovation came into being. Priority was given to the industrial research management model with its objective of short-term profitability at the expense of academic research. From that time on, the relationship between science and society has continued to change with four key factors having a great impact:

- following a reduction in public funding available for fundamental research, the concentration of research and innovation in the world of industry;
- the scientific and technological revolution, which is still under way, is closely related to computer and communications technologies, to technologies and to new materials which have led to intellectual, economic and social changes;
- economic globalisation with the multinationals playing an increasingly important role, together with a reduction in functions performed by government bodies in regulating economic activities and the related social repercussions and;
- the multiplication of environmental problems impacting the planet's future as a consequence of the type and level of industrial and economic activities leading to changes in biological, chemical and geological cycles which eventually alter the natural systems.

In this way we are increasingly running the risk of an economic system which obeys only the rules of the market with competition to increase productivity and short-term requirements and speculation. With no social globalisation, economic globalisation is transforming the initial promise of the global village with the threat of faceless market tyranny, entailing growing interdependence between societies, economies, cultures and increasingly harder to tolerate inequality at the heart of societies, with the overall risk that economic war becomes direct conflict between cultures and religions.

Since the origins of humanity, the reproductive yet destructive capability of science and technology has never been greater and it has never given rise to such uncertainty.

Today, more than ever before, we can say that people's concern about the risk of science being abused is well founded. Private and public investors, who are now capable of conditioning us, raise certain issues in the extremely delicate area of bioethics and the danger of projects which are closely connected to military technologies and terrorism. These risks are typical of mankind's weakness and are not inherently attributable to science.

In this scenario, due to the fact that they are acutely aware of the actual risks run and the opportunities afforded by science and technology, scientists and chemists bear fundamental social responsibility. This sense of responsibility is admirably invoked by Brecht's Galileans with their warning: "If men of science fail to react to intimidation exercised by powerful egoists and merely accumulate layers of knowledge, science will forever be weak, and every new machine shall be nothing other than a source of suffering for mankind. And when, with time, you have discovered everything there is to discover, your progress shall be nothing but a constant flight from humanity".

Convinced of the need to render Europe more competitive by leveraging issues such as environmental sustainability and innovation, the European Union has selected six thematic areas which it considers strategic and in which the lawmaker, together with a number of institutional and industrial players, has to produce a harmonic set of rules and standards capable of encouraging the market - the "Lead market initiatives".

Renewable products and bio-fuels both fall within the scope of these six strategic initiatives. These are extremely delicate sectors where, in light of what has been said so far and in light of what we shall soon see, the application of a product-based economy rather than a system-based economy could be extremely dangerous.

The exemple of the chemical industry in Italy

Looking at the future of renewable raw materials, I believe that it would be useful to take as an example developments in the industrial chemical sector in our country.

As I have already stressed, chemistry, an essential branch of science, is not, per se, good or bad. In his book "The same and not the same" the Nobel prize-winner Hoffman states "..... the fact that a creature which is capable of reason can have an ambivalent attitude towards chemicals, seeing both possible harm and potential benefits, is not a sign of irrationality but of humanity. Utility and danger are two opposing factors .... only people whose minds are totally closed to any experience fail to wonder: "Can it be useful? Can it harm me?". This type of question invests the object with a sort of life, linking it in some way to us".

The chemical industry has given Italy great scientists and technologists. Three people to whom Novamont owes its very existence and whose names are inextricably linked to the story of the most important Italian chemical multinational: Montecatini (later Montedison) are Giacomo Fauser, Giulio Natta and Umberto Colombo.

Fauser can claim credit for a process for the production of ammoniac which was more competitive than the German Haber-Bosch process and which, in the space of just five years, led to the creation from scratch of an important new company, Montecatini, with exports all over the world in the following years. This was made possible by combining the skills of a great entrepreneur: Guido Donegani, who was always alive to the importance of innovation, and Fauser's technical skills.

I have read an excerpt from a speech made by Giacomo Fauser at a conference in Novara in which the researcher's enthusiasm and optimism for all the benefits for mankind that could be obtained from synthetic chemicals shone through. In the reasons given for the honorary degree granted to Fauser in 1957 by Milan University it was stated that "Italy owes not only its basic industries to this man, but also a veritable school of chemists, engineers and technicians whom he educated and moulded, before sending them out into the world".

Mr Giustiniani, who was educated at Fauser's School, becoming managing director of Montecatini, had "sufficient forward vision and courage to support Giulio Natta's enterprise and to launch Montecatini into the petrochemical and derivatives business".

From what I have read about Giacomo Fauser and the men who attended his school, I have realised to what extent a dynamic, innovative environment can educate. In an environment in which little importance was given to conventional thought, traditions and established rules and where through tackling and overcoming problems practical knowledge was acquired day after day, giving rise to a competitive gap which formed the basis of intellectual property value.

Giacomo Fauser's and Guido Philadelphia's Montecatini was a company which steadily expanded. A company marked by innovation in terms of the creation of a culture where important industrial companies down the supply chain had close contact with the national and international academic world. The example of Montecatini clearly shows how in those days the success of a company, a research group or a State lay with men and their education.

The fact that in the 1960s Italy was a key player in the polymer sector is down to the technical skills of a great researcher, namely the Nobel Prize winner Giulio Natta as well as a group of entrepreneurs who gained experience in an environment marked by constant innovation; unfortunately this leadership position was lost when the Montedison group was broken up at the end of the 1990s. It is thanks to men such as Natta that the 20th-century is remembered as the century of polymers, in which large synthetic molecules replaced one natural material after another, making a significant contribution to improving our quality of life (the mind goes to improvements in hygienic conditions, the lightness and thus transportability of containers, the preservation of food, etc).

At a certain point however relations between society and institutions broke down. Hoffman contends that "there are no bad molecules, just negligent or criminal human beings". Every synthesised molecule can be harmful or useful according to the context in which it is used. It is chemist's task and mission to investigate old and new substances and to transform them, exploring everything that surrounds us. It is up to institutions to regulate the use of molecules and it is up to the industrial world to guarantee compliance with these regulations. Unlike in other countries such as Germany, in Italy this occurred only partially. The consequence is that there is no longer any large-scale Italian chemical industry, whilst the German chemical industry is a world leader. This is a tangible demonstration of the fact that high standards and compliance with such standards has not penalised industry but strengthened it and rendered it more innovative and competitive.

In Italy, although chemicals have been turned to financial advantage, the approach has not hitherto been a sensible one and consequently has not led to the adoption of appropriate quality standards; one only has to think of Priolo and Porto Marghera: it can realistically be stated that the rift between society and the chemical industry stems from this shortcoming.

Renewable raw materials

The experience of the chemical industry also constitutes a good lesson for the renewable energy and raw materials sector. Taking into account the increased speed of development over the last few years, globalisation and the fact that instead of mineral oil-based substances food crops are now involved, foolish use of these resources could cause greater harm than that done by improper use of chemicals.

This is why today, even more so than in the past, we need a systematic view and a strategy which places mankind and his environment at the centre rather than profit via the adoption of exceedingly high quality standards and a system-based rather than a product-based rationale. The new approach must be informed by local circumstances and must involve all players. Intelligent researchers and entrepreneurs are also essential in the renewable raw materials sector, but without the active involvement of the entire local region and without rigorous system standards which are actively complied with, we run a very real risk of the sector being abused.

As with mineral oil, nature provides us with an enormous range of raw materials from which it is possible to synthesise various chemical intermediates which are similar to those obtained from fossil raw materials as well as a wide variety of molecules and processes for synthesising which are extremely interesting yet hitherto unexplored.

As a consequence of energy-related and environmental problems, renewable raw materials such as vegetable oils, starch from corn and potatoes, cellulose from straw and wood, lignin and amino acids are becoming increasingly important as industrial feedstocks. By resorting to physical, chemical and biological processes these materials can be converted into fuel, chemical intermediates, polymers and specialities in general for which mineral oil has to date been used.

The development of products from renewable raw materials may represent a significant contribution to sustainable development in light of the potential for using less energy to produce them and in light of the wider range of waste disposal options with low environmental impact. It also represents a golden opportunity for developing vertically integrated systems, hopefully involving both farmers and industrial businesses in a joint development effort. For example, I could mention the Novamont concept of local bio-refineries as being emblematic.

However, the future of the sector will be determined by strategies implemented both locally and internationally. There are basically two alternatives. We must decide whether we wish to focus on just a few industrial crops and a few chemical substances, possibly replicating the petrochemical industry. In such a case the space for new small and medium scale companies to be created and grow through research would be highly unlikely and the multinationals would play an increasingly important role. Alternatively, we can focus on local biodiversity, multiplying opportunities provided to us through investigating a range of vegetable materials and local waste products and by products, with an integrated supply chain rationale, reducing the need for transport as far as possible and maximising the creation of knowledge circuits and integrated products with the various local players (universities, research institutes, high schools, voluntary associations, the agricultural sector, institutions and small and medium scale companies). The second possibility does not exclude the first, but concentrates resources and strategic policies on developing virtuous systems in which saving resources becomes the focal point of developing the local area.

Renewable raw materials, by reason of the fact that they are products, are not, as the media would have us believe, a panacea for all the world's problems, from pollution to falling supplies of mineral oil. We have to see beyond the product and understand the limits of the system in which the material is produced, used and finally disposed of. Crops are not all the same and even the same crops may have completely different impacts depending on the geographical area in which they are grown.

In 2006, we witnessed a shift in public opinion from great enthusiasm for energy generated from renewable sources to one of fear and refusal. This was a result of the increase in the prices of food raw materials which was not only attributable to the fact that there has been an increase in the consumption of corn by producers of bio-ethanol, but also to problems related to crop yields stemming from climate problems and the increasing role played by speculators. We can thus appreciate that imprudent management of renewable resources can give rise to fear, which may or may not be justified, but which leads to social instability and the possibility of manipulation by all those who see renewable resources as a threat to their current business, as well as by a media system which, failing in its mission, circulates news stories designed not to inform but to increase the readership or audience.

We need renewable materials in the same way as we need all the other available raw materials, in a system-based economy geared to reducing as far as possible the use of resources with as little environmental impact as possible.

With this system-based rationale it becomes essential to discuss our approach to standards. Renewability and, hence, the carbon content in terms of plant origin of the substance, must not be considered synonymous with low environmental impact. Indeed, there are a great many renewable substances whose cultivation and transformation processes can be completely different from the point of view of their environmental impact.

In order to correctly assess the environmental impact we must eschew generalisations and we must understand the various applications by identifying the most significant impact parameters: a sort of category rule, considering the system in which the product is applied, as well as the production of raw materials, the different ways in which waste and by-products can be disposed of in the system and the desirable outcome.

For example the accidental dispersion of bio-lubricants in the environment is a frequent occurrence. For this reason whether or not the lubricant is biodegradable becomes an absolutely essential feature compared to the reduction in emissions due to its renewable nature. If, as often happens, the bio-lubricant has better lubricating properties than the traditional products, in this case the saving in terms of fuel and emissions as a secondary effect during use, will make a fundamental contribution to the overall reduction in the environmental impact of the specific application.

Biodegradability is a property which is just as important and desirable for bio-plastics when they are used in applications where it is difficult and uneconomical to recycle, where the risks of dispersion and accumulation in the environment are in any case real and where the quantity of residual food is significant. More specifically, it has been estimated by the German Ministry of the Environment that removing organic waste from landfill sites is equivalent to lowering carbon dioxide emissions from 74 to 94 MI tonnes, 11% of the 2020 Kyoto objective for Europe.

There are bio-plastics, for example starch nano-particles, which are capable of strengthening tyre treads giving them low rolling resistance properties. In this application the tyre's lifespan is not improved by the use of the nano-particle, rather the most important aspect is the saving in terms of fuel and carbon dioxide emissions. This is the main effect whilst other positive effects, such as substituting high impact products such as carbon black or high energy consuming products such as silica, make a useful, although much more limited contribution.

Proper assessment of the contribution to the impact on the environment must therefore be capable of clearly identifying the specific important factors in the different systems.

This approach also applies for bio-fuels and bio-energy, but there are aspects which are even more important to assess. It must be considered that the annual worldwide demand for fuel required is around 1.5 billion tonnes and is rapidly increasing. In no way could this need be covered by food crops because the entire planet cultivated for human and animal foods would not be sufficient. We can therefore only envisage covering limited portions of this demand according to the different geographical areas.

Looking at the figures, total corn production, one of the crops which is most widely used in industry, is 700 million tonnes. Italy produces around 10 million tonnes and cannot even meet the requirements of the human food and animal feed sectors, being forced to import much of its needs. It is obvious that in our country corn-based bio-ethanol would not be reasonable, irrespective of the environmental impact factor, whilst it would become sustainable if produced from corn by-products. This will become possible with development of the bio-technological process for enzymatic hydrolysis of cellulose. Energy from by-products and non-plant renewable sources, as well as plant origin bio-based products would therefore seem to be the most promising sectors for Italy.

The situation relating to chemical product supply chains which compared to energy are of a much greater value is totally compatible and there may be synergies with crops.

It should also be stated that it is certainly possible to envisage bio-refineries which use non-food crops grown on marginal land or by means of crop rotation, with crops which can be grown in winter, which do not need water, which are particularly resistant, little affected by problems of bio-remediation. Furthermore, all the various parts can be used. This type of crop is in synergy with food crops and can be specialised with regard to the various technologies with important opportunities for innovation.

To ensure that the problems of credibility so often encountered in the past by the chemicals sector do not reoccur for bio-based products, there has to be deep trust between citizens and sector operators. For this reason if the world of industry adopts a position which is particularly virtuous, imposing stringent standards, avoiding vacuous slogans and providing information with the right level of complexity, the consequence will be to aid development of this market, isolating predators, speculators and quacks, allowing leading figures in academia and in the industry to contribute decisively to developing their local region.

Whilst it is true that there are simple methods such as the ASTM 6866 method based on analysing C14 to determine the proportion of renewable carbon in a product, promoting logos to publicise the mere content of renewable carbon seems to be a dangerous approach in terms of building trust with the various parties. The risk represented by this approach lies in the fact that the term "renewable" can easily be confused with the concept of low environmental impact. In essence, somebody could easily imagine that a product with a higher renewable carbon content is automatically more sustainable than one containing less. As this is not an unambiguous equation it is probable that any experimental verification of the invalidity of the equation could lead to distrust of the entire sector, from which it would be difficult to recover. Then there is also the problem of nullifying or otherwise spoiling the work of years which in much of Europe has made it possible to put in place an effective system of separate collection and organic waste disposal: indeed it has been noted that products classified as renewable, irrespective of their biodegradability, are perceived as such and therefore could easily finish in the organic waste chain. Finally, if there is no clearly stated disposal option, the product could end up in waste disposal processes which are not appropriate. This shows that it is clear that for products which reach the end consumer it would be desirable, maybe through self-regulation on the part of companies, to present renewable products with a sort of ecological footprint, a type of multi-label highlighting the critical impact parameters for specific application during the manufacturing, use and disposal stages of the product.

Renewable resources would therefore provide a real and unique opportunity to rethink the entire process.

Generally speaking, until now in the renewable raw materials sector, it cannot be said that the various industrial and institutional players are acting more wisely than in the past. What happened in 2007 demonstrates that the factors underlying instability of the traditional economy have also had an adverse affect on the nascent renewable sources sector.

What happened is extremely risky and unfortunately the only possible antidote against misuse and misinformation is knowledge and partnership between credible players who have the same level of awareness and who are mindful of the risks and opportunities of the various options as well as being capable of informing others without distorting the message, possibly through documents which commit them to complying with particular behavioural rules.

Within this framework biodegradable bio-plastics may be able to contribute to addressing the environmental problem if we manage to rethink entire application sectors, thereby affecting not only the manner in which raw materials are produced, but also verticalisation of entire agro-industrial non food chains, or which are synergic with food and the way in which products are used and disposed of. This will only be possible if we are capable of envisaging innovations which expand the scope of experimentation to the local region. Only in this way may bio-plastics become a powerful large-scale case study of sustainable development and cultural growth, an example for other sectors too. This is the challenge taken up by Novamont's "Bio-refinery integrated into the local area."

Novamont a system-based economics case study

In the rest of my presentation I shall provide some information about the origins and development of Novamont according to the rationale set out so far.

Some background information

Novamont was established in 1989 under the name of Fertec (Ferruzzi Ricerca e Tecnologia [Ferruzzi Research and Technology]), a strategic research Centre with the aim of integrating chemicals and agriculture according to principles of environmental sustainability: a great project which was the brainchild of Raul Gardini.

At that time, the Montedison group contained the largest agro-industrial group in Europe, Eridania - Beghin Say and Montecatini, as previously stated was one of the most important multinationals in the chemicals sector.

Fertec's job was to create a link between two sectors which up to that time had been completely separated, starting from Eridania - Beghin Say's agricultural raw materials, leveraging the chemical technologies available in Montecatini. The results of research carried out by Fertec were to lead to Montedison's third development stream.

Research was carried out into materials, bio-fuels, lubricants, detergents and the paper industry.

My task was to devise an approach and structure for Fertec dedicated to materials.

In 1992 with the Montedison crisis, Fertec became Novamont and lost its strategic role.

In 1994 Novamont focused only on materials.

In 1996 it was sold by Montedison and bought by the merchant banking unit of Banca Intesa - San Paolo and by other institutional investors.

Novamont's contribution to the bio-plastics sector

The technical results of Novamont's pioneering activities in the bio-plastics sector and specifically in the starch-based bio-plastics sector, is demonstrated by a patent portfolio comprising around 70 basic patents, more than 800 cases throughout the world, and more than 150 articles and various books.

The first series of patents running from 1989 to 2001 protected the first important technical result of Novamont's pioneering activity in the starch-based materials sector: complexation of starch as a consequence of insoluble polymers of the hydrophile-hydrophone type.

The importance of the invention lies in the fact that it is possible to transform starch, an energy resource for plants, into a range of insoluble materials possessing mechanical properties and processing capabilities which are very similar to traditional plastics.

Starch is made up of two components, amylose (a linear polyglucose alpha) and amylopectin (a branched polyglucose alpha with the same molecular structure as amylose and a molecular weight which is slightly greater). In nature the two components are organised into crystalline granules. The crystalline structure is characterised by laevorotatory double helix conformations. The discovery concerns the possibility that after restructuring, starch can be subjected to complexation by synthetic polymers, which affect amylose and not amylopectin. The complex is characterised by a single laevorotatory helix hosting the complexing molecule inside. The complexed amylose can screen single molecules of amylopectin, giving rise to what we have called droplet-like structures, thereby rendering starch resistant to water. It is possible to select starches with a different amylose/amylopectin ratio, different types of complexing agents and process conditions in order to create a wide range of supermolecular structures, from droplet-like to lamellar. In this manner it has been possible to simulate the strength or rigid behaviour of traditional plastics or to create new properties such as in the case of nano-particles of complexed starch, original strengthening for tyres with low rolling resistance. It has also been possible to apply traditional transformation technologies in order to obtain thin films for bags, packaging, hygiene products and other products. These are therefore bio-plastics with the usage behaviour of traditional plastics, which are however biodegradable just like a piece of apple peel, in just a few days together with the residual food waste on the compost or in the soil or in other environments. This large family of bio-plastics also has original characteristics, which are different from those of traditional plastics; thus making it possible to reconsider entire application sectors in order to lessen the environmental impact. The first family of industrial bio-plastics obtained with this technology has been sold internationally under the Mater-Bi® brand.

Proprietary polyesters of the aliphatic and aliphatic-aromatic type have subsequently been developed making it possible to integrate the complexed starch technology upstream, and new developments have been obtained in the transparent film for food packaging, fibres and coatings sectors. In addition, a proprietary technology for the production of monomers from vegetable oils during the optimisation stage has been developed, one which ought to lead to completion of the Novamont Bio-refinery with the construction of a first industrial plant beginning in 2009.

Developed products line: Mater-Bi® and its applications

Beginning with Mater-Bi® it has been possible to work on different solutions which are economically and environmentally sustainable in specific application sectors with a view to rethinking the approach. Some examples:

Agricultural mulch. For a farmer the mulching process using biodegradable film at the end of the growing cycle costs more or less the same as a standard non-biodegradable film. However, the added value of the biodegradable film is its lower environmental cost due to the fact that it is two to three times thinner than traditional films and because it is completely reabsorbed by the soil without accumulation, thereby eliminating economic and environmental costs connected with collecting and disposing of the traditional sheets.

Film made out of Mater-Bi® is certified biodegradable in the soil in accordance with the most prudent international standards and this type of film is recommended by many organic agriculture organisations such as AIAB.

The separate waste collection sector with the PNEO® system. This is a bag with enhanced transpiration capacity for gathering waste. PNEO® slows down the anaerobic fermentation processes which generate unpleasant odours, thereby making it possible to significantly reduce the water content of the waste, by around 20-50%. These characteristics make collecting waste more convenient for local government organisations and they also make it easier to separate waste.

The result is an improvement in the quality of the separate waste collection flows with simplification of waste collection and/or disposal. On top of the environmental advantages this leads to a significant reduction in costs of collection, transport and disposal of waste.

The Mater-Bi® nano-particles used to strengthen rubber to give it low hysteresis: this is a product used by Goodyear in their Biotred technology for tyres with low rolling resistance. The tyres with Biotred technology can save significant amounts of petrol (around 5%, reducing greenhouse gasses by 7 to 10 g/km). On the basis of the results achieved to date, the European Union has recently financed a new project for “run on flat” tyres with rolling resistance reduced by more than 30%, a project which together with Novamont also involves Goodyear and BMW.

Other applications are in the agricultural, hygiene, food-packaging, industrial and catering products sectors. The applications of the Mater-Bi® products have also been considered as case histories in dealings with the EC-CP (European Climate Change Panel) and the EU's Industry Commission on renewable raw materials.

Technical results and patent portfolio at the root of Novamont's creation and growth

The first products patented made it possible for the young research centre spun off from the Guido Donegani Institute, to survive and to become today's Novamont, a medium-sized independent company which is profitable, developed and managed by researchers who are also joint inventors of the Novamont patents whilst the company is financed by institutional investors with a long-term strategic investment approach.

From little more than a research centre, which was demerged from Montedison in 1996 with a negligible turnover, Novamont became a profitable company in 2001, with turnover in 2007 of 49.6 million Euros and a staff of 140 people, 30% of whom are employed in research and development, on which 10% of the turnover is invested. Novamont currently exports around 65% of its production and it is present throughout the world, expanding steadily. Not only is it producing products, but it is creating market supply chains with important industrial partners, ranging from small and medium-sized enterprises to multinationals. We estimate the total business of the supply chain generated by Novamont at around 400 million Euros and increasing steadily. There are companies, for example in the film sector, which have completely converted their production to Mater-Bi®. Manufacturers of machines for the transformation of plastic material are specially creating their products for Mater-Bi®, increasing their presence internationally and enhancing their image thanks to their presence in a sector which is at the cutting edge of technology. This aspect played a fundamental role in the establishment and growth of Novamont, in its spin-off from Montedison in 1996 and also in its management. Currently, Novamont has three different identities which derive from its origin as a research centre: undeniably it is an industrial enterprise which is steadily expanding, it is an incubator for new technologies and also a training centre. Over the last eight years Novamont has played host to 81 young people: from internships for schools up to post-graduate qualifications in bio-technologies for bio-plastics with a view to training young people and providing them with specialised technical skills as well as a strong systematic vision. The training centre and the incubator have strong relations with universities and research centres.

Model of the "Bio-refinery integrated into the local region"

Being an incubator for new projects, Novamont is capable of extending and expanding its skills by widening the range of proprietary technologies and by extending the boundaries of applications. Thanks to this characteristic, it has been able to equip itself with technology required to ensure upstream integration, something which is at the basis of the bio-refinery. The concept of a bio-refinery which is integrated into the local region and that Novamont is implementing with determination, is an important element in its approach to innovation and may also represent an example of a new corporate model, a project which links the company to the local region and which creates a strong base from which to launch a company in the international market.

Considering the type and nature of the Italian market, if we want to use local renewable raw materials we must –prudently - rethink our agricultural system (which has now become one of the sectors which squanders the most energy); this means focusing on specialist crops for specific technologies which we are developing. In the case of the bio-refinery this means working with different oleaginous crops, adapting them and deciding how and where to grow them, what type of agronomic system to adopt, what rotation system, how much water and nitrogen, logistics and the crushing method. This systematic approach leads us to analyse the opportunities provided by energy production from waste products as well as involving farmers directly in the industrial supply chain, making them an integral part of the innovation process. An example of this is our cooperation with Coldiretti, which led to the establishment of a company in which Novamont owns a 50% stake whilst the other half is held by a co-operative of 600 local farmers. For now research is focusing on different oleaginous crop genotypes around the Novamont plants. This type of alliance makes it possible to work in the local region at a cultural level, thereby turning it into an extensive experimentation area. At the centre there is the Terni bio-refinery which was inaugurated in 2002 and which when it is running to full capacity, as of the end of 2008, will reach a production capacity of 60,000 t/a.

Just 70,000 ha of corn and 600,000 ha of oleaginous non-food crops would be sufficient to meet Italy's total requirements for flexible packaging plastics, amounting to around 1.5-2 million tonnes. Considering that in Italy cultivatable land amounts to 15 million ha it is obvious that bio-plastics are not going to affect the food chain and will actually strengthen it. Mater-Bi® and the related applications, Novamont and its bio-refinery model which is integrated in the local region have been, and still are, a simple yet tangible demonstration of the potential for small and medium-sized companies based on innovation and research, experimenting with new economic models based on enhancing the local area and on integration and partnership with the various stakeholders.

Conclusions

Novamont is an experimental model which continues to evolve in terms of research and as an innovation model. Areas of research cover macromolecular chemistry, traditional synthesis chemistry, microbiology, more recently, biotechnology combined with chemical processes, process engineering, transformation technologies and agronomic aspects connected with non-food crops and with experimentation of biodegradable materials in agriculture.

The investigation of innovative models relates to a system rethink with: training, management of complex research projects; the development of partnerships, active participation in defining quality standards, strategic management of intellectual property, cultural activity, integrated supply chains and case histories.

It is a veritable laboratory in every sense of the word in which I was lucky enough to develop my skills, to see people around me develop their skills and which allowed me to create a unique experience to assist those whose wish to take part in this system-based economic experiment.

Today, the challenge for Novamont is to become a catalyst for this country's development in this sector, fully implementing the "Bio-refinery model closely linked to the Territory" by working in partnership with the agricultural, industrial, institutional and academic sectors. We hope that our experience can also be of benefit in defining our country's development strategy in the renewable raw materials sector, with an approach which demonstrates a level of wisdom which has to be much deeper than in the past.

Curriculum vitae

Catia Bastioli was born in Foligno on 3 October 1957.
After graduating in Pure Chemistry in 1981 at the University of Perugia where she obtained top marks, in 1985 she started attending the school of Business Administration ("Alti Potenziali Montedison") at the Milan Bocconi University.
Project Leader from 1984 to 1988 at the Guido Donegani Institute for the Montedison Strategic Composite Materials Project, and Project Manager for "Biodegradable Materials from Renewable Sources" at the Ferruzzi Research and Technology Center, Ms Bastioli entered Novamont in 1991 as a Director, becoming Technical Director in 1993, and then Managing Director in 1996. Today she is Chairman and Chief Executive Officer.
Catia Bastioli has been a member of EU working groups such as the Committee for "Renewable Raw Materials" of the Directorate General Industry and the ECCP (European Climate Change Program).
She is a member of the Executive Committee of PlasticsEurope Italia and President of the PlasticsEurope "Bioplastics " European working group. She has been a member of numerous Advisory Boards set up by Research institutes and university spin-offs.
President of Assoscai, Italy's Association for the Environmental Sustainability and Competitiveness of Enterprises, she was recently elected Director of Finpiemonte (regional development agency) by the Piedmont Regional Authority.
Since 2004 she has been a lecturer in the Faculty of Pharmacy/Biotechnology, at the "Amedeo Avogadro" University of Eastern Piedmont.
Author of more than 100 papers on various scientific and industrial subjects published in International Journals, she has also contributed to international reports dealing with renewable materials on behalf of leading institutional organizations. She has been an invited speaker at international conventions on the subjects of renewable raw materials, biorefineries, intellectual property and plastics and bioplastics in general.
She is the author of the "Handbook of Biodegradable Polymers", published by Rapra Technology Limited in 2005.
Ms Bastioli is the inventor of more than 80 patents and patent applications in the sectors of synthetic and natural polymers. The patents in the sector of starch-based materials are a significant part of the Novamont patent portfolio.
Catia Bastioli has won numerous international awards for her discoveries in the field of starch-based biodegradable materials; most notably, on April 18, 2007 she was nominated for the "European Inventor of the Year 2007" for her patents filed in the years 1992-2001.