environmental report
BEET GROWING AND SUGAR PRODUCTION IN EUROPE
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For over 200 years, the cultivation of sugar beet has formed the basis for sugar production in Europe. Beet farmers and sugar producers ensure that European consumers are reliably supplied with this natural product. At the same time, they jointly bear responsibility to provide the high product quality demanded by sugar users and consumers and to comply with the increasingly tough environmental standards expected by society. These high standards apply not only to growing sugar beet, but also to the sugar extraction operation.

Against this background, the International Confederation of European Beet Growers (CIBE) and the European Committee of Sugar Manufacturers (CEFS) decided to document their environmental objectives and achievements in a joint report. The report explains the steps taken in recent years in both growing and processing sugar beet, and provides a detailed analysis of the environmental practices and standards implemented in each.

In virtually no other agro-industrial production sector is the co-operation between farmers and the beet processing companies as close as in the sugar sector. Thanks to this co-operation, the European beet and sugar sector has been able to develop, through a combination of research, development, technology transfer and investment, a high level of environmental sustainability. The examples in our report illustrate the positive effects which these beneficial measures have had over many years. They also demonstrate the substantial, and increasing, investment being made to continuously improve environmental performance across the sector. While further environmental progress is, despite constant technical progress, increasingly difficult and costly to achieve, Europe’s beet farmers and sugar industry remain fully committed to this objective.

CIBE and CEFS believe their report will constitute a valuable reference manual for all institutions and individuals interested in the environment and the beet and sugar sector. We also hope it will provide a useful source of information to beet growers and the sugar industry in Central and Eastern European countries.

Jan Kirsch
President of CIBE

Johann Marihart
President of CEFS

February 2003
key environmental messages

Sugar beet growing in the EU is carried out in a professional, responsible and environmentally conscious manner. The beet grower’s activities are the very essence of sustainable farming:

> By its very nature, sugar beet forms part of a crop rotation and is not grown as a continuous monoculture;

> Growing sugar beet in a cereal based rotation provides environmental benefits such as improving both the structure and the long-term fertility of the soil as well as increasing diversity of flora and fauna;

> Sugar beet performance (root yield, sugar content, sugar extractability) has increased considerably over the years, while inputs (fertiliser, plant protection products) have been reduced;

> Sugar beet is a very efficient nitrogen user, reducing the level of mineral nitrogen in the soil;

> The increased practice of using a nitrogen trapping intermediate (or catch) crop before beet prevents groundwater pollution due to leaching during the intercrop period;

> The use of other crop macro-nutrients such as potassium and phosphorus has also decreased significantly;

> Beet growers systematically use early warnings, crop damage thresholds and information systems in order to reduce the use of plant protection products and to optimise the timing and quantity of application;

> The use of plant protection products has been reduced considerably over the past two decades;

> There are strict controls regarding the authorisation and use of plant protection products, which guarantees the highest standards of food safety;

> Sugar beet has a comparatively low water requirement;

> Systematic over-irrigation is avoided by sound and strictly controlled irrigation management;

> Appropriate harvesting practices limit and continue to reduce soil tare;

> Sugar beet has great potential as a bio-fuel.
key environmental messages

The beet sugar industry manages and continually reduces its environmental impact in a professional and responsible manner. Specific examples include:

- All parts of the beet are used and converted into valuable products without waste;
- Soil removed from the fields and brought into factories is minimised;
- The soil which is brought into factories is put to productive use wherever possible, for example by applying it to land to provide agricultural benefit or in civil engineering works;
- Beet transport to the factories is highly efficient, thereby minimising road congestion;
- The delivery of sugar and other products (animal feed, molasses etc) to customers is arranged to minimise fuel usage and to avoid traffic burdens.
- Lime, a by-product of the sugar extraction process, is produced and sold as a soil conditioner, so helping to preserve valuable limestone reserves.
- The network of factories ensures that the sugar is sold locally, thereby minimising food miles;
- The sugar industry has invested heavily to minimise the consumption of fresh water;
- All effluent water is thoroughly treated, physically and biologically, before reuse in agriculture or discharge to local water courses. Water quality is continuously monitored to guarantee that it meets legal requirements and that river quality is safeguarded;
- Where anaerobic treatment of effluent water is used, the flammable biogas generated is captured and used in the combustion processes. This reduces the quantity of fossil fuel used;
- The beet sugar industry generates its own steam and electricity requirements using ultra-efficient Combined Heat and Power (CHP) technology. Excess electricity is sold to other users;
- Through heavy investment in state-of-the-art technology and by a continuous focus on energy efficiency, the sugar industry has minimised the amount of energy needed to produce the sugar;
- This energy efficiency minimises greenhouse gas, carbon dioxide, and other associated boiler emissions;
- The thermal centre of the process is the use of complex multiple-evaporation technology to concentrate the dilute sugar juice in preparation for crystallisation. In this way, each unit of steam will evaporate up to 5 units of water;
- Hazard analysis and critical control point techniques are used in the production process to guarantee the safety of food and animal feed;
- Environmental management systems are extensively used to assess the risks and manage them;
- Ecology - the sugar industry creates beneficial wildlife habitats, the opposite of the traditional image of the effects of industrial activity.
where does sugar come from?

HISTORY

For a long time, sugar was a highly-coveted and expensive sweetener which was derived exclusively from sugar cane cultivated overseas. Only in the middle of the 18th century was it discovered in Europe that local beet, grown as animal feed, also contained sugar. After the successful selection of a beet with a high sugar content from among various fodder beet species, the world’s first beet sugar factory was established in Silesia in 1801. In the years that followed, beet growing and beet processing gradually developed throughout Europe. And so the basis for European beet sugar production was created. Today, beet farmers and the sugar industry ensure that European consumers receive a high-quality foodstuff produced in full accordance with Europe’s strict environmental, quality and social standards.

PHOTOSYNTHESIS

In photosynthesis, the energy from sunlight is absorbed by plant leaves and converted into chemical compounds unique to plants. In so doing, water molecules are split off, and oxygen formed during this reaction is released. In the course of these biochemical transformations, carbon dioxide from the air is converted into sugar, which is composed of one molecule of glucose and one molecule of fructose.

The carbohydrate sugar derived from the plant’s leaves is stored in the beet’s root in concentrations of up to 20 percent. Thus the final product is already present in the beet, and undergoes no further modification during the sugar extraction process.

responsibility for rural areas

Sugar beet is grown and processed in all countries of the European Union (with the exception of Luxembourg) and has a special significance for many rural areas. This is due both to the indispensable contribution of beet growing to the economic welfare of 300,000 farms and also to the importance of the sugar industry for creating jobs in those regions. The disciplines required to grow beet, and to supply it regularly to factories, have led to efficiently operating technical networks. These have been successful in achieving progress, not only in the beet sector but also in agriculture in general. Sugar beet is a perishable product which cannot be transported over long distances. This explains why sugar factories are located in traditional beet cultivation areas. They are not only suppliers of sugar, but also produce animal feed as well as other products (e.g. sugar factory lime). These products are for the most part marketed in the region, and thus help bolster the economic strength of the rural areas of Europe.

In addition to its economic value, the European sugar sector also has a substantial, and beneficial, environmental impact in those regions where beet is cultivated.
Beet and sugar production in the EU is based on a market organization (known as the common organization of the markets in the sugar sector) which has stabilized production for many years. In 2001/2002, the area devoted to beet cultivation in the European Union amounted to around 1.8 million hectares. Around 300,000 farmers in 14 EU Member States grow sugar beet on their farm, with an average area per farm of about 6 hectares. Beet rarely accounts for more than 25% of a farm’s total arable area. As a result of increasing yields, the area devoted to beet growing has been diminishing steadily. The number of farms on which sugar beet is grown has also decreased as the industry has rationalised.
In recent years the number of EU sugar factories has fallen sharply, as the industry has undergone major rationalisation driven by the need to improve efficiency. This development has also been made in response to the significant fall in the real value of the sugar intervention price since the mid-1980s. The number of factories has been reduced from 213 in 1991/92 to 135 in 2001/02. Virtually every country and region of the EU is affected by this continuing development. The number of employees in the sector has followed suit. During the 2001/02 processing season, they numbered 33,599, a fall of 45% since 1991/92.

### STRUCTURAL RATIONALISATION IN THE SUGAR INDUSTRY (ALL EU COUNTRIES)

<table>
<thead>
<tr>
<th>Processing season</th>
<th>Number of employees during the processing season</th>
<th>Number of employees between the processing seasons</th>
<th>Number of sugar factories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991/92</td>
<td>61,698</td>
<td>39,214</td>
<td>213</td>
</tr>
<tr>
<td>2001/02</td>
<td>33,599</td>
<td>20,571</td>
<td>135</td>
</tr>
</tbody>
</table>

Although the number of direct employees has decreased during recent years, the sugar industry has an important economic function in rural areas, where it guarantees jobs and training positions. Taking account of direct and indirect employment, the sugar factories in the EU support almost 300,000 jobs. As well as being the processor of sugar beet, the sugar factories are also a partner for numerous small businesses and ancillary suppliers.

### KEY FIGURES PROCESSING SEASON 2001/2002

<table>
<thead>
<tr>
<th>Countries</th>
<th>Distribution of EU sugar factories by country</th>
<th>Processed beet (Mio.tons)</th>
<th>Sugar production (expressed in 1000 tons of white sugar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>3</td>
<td>2.77</td>
<td>400</td>
</tr>
<tr>
<td>Belgium</td>
<td>8</td>
<td>5.42</td>
<td>840</td>
</tr>
<tr>
<td>Denmark</td>
<td>3</td>
<td>3.07</td>
<td>501</td>
</tr>
<tr>
<td>Finland</td>
<td>2</td>
<td>1.07</td>
<td>146</td>
</tr>
<tr>
<td>France</td>
<td>34</td>
<td>24.46</td>
<td>3686</td>
</tr>
<tr>
<td>Germany</td>
<td>30</td>
<td>24.73</td>
<td>3703</td>
</tr>
<tr>
<td>Greece</td>
<td>5</td>
<td>2.83</td>
<td>314</td>
</tr>
<tr>
<td>Ireland</td>
<td>2</td>
<td>1.37</td>
<td>207</td>
</tr>
<tr>
<td>Italy</td>
<td>20</td>
<td>9.91</td>
<td>1284</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>5</td>
<td>6.05</td>
<td>953</td>
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<tr>
<td>Portugal</td>
<td>1</td>
<td>0.36</td>
<td>54</td>
</tr>
<tr>
<td>Spain</td>
<td>13</td>
<td>6.95</td>
<td>941</td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td>2.64</td>
<td>402</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>7</td>
<td>8.33</td>
<td>1223</td>
</tr>
<tr>
<td>TOTAL EU</td>
<td>135</td>
<td>99.96</td>
<td>14,654</td>
</tr>
</tbody>
</table>

Source: CEFS
DISTRIBUTION OF BEET GROWING AREAS AND SUGAR FACTORIES IN THE EU COUNTRIES, 2001-2002
sugar beet
a strong performer at an ecological level

ROTATIONAL CROP
Sugar beet is a rotational crop (grown on the same field only every three to five years) and practically never grown for continuous monoculture. As a root crop it has become a very valuable part of arable farming because the growing of sugar beet has the effect of breaking up the mainly cereal based crop rotations used in land cultivation areas. The production methods used in sugar beet farming, particularly the principle of growing sugar beet in a rotation, are characterised by environmental compatibility and sustainability.

DRY MATTER PRODUCTION
Sugar beet yields a considerable quantity of dry matter. Its root contains about 15% sugar, the remaining (roughly 10%) dry matter consisting of pulp and molasses, the rest being water. The leaves of sugar beet remain on the fields after harvesting where they are reincorporated into the soil, improving the latter’s nutrient status thereby benefitting the following crop in the rotation.

> PRODUCTION OF DRY MATERIAL FROM VARIOUS CROPS

Source: IRBAB, Belgium
the conservation of genetic and ecological diversity

INCREASED GENETIC DIVERSITY
Sugar beet originates from the “Silesian White” variety, chosen by Achard in 1786 for its sugar content of 7%. Since then, progress in breeding techniques and other related research, including traits for pest and disease resistance, have contributed to the improved productivity of sugar beet, without compromising the genetic diversity of the original wild beet species.

BENEFITS FOR CROP ROTATIONS
Sugar beet plays the role of a break crop in the arable rotation for combinable straw-yielding crops (cereals). Because sugar beet is not a host to pests and diseases which generally affect combinable crops, the cultivation of sugar beet reduces the levels of weeds, diseases and pests in the rotation, and therefore reduces the amount of pesticides applied. Sugar beet thus plays an important part in integrated weed and pest management of arable crops.

BENEFITS FOR THE SOIL
Sugar beet is a deep-rooting crop (the intense network of root fibres penetrates into the soil as far as 2 m and even up to 3 m), and so contributes to the creation and maintenance of good soil structure (root and root fibre canals improve soil porosity). It also adds organic matter (root fibres, rootlets, beet tops and leaves after harvesting) to topsoil, encouraging a more diverse soil fauna (soil invertebrates) which in turn serves as an important food source for wildlife.

BENEFITS FOR WILDLIFE
The presence of sugar beet on a farm increases biodiversity of both flora and fauna. Stubbles from the previous crop and late harvested sugar beet fields create important resources for wildlife, in particular providing food for overwintering farmland and other migrant birds. The nature of the sugar beet crop also means that fields retain an open vegetation structure, including areas of bare soil, until late spring which supports many ground-nesting bird species. For example, in the UK sugar beet is recognized by wildlife organizations as an important crop for birdlife, including internationally significant populations of stone curlew and pink-footed goose.
sugar beet
an efficient nitrogen user

A VIGOROUS CROP

Once emerged, sugar beet is less vulnerable to climatic variations than many other crops. This is principally because unlike most other field crops sugar beet does not go through a potentially stressful reproductive phase during its first year of growth. There is thus a relatively low year to year yield variability, which facilitates good input management.

NITROGEN USE REDUCTION

Overfertilising of sugar beet with nitrogen has negative consequences for both the beet grower (low sugar content and therefore lower beet payment) and the sugar industry (lower beet quality and therefore poorer sugar extraction performance). Continuous improvement in the analysis of the beet’s nutrient requirements and of soil nutrient availability have permitted the precise determination of fertiliser requirements. This has resulted in the application of less fertiliser, as well as better timing and improved application techniques. Sugar beet is a deep-rooting crop (up to 3 m) and an excellent nitrogen user, extracting most of the available nitrogen left in the soil by preceding crops. It therefore requires only 60 to 160 kg of N fertiliser application (depending on the use of organic fertiliser and on a range of site specific characteristics like soil type and climate). In Germany for example, N-application has been reduced by 50% in ten years.

> EVOLUTION OF MINERAL NITROGEN-FERTILISER APPLICATION IN GERMANY, 1994-2000

In the UK, N-application has been reduced from 160 kg/ha to 105 kg/ha in 25 years.
In Spain, N-application has been reduced from over 250 kg/ha to about 150 kg/ha in 10 years.
In France, N-application has been reduced from 180kg/ha to 140 kg/ha in 20 years.
high nitrogen use efficiency

INCREASED CROP YIELD - LOWER NITROGEN USE

Improvements in crop production techniques combined with advances in seed breeding have led to a substantial increase in sugar yield per hectare over time at the same time as nitrogen applications have been reduced. The efficiency of nitrogen use by sugar beet has therefore been considerably improved.

> INCREASE IN SUGAR YIELD (t/ha) AND REDUCTION IN NITROGEN APPLICATION (kg/ha), 1977-2000 IN FRANCE

In Spain the amount of nitrogen used to produce a ton of sugar beet has been more than halved since 1985.

EFFECTIVE NUTRIENT UPTAKE

Being a deep-rooting crop, sugar beet captures nitrogen and other nutrients from all soil layers including the lower ones, contrary to other arable crops typically found in crop rotation systems. Thus, growing sugar beet helps to minimize leaching of nutrients from the soil.

NITROGEN IN THE SOIL AFTER THE BEET CROP

Very little residual mineral nitrogen (less than 30 kg/ha, significantly less than other crops) is left in the soil after sugar beet. It is an ideal crop for extracting nitrogen from the soil and thus prevents ground water pollution due to leaching.

NITROGEN TRAPPING INTERMEDIATE CROPS

There is an increasing use of cover crops, such as mustard after cereal crops preceding beet, in order to trap the nitrates available in the soil and thus reduce groundwater pollution due to leaching during the intercrop period. This is particularly widespread in Austria (70% of beet area).
Apart from nitrogen, the other crop macronutrients are phosphorus and potassium. Their use has also been reduced considerably over the years. For example in the UK sugar beet crop, potassium has dropped from 230 kg/ha to 126 kg/ha and phosphorus from 124 kg/ha to 66 kg/ha since 1960. In Spain, potassium has dropped from 270 kg/ha to 50 kg/ha and phosphorus from 180 kg/ha to 100 kg/ha.
sugar beet

a crop using less plant protection products

A SUBSTANTIAL DECREASE IN USE

During its development, sugar beet requires a certain number of treatments in order to protect it from weeds, pests and diseases. The traditional method to deal with weeds is inter-row hoeing or harrowing, which is purely mechanical.

Plant protection products are also used, but in a strictly controlled way. Everywhere in Europe, farmers use early warnings, crop damage thresholds and information systems to reduce the applications of plant protection products and to optimise their timing. The reduction in the use of plant protection products in the past decade is also to some extent due to more effective seed treatment (covering about 5 m²/ha) which obviates the need for insecticide treatments (covering the entire field) during growth. As a result, foliar treatments against insects during crop growth have virtually disappeared.

For example in Germany, insecticide use has been reduced from three foliar treatments to a single treatment of the beet seed.

In France, the use of insecticides and fungicides in beet growing has decreased by respectively 50% and 75% since 1980, while in the UK insecticides have been reduced by over 95% since 1982.

Another important factor in reducing the use of plant protection products is the breeding of resistant/tolerant beet varieties. In Greece, Spain and southern Italy, the use of beet leaf spot (cercospora) tolerant varieties has lead to a reduction in foliar treatments against the disease. Other pests and diseases such as nematodes, rhizomania and rhizoctonia are dealt with biologically by the use of resistant or tolerant varieties and/or the strategic use of resistant catch crops (oil radish, mustard).
maintaining the highest standards of food safety

Sugar beet is closely monitored to provide the highest standards of food safety. A variety of techniques are used to do this, including auditing plant protection product applications on the crops and checking for residues in the plant.

MONITORING PLANT PROTECTION PRODUCT RESIDUES

In France for example, the national sanitary authorities carry out analyses for residues of plant protection products in fresh sugar beet at regular intervals. These analyses confirm positive compliance with all relevant food safety regulations. Those few substances which are detected are always below the official limits (maximum residue limit) imposed by the national sanitary authorities.

The purpose of these analyses is not to determine the risk of sugar being contaminated since this risk is eliminated by the process of sugar production. It is rather to verify that the plant protection products are used by the growers according to good agricultural practice and in conformity with the relevant regulations.

AUDITING PLANT PROTECTION PRODUCT APPLICATIONS

In the UK for example, detailed auditing is carried out on a random sample of growers each year to ensure that pesticide use documentation is correct, and that applications conform with the relevant regulations and guidelines approved by the authorities.

sugar beet
an efficient water user

COMPARATIVELY LOW WATER REQUIREMENT

Water requirements of sugar beet are about 50% of the water requirements of sugar cane.

In most growing regions in Europe sugar beet has a relatively low water requirement. Sugar beet makes very efficient use of soil water and can thus withstand much drier conditions than other crops without affecting quality or yield significantly.

In Belgium, Ireland, Denmark and Finland sugar beet is not irrigated at all. In the UK, Germany, France and Sweden and the Netherlands only a small proportion of beet area is irrigated. In Italy and Austria, between one quarter and one third of beet area can be irrigated. Only in Spain (80%), Portugal (100%) and Greece (100%) is irrigation widespread.
SUGAR BEET GROWING - USING A PRECIOUS RESOURCE SPARINGLY

Systematic over-irrigation of the beet crop does not occur. This is ensured by sound and strictly monitored irrigation management. The crop’s water requirement is determined at all stages of development, providing a sound basis for irrigation recommendations (both quantity and timing). Irrigation is carried out in close co-operation with local water authorities and is subject to strict rules and taxes. For example, in Spain most beet growers using irrigation are part of a national irrigation plan which consists of a legal framework to control and to optimize the use of this precious resource in order to assure the sustainability of irrigation. This has led to a reduction in water use by up to 50% in recent years and thus to a significantly lower quantity of water used per tonne of beet produced. This helps to maintain levels of river flow and ground water reserves.

sugar beet and soil conservation

ENHANCING SOIL FERTILITY

In developing an extensive and deep root network, sugar beet improves soil structure and soil biological status in the lower soil strata. The leaves (some 5-7 tonnes dry material/ha), beet tops and bits of roots and root hairs left in and on the ground after harvesting also play a role in returning nutrients to the soil which will be available for subsequent crops.

AVOIDING EROSION

In order to reduce the risk of erosion in the spring before leaf canopy is fully developed, farmers increasingly use soil conservation techniques such as sowing into a mulch and/or minimum cultivation. In Germany, for example, reduced soil preparation techniques were developed in the early 1980s. Today over 20% of beet area is sown into mulch. In Austria, this is done on one third of total beet area. Due to its long growing season and its extensive leaf canopy, sugar beet provides a better and longer lasting ground cover than most of the rotational crops in Europe. Sugar beet is therefore one of the best crops for avoiding soil erosion by water and wind.
sugar beet and soil tare

During harvesting, a small quantity of soil adhering to the beet is removed from the field. This soil tare leads to additional transport, cleaning and recycling costs.

The inter-professional agreements between beet growers and the sugar industry provide for incentives to reduce soil tare. This has dramatically reduced the level of transport necessary to bring the beet to the factory.

There are various techniques which can be used throughout the crop cycle to achieve this. One very effective technique is to clean the beet during loading, which has become increasingly widespread throughout the EU. For example, over 90% of beet in Germany and the UK and well over 60% of beet in Denmark and Sweden are pre-cleaned in this way, resulting in a considerable reduction in soil tare (in general by over 50%).

> REDUCTION IN SOIL AND TOP TARE IN GERMANY, 1980-2001

Sugar beet growers, the sugar industry and the relevant research institutes are continuing their joint efforts to reduce soil tare even further.

sugar beet and precautions against soil compaction

Development of wide tyres and the use of low pressure tyres have reduced the risk of soil compaction caused by agricultural machinery. This is even more effective when combined with soil conservation techniques and good timing of field operations.
Studies trying to identify the most suitable crops for the energy-efficient production of bio-fuels have shown that sugar beet has one of the most positive energy balances of all field crops, requiring inputs of some 14-40 GJ (giga-joules)/ha/year and having an energy output of between 110 and 325 GJ/ha/year. For example, according to a study from 1997/98, beet growing in France has an average energy efficiency of 9.75 MJ (mega-joules) of products coming from the field for each MJ consumed in beet growing.

Thus sugar beet has the highest bio-fuel potential of all crops, being able to produce over 5 t of bio-ethanol per hectare per year. In France, some 12 000 ha of sugar beet are currently dedicated to bio-ethanol production. Several other EU countries are studying the possibilities for bio-ethanol, in response to the EU’s objective to meet its Kyoto target to reduce greenhouse gas emissions.
sugar production process

PROCESS SEQUENCE

The objective of beet processing in sugar factories is to extract the sucrose stored in the beet cells and transform it into sugar crystals. The process used for this is based on the fundamental processing steps shown below.

In environmental terms, it is important to note that all parts of the beet are used and converted into valuable products without waste. In greater detail, the following process steps take place during sugar production:

BEET PREPARATION

After delivery, the sugar beet (which for the most part has been pre-cleaned directly in the fields) is transported via conveyor belts or water channels into the beet washing installation. There the remaining adhering soil is removed and the leaves and stones are separated. The cleaned beet is cut up into slices, called "cossettes", ready for sugar extraction.

SUGAR EXTRACTION

The sugar in the cossettes is then extracted. It is dissolved from the cossettes with warm water, to form a roughly 15% sugar solution – the so-called "diffusion juice". The exhausted beet cossettes are then pressed and dried to produce a high energy and top quality animal feed.

JUICE PURIFICATION

Apart from sugar, diffusion juice also contains other components (e.g. proteins) derived from the crop. These are removed in a purification process involving the addition of lime. The lime is then filtered and dried for use as a soil conditioning agent in agriculture. The resultant clear solution of sugar is called "thin juice".

JUICE CONCENTRATION/EVAPORATION

In the evaporation station, water is removed by evaporation from the thin juice in a series of successive evaporating vessels until a syrup with a concentration of around 70 percent dry matter is obtained. This "thick juice" is viscous, golden yellow and clear.

CRYSTALLISATION

The thick juice is first further evaporated in specially designed pans, until sugar crystals form. The crystals and accompanying final syrup are then centrifuged to separate the two components. The final syrup, which still contains 50% sugar, is called molasses and is used in a variety of market applications. The centrifuged sugar is dried and stored in silos, before being sieved and packaged to the highest quality customer standards.
The following diagram illustrates the process of sugar production in simplified form. In practice there are differences between individual factories and companies, but the fundamental process is the same everywhere.
use of products related to sugar production

The European sugar industry has a long tradition in maximising the use of by-products from the beet processing operation, all of which are used in productive applications.

STONES, SOIL AND BEET LEAVES

During transport and the washing process, adhering soil, leaves and stones are separated from the beet. The wash water also contains beet fragments, which are screened and recycled.

The soil can be directly returned to the fields by land spreading or is stored in settling ponds in order to dry out and to form high quality arable soil.

This is then used in a wide range of productive applications, including agricultural land improvement, the sports amenity industry, civil engineering and housing construction, garden centres (horticulture), land reclamation and landfill site restoration.

Stones which are separated from the beet are used in road building and in the construction industry.

Beet leaves and roots, which also accumulate during the washing process, are an energy-rich and easily-digestible feed for ruminants.

BEET PULP

Beet pulp is an excellent energy-rich cattle feed, which is either used as part of compound feed products or fed directly. In many countries, the animal feed is highly valued by the beet growers, who collect it from the factory during the processing season as return loads of empty beet lorries, so saving unnecessary transport.

The processing and utilisation of animal feed is subject to the strict legal feed regulations of the European Union, as well as the respective national provisions. The annual production of beet pulp in the EU amounts to around 8 Mio. t of pressed and 5.5 Mio. t of dried product.

SUGAR FACTORY LIME

Lime from the juice purification process is filtered and dried to make a soil conditioning product for agricultural land. In addition to lime (calcium carbonate), it also contains other valuable nutrients like magnesium, phosphate and potassium, and is used to improve soil structure and reduce acidity.

It is marketed in a range of product types, to provide farmers with the most suitable forms for spreading on their land. The sugar industry thus makes a valuable contribution to environmental recycling, by providing farmers with a sustainable product which avoids the extraction and use of valuable and limited limestone reserves. Sugar factory lime is recognized as a fertilizer within the EU’s regulation on organic production of agricultural products.
The production of biogas, as part of the water treatment process, makes an environmentally-friendly and sustainable contribution to reducing the use of fuel. This biogas, which has a methane content of around 75%, is a valuable ingredient in sugar production, where it helps reduce imported energy consumption.

Even though sugar factory lime is a valuable soil conditioning product, the sugar industry is striving to reduce its consumption of limestone. As a result, the quantity of limestone which is used to purify the juice has been reduced in recent years. The example of an Italian sugar company shows that limestone consumption has been reduced by 25% between 1992 and 2001.

MOLASSES

Molasses, the final syrup from the crystallisation stage of the process, is used in a wide variety of market applications. These include use as a feedstock by fermentation industries to produce high value pharmaceuticals, citric acid, yeast and specialist biochemicals. It is also widely used in the alcohol distillation industry. However, the largest single application is as a supplement for animal feed, where it can either be sold to feed manufacturers or farmers (e.g. to add to silage grass and maize to improve product quality), or can be added directly to animal feed at the sugar factory.

The sweet taste and relatively high energy content make molasses a highly appreciated raw material for the producers of mixed feeds. Molasses is used in both energy feed and mineral feed for virtually all types of animals. Of particular importance is the high digestibility of its organic ingredients. The annual production of molasses in the EU amounts to around 4 Mio. t.

LIMESTONE CONSUMPTION IN AN ITALIAN SUGAR COMPANY

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Efficient beet processing requires accurate control of enormous commodity flows, and continuous beet delivery to the factory. The objective is to assure the factory’s supply of raw materials without costly intermediate storage of beet on the factory site. Harvesting sugar beet from the field and its delivery to sugar factories therefore take place according to a precise schedule. In this way, the traffic burden due to transport vehicles is kept as low as possible, without causing long waiting times for the deliverers.

In order to minimise the traffic burden for residents living near sugar factories, several measures have been introduced. These include the establishment of washing installations for the beet vehicles on the factory site, and the creation of special access routes to the factory.

In recent years, rationalisation pressures within the sugar industry have led to the closure of factories all over Europe. This has meant that sugar beet has to be transported over longer distances. But at the same time, the sugar industry has pursued a policy of transport rationalization in order to reduce the environmental effects of beet transport. Beet farmers are encouraged, through targeted information and various handling improvements made in the factories, to deliver in larger vehicles. This reduces the number of trips and thus results in fewer kilometres travelled, lower fuel consumption and less noise.

Due to the restructuring of the French sugar industry, the number of production sites between 1990 and 2000 was reduced from 50 to 35. To minimise the increase in average transport distances, the companies involved organised the beet deliveries more efficiently so that these closures had the least possible impact on beet transport arrangements.
Recent restructuring has led to the closure of factories and thus to an increase in average transport distance for beet. However, local processing of the raw material is still a characteristic and, from an ecological perspective, significant feature of the European sugar industry.

> NUMBER OF VEHICLE MOVEMENTS IN A GERMAN SUGAR COMPANY

This example of a German sugar company shows that the number of vehicle movements has actually been reduced during recent years, despite industry restructuring.

Source: Nordzucker
One of the objectives of the European sugar industry is to keep fresh water consumption to an absolute minimum. In order to reach this goal a number of different measures are applied.

**CONDENSATE AND PRESS WATER RECYCLING**

The most important source of water in the factories is the sugar beet itself. It contains about 75% water, most of which is turned into steam during the production process, and then condensed. This condensate is used for beet transport and washing water, as well as for extraction and crystallisation. This enables the sugar factory to reduce fresh water use to a minimum.

Water from pressing the exhausted pulp is also recycled. This means that sugar factories not only keep fresh water consumption to a minimum but also avoid producing waste water from the pulp pressing.

The example of a German sugar company shows that the fresh water consumption has been reduced by 200,000 m³ since 1995. This corresponds to a reduction of 50% for an unchanged volume of sugar production.
In sugar factories, the water which is used for beet transport and cleaning is recycled several times, therefore minimising fresh water consumption.

When beet is delivered to sugar factories, it is either unloaded directly from the transport vehicles or flushed along with water in a channel, ending up in the washing installation. In order to be able to recycle the transport and washing water, it is necessary to separate soil, plant parts and stones after the washing process, using screening systems. The water then flows into settling ponds. After the remaining soil has settled out, the decanted water is reused for transporting and washing the beet.

*Water cleared and purified to high environmental standards is discharged to river.*
**biological water treatment**

The sugar industry has developed efficient water treatment systems which fulfill legal requirements and comply with local quality standards. In Southern Europe extensive treatments like lagooning or land spreading are normally used. In Northern regions purification takes place by a combination of techniques in water treatment plants. The water remaining in the settling ponds after sedimentation, which cannot be used again, is further purified in water treatment plants. The individual components of a beet sugar factory water treatment system vary from factory to factory but generally consist of soil settlement ponds and some form of biological treatment plant.

> **SCHEMATIC PRESENTATION OF WATER TREATMENT**

The objective of biological water treatment is to reduce the organic load of the water to such an extent that it can be returned to water courses without harming the environment.

Originally, water treatment consisted of soil settlement in large lagoons followed by storage of the water for a period of a couple of weeks to a couple of months, during which naturally-occurring bacteria reduced the biochemical oxygen demand (BOD) of the water (natural purification).

As environmental performance improved, the industry invested in intensive treatment plants, which mostly combine anaerobic and aerobic systems. Anaerobic systems can treat high concentrations of BOD. Thus water does not need to be stored for so long and odour formation is reduced. After anaerobic treatment, the water is fed to an aerobic plant where nitrification/denitrification takes place. Overall, these treatments reduce the BOD as well as the COD (chemical oxygen demand) in the water by more than 90%, allowing the water to be directed to local water courses with complete safety. In the South of Europe, due to the higher temperatures, treatment can take place in open lagoons.

Valuable methane gas is produced in the anaerobic process. This biogas is used as a sustainable alternative either for fossil fuel in beet pulp drying, or in boilers for producing steam.

> **RESULT OF BIOLOGICAL WATER TREATMENT IN A DUTCH SUGAR FACTORY**

The results of waste water treatment in the Dutch sugar industry indicate the high performance of biological water treatment plants.

The results of waste water treatment in the Dutch sugar industry indicate the high performance of biological water treatment plants.

<table>
<thead>
<tr>
<th>COD - sources</th>
<th>COD - reduction</th>
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<tbody>
<tr>
<td>Others</td>
<td>Effluent discharge</td>
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<tr>
<td>Condensates</td>
<td>Aerobic treatment</td>
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<tr>
<td>Beet washing</td>
<td>Anaerobic treatment</td>
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Source: Dutch sugar industry
energy efficiency

In recent years, the sugar industry has made great efforts to lower its use of primary energy. This objective has been reached, due to a combination of heavy investment in combined heat and power systems, installation of multi-effect evaporation, improvement of mechanical cossette pressing and the introduction and development of process control technology.

Over a long period, from 1946 to 1998, energy consumption by French sugar factories was reduced by a factor of three, dropping from 2600 Mjoules per tonne of beet to 819 Mjoules. Between 1970 and 1998 a reduction of 40 % has been achieved.
CLIMATE CHANGE PROTECTION

Improvements achieved in sugar factories all over Europe in the field of energy-efficiency have also led to lower atmospheric emissions. For this reason the successful efforts of the sugar industry to reduce its energy consumption have also made a major contribution towards alleviating climate change. The decreasing use of fossil energy sources is directly related to a reduction in CO₂ output, so contributing to the European Union’s objectives to reduce CO₂ and other greenhouse gas emissions.

> CO₂ EMISSION IN THE GERMAN SUGAR INDUSTRY (1999-00 AND 2000-01 PRELIMINARY DATA)

![Graph showing CO₂ emission in the German sugar industry](source: Statistisches Bundesamt)

COMBINED HEAT AND POWER SYSTEMS

Sugar factory power generation is a combined heat and power ("CHP") system, because the electrical power, and the steam which generates it, are both used efficiently in the manufacturing process. High pressure steam drives a turbine and generator, producing the electricity needed to power the factory. The low pressure (exhaust) steam which leaves the turbine is then used for evaporation, and other functions in the factory. These CHP systems are much more energy-efficient than conventional power stations which have no application for the low pressure exhaust steam. The electricity thus produced powers the factory and can also be exported to the electricity grid.
MULTI-EFFECT EVAPORATION

After purification, sugar juice contains about 15% sugar. This requires concentrating to above 68% to allow sugar crystallisation and extraction. The process which does this is called “multi-effect-evaporation”. It is based on a principle of re-using the heat energy in the steam from each evaporation by using it again in the next evaporator. This means that, for example in a five stage evaporation process, one kg of steam is able to evaporate five kg of water from the juice. This process is therefore highly efficient. The condensate from the final evaporator is finally recycled to the boiler for steam generation.

PULP PRESSING

Once the sugar has been extracted from the sliced sugar beet roots, a high energy fibrous material called “pulp” is left. This has to be pressed to remove excess water, and to recycle the small amount of sugar it still contains. The sugar industry has invested heavily in improving the efficiency of this pressing process, to save fuel needed for pulp drying, and to improve product quality.

> AVERAGE DRY MATTER CONTENT OF PRESSED PULP IN A GERMAN SUGAR COMPANY

This example of a German sugar company shows that the average dry matter content of pressed beet pulp increased from around 19 % in 1970 to 33 % in 2001.
packaging and transport

PACKAGING REDUCTION

Approximately 80% of the sugar produced in Europe is delivered to large-scale buyers. Only around 20% is purchased by private households.

Deliveries to large-scale buyers are primarily made with silo trains, special trucks and barges, so that no packaging is required. A further and essential saving in packaging results from the increasing delivery of sugar in reusable containers. Furthermore, where packaging material is used, savings have been realized during recent years with both large-scale buyers and private households.

The other products related to sugar production (e.g., animal feed and molasses) are mostly transported in bulk and no or almost no packaging is used.

SHORT TRANSPORT DISTANCES

The European sugar industry ensures that the 13 million tonnes of sugar needed to meet EU requirements does not have to be transported over long distances, but can be produced locally. European sugar thus ranks amongst those "raw materials" which are not only produced in an environmentally sound manner but are also – from the point of view of avoiding unnecessary transport – produced and marketed in close proximity to the consumer. Any other situation would be completely undesirable environmentally, and would lead to a substantial increase in “food-miles”.

noise and odour emissions

Most sugar factories were originally set up in rural and sparsely populated areas. Due to the urbanisation of many rural communities and the expansion of residential areas, however, sugar factories today are often located in the immediate vicinity of residential areas. This gives rise to several related environmental protection requirements.

NOISE EMISSIONS

During processing, noise emissions are produced at various points. In order to protect both employees and the residents in the surroundings of the sugar factory from noise, a variety of specific noise reduction measures have been adopted. When new machines or equipment are acquired, noise prevention is one of the leading considerations.

ODOUR EMISSIONS

The majority of odour emissions are generated during pulp drying and water treatment. By improving drying technologies, optimising measurement and control technology and improving ventilation systems and water treatment systems, odour emissions have been reduced. Today this is a field of research for further improvement.

introduction of environmental management systems

Integrated management systems are designed to combine environmental protection, occupational safety and quality assurance into a single binding concept. Many of the systems introduced by the European sugar industry also include the production of the raw material on the farms.

All sugar companies have detailed management systems. In many cases these conform to EMAS (Eco-Management and Audit Scheme) or to ISO 14001.

ECOLOGICAL BENEFITS

The lagoons used for water storage and treatment attract wildlife, especially birds. These beneficial habitats, some of which have been designed “sites of special scientific interest”, are therefore another example of how the European sugar industry has developed in partnership with its environment.
list of sources

> AIMCRA :  
Asociación de Investigación para la Mejora del Cultivo de la Remolacha Azucarera, Valladolid, Spain.

> ARGE :  
Arbeitsgemeinschaft Zuckerrübenbau Rheinland, Bonn, Germany.

> BRITISH SUGAR :  
Peterborough, Great Britain.

> CEFS :  
Comité Européen des Fabricants de Sucre, Bruxelles, Belgium.

> CIBE :  
Confédération Internationale des Betteraviers Européens, Paris, France.

> ERIDANIA :  
Ferrara, Italy.

> IfZ :  
Institut für Zuckerrübenforschung, Göttingen, Germany.

> IIRB :  
Institut International de Recherches Betteravières, Bruxelles, Belgium.

> IRBAB :  
Institut Royal Belge pour l'Amélioration de la Betterave, Tienen, Belgium.

> ITB :  
Institut Technique Français de la Betterave Industrielle, Paris, France.

> NORDZUCKER :  
Braunschweig, Germany.

> RRV :  
Rheinischer Rübenanbauerverband, Bonn, Germany.

> SNFS :  
Syndicat National des Fabricants de Sucre, Paris, France.

> STATISTISCHES BUNDESAMT :  
Wiesbaden, Germany.

> SÜDZUCKER :  
Mannheim/Ochsenfurt, Germany.

> WVZ :  
Wirtschaftliche Vereinigung Zucker, Bonn, Germany.
notes
CIBE is the International Confederation of European Beet growers.
CEFS is the European Committee of Sugar Manufacturers.

The information given in this report refers to beet growing and sugar production within the Member States of the European Union.