# Focus on raw materials could reap big rewards

## Pay close attention to feedstock risks and opportunities in refining cellulosic biofuels and steal a lead over rivals, says **Anna Rath**

As the focus of the cellulosic biofuels industry shifts from making individual technologies function at experimental scale to integrating the entire value chain at commercial scale, issues of feedstock availability, cost and quality become paramount.

A perpetual supply of feedstock that meets biorefinery requirements is necessary to avoid downtime and minimise operating costs. Cheaper feedstock of the same quality provides reduced total production costs. Improved feedstock quality can reduce both capital and operating costs per litre of biofuels by enabling more fuel to be produced from the same quantity of biomass with less processing.

Leading energy crop companies such as Ceres are working to address these issues through advanced breeding, biotechnology and optimisation of crop management practices.

Maintaining constant operations at a biorefinery, to minimise operating costs and thereby maximise profitability, requires an assured supply of feedstock. This is driving many biorefineries to enter into long-term contracts with nearby growers to supply feedstock in a pre-agreed form (bale size, moisture content etc) at a pre-agreed location (on-farm v delivered) for a pre-agreed price.

Frequently, this price can vary within a specified range, with the actual price tied to the value of the end-product through a proxy like the price of oil.

In many ways, through these long-term contracts, the biorefineries are securing biomass reserves for their use in the same way that an oil company would secure, through a lease on an oil field, oil reserves to be used in its refineries.

Specifying feedstock characteristics is an important part of these contracts and will become more important as biorefineries become savvier about what feedstock characteristics are optimal for their process (see discussion of feedstock quality below).

In the extreme case, a biorefinery could be forced to suspend operations even with feedstock on hand if, for instance, the moisture content were in excess of what could be tolerated by the process and an appropriate dryer were unavailable.

It is common for these grower contracts to serve also as a mechanism for risk mitigation for the biorefinery. For instance, a biorefinery may contract for only 70% of a grower's typical yield, but also take an option on any excess, helping to ensure a supply cushion if some growers experience reduced yields or crop failure.

Crop mix represents another opportunity for risk mitigation. Using multiple varieties and/or multiple species to feed a refinery can reduce pest and disease risks. Incorporating some varieties selected for their drought or heat tolerance can help ensure yield stability, especially when practising dryland farming on more marginal acres. Biorefineries can also use species with different harvesting times to ensure a more continuous supply of feedstock and reduce seasonal risks.

### SERVICE OPPORTUNITY

The need for an assured feedstock supply creates the opportunity for another entrant in the value chain. Companies with strong local agricultural knowledge or agricultural equipment expertise are considering developing operations that would collect biomass for delivery to biorefineries.

They could collect the biomass being grown under the grower contracts with biorefineries or act as harvesting and supply companies contracting with the farmers, such that refineries need only contract with supply companies rather than many growers, thus allowing them to push the risk of feedstock supply onto another entity.

If the supply company serves multiple biorefineries in relatively close proximity, this model offers some risk mitigation by allowing the supply company to move biomass from one biorefinery's area to that of the adjacent biorefinery if necessary. This same type of risk mitigation could also be practised by a biorefinery company running multiple refineries in the same area.

All of the issues discussed above exist whether the contemplated feedstock is agricultural residues or dedicated energy crops (less so for forest residues or waste products such as urban wood waste or municipal solid waste).

Energy crops, while superior in other regards (harvesting and transportation costs, opportunity for composition optimisation, etc), have additional issues related to feedstock availability. Namely, there is limited information about which are the optimal species and varieties to grow in a given location and what the optimal growing practices would be in that location to ensure successful stands and maximum yields. For many energy crops, there may also be issues with limited seed availability and questionable seed quality.

These crops simply do not have the benefit of the long

### CERES' POLICY PRIORITIES FOR US ENERGY CROPS

- Support pilot and demonstration programmes, allowing growers to gain experience with dedicated energy crops and more information to be gathered on optimal management, harvesting, transportation and storage practices.
- Create a transitional assistance programme to compensate growers for opportunity costs associated with low first-year yields from perennial dedicated energy crops.
- Ensure that dedicated energy crops are not disadvantaged relative to traditional commodity crops in terms of crop insurance and other federal risk management programmes.
- Make available grants, loans and loan guarantees to facilitate the construction of the first generation of cellulosic biorefineries coupled with incentives for them to begin using dedicated energy crops as feedstocks.
- Create a matching programme to create incentives for growers to begin growing dedicated energy crops by providing payments that match the per tonne payments they receive from the biorefinery.

history of improvement and knowledge development that has accompanied our more traditional crops. In some ways this is good news, because the opportunities for improvement are therefore that much greater.

As it relates to risk mitigation, though, this lack of knowledge is pushing leading biorefinery companies in the direction of working directly with energy crop companies that can help them to answer questions of optimal variety mix and growing practices for their particular location and provide an assured supply of high quality seed.

Many approaches already exist to help offset or manage the risks associated with feedstock availability. As the industry continues to mature, additional approaches will develop and all will become more sophisticated. Careful consideration of how to manage these risks will be essential for maximising biorefinery profits.

## FEEDSTOCK COST DOMINANT

In mature fuel and bulk chemical industries, feedstock often represents 50% or more of the total cost of the finished product. This is true for petrol and for ethanol derived from maize starch and it will be true for cellulosic biofuels as well. As a result, reductions in delivered feedstock cost can have a large impact on total production cost, either through a lower cost of harvest and transport per tonne or a lower grower payment per tonne.

Harvesting and transportation costs for biomass can easily be as much as $25/t, which translates roughly to $0.25–0.42/gallon ($0.07–0.11/litre) of biofuels depending on the efficiency of the conversion process being used.

The best way to minimise harvest and transport costs for a given scale of biorefinery is to maximise biomass yield/hectare. This reduces transportation costs because the biorefinery can get the amount of feedstock it needs within a smaller radius and thus have a shorter average transport distance (Figure 1). Harvesting costs are also reduced by higher yields because the total cost of running harvesting equipment through the field is increased relatively little as yield increases, but the total harvest cost can now be allocated over more tonnes.

Higher biomass yields also mean more farmer income per hectare and greater net profit both per hectare and per tonne. This is because the marginal cost of producing an additional tonne of biomass on a given hectare is tiny relative to the fixed costs of production per hectare.

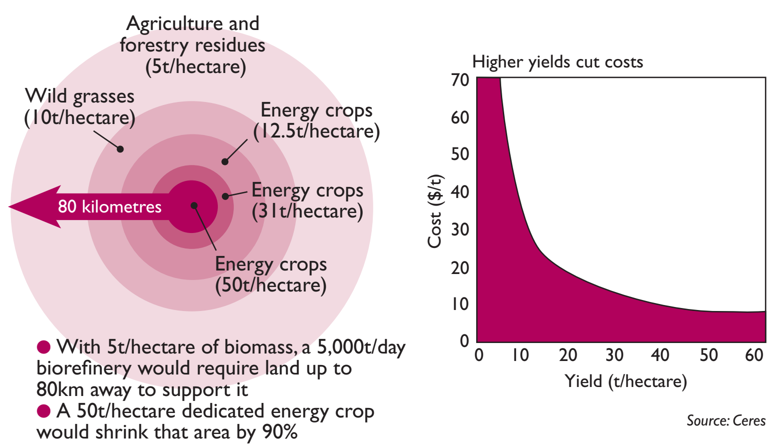
Some of this increased profit margin will be captured by the seed provider supplying the higher-yielding varieties, some will be captured by the grower and some will be passed on to the biorefinery in the form of a lower grower payment per tonne of biomass.

Traits other than yield improvements can also have a positive effect on net profit per tonne by reducing production costs. Drought tolerance can reduce or eliminate irrigation costs on some acres. Nutrient use efficiency can reduce both the amount spent on inputs themselves and the amount spent on applying them.

Lower input requirements also improve the net energy ratio of crops (renewable energy generated divided by fossil fuel energy required). As we move towards a greater focus on greenhouse gases and carbon sequestration, this benefit may be able to be monetised through aggregation of carbon credits, etc. It may also be possible to monetise increases in root biomass and thus below-ground carbon sequestration.

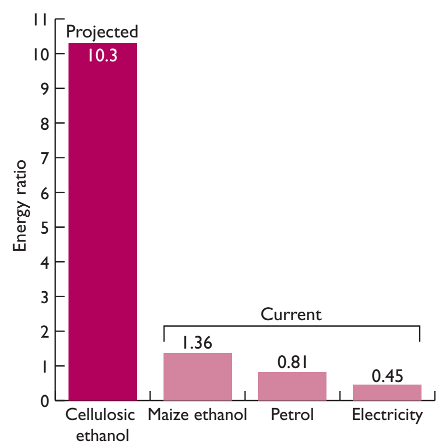
Advanced breeding techniques and biotechnology are being used to bring about significant improvements in biomass crop yields and reductions in production costs. Developments in markets and legislation related to greenhouse gases and carbon sequestration could provide additional revenue streams to growers (Figure 2).

**Figure 1. Better crop yields reduce feedstock costs**




*Source: Ceres*

**Figure 2. Energy balance ratio (energy delivered to customer/fossil energy used)**




*Source: Biofuels Joint Roadmap, June 2006, US Department of Energy, data derived from Brinkman et al 2005*

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All of these could translate into reductions in delivered feedstock costs as some of the grower's increased profit margin is shared with their customer, the biorefinery. This reduction, coupled with savings on harvest and transport costs generated by higher yields could amount to significant decreases in the total production costs of biofuels.

## QUALITY AFFECTS ECONOMICS

Different processes have different feedstock quality requirements, but optimising feedstock composition can have a dramatic effect on the economics of all processing technologies.

For biochemical processes, features such as total fermentable sugars and ease of conversion under less extreme pre-treatment conditions or with lower enzyme concentrations are critical. For thermochemical processes, issues of feedstock density, moisture content and ash content are more important.

All of these characteristics can be addressed through careful selection of appropriate species and varieties, optimal management practices including harvesting, transportation and storage and feedstock improvement through breeding and biotechnology.

Selection of optimal species and varieties offers perhaps the greatest potential for optimising feedstock composition and quality. Growing location and management practices can also have significant impact. High-silica soils, for instance, can affect ash content and ash melting point. Harvest timing and harvest height can affect moisture content, ash content and overall composition.

Typically biorefineries, whether biochemical or thermochemical, will prefer a more homogenous feedstock. Greater homogeneity allows for greater optimisation of the process for the feedstock and thus higher biofuel yields.

Given the benefit of using multiple varieties and/or multiple species around a biorefinery for risk mitigation, though, the biorefinery can run multiple 'campaigns'. Each campaign consists of a specific, homogenous feedstock coupled with the appropriate optimised process conditions.

As the cellulosic biofuels industry matures, energy crop varieties will be selected not just for yield, yield stability and suitability for a given geography, but also on the basis of their suitability for a particular conversion process.

A biorefinery may choose to control its feedstock quality through purchasing seed of preferred varieties directly from seed companies and supplying these to growers as part of their contracts. It may choose to specify in its contracts with growers one or more varieties that it deems acceptable. Or, it may simply pay different rates per tonne for different levels of feedstock quality.

There are significant opportunities for optimisation of feedstock composition and thus improvement of biorefinery economics through breeding and biotechnology. Increasing fermentable sugars for biochemical processes or energy content for thermochemical processes enables more biofuels to be generated per tonne of biomass. This means the same size biorefinery can produce more biofuels, which reduces capital expenditure per litre of capacity.

Feedstock availability, cost and quality are all critical issues

Reducing the severity of pre-treatment or the enzyme concentrations required for conversion can lower operating expenditures per litre of biofuels derived from biochemical processes. Improving ash content and composition can have a similar effect for thermochemical processes.

Use of optimised feedstock offers significant cost advantages for all processing technologies. As the industry matures and more optimised feedstocks become available, companies that have invested in understanding and gaining access to optimised feedstock for their processes will benefit.

Relative to other segments of the value chain, feedstock and the potential for feedstock improvement have thus far received relatively little attention and support. Nevertheless, feedstock availability, cost and quality are all critical issues for commercial operations.

The opportunities for improving the overall economics of cellulosic biofuels through risk management and feedstock improvement are significant. The technologies required to drive feedstock improvements are available and being deployed to meet these challenges.

As the industry wakes up to the opportunities and challenges surrounding commercial-scale operations, biorefinery companies that carefully consider the risks and exploit the opportunities associated with feedstock will have a decided advantage over those that do not.

*Anna Rath is director of business development at energy crop company Ceres. E-mail: arath@ceres-inc.com*