

Minimum selling price (MSP) calculation

Here, we show a detailed MSP calculation for the basic design (corn stover feedstock with xylose burning case) as an example. To determine the MSP of butene oligomers, biofuel revenue (BR) from the sales of these biofuel components should be determined at the breakeven point where total revenues and total costs are equal. For the basic design, total revenues include the revenues generated from biofuel and excess electricity sales, whereas total costs include operating costs, return on investment and income tax.

After performing a detailed power cycle analysis, electricity revenue (ER) from the excess electricity sales is found to be \$28.2 MM/yr as given in Table 5. Hence, the only unknown component of the revenues is the biofuel revenue (BR).

The cost components are as follows;

- Operating costs (OC): \$85.6 MM/yr (Table 4)
- Return on investment (ROI) depends on the total project investment (TPI) (\$487 MM), the discount rate (DR) (6.74%) and the equipment life span (ELS) (20 years).

$$ROI = \frac{DR \times (1 + DR)^{ELS}}{(1 + DR)^{ELS} - 1} \times TPI \quad ROI = \$45 \text{ MM/yr}$$

- Income tax (IT) is calculated by the following equation by assuming that the tax rate (TR) is 35%.

$$IT = TR \times (BR + ER - OC - DC)$$

where DC (\$21.4 MM/yr) is the depreciation cost of unit equipments assuming a 7-year depreciation period for the process equipments and a 20-year period for the power generation unit.

$$IT = 0.35BR - 27.6$$

At the breakeven point, total costs should be equal to total revenues.

$$BR + ER = OC + ROI + IT$$

$$BR + 28.2 = 85.6 + 45.0 + 0.35BR - 27.6$$

$$0.65BR = 74.8 \Rightarrow BR = \$115.1 \text{ MM/yr}$$

The technoeconomic evaluation of this process is based on a lignocellulosic ethanol production process presented in the literature (Kazi *et al.*, 2010). The amount of butene oligomers produced should be expressed in terms of ethanol equivalent according to energy density of the products. In the ethanol process, 53.36 MMgal/yr of ethanol is produced; the product energy content is 4.48 TBtu annually by assuming a higher heating value (HHV) of 1.3 MBtu/kmol. In our process, 720,000 kmol of butene oligomers are produced annually. By assuming a HHV value of

2.57 MBtu/kmol, the energy content of biofuel components produced annually is found to be 1.85 TBtu per year, which is 41.3% of that of the ethanol production process. Using this ratio, total annual product energy of our process in terms of ethanol equivalent is calculated to be 22 MMgal/yr. Since the biofuel revenue of our process is \$115.1 MM/yr, the MSP of butene oligomers is \$5.23 per gallon of ethanol equivalent. Given that the energy densities of gasoline and ethanol are 133.8 MJ/gal and 88.6 MJ/gal respectively, the MSP of butene oligomers is found to be \$7.90 per gallon of gasoline equivalent (GGE).

Reference:

F. K. Kazi, J. A. Fortman, R. P. Anex, D. D. Hsu, A. Aden, A. Dutta and G. G. Kothandaraman, *Fuel*, 2010, **89**, S20-S28.