

## Estimates of critical loss thresholds for Terra CO<sub>2</sub> plants at Billingham and Severnside

### Introduction

1. This appendix provides estimates of the critical loss of business necessary to render an increase in ex-works prices for CO<sub>2</sub> at Terra's Billingham and Severnside plants unprofitable. This analysis is preformed for a series of illustrative price rises.
2. The purpose of this analysis is to assess the level of spare capacity at Ince, which may be lost as a result of the merger, in the context of the critical loss of business to Terra. For example, were we to find that the level of capacity at Ince was insufficient to constrain the pricing of Terra at Severnside and/or Billingham, this may indicate that the competitive interaction between Kemira and Terra pre-merger in the supply of CO<sub>2</sub> to distributors in the UK was limited.
3. The question of how much capacity is enough to constrain Terra at Severnside and Billingham depends critically upon the price cost margin at each site.
4. A price rise is profitable if and only if the net revenue increase as a result of a price rise, plus any cost savings, is greater than zero. To assess this we use the *critical loss* formula.
5. For constant marginal costs, it can be shown that the *critical loss* for a  $t$  per cent price increase is:

$$(\Delta q/q) \geq t/(m + t)$$

where  $m = (p - c)/p$  is the initial percentage margin.

6. To calculate the critical loss threshold we need three pieces of information:
  - the current price (ex works) ( $p$ );
  - the level of avoidable costs ( $c$ );<sup>1</sup> and
  - the current level of output ( $q$ ).
7. Once the *critical loss* threshold has been calculated, in order to evaluate the profitability of a potential price rise there also needs to be an assessment of the *actual loss* in sales that would be likely to occur in the event of that price rise.
8. In this case, we do not have sufficient information to estimate the elasticity of demand and so cannot estimate directly the likely actual loss as a result of a price rise. However, a more limited assessment of the likelihood of the actual loss being greater than the critical loss is possible by assessing the level of spare capacity among the parties' competitors. Even if customers are price sensitive and would be willing to switch in the event of a price rise, their ability to do so may be constrained if rival suppliers do not have sufficient capacity to supply them.

---

<sup>1</sup>Avoidable costs are defined as those costs that would not be incurred for a given reduction in output volume.

9. If the level of capacity available among the parties' competitors is smaller than the *critical loss* threshold, then we can infer that the *actual loss* as a result of a price rise is likely to be lower than the *critical loss* threshold and that the price rise is likely to be profitable. However, if the level of capacity is larger than the critical loss threshold, this does not necessarily mean that a price rise would not be profitable.<sup>2</sup>
10. It is important to note that by definition, when assessing the profitability of a price rise for an individual firm, pre-merger the actual loss will exceed the critical loss and price rises will not be profitable. If this were not the case, then the supplier in question would have been forgoing a profitable opportunity to raise prices, which would indicate that that firm is not profit maximizing.

### The critical loss thresholds

11. The parties submitted sales data, from which we calculated their current levels of output and current average prices for CO<sub>2</sub>. In addition, Terra submitted information regarding its fixed and variable costs of production at Billingham and Severnside. We used Terra's estimates of variable cost as our measure of avoidable cost. The costs that would be avoided at each plant for a 1-tonne reduction in output were as follows.

TABLE 1 Avoidable costs at Billingham and Severnside, YTD December 2006

Cost item	£ per tonne	
	Billingham	Severnside
Raw materials—other CO <sub>2</sub>	( )	)
Electricity		
Steam		
Water		
<b>Total avoidable cost</b>		

Source: Terra.

12. The critical loss thresholds for a 5 and a 10 per cent increase in price are shown in Table 2.

TABLE 2 Estimates of Terra critical loss thresholds for a 5 and 10 per cent price rise

	Volume (tonnes) (1)	Ex-works selling price (p) (£/t)	Avoidable cost (c) (£/t) (2)	Gross margin (£/t)	Gross margin (p-c/p) (%)	Critical loss (%)	Critical elasticity*	Critical loss volume
<b>5% price rise</b> [✂]	( )	)	)	✂	)	)	)	)
Terra Billingham								
Terra Severnside								
Total Terra								
<b>10% price rise</b> [✂]	( )	)	)	✂	)	)	)	)
Terra Billingham								
Terra Severnside								
Total Terra								

Sources: (1) 2006 sales data submitted by Terra, 13 April 2007. (2) Cost data submitted by Terra.

\*Constant elasticity assumption.

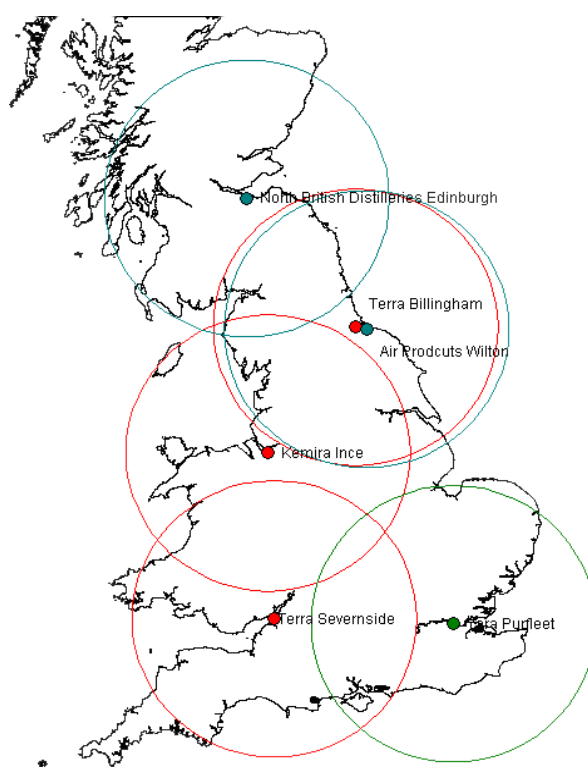
<sup>2</sup>This would require an estimate of the elasticity of demand.

## Pre-merger constraints

13. The Kemira/Air Liquide facility at Ince produced [X] tonnes of CO<sub>2</sub> in 2006. The total capacity of the facility is approximately [X]<sup>3</sup> tonnes giving an approximate level of spare capacity at Ince of [X] tonnes. From this, we can conclude that in 2006 the level of capacity at Ince was sufficient to potentially constrain the ex-works pricing of Terra's plants at Billingham and Severnside pre-merger at least for price rises up to 15 per cent.<sup>4</sup> This would be true for an individual price rise at each plant, or alternatively for a simultaneous price rise at both plants.
14. Ince is not the only potential alternative that distributors may seek to switch to. Figure 1 shows that, based on an illustrative 100-mile radius, Billingham would potentially be constrained by plants at Ince, EDL at Edinburgh, Air Products at Wilton and possibly by Yara at Teesside, although this is predominantly an export terminal.<sup>5</sup>

FIGURE 1

### Illustrative delivery and collection radii for UK sources of CO<sub>2</sub>



Source: CC.

15. Figure 1 also shows that the Terra plant at Severnside would potentially be constrained by the Ince facility and Yara at Purfleet.
16. Table 3 shows CC estimates the level of spare capacity at each source of CO<sub>2</sub> in 2006 based on third party responses.

<sup>3</sup>Source: Air Liquide & Kemira. Based on [X] days of operation per year at [X] tonnes per day.

<sup>4</sup>The critical loss threshold for a 15 per cent combined price rise by Terra is [X] tonnes.

<sup>5</sup>Because there is a degree of geographic overlap between these plants, distributors can potentially choose between these sources of CO<sub>2</sub> to supply their customers located within the areas of overlap.

TABLE 3 Rival suppliers' spare capacity, 2006

Supplier	Output 2006 (tonnes)	Stated total capacity (tonnes)	Spare capacity (tonnes)
Yara Teesside Yara Purfleet Air Products Wilton NBD Edinburgh		×	

Source: CC estimates based on third party responses.

Note: Yara output figures are net of exports.

17. As Table 3 shows, pre-merger the available capacity at Purfleet was insufficient to constrain the pricing of Terra at Severnside. Yara had spare capacity of around [×] tonnes at Purfleet, which is smaller than the critical loss threshold at Severnside of [×] tonnes. It would therefore seem that Ince was potentially an important constraint on the ex-works pricing of Terra at Severnside.
18. At Billingham, distributors potentially have the choice of NBD Edinburgh, Air Products Wilton and Yara Teesside; as well as Ince. The combined capacity of NBD Edinburgh, Air Products Wilton and Yara Teesside in 2006 was [×], which would be sufficient to allow distributors to inflict a critical loss on Terra for both a 5 and a 10 per cent price rise. However, the majority of that capacity is accounted for by Yara, with [×] at Wilton and [×] tonnes at NBD Edinburgh. As discussed in Appendix F, additional supplies via Yara appear to carry a significant extra cost. It would therefore seem that pre-merger, the Ince facility was an important constraint on Terra pricing at Billingham.

## Summary

19. In summary, it appears that the Kemira/Air Liquide facility at Ince in Cheshire had sufficient capacity potentially to impose a significant constraint on the behaviour of Terra pre-merger. There will remain additional potential constraints on Terra's pricing post-merger. However, it would appear that these would have been insufficient to constrain the pricing of Terra in themselves pre-merger. This raises the possibility that the removal of Ince as an alternative source of CO<sub>2</sub> may allow the joint venture to raise prices post-merger.