Switching from packaged chlorine to different water disinfection methods

1. In this appendix we present evidence on switching from packaged chlorine to alternative water disinfection methods.[1]

Different water disinfection methods

2. Table 1 describes the different types of water disinfection methods available and Table 2 lists some of the major trade-offs associated with various disinfection technologies.

TABLE 1 **Description of different types of water disinfection methods**

Chlorine gas	Also known as elemental chlorine, is a powerful oxidizing and disinfecting agent that is transported and stored as a liquefied gas under pressure. Water treatment facilities typically use chlorine in cylinders or drums. Some large systems use bulk.
Chlorine dioxide	A powerful disinfectant and oxidizer generated on-site. Although it contains chlorine atoms, it disinfects through a different mechanism to that of chlorine.
Ozone	A powerful oxidizing and disinfecting agent generated on-site by passing oxygen or dry air through a system of high voltage electrodes.
Sodium hypochlorite (often referred to as liquid bleach)	A chemical compound used to add chlorine to water. It is transported and stored in solutions containing 5 to 20 per cent chlorine. It can be generated on site, but is more commonly shipped by truck in containers.
Ultraviolet (UV) light	Generated by special lamps. It disinfects by penetrating the cell wall of an organism and hindering its ability to reproduce.

Source: American Chemistry Drinking Water Chlorination: A Review of Disinfection Practices and Issues Report.

[1] Water disinfection is only a concern for water companies and not for industrial customers.

TABLE 2 **Comparing disinfectants**

Disinfectant	*Advantages*	*Limitations*
Chlorine gas	—Highly effective against most pathogens —Provides 'residual' protection required for drinking water —Operationally the most reliable —Generally the most cost-effective option	—By-product formation —Special operator training needed —Additional regulatory requirements —Not effective against Cryptosporidium
Chlorine dioxide	—Effective against Cryptosporidium —No formation of THMs, Haas —Provides better taste and odour control than chlorination	—By-product Formation (chlorite, chlorate) —Requires on-site generation equipment and handling of chemicals —Generally higher cost than chlorine
Sodium hypochlorite	—Same efficacy and residual protection as chlorine —Fewer training requirements than chlorine —Fewer regulations than chlorine	—Limited shelf-life —Same by-products as chlorine gas, plus bromate and chlorate —Higher chemical costs than chlorine —Corrosive; requires special handling
Ozone	—Produces no chlorinated THMs, Has fewer safety regulations —Effective against Cryptosporidium —Provides better taste and odour control than chlorination	—More complicated than chlorine or UV systems —No residual protection for drinking water —Hazardous gas requires special handling —By-product formation (bromate, brominated organics and ketones) —Generally higher cost than chlorine
Ultraviolet	—No chemical generation, storage, or handling —Effective against Cryptosporidium —No known by-products at levels of concern	—No residual protection for drinking water —Less effective in turbid water —No taste and odour control —Generally higher cost than chlorine

Source: American Chemistry Drinking Water Chlorination: A Review of Disinfection Practices and Issues Report.

3. In designing a disinfection system, a treatment facility must consider a number of factors, including efficiency against pathogens; regulatory compliance; reliability of disinfection system; safe and easy shipping, storage and handling of disinfectants; potential hazards to people and the environment from chemicals and equipment; potential to form disinfection by-products; and affordability (considering capital investments and costs).

4. The considerations for wastewater treatment are different from those for drinking water treatment and no single disinfection method is right for all facilities. While the regulation sets minimum standards for microbial protection and limits levels of disinfection by-products in drinking water, the Drinking Water Inspectorate (DWI) does not dictate which disinfection method to use. Decisions for individual facilities are made locally, based on local water quality conditions.

Sodium hypochlorite

5. Sodium hypochlorite, often referred to as liquid bleach, can be purchased in packages and can also be generated on site by the water companies through 'On-site Electrolytic Chlorination' (OSEC).[2] Below we distinguish between purchasing sodium hypochlorite and OSEC where appropriate.

Parties' views

6. The parties contended that sodium hypochlorite was packaged chlorine's closest substitute, based on its water-cleaning characteristics, the fact that some water utilities had switched to sodium hypochlorite from chlorine (examples of historical switching have been provided), and because sodium hypochlorite was said to be safer to handle than packaged chlorine.

7. Ineos Chlor, however, told us that the decision to switch to sodium hypochlorite could not be made overnight. It said that when looking at the formal hypothetical monopolist test, a 5 or 10 per cent price increase in packaged chlorine would not cause enough customers to switch away to sodium hypochlorite but that there was a trend to move away from chlorine for reasons other than price.

Third-party evidence and views

8. We received evidence from customers in hearings and submissions on past switching to sodium hypochlorite.

9. Third parties told us that sodium hypochlorite was technically a viable substitute for chlorine: it achieved the same result. However, the key question for us is whether it is a competitive constraint. In the absence of estimates for own-price and cross-price elasticity of demand from the parties, we considered evidence on customer

behaviour before looking at price differentials and switching costs to help judge how likely it was that a small but significant non-transitory increase in price would induce switching.

10. We reviewed evidence provided by customers on their past switching behaviour. We found that switching was *not price driven*. It has been driven by non-price factors, such as health and safety, increased regulatory compliance and planning restrictions issues. This was a consistent finding from all customers. Customers also told us that sodium hypochlorite was not practical to use at all sites (for example, remote sites) as the chlorine content (approximately 14 to 15 per cent) deteriorates over time and concentration levels need to be maintained, a process that requires site visits.

11. Further, all customers that responded to our questionnaire told us that they would not switch to alternative disinfectant methods (including sodium hypochlorite) if the price of packaged chlorine increased by 5 to 10 per cent.

Differentials in price and switching costs

12. According to the parties and customers, sodium hypochlorite is more expensive than chlorine (see Table 3). Ineos Chlor told us that sodium hypochlorite was not sold in cylinders and that therefore we should only compare drums, whilst BOC told us that the cost differential in cylinders was only 8.5 per cent, which provided scope for substitution. Some customers estimated that sodium hypochlorite was around three times as expensive to achieve the same level of disinfection, which was consistent with the data provided by BOC. We consider that the price differential alone does not provide scope for switching away from packaged chlorine.

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[2]Onsite electrolytic chlorination systems produce sodium hypochlorite on demand, on the spot through the electrolysis of a brine solution.

TABLE 3 **Comparison costs of treating the quantity of water achieved with one package of chlorine**

	Price per unit *£*	*Volume required*	*Total cost* *£*
Cylinder—chlorine	[✂]	[✂]	[✂]
Cylinder—sodium hypochlorite	[✂]	[✂]	[✂]
Drum—chlorine	[✂]	[✂]	[✂]
Drum—sodium hypochlorite	[✂]	[✂]	[✂]

Source: The parties' response to our questionnaire.

Note: Due to physical constraints we consider that it is only appropriate to compare drums with drums and cylinders with cylinders.

13. We were also told that water companies would derive some cost savings from switching to sodium hypochlorite from chlorine, for example there was no requirement for maintenance of breathing apparatus and insurance premiums would be reduced since a dangerous gas (chlorine) was not being stored.[3] The only piece of customer evidence that demonstrated that these benefits were non-trivial, and that contradicted the majority of customers who said sodium hypochlorite was more expensive, was that [one customer] told us that it found the conversion to sodium hypochlorite to be cost neutral.

14. We found that there was a fixed conversion cost associated with switching, including a change in dosing equipment and the installation of bulk tanks or an OSEC plant. Cost estimates varied. [One customer] told us that switching would be costly as it would require extensive engineering effort, plant redesign and change to processes. BOC estimated that the cost for a water treatment facility using the equivalent of 8 tonnes a year was £30,000 to £40,000. [A second customer] told us that it cost £1 million to replace chlorine. [A third customer] told us that the capital investment for OSEC equipment was approximately £250,000 per site. [A fourth customer] told us that OSEC would provide the right quantities of chlorine but at a significant capital and operating cost. [A fifth customer] said that it would need to build dosing and

[3] [✂]

storage facilities and the cost of building these facilities would be in the millions of pounds.

15. We also considered whether a threat of long-term switching could, in theory, be a constraint on short-term pricing. Indicators that this is so would be evidence that the parties monitor the price of sodium hypochlorite, evidence customers have threatened to switch to sodium hypochlorite and evidence that the parties have responded to a threat of switching. We have not received such evidence. Both of the main parties told us that they had no information about price elasticities of demand. Further, BOC told us that it had relatively limited knowledge of the costs that would be involved in switching water treatment methods and Ineos Chlor did not provide any estimates. In terms of a credible threat at the tendering stage, customers told us that suppliers of sodium hypochlorite had never competed against packaged chlorine distributors during the tender process. The parties told us that sodium hypochlorite was a constraint at current prices but customers did not appear to be threatening to switch at the tendering stage at current prices.

Other disinfection methods (chlorine dioxide, ultraviolet light and ozone)

Parties views

16. The parties contended that other substitutes (such as chlorine dioxide, ultraviolet light and ozone) would continue to develop in the next five years.[4]

Third party evidence and views

17. There was some evidence that ultraviolet light and ozone disinfection methods are used by some customers at certain sites.[5] We are not aware of any customer using chlorine dioxide.

18. Customers told us that these alternative disinfection methods (ultraviolet light, chlorine dioxide and ozone) were not an absolute substitute[6] for chlorine. This was because they did not provide the necessary residual disinfection (ie a continuing presence of disinfectant in the water to ensure purity as it passes through supply pipes to consumers) and continued to require treatment with chlorine or sodium hypochlorite to maintain residual protection.

19. All customers that responded to our questionnaire told us that they would not switch to alternative disinfection methods in response to a 5 per cent increase in the price of chlorine.

Differential in price and switching costs

20. In terms of price differentials and conversion costs, we were told [✂] that even with a 10 per cent increase in chlorine prices, ozone would be more expensive than chlorine. One customer [✂] also told us ultraviolet light and ozone were more expensive to operate than chlorine gas or sodium hypochlorite. BOC told us that an ultraviolet installation replacing an 8-tonne chlorine installation cost £10,000 to £20,000 but no data for the running cost of ultraviolet light has been provided. Responses from two ozone suppliers also demonstrated limited substitution. [✂] told us that in the last two years it had not supplied any customers with ozone generation as a substitute for chlorine and [✂] focus is primarily swimming pool disinfection.

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[4]The parties initially told us that bromine derivatives were possible substitutes; however, they did not provide evidence to substantiate this. BOC told us that it believed the term covered any chemical compound which included the element bromine. Bromine derivatives are not routinely used for disinfecting water because of their taste, although they are used in emergencies. Ineos Chlor did not respond to the further information request.

[5][✂] uses UV and ozone. [✂] uses ozone. [✂] uses UV.

[6]Chlorine dioxide: [✂] said that there are potential problems with by-products.