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BENCHMARKING AND SECURITY OF SUPPLY IN THE UTILITIES SECTOR

In the utilities sector, integration of security of supply in benchmarking models could affect the incentive for monopoly companies to be economically efficient.

In Denmark and many other countries, benchmarking models are used to imitate competitive pressure which does not otherwise exist among natural monopoly companies in the utilities sector. The aim is to boost the incentives for companies to make cost-effective decisions.
At the same time, it is crucial that Denmark's high security of supply is maintained.

Security of supply is not directly included in the benchmarking models used. This working document highlights methodological issues with integrating security of supply into existing economic benchmarking. Such an integration can boost the incentive for companies to maintain a high security of supply, but could simultaneously weaken the utility companies' economic efficiency.

Read the full working paper on the next page. This working paper is the first in a series on the same topic.

This is the first working paper in a series on benchmarking in the field of utilities. During the period from 2019-2021, the Danish Water Regulatory Authority under the Danish Competition and Consumer Authority will carry out methodological analyses on the area of benchmarking. The results will be published on an ongoing basis.

Natural monopolies in the utilities sector

In Denmark, parts of the utilities sector are characterised by the companies being natural monopolies.[1] As opposed to well-functioning markets, the utilities sector is not exposed to a competitive pressure which leads to efficient operation, lower prices, better quality and innovation. Therefore, regulation is needed to ensure efficient operation and low prices for consumers and companies.

In both Denmark and abroad, benchmarking models are used in the regulation of utility monopolies (electricity, water, etc.) as a tool to imitate the otherwise lacking competitive pressure.

The benchmarking models compare the efficiency of the individual companies, and efficiency requirements are then imposed on the least efficient companies. These individual efficiency requirements are to incentivise the least efficient companies to make better use of their resources.[2]

In Denmark, we have a utilities sector with a high supply security. For example, in the water supply sector a high supply security reflects an insurance that the supplied water is subject to high health and environmental standards, see box 1. Among other things, the security of supply is guaranteed by minimum requirements set out by environmental regulation.[3]

In an ordinary benchmarking model which focuses solely on economic efficiency, companies have no economic incentive to achieve a higher security of supply than the minimum levels to be complied with. In this instance, the benchmarking model supports the notion that the centrally set minimum targets are achieved cost-effectively. Therefore, in the current benchmarking model, there is no contradiction between the desire for economic efficiency and the opportunities to be ambitious with regard to, for example, environmental protection by stepping up minimum legal requirements.

One option available is to integrate security of supply (possibly beyond a certain minimum level) as a separate target – in line with economic efficiency – in the benchmarking models. This would introduce a trade off in the sense that a utility company could have a lower economic efficiency requirement (i.e. it performs better under economic benchmarking) if it uses resources to achieve a level of ambition, in terms of security of supply, which is relatively high compared to other companies.

In this way, an integration of supply security in benchmarking models could boost the incentive for companies to provide a level of supply security which goes beyond any statutory minimum requirement. On the other hand, the overall pressure to improve efficiency is reduced in the utilities sector.

Box 1. **What is security of supply?**

In the utilities sector, security of supply has traditionally been measured as the average number of minutes that consumers are without their utility service. Nowadays, however, security of supply not only covers reliability of supply but also, for example, the quality of the utility service.

In the water sector, inadequate security of supply can, for example, lead to a boiling recommendation (inadequate quality) or may be caused by a burst pipe (absence of supply).

A recommendation to boil is issued when consumers are advised for a period to boil their water before use, for example before drinking or cooking.

A burst pipe affects the reliability of supply, as it causes stoppages. It can be both planned and unplanned, for example as a result of pipes being dug up or worn.

Security of supply in the water and waste water sector covers conditions which companies can influence, but also circumstances which they cannot or only partly influence. For instance, these could be conditions governed by the environmental regulation, with minimum requirements e.g. for environmental or health reasons, and others not.

Current benchmarking practice

In the economic regulation of the utilities sector, the most commonly used benchmarking models are Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The models have in common that they calculate the utility companies' efficiency, but they differ in the sense that the two models are subject to different characteristics.

1 This concerns the electricity, gas, district heating and water sectors.
2 In addition to the individual efficiency requirements set through benchmarking, general efficiency requirements are also imposed on all companies to reflect the overall productivity growth in comparable competitive sectors.
3 Energy Commission: Background note on security of supply (2016); Rambøll: Analyse af forsyningssikkerhed på vandområdet [Analysis of security of supply in the water sector] (2018).

The DEA model calculates companies' efficiency by comparing the inefficient companies with the most efficient companies in the sector.[4] On the one hand, the DEA model has the advantage, when compared with the SFA model, that fewer assumptions about the underlying production function are made. On the other hand, the model has the drawback that observational errors in data for the most efficient companies can lead to an overestimation of the efficiency potentials of the other companies.

As opposed to the DEA model, the SFA model more explicitly takes into account that there may be observational errors or defective data. Therefore, the calculation of the companies' efficiency needs to be corrected for any such observational errors in the SFA model. The SFA model has the drawback that more assumptions are made than in the DEA model. Furthermore, the SFA model can in practice be difficult to set up as it must meet a number of statistical conditions. By contrast, the SFA model is more accurate than the DEA model when these assumptions are otherwise met.[5] As there are different advantages and disadvantages with the two benchmarking methods, both models are used to assess the efficiency potentials in the water sector.

The following section focuses on some of the challenges that may be faced when incorporating security of supply into a DEA model.

The most efficient companies set the front
In the utilities sector, the input-orientated DEA model is themost commonly used since it is assumed that companies only can reduce their costs (input), since they do not have the opportunity to increase their supply volume (output). This assumption will be the starting point in the situation described below.

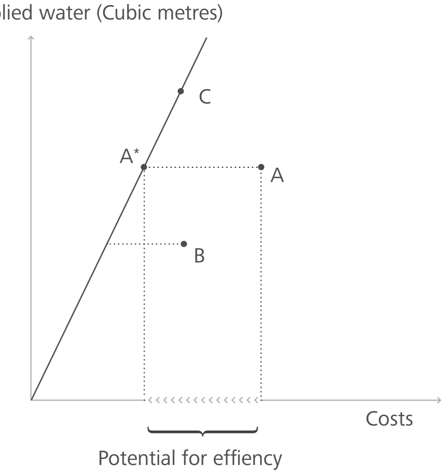
In a simplified example from the water sector involving three water companies (A, B and C), the efficiency of each company is calculated based on the ratio of their cost level (input) to the cubic metres of water they have supplied (output). A high value for this ratio reflects a low level of efficiency. It is the company or companies that achieve the highest efficiency, which sets the front.

It can be seen from figure 1 that Company C is the most efficient company since it has the lowest cost per cubic metre of water supplied.

Companies A and B are not as efficient as Company C. This means that Companies A and B have the same or higher costs than Company C, and that they both have lower water production than Company C. Therefore, Companies A and B are located in the figure to the right of the frontline. Companies which are to the right of the frontline have efficiency potential.[6]

Therefore, Companies A and B could reduce their costs to become as efficient as Company C. This is illustrated in Figure 1 for Company A, where the horizontal distance between Company A and the frontline corresponds to the company's efficiency potential. Point A reflects the company's current efficiency, whereas point A*   reflects Company A's actual cost level. Company A can therefore reduce its cost per cubic metre of water to achieve point A', where the company would be as efficient as Company C.

Figure 1
Frontline in DEA model with one output



Source: Own production.

This is a simplified example compared to the benchmarking, which is actually done today, since the efficiency of the suppliers in the example is based only on their cost-effectiveness for one parameter: Amount of water supplied.

In practice, benchmarking of the utilities sector takes into account the fact that different framework conditions exist when, for instance, supplying water.

DEA model with security of supply
When security of supply is included in the DEA model, this affects the results of this input-orientated model. Security of supply can be considered as an additional output parameter, so that the model is now expanded to include two output parameters: Water supplied and security of supply.

4 Read more at: www.kfst.dk/media/54238/dea-modellen.pdf
5 Bogetoft & Otto: Benchmarking with DEA, SFA, and R. (2011).

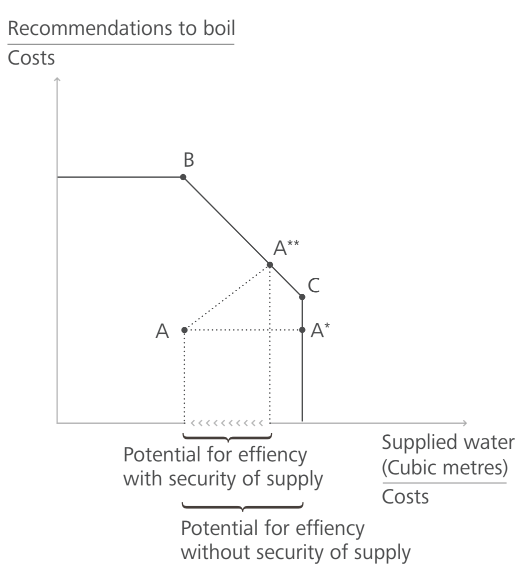
6 In practice, companies' revenue caps also have an impact on the efficiency requirements set. This working paper simplifies the potential for situations where a company is not on the frontline.

Security of supply can be calculated in various ways, cf. Box 1. The following calculation assumes that security of supply can be measured by the absence of recommendations to boil. In this case recommendations to boil indicate the annual number of hours without consumers being advised to boil their water before use.

Both of these output parameters enable the DEA model to maximise the companies' efficiency based on an individual combination of cost efficiency with regard to supplying water and the recommendation to boil respectively.

This is illustrated in Figure 2, where the two axes show the production of water divided by each company's (total) costs and the production of security of supply (recommendation to boil) also divided by each company's costs. The figure includes the same three companies (A, B and C) as in Figure 1, but Figure 2 differs by including information on the companies' security of supply given the companies' cost level.

Figure 2
DEA with two outputs and few companies



Source: Own production.
Note: Notice that the Y axis indicates the number of hours without a recommendation to boil divided by the costs.

Figure 2 shows that Company C still supplies the most water, given its cost level. Therefore, Company C continues to set the frontline. In this example though, Company B has the highest number of hours without a recommendation to boil, given its cost level. This means that Company B is the company which delivers security of supply in the most cost-effective manner. Therefore, Company B now joins Company C in setting the actual frontline. When security of supply is included in the benchmarking, there is no longer any efficiency potential for Company B. The company's efficiency requirement is reduced because it has a high security of supply.

Company A is not the most efficient either in terms of producing water or security of supply. Therefore, Company A still has potential for efficiency improvement. However, Figure 2 illustrates that Company A's efficiency potential in comparison to the previous example without security of supply is reduced in the situation where security of supply is included as an output parameter.

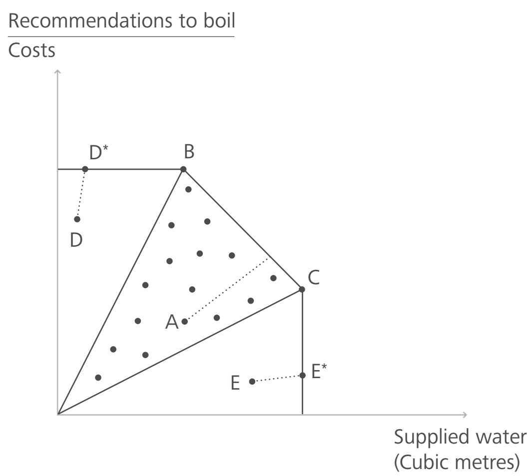
In the example without security of supply, Company A must reduce its costs, which corresponds to the distance between points A and A*, cf. Figures 1 and 2. This is because Company A only had the opportunity to minimise its costs per cubic metre of water supplied.

In Figure 2, where security of supply is included, Company A is identified as having a smaller efficiency potential, given the distance between points A and A**. This is because the company can achieve the same efficiency as Companies B and C by a (convex) combination of reducing its costs per cubic metre of water supplied and per hour without a recommendation to boil, respectively. Although Company A is not among the most cost-effective in terms of either water supplied or recommendation to boil, the company still experiences a reduction in its efficiency potential when security of supply is included in the DEA model. Thus, the overall efficiency pressure in the sector is being eased.

Figure 3 is a continuation of the example from Figure 2, but now includes more companies. The figure shows how all companies, with the exception of Companies D and E, are compared against the frontline, which is the distance between points B and C. Company D does not produce much water relative to its costs, but on the other hand, it is among the companies where the number of hours without a recommendation to boil is high relative to the costs.

This combination means that the company cannot be compared against the same frontline as the other companies. Therefore, the DEA model has calculated a trade-off between a recommendation to boil and water supplied, which places the company outside the black markings. This means that the model has ignored the company's economic performance in terms of water supplied in favour of a recommendation to boil when determining the potential for efficiency improvement. As a consequence, Company D can only achieve a higher efficiency by reducing its costs for recommendations to boil. This corresponds to company D going from point D to D*.

Figure 3
DEA with two outputs and many companies



Source: Own production.

Figure 3 shows the special case where Company D can completely choose to ignore its cost-effectiveness in terms of water supplied. In theory, Company D does not have any incentive to improve its cost-effectiveness in terms of water supplied, as it does not achieve a higher efficiency hereby in the DEA model. In contrary, this gives rise to the case where the DEA model could boost Company D's incentive to improve its cost-effectiveness in terms of recommendations to boil, but at the same time lower the incentive to streamline the costs of supplying water.

In Figure 3, the model will not ”penalise” Company D for weakening its position in terms of the cost-effective supply of water, as the model does not identify potential for efficiency improvement in water production. This means that the overall efficiency pressure in the sector is reduced, resulting in a situation where the efficiency potential does not benefit consumers. This could be in the form of lower supply prices.

Figure 3 also illustrates the opposite situation where a company has no incentive to become more efficient by raising the level of security of supply. Company E could reduce its potential for efficiency improvement by moving to point E*. This amounts to the company supplying water in a more cost-effective manner regardless of how efficient it is at providing security of supply. In points E and E*, the model will not ”penalise” Company E if it delivers security of supply in a less cost-effective manner, even though security of supply is included as an output parameter in the DEA model.

What importance should be attached to security of supply?

The examples in Figures 2 and 3 illustrate that when security of supply is integrated into a DEA model as a standalone output parameter all else being equal, it will result in more companies being identified with a higher efficiency level. This reduces the overall pressure to improve efficiency in the sector. Conversely, some companies may appear inefficient in the benchmarking when security of supply is not taken into account. This would be the case if there are companies who aspire to a higher level of security of supply than other companies (beyond any statutory minimum) and therefore also have higher costs.

As mentioned, the example from Figure 3 includes security of supply and water production as two separate output parameters. These two output parameters are technically equal in the sense that one does not have a higher value attached to it than the other parameter. If the regulator is aware of the value attached by water consumers to security of supply in relation to water consumption (e.g. measured by willingness to pay), benchmarking could be done with a single total output parameter instead of two separate output parameters.

The total output would simply amount to the total value of water consumption and security of supply.

If the total output is used in benchmarking, the calculation of the companies' efficiency would take into account the importance which water consumers attach to security of supply.

However, such an approach requires that the willingness to pay for security of supply is estimated. In Denmark there are various estimations of supply security in the water sector, but no one is aware of any similar estimations about the willingness to pay for increased security of supply. At the moment, it is therefore hardly possible to base the weighting given to security of supply in the benchmarking model on the willingness to pay of water consumers.

Benchmarking with minimum requirements for security of supply

If security of supply is included as an additional output parameter in a DEA model, this does not necessarily guarantee that a higher security of supply will be achieved. This was illustrated by Figure 3, where Company E could end up on the frontline by becoming more efficient at supplying water, without becoming more efficient in terms of providing security of supply.

If all the companies are close to Company E, they will not have an incentive to increase their efficiency in terms of providing security of supply. In that case, there is no incentive to achieve a higher level of security of supply.

Instead of this, a given level of security of supply can be safeguarded by established minimum requirements for security of supply in all companies. This is reminiscent of the regulation which is already currently in place, where a number of limits in the environmental regulation need to be observed. For example, pesticides must not be detected above a certain threshold value in drinking water.

There is no contradiction between economic benchmarking and security of supply requirements. Minimum security of supply requirements can be seen as a framework condition with which all companies must comply. Given this common framework, it is still possible to investigate whether some companies are not efficient during ”ordinary” benchmarking of the cost of supplying water or managing waste water.

It must be expected that minimum requirements for the security of supply level (or tightening of previous minimum requirements) will increase production costs for all companies which have not previously met the minimum requirement.

If the introduction of a higher minimum security of supply requirement leads to the same relative increase in costs for all companies, this will not affect benchmarking and efficiency requirements for the companies. This is because the costs for the companies in the frontline will increase just as much as the costs for the other companies. In this case, the individual efficiency requirements will remain unchanged.[7]

If more ambitious minimum requirements are introduced for security of supply, it may be necessary to lift the revenue cap for companies so that they have the opportunity to perform the new tasks.

Already nowadays, water companies, which are going to perform new tasks based on considerations such as environment or security of supply, are allowed to charge higher prices so that they have resources available to carry out these tasks. Therefore, the current benchmarking of companies provides a good opportunity to pursue politically-determined goals for security of supply and environmental protection.

Economic benchmarking combined with minimum security of supply requirements has the advantage that it can directly ensure a certain level of security of supply. However, as already mentioned, benchmarking will not reward companies providing security of supply at a higher level than the minimum requirement. On the contrary, the companies in question will appear less economically efficient. Thus, economic benchmarking with minimum requirements for security of supply does not necessarily incentivise individual companies to achieve a higher level of security of supply than the centrally-set minimum requirement.[8]

If, instead, security of supply is included as an additional output parameter in a DEA model (in a situation with no minimum security of supply requirements), it could provide an incentive for a higher level of security of supply. However, this means that the overall efficiency pressure is reduced. There is also a risk that the companies will not have any incentive to provide security of supply in a more efficient manner, cf. the example of company E in Figure 3.

Several parameters reduce efficiency pressure

This working document has described how incorporating security of supply into standard versions of a DEA benchmarking model can affect the measured efficiency of companies.

As there are currently no estimates regarding the consumers’ willingness to pay for better supply security, indicators for security of supply can be included as supplementary output parameters in the model. In the most commonly used DEA model, multiple output parameters will consequently lead to a higher efficiency calculation for more companies. In general, companies will find their efficiency unchanged or improved as the number of output parameters increases.

Therefore, the model identifies more companies as efficient, which overall reduces the efficiency pressure and can lead to higher prices for utility services.

Next step

The technical options for adding security of supply to a benchmarking model can also be considered in light of other more complex methods used in benchmarking. At the Danish Competition and Consumer Authority, we will be working on various possible solutions in the coming years, where we will address these more advanced benchmarking methods. In addition, we will explore the possibility of integrating security of supply directly into the companies’ operating and installation costs, which are currently included in the benchmarking.

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7 Natural conditions etc. may cause that some companies may find it more costly to comply with a higher security of supply level. However, this can be taken into account in the benchmarking. By analogy, benchmarking models currently used take into account the fact that it may be more expensive to supply water to citizens in sparsely populated areas.

8 Determining the proper health-related security of supply level is, in some cases, based on specialist knowledge in areas like risk assessment and epidemiological contexts. This suggests that it is still a central authority and not the individual utility companies which determines the appropriate level of security of supply parameters of this kind.