# 4 PROPOSED SOLUTION: BENCHMARK-AND-TRADE MODEL

## 4.1 Introduction

The previous chapters evaluate the situation of the electricity demand and efficiency in South Africa. Although the picture presented is rather dismal, there is scope for improvement at the economy-wide level as well as the sectoral level. This chapter presents the thesis' proposed solution to the problem of the high and increasing electricity intensity of the country: a sectoral benchmark-and-trade system.

Benchmark-and-trade systems aspire to steadily improve the participants' environmental performance by targeting certain indicators such as the greenhouse gas emissions (GHG) or particularly $CO_2$-emissions. They do so by awarding the successful participants with monetary incentives through trading with the less successful ones. As Fell, Mackenzie & Prizer (2008) state, from an economic viewpoint, these systems aim to internalise the externality of emissions by creating a market.

In the application of the proposed benchmark-and-trade system, the target indicator is the electricity intensity and the participants in the trading are various important sectors from both an environmental and an economic viewpoint. The purpose of this chapter is to present the theoretical system, discuss its characteristics in comparison with past international applications and illustrate, with examples, how the system would operate as well as its possible benefits or losses comparing it to the alternative of carbon tax.

The chapter proceeds as follows: Section 4.2 discusses the proposed theoretical mechanisms while Section 4.3 presents a few scenarios based on the implementation of different benchmarks for the initial phase of the programme under different price assumptions. Section 4.4 discusses the advantages of a benchmark-and-trade system to carbon tax; while Section 4.5 analyses whether or not the proposed system has all the desired characteristics to be successful. The final section summarises and concludes.

## 4.2 Theoretical system

Firstly, it is imperative to comprehend how a benchmark-and-trade system operates theoretically as well as to analyse its main elements, in order to be able to propose it for the South African case. Choosing the target indicator is the most essential decision for the future successful implementation of the system. As was discussed in the Chapter 2: Literature review, the majority of the previously used or proposed cap-and-trade systems, whether they are still in effect or not, aim at the reduction of different types of greenhouse gas emissions, such as $CO_2$ and $SO_2$.

With these indicators targeted, the systems deal with the harmful results of a specific action, that is to consume energy. Looking at the picture holistically however, it might prove more beneficial to target the cause behind the problematic conditions and not the results. In South Africa where the generation of electricity is in its majority dependent on coal burning, the main reason for the high emission levels is considered to be the consumption of electricity.

Taking this into account, the proposed system aspires towards the reduction of electricity consumption without ignoring the decisions regarding the participants' economic output. Hence, the system's main objective is the reduction of electricity intensity of the South African industrial sectors where electricity intensity has been defined as the ratio between the electricity consumption of the sector and its output.

Apart from the targeted indicator, the success of a benchmark-and-trade system is highly dependent on its good design and on three other essential decisions (Shammin &Bullard, 2009):

- The determination of the level of the benchmark.
- The definition and allocation of tradable credits/allowances.
- The formula for the initial distribution and trading of the credits/allowances.

In the proposed model, the benchmark is chosen to be subject to the average of the OECD members for each sector. The group of OECD countries is selected because South Africa needs to be compared with international 'best practice' in order to have the chance to learn and improve. Moreover, the South African electricity sector resembles that of advanced economies' and hence, needs to be compared against their industrialisation levels and sophistication.

However, the majority of the South African sectors' electricity intensity is substantially worse off than their OECD counterparts. Given the fact that the difference is immense, the proposed standards should initially reach lower goals.

Next, it is important to discuss the definition and allocation of credits/allowances in the system. As Braun (2009) points out, in some systems the members receive allowances depending on their historical performance adjusted for the programme's benchmark. The benchmark usually decreased through the consecutive phases (APX Power Markets, 2008).

Taking into account the important and desirable principles of administration ease and transparency, the proposed system suggests a straightforward method to determine the credits/allowances to be traded. Using a *grand-fathering* method, the regulator allocates credits/allowances to each sector per phase based on their performance during the previous phase. For every percentage of difference between the South African and the benchmark's electricity intensity, one credit/allowance is assigned (either to be supplied or demanded by the sector).

Evaluating the benchmark and targets recursively in the beginning of every phase shows that it will be not enough for the sectors and the country in its entirety to reach a specific target in the first period only. The increasing efficiencies of the OECD members due to their choices of newer and more efficient technologies will motivate the South African sectors to always keep up with these improvements.

This approach ensures, firstly, that each sector is being assessed based on its comparative performance to a standard benchmark, and secondly, that at any given time the participants are aware of the levels of their targets.

Following the traditional decision-making tree for benchmark-and-trade systems, Figure 4.1 presents a picture of the decisions of a participant in the proposed system. The first question to be answered is of strategic importance because it classifies the sector as a 'buyer' or 'seller' of credits/allowances. In case the electricity intensity is above (below) target, which means that South Africa is worse (better) off, the sector will act as a buyer (seller) in the trade.

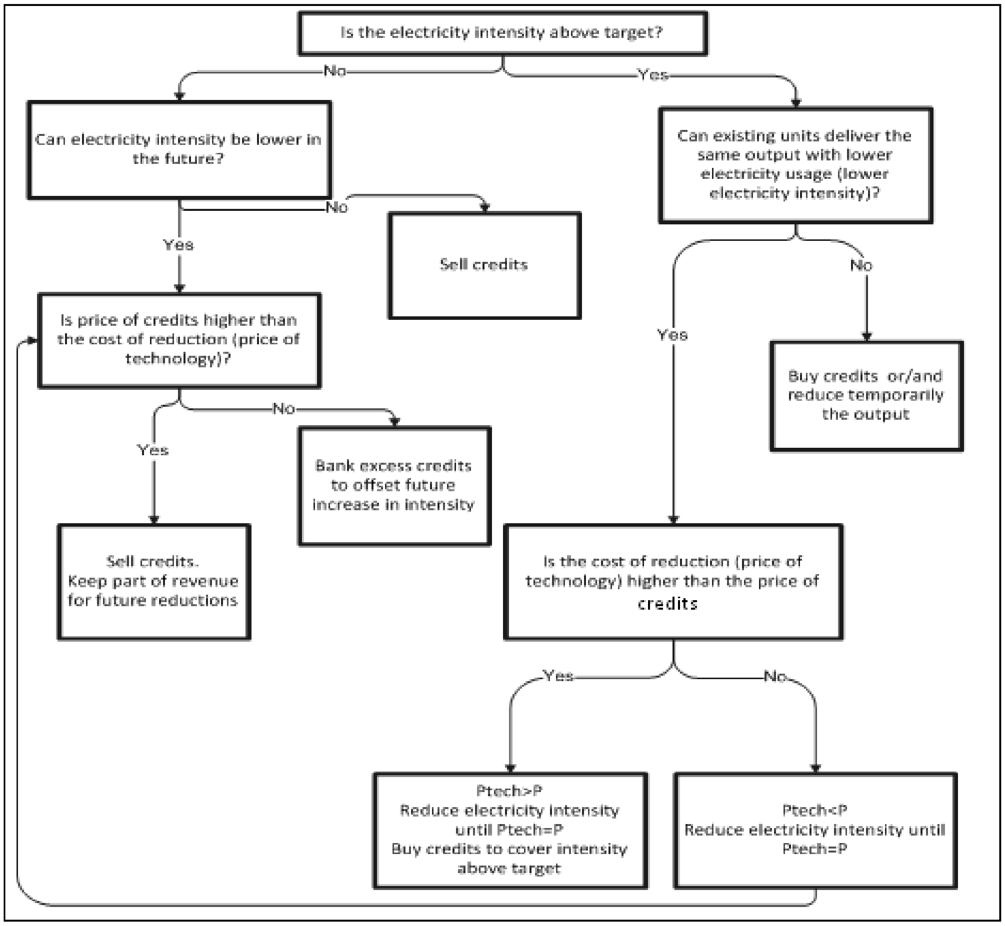


**Figure 4.1 Participants' decision-tree in the proposed benchmark-and-trade system**

Note: Firstly the participants need to answer the question of whether their intensity is above or below the set target. That defines them as sellers or buyers in the market. In case they are sellers (intensity lower than benchmark), they should evaluate if their intensity can lower in the future: if no, then they sell credits; if yes, the price of credits should be higher than the price of technology in order to sell; otherwise they bank the excess credits. Similar events occur in the case of a buyer of credits. If the electricity intensity can lower in the future then, depending on the comparison between the price of technology and the price of credits, the participant either buys credits or reduces its electricity intensity. If, on the other side, the electricity intensity cannot be reduced, the sector is obliged to buy credits.

Next, the participant, either a buyer or a seller, faces a question about its potential of reducing its electricity intensity further in the future or not. This question's significance lies with the fact that this system aims to improve the sectors' electricity efficiency levels without affecting their economic output.

Finally, the third question posed to the participants is concerned with the cost of reduction or the price of technology needed to decrease the levels of electricity intensity.

All-in-all, Figure 4.1 introduces important new elements to the discussion: a) the opportunity of banking credits/allowances, and b) the concept of the cost of reduction or the price of technology.

With regards to banking, Stavins (2008) states that it is imperative for the participants to be allowed to bank and/or borrow credits between different (consecutive) time periods, within the same phase. This can decrease the uncertainty and allow the sectors to make informed choices before deciding to reduce their intensity depending on the costs of the specific time period. To avoid injustice however, banking and borrowing are only allowed within a single phase. This way, the sectors are evaluated based on their performance in the previous phase in comparison with the OECD performance without taking into consideration strategic decisions within the market and exogenous factors affecting the decisions in the short-run.

The second concept introduced by Figure 4.1 is the price of technology. It can be explained as the cost to a sector or a company to replace its current production methods with newer, more advanced and more efficient technologies. This cost can vary from one time period to another depending on various factors such as the openness of the economy that will allow the transfer of new technologies.

Moreover, in high levels of efficiency, even better technologies become scarce and hence, more expensive. The price of technology is a contributing and key factor to the representation of the total supply curve of credits/allowances.

The International Energy Agency (IEA) has developed an energy efficiency database, entitled INDEEP, under the IEA DSM agreement (http://dsm.iea.org) in 1994. This database includes and evaluates the quality of 229 programmes from 14 countries aiming at the improvement of energy efficiency.

The most common technologies employed are presented in Figure 4.2.

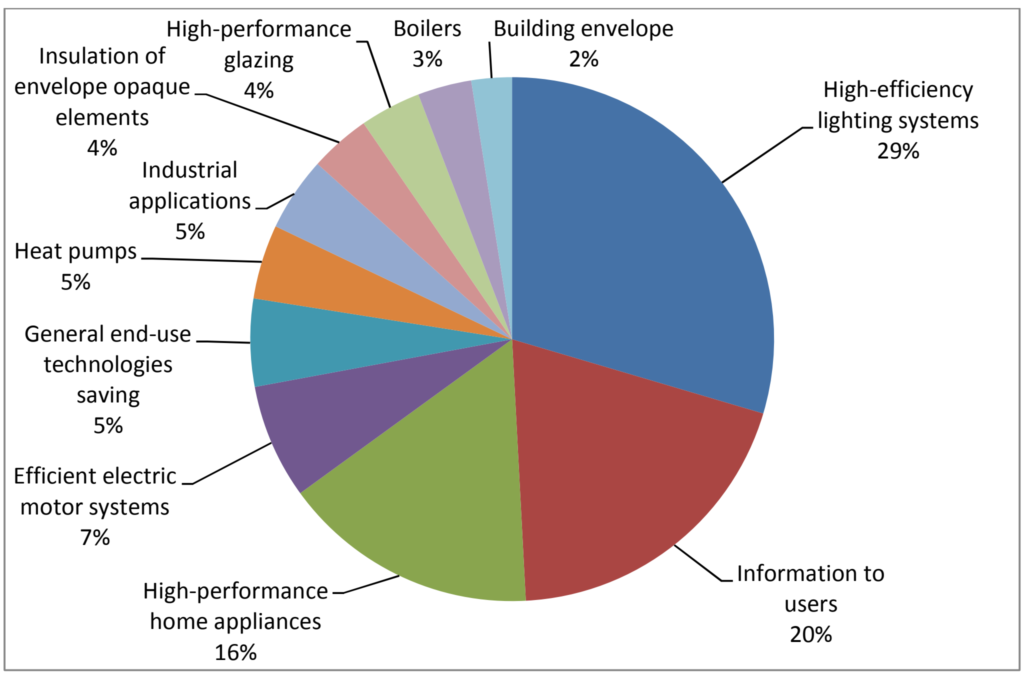


**Figure 4.2 Number of programmes by type of technology used**
*Source:* International Energy Agency (2004a)

Figure 4.2 shows that 29% of the programmes produce energy savings by using more efficient lighting, while immaterial techniques such as improved information to the users are preferred by 17% of the programmes (International Energy Agency, 2004a).

The costs of these technologies, according to INDEEP (2004), include utility costs and non-utility costs. Only 94% of the programmes included in the database had cost data available: 60% annual cost data and 40% cumulative cost data. The majority of the programmes cost between 100,000 and 1 million Euros but depending on the specific characteristics, they can cost up to 100 million Euros (Figure 4.3).

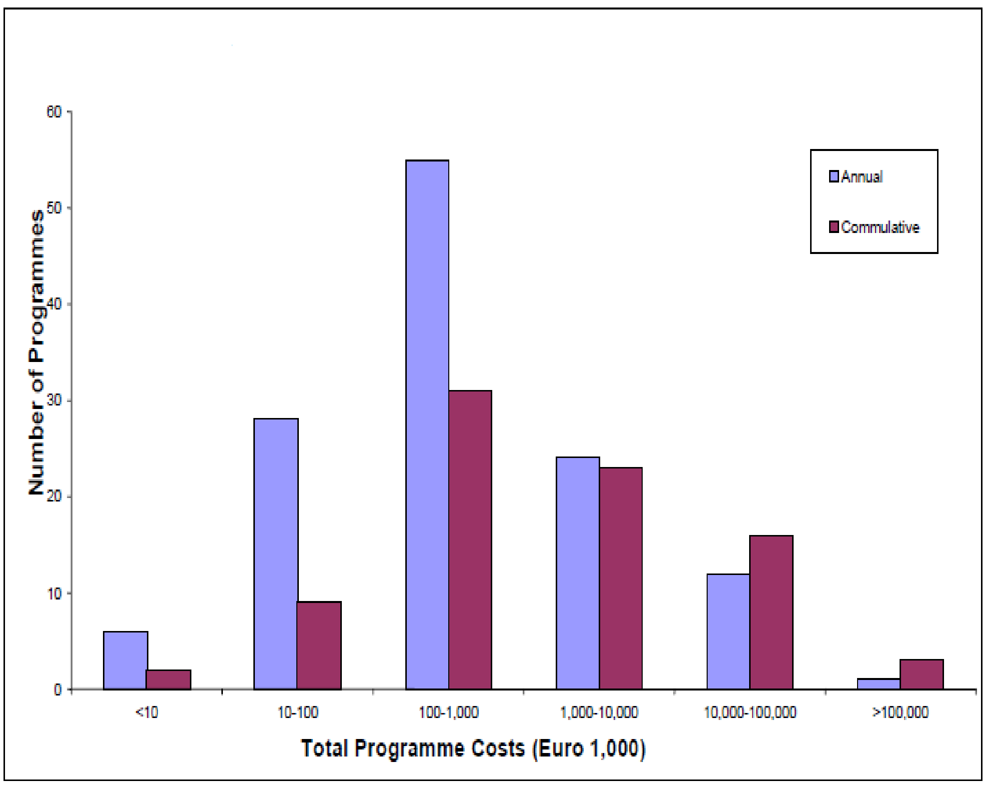


**Figure 4.3 Number of programmes vs. total programme costs**
*Source:* INDEEP database (2004)
Note: The costs are shown in Euros (exchange rate date 1/1/2000) and are spread out over the period 1993 to 1999.

The results depicted in Figure 4.3 confirm the fact that the cost of technologies aspiring to improve energy efficiency varies broadly and hence, it is not possible to be quantified per sector and per time period.

Eventually, the market created will have numerous similarities with an oligopoly. Firstly, under an oligopoly there are few suppliers (sectors) and each of them is influenced by the actions of the others. In the proposed model, only sectors that are better off than the standard can be suppliers in the trade.

Another similarity is the existence of barriers to entry. In this case, the market's rules and regulations create the barriers by defining which sectors are suppliers and which are consumers of the credits based on their comparative performance. Hence, a sector cannot become a supplier later in a particular phase.

The overall relationship of the price and the quantity of credits/allowances supplied follows basic economic theory: the higher the price, the higher the quantity supplied. However, the behaviour of the sellers (suppliers) changes depending on price of the technology compared to the price of the credits/allowances.

For as long as the price of the credits/allowances is lower than the price of technology, the supply curve is relatively inelastic (Figure 4.4). That is for every given increase in price, the increase of quantity supplied is smaller ($-1<e<0$). When this inequality holds, the suppliers lack incentives to sell credits because the revenue from the sales cannot cover the potentially desirable change in technology.

Conversely, if the price of credit becomes higher than the price of technology, the suppliers react with higher increases of the quantity supplied for the same percentage increases of price (supply curve relatively elastic, -∞<e<-1). If this inequality holds the suppliers have additional motivation to sell credits in order to achieve profits.

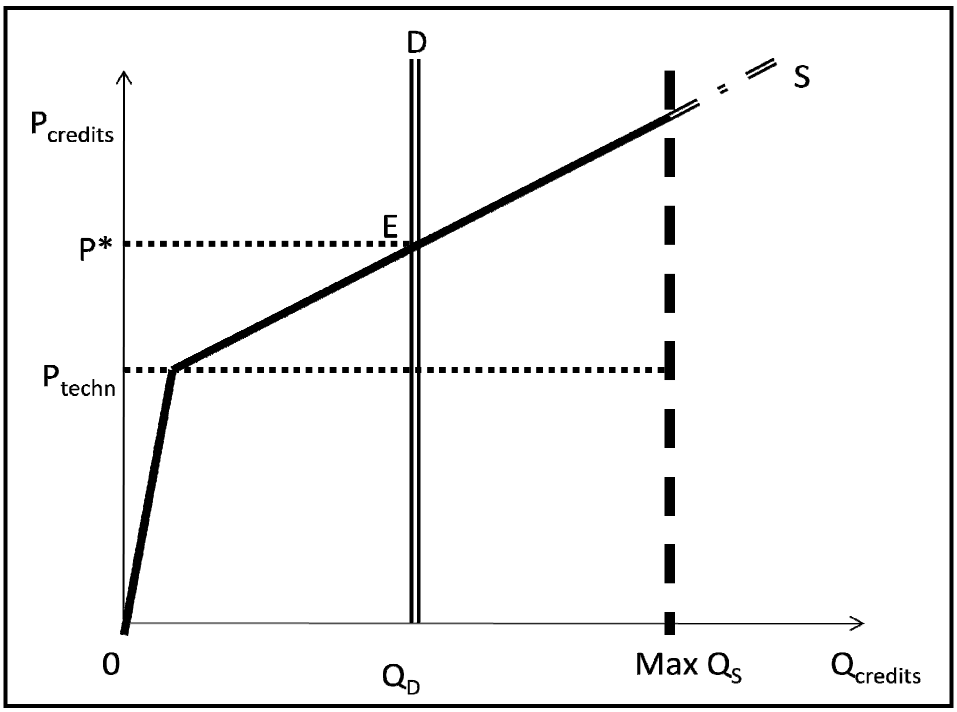


**Figure 4.4 Total demand and supply of credits/allowances**

Note: The equilibrium price (P*) of a hypothetical market of credits/allowances is presented here, showing the interaction between the demand curve (D) and supply curve (S) for credits. The supply curve (S) is presented to be relatively inelastic for prices lower than the price of technology ($P_{techn}$): no motivation for the suppliers to sell credits. For prices higher than the price of technology, the supply curve becomes relatively elastic: the increase of quantity demanded is higher than the increase of price that caused it. The dotted line (max $Q_s$) shows the maximum quantity of credits that can be supplied. Hence, any quantity higher than this cannot be provided by the suppliers; then the regulator should intervene in the market. On the other side, the demand curve is not dependent on price since the sectors to demand and the amount of credits is determined by the design of the system. Point E shows the equilibrium position of the market where price is equal to P* and the traded quantity is $Q_D$.

It can also be seen that the supply cannot increase indefinitely. This is due to the method of determining the credits/allowances based on their difference to the

OECD industrial sectors' electricity intensity: there are a specific number of credits to be traded in the market.

In order to be able to determine the price of the credits/allowances, the total demand curve is also required. Contrary to the supply, the total demand of credits/allowances is constant and independent of the price. The sectors whose electricity intensity is higher than the benchmark are obliged to buy the necessary credits/allowances as a form of a fine for their performance. Hence, the quantity demanded in the market is constant (Figure 4.4).

Figure 4.4 presents the market including both total supply and demand curves to show how the price of the electricity intensity credits/allowances is determined. The equilibrium price (P*) is depicted at point E where the total demand and supply curves cross each other. In other words, that is the maximum price that the consumers (buyers) are prepared to pay per credit.

The system applies first-degree price discrimination, which is defined as the situation "when each consumer is charged the maximum price he or she is prepared to pay for each unit of the product" (Fourie and Mohr. 2007). Hence, the price in this simple equilibrium is P* for each credit.

The situation presented in Figure 4.4 is not the only possible setup in such a benchmark-and-trade system. Depending on the standard chosen, the constant demand curve might cross the supply curve before the point where elasticity changes. That would mean that the equilibrium price (maximum price consumers are prepared to pay) would be lower than the price of technology.

It is also likely that the total demand curve (also representing the maximum quantity of credits/allowances demanded) is on the right side of the line showing the maximum quantity supplied. In that situation, a shortage of credits/allowances will exist since the amount of credits/allowances that can be supplied in the market cannot cover the demand for credits/allowances from sectors whose electricity intensity is higher than the standard chosen (both scenarios are presented in the following section in detail).

In circumstances like these, the role of the regulator is significant not only for the smooth implementation of the system but also for its interference in the trade. As mentioned before, the sectors whose intensity is above the target are obliged to buy credits/allowances from other sectors. However, in this case, the rest of the sectors are not in possession of more credits/allowances to supply; hence, the consumers will need to purchase credits/allowances from the regulator. The lowest price charged by the regulator would be P* but a higher price might be charged in order to motivate the sectors to improve their electricity intensity levels.

Next, an application of the theoretical system is presented and discussed by showing different possible standards.

## 4.3 Results

In this section, South African and the OECD electricity intensity data are employed assuming that 2006 is the starting year of the first phase. Before describing the analysis, it is significant to mention that the model is presented for a better understanding of how a system such as the one proposed would operate in real life. However, it can only be hypothetical because with the information available, the price of credits/allowances cannot be determined numerically. The price can only be identified comparatively with the price of technology, which is also difficult to be estimated for two reasons:

- The cost of production technology the participants use is difficult to be estimated and/or changes in the short-run.
- The cost of technology that will enhance the electricity efficiency of the participants varies.

Therefore, the price elasticities presented are all hypothetical and subject to alterations in reality and three different scenarios for the price of the credits are discussed.[7] The main scenario assumes that the price of the credits is equal to the carbon tax on electricity generated imposed by the South African government of R0.02 per kWh consumed; while the other two scenarios assume conditions where the price is lower and higher than the carbon tax by R0.01/kWh, respectively.

The difference between the sectoral intensities of South Africa and the OECD is substantial and could possibly not be covered in one phase. Hence, different scenarios for Phase I of the system are proposed. The benchmarks after the implementation of Phase I will have to be re-estimated taking into account the progress both the South African and the OECD sectors made during Phase I.

[7] The reason why the sectoral price elasticities of section 3.2 were not used is that, with the exception of the overall industrial sector, the elasticities were not statistically significant and hence, not accurate for being used any further.

Each standard is a proposition on how the trade will be in Phase I. The standards to be discussed are as follows:

- Standard 1: 20 times the OECD electricity intensity
- Standard 2: 10 times the OECD electricity intensity
- Standard 3: OECD electricity intensity

In Table 4.1, the difference between the South African industrial sectors' electricity intensity levels and their OECD counterparts is presented, according to the standard chosen. As discussed in the theoretical representation, one percentage is equivalent to one credit. Also, a negative (positive) sign shows that the South African sector is more (less) intensive than the standard chosen, hence it will become a supplier (consumer) of credits/allowances in the trade.

It can be seen that a number of sectors ('construction', 'food and tobacco', 'machinery' and 'transport equipment') remain suppliers in the trade regardless of the benchmark chosen. However, sectors such as 'mining and quarrying' and 'non-metallic minerals' are worse off for all the proposed selected benchmarks and hence, they are the consumers of the market. However, the rest of the sectors change roles according to how strict the chosen benchmark is. For instance, 'agriculture' would have to act as a supplier under Standard 1.

**Table 4.1 Difference of electricity intensities (South Africa- Standards) in 2006***

| | Standards | | |
|---|---|---|---|
| Sectors | 1 | 2 | 3 |
| Agriculture and forestry | ***1%*** | -97% | -1871% |
| Basic metals** | ***51%*** | ***1%*** | -887% |
| Chemical and petrochemical | ***70%*** | ***41%*** | -495% |
| Construction | ***100%*** | ***100%*** | ***98%*** |
| Food and tobacco | ***96%*** | ***91%*** | ***11%*** |
| Machinery | ***99%*** | ***98%*** | ***81%*** |
| Mining and quarrying | -20% | -141% | -2306% |
| Non-metallic minerals | -31% | -162% | -2518% |
| Paper, pulp and printing | ***50%*** | ***1%*** | -891% |
| Textile and leather | ***68%*** | ***35%*** | -549% |
| Transport equipment | ***96%*** | ***92%*** | ***20%*** |
| Transport sector | ***67%*** | ***34%*** | -563% |
| Wood and wood products | ***87%*** | ***75%*** | -154% |

Notes: *Number in bold (positive sign) show that the sector is better off than the benchmark chosen and hence they are suppliers of credits and the non-bold (negative sign) indicate the sector's intensity is higher than the benchmark's and therefore, the sector is a consumer of credits.
** 'Iron and steel' and 'non-ferrous metals'

Under Standards 2 and 3, however, it is more electricity intensive than the selected benchmarks and hence, it plays the role of a consumer in the market.

It should be noted here that in a benchmark-and-trade system, the participants are free to decide whether they prefer to trade in the market or rather reduce or increase their electricity consumption in order to meet the benchmark proposed. However, in the next phase even the sectors that preferred to participate fully in the trade have an economic incentive to do so. Also, a number of sectors will combine the two options, trading some credits and adjusting their electricity consumption accordingly.

Next, the first case is presented where all the sectors participate willingly in the market without changing their electricity consumption behaviour. Subsequently, the results of the situation where all the sectors decide to alter their consumption in order to meet the benchmark chosen will be presented.

After translating these differences into credits/allowances, one can calculate the total demand of electricity intensity credits/allowances and the maximum credits/allowances to be supplied in the benchmark-and-trade market. Table 4.2 summarises the total supply and demand of credits/allowances for each of the standards.

**Table 4.2 Total demand and supply of credits/allowances in 2006 for different standards implemented**

| | **1** | **2** | **3** |
|---|---|---|---|
| **Total demand (TD)** | 51 | 399 | 10 233 |
| **Total supply (TS)** | 785 | 567 | 211 |
| **Difference (TS-TD)** | 734 | 168 | -10 022 |
| | surplus | surplus | shortage |

It can be seen that the stricter the benchmark is (Standard 3), the less sectors are able to supply the market with credits/allowances; while for more lenient benchmarks (Standard 1), the majority of the South African industrial sectors are better off than the benchmark. The opposite holds for the total supply: the stricter the benchmark is, the lower the total supply for credits/allowances.

To provide a general picture on how the market would look, each of the three different standards are presented next. Standard 1 shows a market where the total demand is very low; Standard 2 presents a market where total demand and total supply do not differ substantially, and finally Standard 3 shows a market where total demand is by far higher than the total supply.

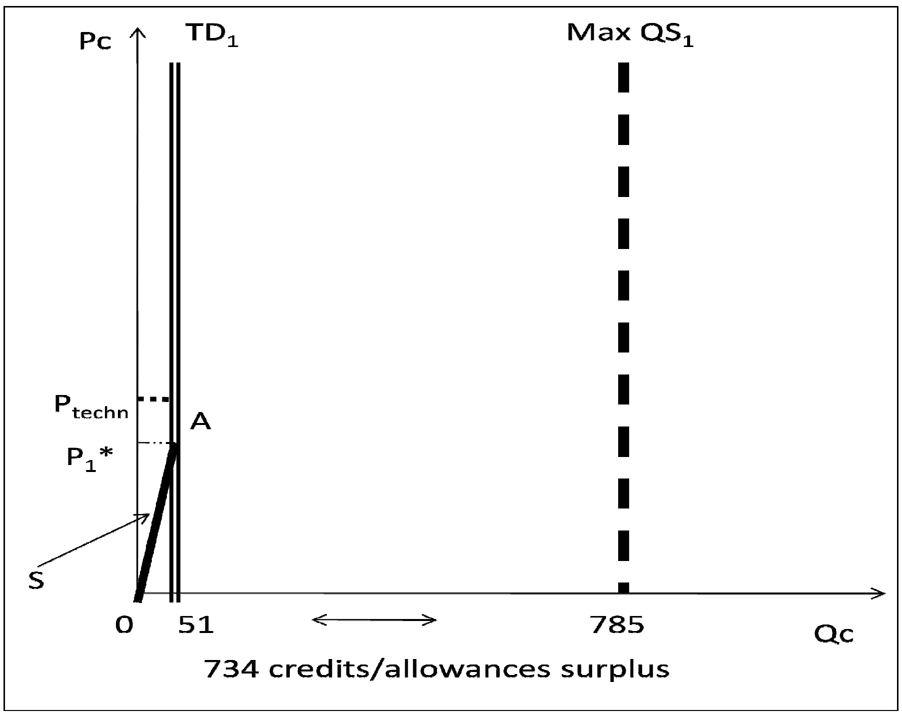


**Figure 4.5 Equilibrium at Standard 1**
Note: The equilibrium point (A) is where the total demand curve (TD1) crosses the total supply curve (S). So the equilibrium price of the market is $P_1$* and the equilibrium quantity is equal to the total quantity demanded (51 units). The suppliers, however, are able to provide more credits (max $QS_1$) and hence, there is a surplus in the market of 734 credits. The equilibrium price is lower than the price of technology so the supply curve has not reached the turning point of its slope.

When choosing Standard 1, the total demand for credits/allowances (TD) is significantly lower (51 credits/allowances) than the maximum quantity that can be potentially supplied (785 credits/allowances). This is because Standard 1 is a highly lenient benchmark and the majority of sectors are below the set target. Only ‘mining and quarrying’ and ‘non-metallic minerals’ are still more intensive than the standard and hence, they constitute the total demand in the market.

Figure 4.5 presents the equilibrium under Standard 1. In this example, due to the limited quantity demanded, the supply curve crosses the demand curve at a price level lower than the price of technology (point A). In this benchmark, the consumers buy all their credits/allowances from the suppliers of the market; hence there is no interference by the regulator. So, the consumers’ expenses will be equal to the suppliers’ revenue which is equal to $P_1^*$ x $TD_1$(= 51 credits/allowances).

The difference between Standard 1 and Standard 2 is that the total demand is not so small in comparison with the total supply. Standard 2 is stricter than Standard 1 (100% of the OECD sectoral electricity intensities). In Figure 4.6, the equilibrium under this targeted benchmark is presented.

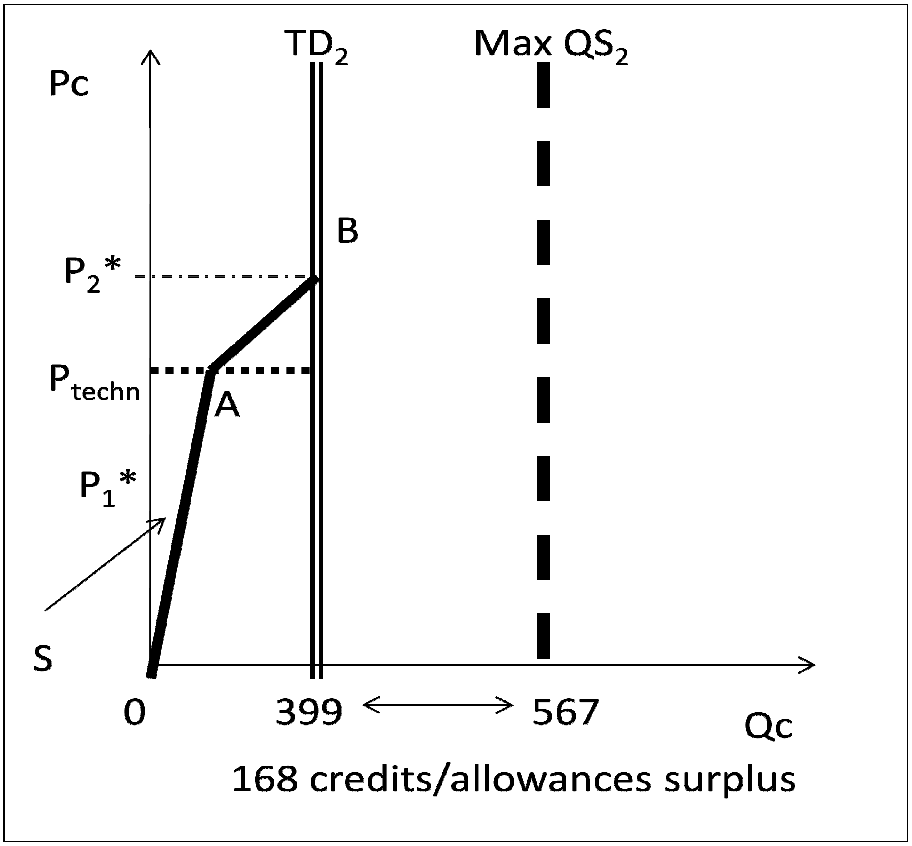


**Figure 4.6 Equilibrium at Standard 2**

Note: The equilibrium point (B) is where the total demand curve (TD2) crosses the total supply curve (S). So the equilibrium price of the market is $P_2$* and the equilibrium quantity is equal to the total quantity demanded (399 units). The suppliers, however, are able to provide more credits (max $QS_2$) and hence, there is a surplus in the market of 168 credits. The equilibrium price is higher than the price of technology so the equilibrium point B is higher than the supply curve's turning point (A).

It is seen in Figure 4.6 that the equilibrium price in this standard is higher than the price of technology since the supply curve becomes more elastic before it crosses the total demand. As in the previous example, the consumers' expenses are equal to the producers' revenue (no regulator interference), $P_2$* x $TD_2$ (= 399 credits/allowances).

A completely different picture is depicted if Standard 3 is chosen. Standard 3 is the strictest of all because it aims at reaching exactly the OECD electricity intensity levels. Towards this aim, the total demand for credits/allowances is high (10,233 credits/allowances) because the majority of the South African sectors are worse off than their OECD counterparts, while there will still be industrial sectors whose electricity intensity is lower ('construction', 'food and tobacco', 'machinery' and 'transport equipment').

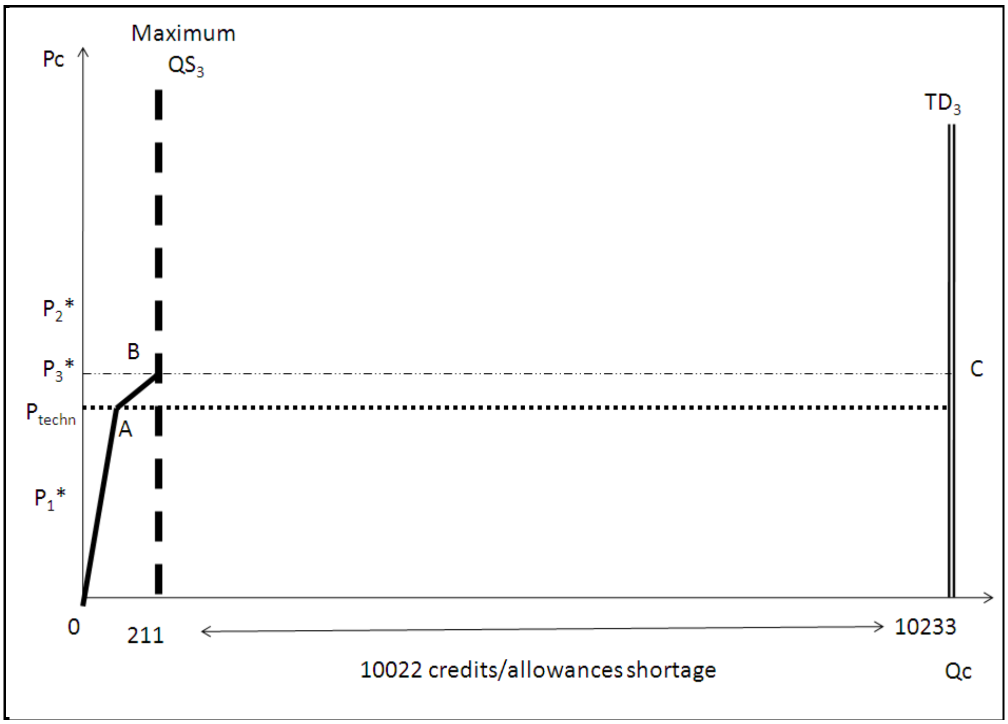


**Figure 4.7 Equilibrium at Standard 3**

Note: The equilibrium in this case is at point (B), higher than the price of technology ($P_{techn}$), after the turning point of the supply curve. This is because under a strict benchmark such as Standard 3, the maximum quantity supplied (only 211 credits) is substantially lower than the total demand for credits ($TD_3$ = 10,233 credits). Owing to this, the market experiences a shortage of credits (10,022 credits) that the regulator is obliged to supply at a certain price equal to or higher than the equilibrium price $P_3$*.

Also, the equilibrium price is higher than the price of technology; however, it is lower than in Standard 2 because the credits/allowances available to sell are lower (211 credits/allowances).

Hence, the regulator of the system needs to offer the credits/allowances that are in shortage (10,022 credits/allowances) charging at least the equilibrium price per credit. The consumers' expenditure is divided between the suppliers and the regulator. The consumers' expenditure is equal to $P_3^*$ x $TD_3$ (= 10,233 credits/allowances) from which $P_3^*$ x $maxQS_3$ (= 211 credits/allowances) is paid to the suppliers and $P_3^*$ x shortage (= 10,022 credits/allowances) to the regulator.

In summary, the graphical representation illustrates the fact that the following are crucial factors in determining the credits' price and the system's success:

- Choice of standard
- Price of technology
- Starting point of efficiency for each sector

These aspects of the system determine whether a sector is a supplier or a consumer of credits, the amount of credits offered and demanded in the market and the need for intervention by the regulator.

Presenting these three possible scenarios on how this market would operate by selecting different benchmarks raises questions on how the South African economy will be affected, whether the output will be reduced to meet the targets, and how much the various sectors will gain or lose by the implementation of the system. Before we extend the analysis with numerical examples, it is useful to summarise the two separate roles the sectors might have to play (Table 4.3).

**Table 4.3 The meaning of a sector being a consumer or a supplier in the benchmark-and-trade system**

| Consumer | Supplier |
|---|---|
| Worse off than the benchmark | Better off than the benchmark |
| More electricity intensive or less electricity efficient | Less electricity intensive or more electricity efficient |
| It will have to cut on its electricity consumption (assuming output remains the same) | It can increase its electricity consumption and still be within the limits set by the benchmark |
| It will have to buy credits in the market (expenses) | It could sell credits in the market (savings) |

To account for possible decreases in production to meet the efficiency requirements of the system, a strong assumption is held for the rest of this chapter: economic output of the sectors remains the same and hence, the sectors can only improve their intensity by reducing their electricity consumption.

In the proposed system, the differences between South Africa and the OECD can be translated into units of energy. Table 4.4 presents the differences per sector converted into GWh.

**Table 4.4 Changes in electricity use to be implemented to reach the benchmarks (GWh)***

| Sectors | Standard 1 | Standard 2 | Standard 3 |
|---|---|---|---|
| **Agriculture and forestry** | 85.09 | -5,668.08 | -109,225.09 |
| **Basic metals **** | 11,966.39 | 300.62 | -209,683.27 |
| **Chemical and petrochemical** | 7,085.10 | 4,087.00 | -49,878.90 |
| **Construction** | 58.09 | 58.03 | 56.93 |
| **Food and tobacco** | 722.42 | 688.88 | 85.26 |
| **Machinery** | 46.08 | 45.65 | 37.79 |
| **Mining and quarrying** | -5,727.07 | -39,691.77 | -651,056.50 |
| **Non-metallic minerals** | -804.59 | -4,214.29 | -65,589.03 |
| **Paper, pulp and printing** | 885.56 | 14.98 | -15,655.33 |
| **Textile and leather** | 353.57 | 183.8 | -2,872.15 |
| **Transport equipment** | 89.32 | 85.61 | 18.72 |
| **Transport sector** | 2,261.82 | 1,139.30 | -19,065.97 |
| **Wood and wood products** | 264.04 | 225.7 | -464.37 |
| ***Economy-wide*** | *17,285.82* | *-42,744.54* | *-1,123,291.91* |

Notes: *The negative sign indicates that the sector will have to save this amount of electricity consumption while the positive sign shows that the sector can increase its electricity use and still be within the set benchmark.
** 'Iron and steel' and 'non-ferrous metals'

For a better understanding of Table 4.4, the 'agricultural' sector is discussed as an example. The electricity consumption of the agricultural sector in 2006 (hypothetical starting year of the system) was 5,838,260GWh and its intensity was 0.320GWh/$millions (PPP adj). In the same year, the OECD average electricity intensity was 0.316GWh/$millions (adjusted PPP); hence, the difference of the two was -1% (see Table 4.1) and the sector will act as a supplier of credits. If the economic output of the sector remained unchanged, then these credits would all be converted into GWh by finding the 1% difference of the total electricity consumption: 1% * 5,838,260GWh= 85,092GWh.

Looking at the overall picture, 'mining and quarrying' and 'non-metallic minerals' are the only consumers of credits/allowances in the market. Employing a stricter standard, such as Standard 2, the 'agriculture' sector also joins the group of consumers while eventually, under Standard 3, the only suppliers in the market are 'construction', 'food and tobacco', 'machinery' and 'transport equipment'.

However, the size of the gain or loss of each sector by its participation in the system is dependent on the price of the credit. Given the fact that the market has not been in effect before, it is difficult to have absolutely realistic price scenarios. However, the baseline scenario can adopt the carbon tax for electricity generation in South Africa that was proposed to be R0.02/kWh (for the other two scenarios, a price lower and a price higher than the tax are selected for a better view of a range of results).

In a benchmark-and-trade system, the sectors are allowed to choose between reducing their electricity usage to reach the benchmark or buy the extra electricity consumption in the form of credits. Also, some of the sectors might decide to combine some form of improvement in their efficiency with purchasing credits. Hence, Table 4.4 illustrates the case where all the sectors decide not to buy or sell credits but increase or decrease their electricity usage to reach the benchmark.

**Table 4.5 Savings and expenses of the participating sectors (in ZAR millions)***

| | *Standard 1* | | | *Standard 2* | | | *Standard 3* | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sectors** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** |
| **Agriculture and forestry** | 0.85 | 1.7 | 2.55 | -56.68 | -113.36 | -170.04 | -1,092.25 | -2,184.50 | -3,276.75 |
| **Basic metals**** | 119.66 | 239.33 | 358.99 | 3.01 | 6.01 | 9.02 | -2,096.83 | -4,193.67 | -6,290.50 |
| **Chemical and petrochemical** | 70.85 | 141.7 | 212.55 | 40.87 | 81.74 | 122.61 | -498.79 | -997.58 | -1,496.37 |
| **Construction** | 0.58 | 1.16 | 1.74 | 0.58 | 1.16 | 1.74 | 0.57 | 1.14 | 1.71 |
| **Food and tobacco** | 7.22 | 14.45 | 21.67 | 6.89 | 13.78 | 20.67 | 0.85 | 1.71 | 2.56 |
| **Machinery** | 0.46 | 0.92 | 1.38 | 0.46 | 0.91 | 1.37 | 0.38 | 0.76 | 1.13 |
| **Mining and quarrying** | -57.27 | -114.54 | -171.81 | -396.92 | -793.84 | -1,190.75 | -6,510.56 | -13,021.13 | -19,531.69 |
| **Non-metallic minerals** | -8.05 | -16.09 | -24.14 | -42.14 | -84.29 | -126.43 | -655.89 | -1,311.78 | -1,967.67 |
| **Paper, pulp and printing** | 8.86 | 17.71 | 26.57 | 0.15 | 0.3 | 0.45 | -156.55 | -313.11 | -469.66 |
| **Textile and leather** | 3.54 | 7.07 | 10.61 | 1.84 | 3.68 | 5.51 | -28.72 | -57.44 | -86.16 |
| **Transport equipment** | 0.89 | 1.79 | 2.68 | 0.86 | 1.71 | 2.57 | 0.19 | 0.37 | 0.56 |
| **Transport sector** | 22.62 | 45.24 | 67.85 | 11.39 | 22.79 | 34.18 | -190.66 | -381.32 | -571.98 |
| **Wood and wood products** | 2.64 | 5.28 | 7.92 | 2.26 | 4.51 | 6.77 | -4.64 | -9.29 | -13.93 |
| ***Economy-wide*** | *172.85* | *345.72* | *518.56* | *-427.43* | *-854.9* | *-1,282.33* | *-11,232.9* | *-22,465.84* | *-33,698.75* |

Notes: *The positive figures indicate the amounts in ZAR millions that the sectors will be able to receive from the participation in the market while the negative figures show the amounts that the sectors will have to spend because they are more intensive than the benchmark chosen.
** 'Iron and steel' and 'non-ferrous metals'

On the other side, Table 4.5 presents the possible savings or expenses in ZAR millions per sector in case the sectors decide not to change their consumption behaviour but purchase or sell credits in the market. The negative (positive) value indicates that the sector is a seller (buyer) in the market and the figure shows its savings (expenses). The signs indicate the reduction or increase of electricity costs of the sectors.

Continuing with the example of the agricultural sector, by being more efficient than the OECD counterpart when selecting Standard 1, it will have savings that will vary from ZAR 0,85–2,55 million (depending on the price). When the price is equal to the carbon tax, then the sector not only would not have to pay any taxes but it would also increase its revenue by ZAR 1.77 million.

However, when Standard 2 is chosen, the agricultural sector is more intensive than the OECD; hence, it is a buyer of credits and eventually it would have to pay in order to acquire the required credits. Its expenses would be ZAR 56,68, ZAR 113,36 or ZAR 170,04 million for each of the price scenarios (ZAR0.01/kWh, ZAR0.02/kWh and ZAR0.03/kWh), respectively.

A similar picture is presented in the case of selecting Standard 3. The agricultural sector is much more intensive than the selected benchmark. Hence, the expenses of the sector to acquire the necessary credits are higher than in Standard 2. Depending on the price of the credit, its expenses would vary between ZAR 1,092 and ZAR 3,276 million.

Although the savings and expenses of the participating sectors as presented in Table 4.5 demonstrate that there will be numerous sectors that will benefit by the system, they cannot really show the importance of the gain or loss of each. Hence, taking the analysis a step further, Table 4.6 presents the savings and expenses as a ratio of the sectors' real output in 2006.

Following the previous example, the agricultural sector will earn 0.001% to 0.003% of its economic output in case of Standard 1; however, it will lose 0.066% to 0.197% (Standard 2) or 1.266% to 3.797% (Standard 3) of each economic output.

The only two sectors that are consumers for all standards ('mining' and 'non-metallic minerals') would have to spend less than 0.1% of their economic output (Standard 1); and less than 0.8% (Standard 2); but much higher at Standard 3: depending on the price from 3.45% to 10.34% for the mining sector and 2.56% to 7.68% for the non-metallic minerals sector.

**Table 4.6 Savings and expenses of the participating sectors as a ratio to their total output, 2006***

| | *Standard 1* | | | *Standard 2* | | | *Standard 3* | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sectors** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** | **R0.01/kWh** | **R0.02/kWh** | **R0.03/kWh** |
| Agriculture and forestry | **0.0010%** | **0.0020%** | **0.0030%** | -0.0660% | -0.1310% | -0.1970% | -1.2660% | -2.5310% | -3.7970% |
| Basic metals** | **0.1100%** | **0.2200%** | **0.3310%** | **0.0030%** | **0.0060%** | **0.0080%** | -1.9310% | -3.8620% | -5.7940% |
| Chemical and petrochemical | **0.0270%** | **0.0540%** | **0.0810%** | **0.0160%** | **0.0310%** | **0.0470%** | -0.1890% | -0.3790% | -0.5680% |
| Construction | **0.0004%** | **0.0010%** | **0.0010%** | **0.0004%** | **0.0010%** | **0.0010%** | **0.0003%** | **0.0010%** | **0.0010%** |
| Food and tobacco | **0.0040%** | **0.0080%** | **0.0120%** | **0.0040%** | **0.0080%** | **0.0110%** | **0.0005%** | **0.0010%** | **0.0010%** |
| Machinery | **0.0010%** | **0.0020%** | **0.0030%** | **0.0010%** | **0.0020%** | **0.0030%** | **0.0010%** | **0.0020%** | **0.0020%** |
| Mining and quarrying | -0.0300% | -0.0610% | -0.0910% | -0.2100% | -0.4200% | -0.6300% | -3.4470% | -6.8940% | -10.3400% |
| Non-metallic minerals | -0.0310% | -0.0630% | -0.0940% | -0.1640% | -0.3290% | -0.4930% | -2.5590% | -5.1180% | -7.6780% |
| Paper, pulp and printing | **0.0200%** | **0.0400%** | **0.0590%** | **0.0003%** | **0.0010%** | **0.0010%** | -0.3510% | -0.7010% | -1.0520% |
| Textile and leather | **0.0090%** | **0.0170%** | **0.0260%** | **0.0040%** | **0.0090%** | **0.0130%** | -0.0700% | -0.1400% | -0.2100% |
| Transport equipment | **0.0010%** | **0.0010%** | **0.0020%** | **0.0010%** | **0.0010%** | **0.0020%** | **0.0001%** | **0.0002%** | **0.0004%** |
| Transport sector | **0.0120%** | **0.0230%** | **0.0350%** | **0.0060%** | **0.0120%** | **0.0180%** | -0.0990% | -0.1980% | -0.2970% |
| Wood and wood products | **0.0120%** | **0.0240%** | **0.0360%** | **0.0100%** | **0.0210%** | **0.0310%** | -0.0210% | -0.0420% | -0.0630% |
| ***Economy-wide*** | **0.136%** | **0.268%** | **0.404%** | -0.394% | -0.788% | -1.185% | 9.931% | 19.861% | 29.795% |

Notes: *The positive figures indicate the sectors that are better off than the chosen benchmark and hence, are suppliers in the market, they earn a percentage of their output. The negative percentages show the proportion of their output that the consumers in the market have to spend.
** 'Iron and steel' and 'non-ferrous metals'

## 4.4 Comparison with carbon tax

Taxation is one of the main proposed alternatives to benchmark-and-trade systems to deal with the increasing trends in $CO_2$-emissions and energy consumption. More specifically, South African authorities have proposed the implementation of a tax on electricity consumption. The idea behind taxing consumption instead of emissions is relatively simple: the main reason for $CO_2$-emissions in the country is the production of electricity which is 80% coal-generated.

The proposed benchmark-and-trade system and a *carbon tax* have the exact same objective: the reduction of $CO_2$-emissions. However, the two systems operate through different channels. The taxation aims to make electricity consumption more expensive so that the users will have to decrease consumption in order to avoid extra taxation. Therefore, with the reduction of electricity consumption, the $CO_2$-emissions are expected to decrease. A possible drawback of this is the fact that certain users will prefer to decrease their production towards a higher reduction of electricity consumption, with detrimental effects to the economic growth of the country.

In addition, measuring the $CO_2$ emissions in a disaggregated level, as was discussed in National treasury (2010), can be proven complicated, difficult and time-consuming. Hence, currently, the *carbon* tax is imposed on the electricity usage of the consumers with the assumption that the electricity generation and consumption is highly linked with GHG emissions.

On the other side, the electricity efficiency benchmark-and-trade system is a market-based system that will provide users with economic incentives to improve their efficiency levels while also taking into account their economic output. The channel of this system works through the improvement of electricity efficiency in order to gain in the created market by reducing electricity consumption and hence, $CO_2$-emissions in a specific period of time (Chameidis & Oppenheimer, 2007).

**Table 4.7 Comparison* of economic impact of carbon tax and benchmark-and-trade to various sectors (2006)**

| | Carbon tax | Standard 1 | Standard 2 | Standard 3 |
|---|---|---|---|---|
| Sectors | Payments (ZAR mil)* | Savings and expenses (ZAR mil)** | Savings and expenses (ZAR mil)** | Savings and expenses (ZAR mil)** |
| Agriculture and forestry | -116.47 | 1.7 | ***-113.36*** | -2,184.50 |
| Basic metals*** | -456.43 | 239.33 | 6.01 | -4,193.67 |
| Chemical and petrochemical | -200.88 | 141.7 | 81.74 | -997.58 |
| Construction | -10.44 | 1.16 | 1.16 | 1.14 |
| Food and tobacco | -15.11 | 14.45 | 13.78 | 1.71 |
| Machinery | -0.93 | 0.92 | 0.91 | 0.76 |
| Mining and quarrying | -563.57 | ***-114.54*** | -793.84 | -13,021.13 |
| Non-metallic minerals | -51.93 | ***-16.09*** | -84.29 | -1,311.78 |
| Paper & Wood products | -41.04 | 22.99 | 4.81 | -322.4 |
| Textile and leather | -10.44 | 7.07 | 3.68 | -57.44 |
| Transport equipment | -1.85 | 1.79 | 1.71 | 0.37 |
| Transport sector | -67.55 | 45.24 | 22.79 | -381.32 |
| Economy wide | -1546.32 | 345.72 | -854.9 | -22465.84 |

Notes: *The estimates for the savings in electricity after a carbon tax implementation are from a CGE application. These results and the benchmark-and-trade system's results are time-neutral reflecting results by sector at the end of an undefined period. Also, the benchmark-and-trade system does not include feedback effects from the residential and commercial sectors or from inter-industry relations while the CGE does.

**The negative signs in the "savings and expenses" indicate consumer-sectors that need to spend these specific amounts; while the positive signs indicate supplier-sectors that receive these amounts from their participation in the market. The green cells show that the standard chosen under a benchmark-and-trade system is better off the case of a carbon tax implementation and the pink cells show that the standard chosen is worse off.

***'Iron and steel' and 'non-ferrous metals'

Regarding the economic benefit for the electricity users, Table 4.7 presents the savings and expenses of the various sectors under the scenario of a carbon tax of R0.02/kWh versus the three different standards of the proposed system when the price of the credits is equal to the carbon tax.

In the case of taxation, the economic sectors will have to pay a certain amount of tax for their electricity usage. However, in the case of the benchmark-and-trade system (depending on the benchmark selected), some sectors will gain from the trade and will be able to cover some of their costs during the period of implementation.

For instance, the agricultural sector will have to pay ZAR 116.5 million to the government if taxation is implemented. However, if Standard 1 of the benchmark-and-trade system is chosen, the sector will be considered one of the suppliers of the trade and hence, it will gain ZAR 1.7 million. The situation would change in case Standard 2 is chosen: the sector is now a consumer of credits in the market and hence, it would have to spend ZAR 113.36 million in order to buy the necessary credits to continue consuming the same amount of electricity. The important point here is that although the sector is a consumer of credits and has to spend, the amount is lower than the alternative of taxation.

A similar example is also presented by the two sectors that are consumers of credits in any of the three proposed standards: 'mining and quarrying' and 'non-metallic minerals'. These sectors will have to spend higher amounts during stricter standards, such as Standard 3, but the comparison between the implementation of a tax and Standard 1 leaves these two sectors better off if Standard 1 is chosen (mining: 79.7%

less under Standard 1 compared to tax; non-metallic minerals: 69 % less under Standard 1 compared to tax).

On the other hand, the participants may decide not to buy or sell electricity efficiency credits but rather adjust their electricity consumption accordingly in order to reach the chosen benchmark. Table 4.8 presents the percentage of electricity reductions or increase each sector needs to reach the proposed standards as well as the decreases of electricity after the implementation of a carbon tax.

**Table 4.8 Comparison* of impact on electricity savings of carbon tax and benchmark-and-trade to various sectors (2006)**

| | Carbon tax | Standard 1 | Standard 2 | Standard 3 |
|---|---|---|---|---|
| Sectors | Savings in electricity (%)* | Savings in electricity (%)** | Savings in electricity (%)** | Savings in electricity (%)** |
| Agriculture and forestry | -0.25% | 0.00% | -0.09% | -1.87% |
| Basic metals*** | -3.43% | 0.05% | 0.00% | -0.89% |
| Chemical and petrochemical | -0.39% | 0.07% | 0.04% | -0.49% |
| Construction | -0.03% | 0.10% | 0.10% | 0.10% |
| Food and tobacco | -0.03% | 0.10% | 0.09% | 0.09% |
| Machinery | -0.41% | 0.10% | 0.10% | 0.08% |
| Mining and quarrying | -0.21% | -0.02% | -0.14% | -2.31% |
| Non-metallic minerals | -0.33% | -0.03% | -0.16% | -2.52% |
| Paper & Wood products* | -0.31% | 0.14% | 0.08% | 0.00% |
| Textile and leather | -0.25% | 0.07% | 0.04% | -0.55% |
| Transport equipment | -0.36% | 0.10% | 0.09% | 0.02% |
| Transport sector | -0.20% | 0.07% | 0.03% | -0.56% |
| ***Economy-wide*** | *-6.19%* | *0.73%* | *0.17%* | *-8.90%* |

Notes: *The estimates for the savings in electricity after a carbon tax implementation are from a CGE application. These results and the benchmark-and-trade system's results are time-neutral reflecting results by sector at the end of an undefined period. Also the benchmark-and-trade system does not include feedback effects from the residential and commercial sectors or from inter-industry relations while the CGE does.
**The negative signs indicate consumer-sectors that need to reduce their electricity usage; while the positive signs indicate supplier-sectors that can even increase their consumption if they choose too. The green cells show that the standard chosen under a benchmark-and-trade system is better off in the case of a carbon tax implementation and the pink cells show that the standard chosen is worse off.
***'Iron and steel' and 'non-ferrous metals'

Based on these results, when using Standards 1 and 2, all the sectors are worse off compared to the reductions expected from the implementation of a carbon tax of R0.02/kWh. However, under a stricter benchmark, a number of sectors would have to decrease their electricity consumption substantially more than under taxation. The economy-wide electricity usage may be expected to decrease up to 8.9%, higher than the carbon tax case of 6.19%.

Continuing with the 'agriculture' sector example, this sector is expected to reduce its electricity usage by 0.25% after an implementation of a carbon tax. However, under Standard 1, the sector can even increase its usage marginally by 0.0015% since it performs better than the benchmark chosen. Under Standard 2, the sector should decrease its usage by 0.0971% to reach the levels of the benchmark. This decrease is much lower than the carbon tax case. Finally, under Standard 3, the agriculture sector should decrease its usage by 1.8709%, a substantial improvement to the expected decrease due to taxation.

## 4.5 Conclusion

In summary, this chapter proposed a benchmark-and-trade system. Its main target is to improve electricity efficiency levels in South Africa by using a market-based sectoral approach. In the past, benchmark-and-trade systems aimed to reduce greenhouse gas emissions (GHG) and more specifically $CO_2$- or $SO_2$-emissions. The difference of this system is that it aspires to deal with the cause of these emissions: energy consumption, more particularly electricity.

In South Africa, a high proportion of electricity generation is based on coal burning with detrimental effects to the $CO_2$-emissions of the country. Hence, the initial idea of a benchmark-and-trade system was to reduce the electricity consumption of the country. However, such a target could affect the country's economic output severely and therefore the proposed system aspires to reduce the electricity intensity or, in other words to improve the electricity efficiency of the country.

This chapter presented the theoretical mechanisms of the system and discussed some numerical examples based on three different scenarios or standards. The key finding was that, depending on the chosen benchmark, the price of the credits/allowances traded would be different. Also, an important point is that the price of technology is a crucial factor for the participants' decision to change their production methods to more efficient ones.

Taking this analysis a step further, possible price scenarios were examined. Holding the very strong but highly important assumption that sectors kept their economic output constant, they would be able to reduce their electricity consumption (and hence become more efficient) or sell the *capability* of using the specific units of consumption.

Subsequently, a comparison of this system with the implementation of a carbon tax, its main alternative when aiming to improve a country's environmental performance, showed that a benchmark-and-trade system's success and superiority to the carbon tax proposed in South Africa is highly dependent on the choice of the benchmark. However, with the assumed scenarios, under the benchmark-and-trade system there will always be sectors that profit from it by being the suppliers. Coversely, under taxation, all the sectors will have to increase their expenses. Moreover, if the benchmark-and-trade system is well-designed, a number of sectors such as ‘mining and quarrying’, ‘non-metallic minerals’ and ‘agriculture’ will have to pay vastly less to buy credits/allowances than paying the equivalent tax.

Finally, if the participants of the proposed system decide not to buy or sell credits but rather adjust their electricity consumption to match the chosen benchmark, then there would be no financial gains but only an influence in the electricity consumption of the country. In this case, a strict benchmark can achieve higher electricity savings than the implementation of a carbon tax system.