# The identification and export promotion of low-carbon environmental goods in South Africa

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TAKE OUR ENVIRONMENT INTO ACCOUNT.

# Summary

Economic and environmental objectives are traditionally seen as mutually exclusive, especially in terms of higher economic growth rates that are coupled with higher greenhouse gas emissions. The first aim of this study is to find a possible creative solution, in which higher economic growth can be coupled with lower greenhouse gas emissions, also known as low-carbon growth.

The literature review shows that the economic growth aspect of low-carbon growth can be achieved by increasing exports. The other part of low-carbon growth, namely lower greenhouse gas intensity, can be achieved by diffusing low-carbon technologies (or environmental goods). The World Trade Organisation also encouraged the liberalisation of environmental goods. Therefore, low-carbon growth could be achieved by promoting the production and exports of low-carbon environmental goods.

Although the World Trade Organisations has encouraged the liberation of environmental goods, there is no official list of environmental goods. Therefore, the second aim of this study is to derive a list of low-carbon environmental goods from existing lists of environmental goods. Thirty-nine low-carbon environmental goods are identified for the purpose of this study. The Decision Support Model (DSM) is used to identify realistic export opportunities for these environmental goods.

These low-carbon environmental goods were ranked based on three criteria: i) their potential environmental benefits, ii) South Africa's capacity to produce these goods, and iii) their potential economic benefits. The five low-carbon environmental goods that ranked the highest are photosensitive semiconductors (HS-6: 854140), towers and lattice masts (HS-6: 730820), electrical control and distribution boards smaller than 1kV (HS-6: 853710), gearing, ball screws, speed changers, torque converter (HS-6: 848340), and static converters (HS-6: 850440).

The exact environmental uses, producers, intensive and extensive export opportunities of the top five goods were discussed. The best overall intensive export opportunities according to potential export value are HS-6: 854140; photosensitive semiconductors (USD 922,362,000) to Germany and HS-6: 853710; electrical control and distribution boards smaller than 1kV, to the United States (USD 838,671,000). The best overall extensive export opportunities according to their potential export value are HS-6: 854140; photosensitive semiconductors to China (USD 953,255,000) and HS-6: 854140; photosensitive semiconductors to Hong Kong (USD 363,505,000).

The results of this study will enable policy-makers to make optimal decisions regarding which environmental goods to produce and export.

**Keywords:** greenhouse gas, export, low-carbon growth, environmental good, DSM

**JEL codes:** O33, Q42, Q56, F14, F18

# Opsomming

Ekonomiese- en omgewingsdoelwitte word tradisioneel gesien as wedersyds uitsluitend, veral in terme van hoër ekonomiese groei en die hoër uitset van groenhuisgasse. Die eerste doel van die studie is om ŉ moontlike kreatiewe oplossing te kry waar hoër ekonomiese groei met laer groenhuisgas-uitsette gepaard gaan. Hoër ekonomiese groei tesame met laer groenhuisgas-uitsette word ook lae-koolstofgroei genoem.

Die literatuurstudie wys dat die ekonomiese groei-komponent van lae-koolstofgroei deur verhoogde uitvoer bereik kan word. Die ander deel van lae-koolstofgroei, naamlik ŉ laer koolstof-intensiteit, kan deur die verspreiding van lae-koolstoftegnologieë (genaamd omgewingsgoedere) bereik word. Die Wêreld Handelsorganisasie (WHO) het ook die liberalisering van omgewingsgoedere aangemoedig. Dus kan lae-koolstof groei moontlik bereik word deur die produksie en uitvoer van omgewingsgoedere aan te moedig.

Al het die WHO die liberalisering van omgewingsgoedere aangemoedig, bestaan daar nog nie ŉ amptelike lys van omgewingsgoedere nie. Die tweede doel van die studie is dus om ŉ lys van lae-koolstofomgewingsgoedere vanuit vier bestaande lyste saam te stel. Nege-en-dertig lae-koolstofomgewingsgoedere is vir die doel van die studie geïdentifiseer. Die *Decision Support Model* (DSM) is gebruik om realistiese uitvoergeleenthede van die goedere te identifiseer.

Hierdie lae-koolstofomgewinggoedere is gerangskik gebaseer op drie kriteria: i) hul potensiële omgewingsvoordele, ii) Suid-Afrika se kapasiteit om die spesifieke produk te produseer, en iii) hul potensiële ekonomiese voordele. Die vyf lae-koolstofomgewingsgoedere wat hoogste geklassifiseer is, is fotosensitiewe halfgeleiers (HS-6: 854140), torings en roostermaste (HS-6: 730820), elektriese beheer en verdeelborde kleiner as 1kV (HS-6: 853710), hefboomfinansiering, balskroewe, spoedwisselaars, koppelomsitter (HS-6: 848340), en statiese omvormers (HS-6: 850440).

Die presiese gebruike van die goedere in ʼn omgewingskonteks word beskryf, en die produsente in Suid-Afrika sowel as die intensiewe en ekstensiewe uitvoergeleenthede van die top-vyf lae-koolstofomgewingsgoedere word ook bespreek. Die algeheel beste intensiewe uitvoergeleenthede is HS-6: 854140; fotosensitiewe halfgeleiers (USD 922,362,000) na Duitsland en HS-6: 853710; elektriese beheer en verdeelborde kleiner as 1kV na die Verenigde State van Amerika (USD 838,671,000). Die algeheel beste ekstensiewe uitvoergeleenthede is HS-6: 854140; fotosensitiewe halfgeleiers na Sjina (USD 953,255,000) en HS-6:854140; fotosensitiewe halfgeleiers na Hong Kong (USD 363,505,000).

Die resultate van die studie sal beleidmakers in staat stel om optimale keuses te maak aangaande watter omgewingsgoedere te produseer en uit te voer.

**Sleutelwoorde:** groenhuisgas, uitvoerbevordering, lae-koolstofgroei, omgewingsgoedere, DSM

**JEL-kodes:** O33, Q42, Q56, F14, F18

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## List of abbreviations

| | |
|---|---|
| $CO_2$ | Carbon dioxide |
| $CO_2$-eq. | Carbon dioxide equivalent. |
| COP | Conference of Parties |
| CTESS | Committee on Trade and Environment Special Session |
| DSM | Decision Support Model |
| DTI | Department of Trade and Industry |
| EGS | Environmental Goods and Services |
| FERDI | *Fondation Pour Les Etudes Et Recherches sur le Développement International* / Foundation For The Study And Research on International Development |
| GATT | General Agreement on Tariffs and Trade |
| GHG | Greenhouse gas |
| Gt | Gigatonne |
| HS | Harmonized System |
| HS-6 | Harmonized System six digit level |
| ICTSD | International Centre for Trade and Sustainable Development |
| IISD | International Institute of Sustainable Development |
| IPCC | Intergovernmental Panel on Climate Change |
| ITC | International Trade Centre |
| NES | Not Elsewhere Specified |
| ppm | parts per million |
| RCA | Revealed comparative advantage |
| UN COMTRADE | United Nations Commodity Trade database |
| UN | United Nations |
| UNFCCC | United Nation Framework Convention on Climate Change |
| USD | United States Dollar |
| WB | World Bank |
| WCC | World Climate Conference |
| WTO | World Trade Organisation |
| WWF | World Wide Fund for Nature (in USA known as World Wildlife Fund) |

# Chapter 1: Introduction

> *To say that history ended in 1806 meant that mankind's ideological evolution ended... (current ideology's) theoretical truth is absolute and could not be improved upon.*

(Fukuyama, 1989)

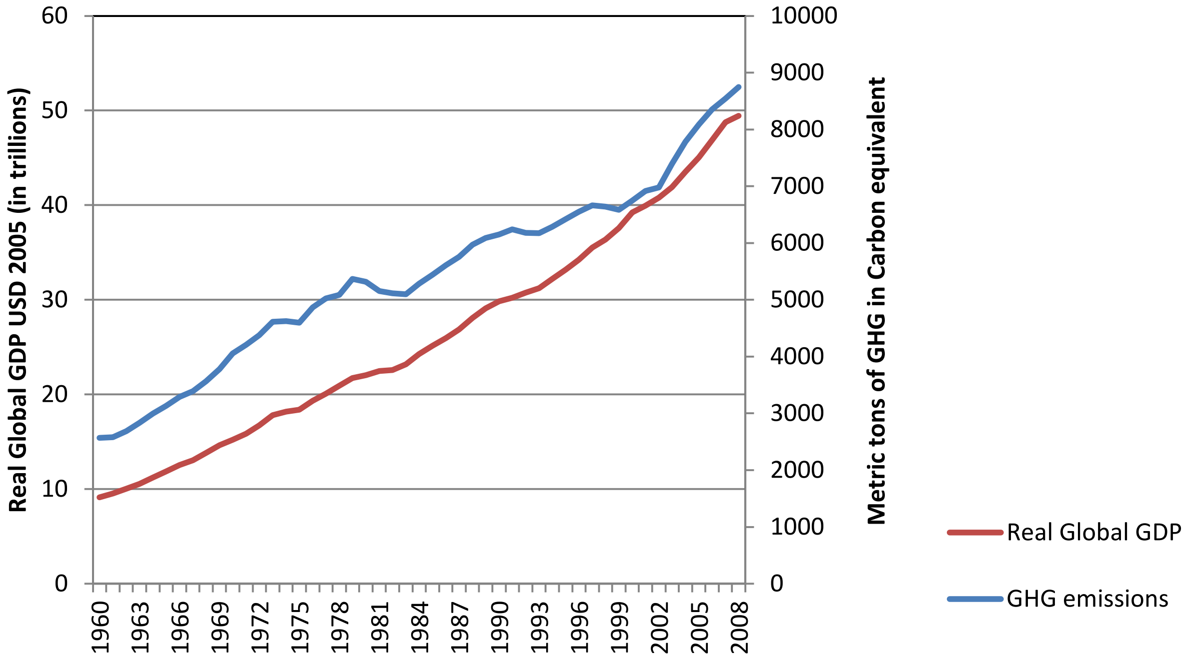
## 1.1. Background and motivation

The existing global post-industrialisation economy has various astonishing abilities. So great that Francis Fukuyama described it as the end of history because humankind had the answer to which political-economic ideology is paramount (Fukuyama, 1989). Fukuyama argued that theoretically no alternations could be made that will improve the current ideology. Yet it is clear that the current global political-economic system is not perfect; not only in its implementation but it also has theoretical shortcomings. There are certain development constraints, particularly environmental constraints that restrict unlimited economic growth (Czech, 2000:177). The economy cannot increase indefinitely without losing at least some of the natural environment.

There is not only theoretical disharmony in how the current economic-political ideology perceives the environment, but this disharmony between the environment and the economy is also visible daily in a wide variety of indicators. One important indicator is the increase in average global temperatures, which natural scientists mostly agree are due to greenhouse gasses emitted during various human activities (ASSAf, 2011:65; Tamiotti, The, Kulaçoğlu, Olhoff, Simmons, & Abaza, 2009:26). Other indicators include a decrease in biodiversity, the depletion of natural resources, the decline in air and water quality, the increasing deforestation and the accumulation of waste (WWF, 2010).

The increase in greenhouse gas emissions since the industrial revolution has caused the average temperatures of the earth to increase substantially (Tietenberg & Lewis, 2009:3) (see section 2.5.3). The strong correlation between the number of economic activities and its environmental impact is particularly clear if viewed in terms of greenhouse gas emissions, as seen in figure 1.1.

Figure 1.1. Global greenhouse gas emissions excluding land usage and real global GDP (1960-2008)




*Sources*: Boden, Marland and Andres (2010) and World Bank (2012).

Due to the presence of natural atmospheric greenhouse gasses the average global temperature 14°C instead of -19°C (World Meteorological Organisation, n.d.). If the correct compositions of atmospheric gasses are not maintained, the global temperature range will shift outside this optimal range of organic life forms. Since every economic activity results in some emission of greenhouse gasses, it is difficult to implement policies that will simultaneously address environmental objectives such as lower greenhouse gas emissions and economic objectives, such as economic growth (see section 2.2). Thus far, policies have favoured economic concerns above environmental concerns (Low, 2011:2).

South Africa, as most other countries, aspires to increase the country's economic growth rate, in order to decrease unemployment and income inequality. The South African National Development Plan for 2030 identified a number of key drivers of change that are expected to have a significant impact on South Africa's economic growth and one of these drivers is the environment (National Development Commission, 2011). However, because of the positive relationship between economic activities and environmental impact, especially in terms of an increase in greenhouse emission (Perman, Ma, Common, Maddison, & McGilvray, 2003), such a strategy may lead to conflict between aspirations to increase socio-economic welfare and protect the environment. The size of the population is also an important aspect to take into consideration.

Although South Africa does not rank among the larger populations of the world, the country is the fourteenth largest carbon dioxide ($CO_2$) emitter (CSIR, 2010:ii). If population size is taken into consideration, South Africa ranks amongst the largest polluters per capita. One of several explanations includes South Africa's fossil fuel consumption, particularly its coal dependency (see section 2.7.1.1). On the other hand coal is one of South Africa's major economic contributors (CSIR, 2010:ii). The high fossil fuel dependency of the South African economy shows how the relationship between economy and environment is often negative.

However, the relationship between the environment and the economy does not necessarily have to be negative. In order to reach a sustainable balance between the environment and the economy, both environmental and economic objectives must be taken into account. Environmental objectives such as lower greenhouse gas intensity could be partially achieved by diffusing[1] technologies that have lower greenhouse gas intensity (see section 2.8.1.). Economic growth, on the other hand, could be increased through increased production and export promotion (see section 2.3). Thus, the two objectives, lower greenhouse gas intensity and economic growth, could be achieved

1 Diffusion of technologies refers to how goods are accepted and then distributed into a society. Section 2.7.2 defines the term diffusing of technologies in more detail.

simultaneously by encouraging production and the promotion of the export of goods that have a high potential to mitigate greenhouse gasses (see section 2.8.).

Even if the production of environmental goods in South Africa is not environmental friendly, the export of these goods can still contribute to a low-carbon society globally and especially in South Africa. This can be done in three different ways; first, increasing the production, even carbon-intensive production, can increase local sales and awareness of low-carbon goods. Second, the low-carbon environmental goods sector in South Africa will grow due to increased exports. Third, an increase in per capita income in South Africa will increase the affordability of low-carbon environmental goods in South Africa.

From a multilateral agreement perspective the Doha Ministerial Declaration has been encouraging the elimination of tariffs and non-tariff measure (NTMs) of environmental goods and services (CTESS, 2007). Although the liberalisation of environmental goods and services has not been made mandatory, liberalisation on environmental goods has already increased (Tamiotti *et al.*, 2009:48).

### 1.1.1. Defining environmental goods.

There are many definitions of environmental goods. Steenblik (2005:1) defined them as goods and services that measure, prevent, limit, minimise or correct environmental damage to various environmental entities. The Organisation for Economic Co-operation and Development (OECD) defined it as goods and services that reduce environmental risk and minimise pollution and resource use (OECD/Eurostat, 1999:9). These definitions refer to the end-use of these goods, for example what happens when a wind turbine is used to generate electricity. The definitions do not refer to the production of these goods, for example while producing wind turbines steel could be mined from sensitive ecosystems, which has a negative environmental impact.

There is, however, no universally accepted definition of environmental goods and services (Balineau & De Melo, 2011:3). The inability to agree on a definition causes problems in classifying goods as internationally accepted environmental goods. There are various methods to identify environmental goods, which include the list approach, the end-use approach and the request-offer approach (Cosbey, Aguilar, Ashton and Ponte, 2010:13-15) (see section 3.2). Policy makers often refer to a list of environmental goods rather than a rigid definition (UN, 2003). Several lists have been submitted by various parties, none of which has been accepted as the official list of environmental goods. For this study, the list approach will be used (see section 3.2).

To identify environmental goods is a complex task because many environmental goods can be used for different purposes. Some goods have multiple end-uses that can damage the environment, for example if gears are used in wind turbines, it has a positive environmental effect, but when the same gears are used in generating electricity from coal combustion, it has a negative environmental effect. In this study the issue of multiple uses will not be taken into consideration (see also section 1.6).

All environmental goods have, in a certain respect, a role of guaranteeing environmental quality and can be divided accordingly into sub-groups. Some of these sub-groups of environmental goods include; pollution control, waste management, renewable energy plants and environmental monitoring. According to the International Institute of Sustainable Development (IISD) only the one sub-group consisting of *Renewable Energy Plants,* has a high potential for reducing greenhouse gas emission (Wooders, 2009:4). Low-carbon environmental goods are goods that have a high potential to reduce greenhouse gas emissions in its end-use (Solarpowernotes, n.d.). Therefore, this study will focus on the thirty-nine environmental goods identified by the World Trade Organisation (WTO), World Bank (WB), International Centre of Trade and Sustainable Development (ICTSD) and *Fondation pour les Etudes et Recherches sur le Développement International* (FERDI) (from here on named the Foundation for The Study and Research on International Development) that are classified as *Renewable Energy Plant*, and are therefore low-carbon environmental goods.

### 1.1.2. Linking environmental goods with exports

In order to increase South Africa's exports a study was undertaken by Steenkamp, Rossouw, Viviers & Cuyvers (2009) to identify export opportunities for South Africa by using the Decision Support Model (DSM). The DSM is a model that uses a series of filters in order to identify the best suited export opportunities for a specific country. The DSM starts with all possible product-country combinations and eliminates these on the ground of political and economic risks and production possibilities. Therefore, the DSM focuses on the demand-side for export opportunities from South Africa to the rest of the world. For a holistic approach, the world's demand for South African products[2] cannot be researched in isolation; the South African supply of possible products should also be included. Although DSM shows the optimal demand-side of export opportunities from South Africa, this study aims to also focus on the supply-side or production of those products that can specifically be listed as environmental goods. The revealed comparative advantage (RCA), export market share and export market growth of these products will also be taken into account (see section 3.5.1). In order to be able to focus on achieving economic growth as well as lowering greenhouse gas emissions, it is necessary to identify South Africa's export opportunities of the 39 low-carbon environmental goods as identified in section 3.2.

## 1.2. Problem statement

Economic and environmental objectives are traditionally seen as mostly opposing: continued economic growth increases pressure on certain biophysical limits that result in symptoms such as extinction, resource shortages and climate change (Czech, 2000:177). It is difficult to enforce a policy that would simultaneously add value to both economic objectives, such as economic growth and environmental objectives, such as a decrease in greenhouse emissions. The South African

[2] While the terms 'goods' and 'products' are used interchangeably in this study, the term 'goods' will be used more in the context of environmental aspects and the term 'product' will be used more in a trade context. This is done to be consistent with WTO negotiations, which refers to environmental goods and the DSM, which refers to products.

National Development Commission identified export promotion as a driver for economic growth and also identified the environment as a key driver for change. Therefore, a policy should be developed that could simultaneously encourage exports and have a positive effect on the environment.

## 1.3. Research objectives

The objectives of this study are as follows.

i. To give a holistic view of a green economy, what factors are necessary contributions to a green economy and how these contributions interact (see section 2.2).

ii. To illustrate the importance of exports as a means to increase economic growth (see section 2.3).

iii. To give a short description of exports in South Africa and how the DSM can be used to encourage exports (see section 2.4).

iv. To describe the current state of the environment in terms of greenhouse gas emissions and more specifically the effect thereof on anthropogenic climate change (see section 2.5).

v. To give a short history of current international mitigation policies and laws relating to greenhouse gas emissions (see section 2.6).

vi. To focus further on the South African environment, the South African energy sector and current policies to mitigate greenhouse gasses in South Africa (see section 2.7).

vii. To creatively link exports and lower greenhouse gas emissions in such a manner as to increase economic growth and decrease the total environmental pressure thereof (see section 2.8).

viii. To establish a list of environmental goods on Harmonised System Six (HS-6) level that have a high potential to reduce greenhouse gas emissions and to identify realistic and feasible export opportunities for these goods by using the DSM (see section 3.2. and Appendix B).

ix. To rank low-carbon environmental goods further on the basis of three criteria; a) potential environmental benefits, b) South Africa's production capacity and c) potential economic benefits (see section 3.3 to 3.5).

x. To describe the five best low-carbon environmental goods in terms of:
   - their respective environmental uses (see section 4.2),
   - the major producers of these goods in South Africa (see section 4.3),
   - other economic benefits like the growth in RCA, market share and market growth and potential export value (see section 4.4)

xi. To discuss the intensive and extensive[3] export opportunities of the five best low-carbon environmental goods.

## 1.4. Research method and design

For the study, the research method includes a literature review as well as an empirical study.

The literature review will focus on establishing the link between the enhancement of exports and to suggest means of simultaneously decreasing the environmental impact on the economy. The literature review can be divided into four main parts; the first part of the literature review will focus on the definition of a green economy. The second part of the literature review will focus on the importance of exports as a means to increase economic growth and give a description of both on South Africa's exports and the DSM. The third part will include a description of the environment in terms of greenhouse gas emissions and give a short history of the current international mitigation policies. This part will also investigate the state of the South African environment and current international law and policies will also be discussed that are applicable to the South African economy. The fourth part will propose a possible creative link that could be made between export

[3] Intensive and extensive export opportunities are explained in detail in section 4.5 according to the World Bank's Trade Competitive Toolkit. Intensive export opportunities entail increasing the exports of already existing product-country combinations. Extensive export opportunities entail either the exportation of a new product or the exportation to a new trading partner

promotion and lower carbon emissions in such a manner as to increase economic growth and decrease the total environmental pressure thereof.

The empirical part of the study will firstly entail a detailed process of identification of the environmental goods which have high potential to decrease greenhouse gas emissions in end-use, named low-carbon environmental goods. Secondly, the empirical study will identify export opportunities for the list of environmental goods by using the results of a study on the DSM by Steenkamp (2011). Thirdly, the low-carbon environmental goods will be ranked according to three criteria, potential environmental benefits, potential economic benefits and South Africa's ability to produce the goods. The best five low-carbon environmental goods on the basis of these criteria will be discussed in terms of their respective environmental uses, the main South African producers, growth in RCA, market share and market growth. Finally a description will be given of the intensive and extensive export opportunities of the top five low-carbon environmental goods.

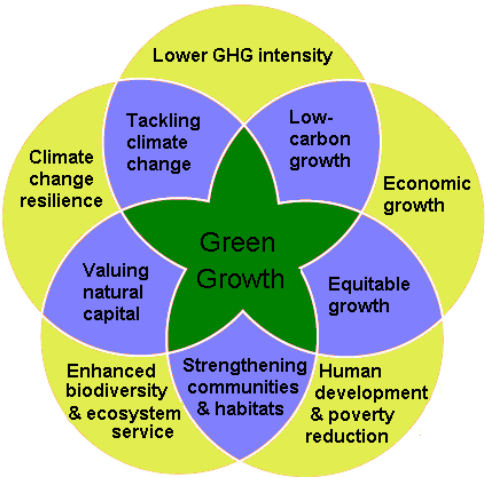
The Decision Support Model approach to identify export opportunities was used (see section 3.5 and appendix B). Methods of the International Trade Centre (ITC) to identify export opportunities were also investigated. The ITC methodology for identifying export opportunities is not used in this study because the ITC methodology focuses on the export opportunities of one specific product to a specific country or countries. Other methods of the ITC, such as calculating a normal distribution of marks in the criteria, will be used.

Interviews with engineers at the Centre for Renewable and Sustainable Energy Studies at the University of Stellenbosch also ensured that the technical aspects of the study are correct (see Appendix C). Discussions with Dr. Fredrik Dalerum from the Centre of Wildlife Management of the University of Pretoria were carried out to ensure that the environmental science of the study was correct (see Appendix C).

## 1.5. Demarcation

As shown n figure 1.2 the environment is a multifaceted entity, a holistic improvement of the environment is too broad for this study. The focus of this study is rather on low-carbon growth, a sub-system of a green economy, which composes of economic growth and lower anthropogenic greenhouse gas intensity (Low, 2011:2). Other economic, environmental and social aspects of green growth fall outside the scope of this study. The various aspects of the green economy will be discussed in more depth in section 2.2.

Figure 1.2: Various aspects in a green economy.




*Source*: Low (2011:2)

The study focuses only on environmental goods (see section 1.1.2) and excludes environmentally preferable goods. Environmentally preferable goods are those goods that have a close substitute that is less environmentally friendly, either in production, end-use of in disposal (Balineau & De Melo, 2011:4).

The environmental impact in the production of these goods will also not be investigated in this study. Only the environmental impact in the end-use of the goods will be taken into consideration (see section 1.1.1).

Environmental services are excluded from this study, even though environmental goods and services are frequently used in unison, for example the goods on a wind farm and the maintenance or operation thereof are seen as environmental goods and environmental services respectively (Barria, Cattafesta, Garrido, Hernandez and Vossenaar, 2004:76).

Adaptation and mitigation policies are both equally important during climate change, but this study will only focus on policies and goods to mitigate anthropogenic climate change (see section 2.5.4). Of the various mitigation policies, the focus of this study will be on the mitigation of greenhouse gasses.

## 1.6. Division and summary of chapters

The chapters of the dissertation are presented as follows:

Chapter 1 contains the motivation, problem statement, research objectives, research method and design, demarcation as well as an overview of the chapters.

Chapter 2 is broadly divided in four parts; the first part is an extensive description of the definition of a green economy. The second part is a description of the importance of export promotion in order to encourage economic growth and a description of South Africa's exports and the inclusion of the results of the DSM (2011) on the identification of realistic export opportunities for South Africa. The third part is a literature review on the state of the environment, policies and international law regarding the environment and greenhouse gas emissions, special focus is given to the state of the South African environment, energy sector and mitigation policies. The fourth part of the chapter makes a creative link between export promotion and decreasing greenhouse gas emissions.

Chapter 3 is an empirical study that identifies environmental goods with a high potential for reducing greenhouse gas emissions and the export opportunities of these goods. Further description of the goods will be given in three regards a) the potential environment benefits of increasing production and exports of the goods, b) South Africa's capacity to produce the goods and c) the potential economic benefits of increasing production and exports of the low-carbon environmental goods.

Chapter 4 describes the top five low-carbon environmental goods that were identified in chapter 3 in terms of their environmental uses, gives details of South Africa producers and other economic characteristics such as the revealed comparative advantage, potential export value and possible intensive and extensive export opportunities.

Chapter 5 will give the conclusions and recommendations of the study. The limitations of the study, as well as further areas of research are also given.

# Chapter 2: Literature review.

> *"And while humankind doubtless had the capacity to destroy life on earth, humankind never had greater capacities and possibilities to safeguard the environment and to improve the living conditions for all people on earth."*

(Volker, 2007)

## 2.1. Introduction.

Traditionally, it is believed that environmental and economic objectives are mostly opposing. Most economic activities, to a greater or lesser degree, are coupled with greenhouse gas emissions (Tamiotti *et al.*, 2009) (see section 1.1). Since the industrial revolution decision making has been skewed towards economic objectives (Low, 2011:2). Yet, it is ever more apparent that this skewed decision making caused significant damage to the environment (see section 2.5). Decision-making should thus be corrected with the complicated task of simultaneously addressing economic and environmental issues.

The environment has various values for the economy in terms of the goods and services it provides (see section 2.5.1). The most fundamental of these environmental services is the provision of a biophysical environment that resides within the limits of organic life (Tietenberg & Lewis, 2009). One of the most critical of the biophysical variables that maintains these limits is a very narrow range in ambient temperatures. This temperature range is created by an atmospheric greenhouse effect which increases the average global temperature from -19°C to 14°C (World Meteorological Organisation, n.d.). The composition of atmospheric gasses should therefore be maintained, since any alterations could shift the global temperature range outside the optimal range of organic life forms. Since every economic activity results in some emission of greenhouse gasses, it is difficult to implement policies that will simultaneously address environmental objectives such as lower greenhouse gas emissions and economic objectives, such as economic growth (see section 2.2).

The aim of this chapter is fourfold: firstly, to provide a detailed definition of the term 'green economy' (see section 2.2); secondly, to describe the importance of increased exports for economic growth (section 2.3), including a short description of South African exports and a brief overview of the DSM (see section 2.4); thirdly, to describe the state of the environment, with special emphasis on the composition of atmospheric greenhouse gasses (section 2.5), including a review of current laws and policies regarding mitigation of anthropogenic greenhouse gas emissions (section 2.6) and with a special focus on the South African environment and mitigation policies (section 2.7); and finally, to create a possible creative solution in which both economic and environmental solutions are taken into consideration (section 2.8).

## 2.2. A holistic view of a green economy.

The environment is a complex entity which requires equally complex solutions to respond to different environmental crises (see section 2.5.1). Although decreasing greenhouse gasses is a necessary step towards a healthy environment, this alone is not sufficient (see figure 1.2). Decreasing greenhouse gasses may have a negative impact on other components of the environment. For example, wind turbines provide energy without emitting greenhouse gasses, but may also have a negative impact on local birds, therefore lowering biodiversity (Erickson, Johnson, Strickland, Young, Sernka & Good, 2001). Similarly, hydroelectric power is another example of a renewable energy source that does not directly emit greenhouse gasses, but the construction of power dams poses immense pressure on the local fauna and flora, and can drastically alter local ecological systems and damage the environmental services they provide (Conzendey, 2011). Furthermore, the production of environmental goods can have a significant impact on the environment, such as the production of solar panels which could pollute the nearby environment with fluoride (Wilson, 2011).

In addition, policymakers not only have to take these complex environmental issues into account, but also complex social and economic issues. So far, the increased environmental degradation has been the result of decision making that has been skewed toward prioritising economic concerns over environmental ones (Low, 2011:2). This unbalanced decision making needs to be corrected, without tending towards an environmental bias. An inclusive solution should be applied that takes economic, social and environmental issues into account. One such possible solution is the achievement of so called green growth.

Green growth is a relatively new term that aims to describe an economy that grows inclusively with environmental, economic and social objectives (Low 2011:1). Environmental objectives include, for example, lowering the greenhouse gas intensity of the economy, maintaining biodiversity, ecosystem services and increasing climate change resilience (see figure 1.2.). Economic objectives include, for example, increasing economic growth (see figure 1.2.). Social objectives include, for example, increasing human development and decreasing poverty (see figure 1.2). These objectives are shown by the yellow circles in figure 1.2. and green growth is defined by the area that simultaneously captures all of the objectives, as indicated by the green star-shape in figure 1.2.. The concept of a green economy is not merely a theoretical concept; there are already some countries that have made significant steps towards implementing a green economy (Panitchpakdi, 2012).

This study will only focus on how to achieve low-carbon growth, a necessary sub-set of green growth (see section 2.2). In figure 1.2, low-carbon growth is the intersection of economic growth and lower greenhouse gas intensity. The greenhouse gas intensity of the economy is the ratio of greenhouse gasses emitted per unit of economic activity (Law Revision Council, 2012). In order to achieve higher economic growth rates, the South African National Development Plan identified export promotion as a key driver. The effect of increased export on economic growth is subsequently discussed.

## 2.3. Economic benefits of export promotion

There are various drivers of economic growth. The National Development Plan identified export promotion as one of the key drivers of economic growth for South Africa (NDC, 2011). Increased exports have an array of positive economic effects. Classical economists such as Adam Smith (1776) and David Ricardo (1817) stipulated the benefits of increased exports with their respective theories of absolute and comparative advantages (Mohr & Fourie, 2008). A study by Naudè, Bosker and Matthee (2010) using data from 1996 to 2001 found that a region that was more open to trade had higher levels of local economic development, better educated population and higher GDP growth.

### 2.3.1. Increased income inflows

Exports are a component of the total income received in a country. Other components include spending by local consumers, government spending and various investments (Mohr & Fourie, 2008:51). Foreign consumers purchase products from South Africa, and therefore the income received by exports is an injection into the South African economy (Mohr & Fourie, 2008:51). Increasing exports increase the circular income-spending-production flow of an economy (Mohr & Fourie, 2008:51), and therefore also increases the foreign exchange received by a country. Furthermore, increased exports have a positive effect on the balance of payments (Mmieh, Owusu-Frimpong & Mordi, 2012; Albaum, Strandskov & Duerr, 2002). The current account shows the difference between exports and imports. Increased exports can pull the current account out of a deficit and a positive current account is an indicator for a favourable investment climate (European Central Bank, 2006). Increased exports can help financing imports of intermediary goods, which in turn is important for economic development.

### 2.3.2. Increased productivity and efficiency

Increased exports also promote economic growth through an increase in productivity. When a market is exposed to foreign competition, there is an increment in the efficiency of firms. Exporting could improve the financial position of a firm, increase the technological base and create a competitive advantage (Mmieh, *et al.*, 2012). This exposure to international competition and possibly new technologies could potentially increase the productivity of workers (Abor, 2012:9). Exposure to new technologies and increased productivity of workers could ensure more efficient use and allocation of resources. The less efficient firms will not be able to compete and eventually exit the market (Egger & Kreickemeier, 2008; Edwards, Rankin, & Schoer 2008:80). This is also evident in South Africa where 10% increased openness in trade led to a 5% increase in long-run total factor productivity gains (Jonsson & Subramanian, 2001).

### 2.3.3. Impacts on employment and wages

Restrictions to trade are often implemented to protect local workers and keep unemployment levels under control (Mohr & Fourie, 2008). However, the relationship between trade liberalisation and employment is not necessarily negative. Trade liberalisation has a greater possibility of having a positive effect on employment if the labour market of the country is flexible (Hasan, 2001). Regulated labour markets might have higher wages, but this is usually coupled with higher unemployment (Hasan, 2001). Increasing trade openness, especially with an economically similar trading partner, could possibly lower union wage claims, support employment growth and increase welfare (Egger & Etzel, 2012). The distribution of wage income tends to equalise when a country opens up to trade with an economically similar trading partner (Egger & Etzel, 2012). Evidence shows that South Africa experienced significant declines in unemployment when trade from the United States and European Union was contracted (Kucera, Roncolato & Von Uexkull, 2012).

Theoretically trade liberalisation or an increase in trade can improve the income flows, worker productivity, efficiency of firms and employment in a country. Further examination should be done if this relationship between trade and the economy is also empirically true in South Africa. The current export situation in South Africa is subsequently discussed.

## 2.4. South African exports

### 2.4.1. Description of South African exports

Before democratisation, sanctions on trade and capital flows, together with political turmoil contributed to South Africa's weakest decade of economic growth since the Second World War (Du Plessis & Smit, 2007). After democratisation, the economic growth rates of South Africa improved. Those higher economic growth rates (post 1994) were achieved by three fundamental economic changes; i) lower interest rates, ii) lower political uncertainty and iii) trade openness and capital flows (Du Plessis & Smit, 2007). As expected, the liberalisation of trade and elimination of trade barriers increased and induced favourable economic growth rates (Du Plessis & Smit, 2007).

More than twenty years after democratisation the positive effects of the drastic improvement in trade openness, have stabilised. South Africa has to concentrate on other factors to further enable trade. According to the Global Enabling Trade Report of 2012, South Africa is improving in enabling trade, while larger countries such as China and the United States are getting worse in enabling trade (Duncan, 2012). The report takes various measures into account such as the tariff levels and the complexity thereof, administration, corruption, logistics, business climate, physical security and government efficiency (Duncan, 2012). Despite the improvements South Africa made in enabling trade relative to larger economics, South Africa still only ranks 64$^{th}$ of 132 countries, while the USA and China are ranked 23$^{rd}$ and 56$^{th}$ respectively (Duncan, 2012). On a firm-level there are many obstacles that need to be overcome to further enable trade, e.g. firms need help to make optimal strategic export decisions when they are confronted with an abundance of data (Kuhn, 2010).

Firms have a lot of information at their disposal to use when making export strategic choices, e.g. data on export quantities, export volumes, export growth and various other trade indicators are easily available from reliable sources such as the ITC and Department of Trade and Industry (DTI). However, the abundance of data and information poses problems in the sorting of valuable data, understanding the importance thereof and utilising it in export strategy decision-making (Kuhn, 2010). Various methodologies are focused on identifying the best export destination for specific goods, such as the shift-share model (Green and Allaway, 1985), the global screening model (Russow and Okoroafo, 1996), the multiple criteria method (ITC, 2012) and the DSM (Cuyvers, Steenkamp & Viviers, 2012). In this study, the DSM will be used as the basis for the identification of realistic export opportunities for a limited list of environmental goods.

### 2.4.2. Identify export opportunities: Decision Support Model

As indicated in section 2.4.1, there are various models and methods to identify export opportunities. One of those methodologies is the DSM which aims to identify export opportunities by not merely investigating a country's traditional or already existing exports but by considering all product-country combinations it identifies new export markets (Cuyvers *et al.*, 2012). The DSM was chosen as an appropriate methodology to identify realistic export opportunities for this study for two reasons. First, this study is not one product specific but a group of products are investigated and second, this study is not one country specific but investigates all possible export opportunities, both existing and new. For both of these reasons the DSM methodology was ideal.

The DSM uses a system of elimination, starting off with all possible worldwide product-country combinations. An example of a product-country combination would be to export product HS-730820 (towers and lattice masts) to Australia. The product-country combinations are identified through a series of filters. The first filter eliminates all countries that show high political and commercial risk in doing business or have an unsatisfactory macroeconomic size and/or growth

(Cuyvers *et al.*, 2012). The second filter eliminates countries that show insufficient size and growth of import demand (Cuyvers *et al.*, 2012). The third filter takes the accessibility of every country for the specific product into account. This filter includes market concentration (measured by the Herfindahl-Hirschman index) and various barriers for entry including transport time and cost, logistic performance of the importing country, *ad valorem* equivalent tariff and non-tariff measures (Cuyvers *et al.*, 2012).

The effects of sudden trade liberalisation after South Africa's democratisation have stabilised (Naudè, *et al.*, 2010). To enable trade further in South Africa, models like the DSM should be used to support export strategic decision making on firm-level. This could encourage economic growth, but to also ensure low-carbon economic growth. The greenhouse gas intensity of the economy should decrease simultaneously (see figure 1.2). To decrease greenhouse gasses, it is firstly important to describe the current state of the environment. The state of the environment will be subsequently discussed.

## 2.5. State of the environment.

The environment is a multifaceted entity. To measure the quality of the environment, more than one aspect of the environment should be taken into consideration. The World Wide Fund (WWF[4]) describes the state of the global environment with a multifaceted method. According to the *Living Planet Report* (2010) the state of the planet is measured in five parts. The first part is the observation of biodiversity. This is done by the *Living Planet Index* that incorporates a wide variety of species from different biomes (WWF, 2010:20). The second part measures the demand humans place on the environment, by calculating the environmental footprint and the water footprint in production (WWF, 2010:32). The third and fourth parts look at services the ecosystem provides,

[4]Also known as the World Wildlife Fund in the United States.

globally and locally, respectively. In order to determine the state of the environment, an array of measures is needed (WWF, 2010:42). An environmental footprint is such a measure that takes an array of environmental factors into account.

### 2.5.1. Environmental footprint

The environmental footprint, as used in the *Living Planet Report* is a comparison between the total demand of humans on the biosphere against the biospheres capacity to renew itself, also known as bio-capacity (WWF, 2010:32). The three components used to measure the environmental footprint are areas needed to provide renewable resources, areas occupied by infrastructure and areas necessary to absorb waste. Areas needed to provide renewable resources can also be defined as cropland, fishing, forests and grazing[5] (WWF, 2010:33). Areas occupied by infrastructure are also termed built-up land and is defined as all the land that is fiscally occupied (WWF, 2010:33). Finally areas that have capacities to absorb waste are defined as the amount of forests required to absorb all the anthropogenic carbon dioxide (WWF, 2010:33). While carbon dioxide ($CO_2$) is often seen as the most significant greenhouse gas (Lucas, 2011), other greenhouse gasses such as methane should not be disregarded as they may have higher abilities to absorb heat per molecule than $CO_2$ (Lashof & Ahuja, 1990). In terms of greenhouse gas emissions the environmental footprint is increasing, because current anthropogenic greenhouse gas emissions surpass the environment's capacity to absorb greenhouse gasses. Therefore, it is also important to discuss greenhouse gasses in more detail and investigate the state of global greenhouse gas emission.

[5] The fishing grounds footprint is calculated by using the area needed to rejuvenate freshwater and marine fish caught. This was calculated by using 1439 marine species and 268 freshwater species. The forest footprint is the amount of timber, pulp, fuel wood and other wood products consumed by specific groups. The grazing land footprint is the area needed to sustain all livestock (WWF, 2010:33).

### 2.5.2 Greenhouse gasses

Greenhouse gasses (GHG) are defined as all the gasses in the atmosphere that have the ability to absorb infrared radiation which increases the average temperature in the biosphere (Lashof & Ahuja, 1990). The United Nations Framework Convention on Climate Change (UNFCCC) identifies carbon dioxide, methane, nitrous dioxide, perfluorocarbons, hydrofluorocarbons, sulphur hexafluoride, carbon monoxide, nitrous oxides, sulphur oxides and volatile organic compounds (VOC) as the minimum greenhouse gasses included in international agreements (UNFCCC, 2004:8).

Greenhouse gasses are important to sustain a suitable temperature range for organic life (Tietenberg & Lewis, 2009). The natural greenhouse effect is vital to sustain life on earth as it increases the average surface temperatures of the earth by 32°C, from -19°C to 14°C (World Meteorological Organisation, n.d.). It is also vital that greenhouse gasses should maintain a sensitive balance in the atmosphere: too much greenhouse gas in the atmosphere could also create an unliveable environment with temperatures which are too high, shifting of seasons and an increasing occurrence of extreme weather patterns (Capôco, 2010:7). Increased greenhouse gasses also have a substantial and unpredictable impact on fresh water, coastal systems, hydrology, food production, fibre production and human health (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks, Howells and Alfstad, 2006). Global warming that has been caused by increased anthropogenic greenhouse gas emissions has been an increasingly important topic. It is therefore important to also state the exact amount of anthropogenic greenhouse gasses in the atmosphere.

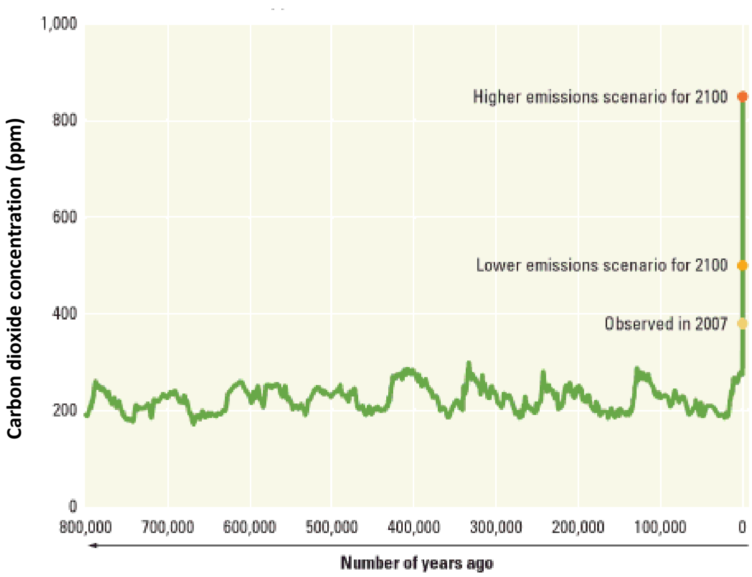
### 2.5.3. State of global greenhouse gasses and global warming

Even before human inhabitation, the earth experienced climate fluctuations. However, the current climate change differs from these previous fluctuations in that it is mainly induced by human activities (World Meteorological Organisarion, n.d.; Houghton, Meira, Filho, Callander, Harris, Kattenberg, Maskell, 1996; Tietenberg and Lewis, 2009:3; Lucas, 2011).

This process started with the industrial revolution, and the subsequent increase in emissions of primarily carbon dioxide as the result of combustion of fossil fuel (Hoffmann, 2010:10). There is a correlation between greenhouse gas emissions and economic activities (see figure 1.1). The atmospheric carbon dioxide level increased from about 280 parts per molecule (ppm) to 470ppm of greenhouse gas in carbon dioxide equivalent ($CO_2$-eq) from pre-industrialisation to 2009/10 (Hoffmann, 2010:10). Figure 2.1 shows carbon dioxide over time, with forecasts of both low and high expected emissions for 2100; where even the low expected emissions scenario is unsustainable (World Bank, 2010:4).

Previous surges in greenhouse gas emission can be observed in figure 2.1 by the peaks of the green line. None of these peaks have the intensity of the current peak in greenhouse gasses (either higher or lower scenarios) which has been caused by human activity. The total anthropogenic carbon dioxide emitted is 9 Giga ton (Gt) and natural sinks absorb 4.3Gt $CO_2$ per year and the rest accumulates in the atmosphere (Lucas, 2011). This is particularly problematic as carbon dioxide accumulates in the atmosphere for hundreds of years (Tambrian, 2012:35).

Figure 2.1: Carbon dioxide over time




*Source*: World Bank (2010)

In a business as usual scenario, the global average temperatures can rise up to 5°C at the end of the twenty first century (NDC, 2011). If a rise in temperatures is to be kept to a 2°C minimum, greenhouse gasses need to be reduced by 50 to 80% in the next ten years (World Bank, 2010:289). The market will not be able to deliver a decrease in greenhouse gasses without international cooperation, mandatory mitigation and adaptation policies and law.

### 2.5.4. Mitigation and adaptation policies

Policies concentrating on ways to lower the greenhouse intensity of an economy are also classified as mitigation policies. Mitigation policies recommend that greenhouse gas intensive emitters such as buildings, transport and industries switch to low carbon technologies (Tamiotti *et al.* 2009: x), in order to reduce the greenhouse intensity of the economy as a whole. Mitigation policies will also include substituting carbon intensive energy made from fossil fuels with cleaner renewable energy sources.

Decision-makers and role-players have certain choices to make regarding climate change adaptation and mitigation. Adaptation is important irrespective of the cause of climate change as adaptation is an increment in the ability of natural systems or of humans to manage climate changes (Tamiotti *et al.,* 2009:50). Adaptation policies and development are frequently simultaneously pursued; development can lessen poverty's exposure to climate change (Capôco, 2010:7).

Mitigation policies, on the other hand, are essential with specifically anthropogenic climate change as it reduces the tempo and impact of climate change (Tamiotti *et al.*, 2009:50). Therefore, in the current anthropogenic climate change, both adaptation and mitigation are necessary. This study focuses on the mitigation policies that are necessary in anthropogenic climate change to lessen the impact various activities have on the biosphere (see section 2.5.4). In this regard international corporation is necessary if consensus on policies and law to reduce anthropogenic emissions sufficiently is to be achieved (Hoffmann, 2003). The relevant environmental policies and laws will be subsequently discussed.

## 2.6. Policies and international law regarding mitigation of anthropogenic climate change.

### 2.6.1. United Nations and International Panel on Climate Change.

In order to address global problems such as climate change, cooperation between the relevant role players and decision makers should be achieved. The history of the politics of climate change dates back to 1979 when the first World Climate Conference (WCC) took place (UNFCCC, 2012). Although climatologists and other scientists noted signs of anthropogenic climate since the 1960's, the Intergovernmental Panel on Climate Change (IPCC) was only founded in 1988 (UNFCCC, 2012). The IPCC is an international governmental organisation focused on the science of climate change and their first scientific report was released in 1990 (UNFCCC, 2012). The second WCC took place in the same year and stipulated the urgency for international cooperation in terms of a global treaty on climate change.

Negotiations by the United Nations for a framework convention on climate change started in 1990 and took place until 1992 when the UNFCCC was finally accepted (UNFCCC, 2012). The first conference by the UNFCCC on climate change was held in Rio de Janeiro in 1992 and is also known as the Earth Summit (UNFCCC, 2012). From then the United Nations held Conferences of the Parties[6] (COP) about annually, which aims to update the treaty. The UNFCCC was officially implemented in 1994 and the first COP took place in Berlin in 1995 (UNFCCC, 2012). Both COP1 and COP2 focused on acknowledging additional anthropogenic greenhouse gasses to the Montreal

6 Conference of the Parties is usually abbreviated with COP, followed by a number indicating the number that specific conference was. For example, the third Conference of the Parties was held in Kyoto Japan, this is usually abbreviated with COP3.

Protocol. The Montreal Protocol focused on the protection of the ozone layer and excluded some greenhouse gasses which were not particularly harmful to the ozone (Hoffmann, 2003).

The Montreal Protocol was replaced in the UNFCCC by the Kyoto Protocol, which included these additional greenhouse gasses, during COP3 in 1997 in Kyoto, Japan (UNFCCC, 2012). Therefore COP4 to COP16 were all based on the Kyoto Protocol (UNFCCC, 2012). Although the Kyoto Protocol was drafted in December 1997, it was only mandatorily implemented in February 2005.

In 2001 the IPCC released the third Assessment Report and detail regarding funding and diffusing technologies (see section 2.8.2). This was accepted in more detail into the Kyoto Protocol (UNFCCC, 2012). In 2007 the IPCC published the fourth Assessment Report on climate change, which then became an increasing popular topic globally.

The Kyoto Protocol expired at the end of 2011 and was replaced during COP17 in the form of the Durban Platform for Enhanced Action in December 2011. The action plan was drawn up and accepted by COP as the beginning of a legally binding agreement to eliminate sufficiently greenhouse gas emissions by 2015, including the major polluters, namely United States of America, India and China (UNFCCC, 2012). The Kyoto Protocol is of special importance for this study as it also focuses on the minimisation of carbon emission in international trade[7] (UN, 1998:3):

> *The Parties... shall strive to implement policies and measures... in such a way as to minimise the adverse effects... (on) climate change, ... international trade, and social, environmental and economic impacts...*

The United Nations was not the only convener for nations that was influenced by climate change, the World Trade Organisation had also various decisions to make in order to ensure effective decision making in terms of international trade. The WTO, its history, its relationship with the United Nations (UN) and decisions towards climate change will be subsequently discussed.

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7 Kyoto Protocol Article 2 paragraph 3.

### 2.6.2. World Trade Organisation

The General Agreement on Trade and Tariffs (GATT) was founded in 1948, with the aim to maintain stability in the international trade community, especially after the turmoil of the Second World War (WTO, 2012). Various GATT discussions took place, the largest of which was the Uruguay Round which lasted eight years, from 1986-1994 (WTO, 2012). The World Trade Organisation (WTO) originated from the Uruguay Round and was founded in 1995 (WTO, 2012).

The WTO serves as a platform for member countries to talk about international commerce. It attempts to liberate international trade and in some instances to maintain certain trade barriers in order to protect consumers or the environment (WTO, 2012). The WTO is an international governmental organisation and member governments are bound by WTO agreements. The agreements are essentially contracts that set legal ground-rules for international trade. Currently the WTO is overseeing negotiations in the Doha Development Agenda that started in 2001 (WTO, 2012).

Only during COP13, were trade and climate negotiations discussed separately. Environmental issues were only formally introduced under the Doha Round and called the Round for Developing Countries and for the protection of the environment (Balineau & De Melo, 2011). The Doha Mandate was a result of the Doha Ministerial Round and was implemented in November 2001 (WTO, 2012). One of the aims of the Doha Ministerial Declaration[8] is (WTO, 2001):

> *(T)he reduction or, as appropriate, elimination of tariff and non-tariff barriers for environmental goods and services.*

South Africa is also a member of both the United Nations and the World Trade Organisation; therefore, the decision made by these entities influences the South African economy. South Africa's

8 Doha Ministerial Declaration paragraph 30iii)

contribution to climate change, in terms of anthropogenic greenhouse gas emissions and policies to mitigate these emissions will be discussed subsequently.

## 2.7. The South African environment and policies to mitigate anthropogenic climate change.

### 2.7.1. The state of the South African environment.

South Africa has a unique and diverse ecology which is affected by the economy in various ways. The total South African species in the Redbook[9] are 777 bird species, 294 mammals, 115 amphibians and 44 reptiles. Biomes are also exposed to the impact of economic activity (DEAT, 2009b:33). Presently thirteen terrestrial ecosystems are endangered, which are mainly savannahs and forested areas (DEAT, 2009b:34). The impact of economic activity is increasingly visible on South Africa's rich freshwater and marine biodiversity: of the 34 broad marine ecosystems in South Africa 12% are critically endangered, 15% endangered and 38% is labelled as vulnerable (DEAT, 2009b:46). Freshwater supplies are also an increasing concern. South Africa is ranked as one of the 20 most fresh water scarce countries in the world (DEAT, 2009b:49).

The impact of the South African economy can be seen on the South African environment. In terms of greenhouse gas emissions, South Africa as part of greater Sub-Saharan Africa is one of the most exposed regions in the world (Onwordi, 2011). Expected increases in temperatures in Southern Africa are 3 to 5°C within this century (Lucas, 2011). Temperatures are expected to increase by 5 to 6°C in the western part of Southern Africa; from Angola to the Kalahari. Temperatures in coastal regions will eventually increase but not immediately as the oceans have an initial cooling effect (Lucas, 2011). Other effects of global warming could include floods, drought and increases of

[9] The Redbook of the International Union of Conservation of Nature (IUCN) lists all the species under various categories of endangerment.

diseases like malaria. Sea levels are expected to rise a meter in Uganda, Kenya, Tanzania, Nigeria, Mozambique and South Africa (Onwordi, 2011).

South Africa is not only exposed to the effects of global warming but is also a significant contributor to current anthropogenic climate changes. South Africa is in real terms the fourteenth largest carbon dioxide emitter globally, despite its relatively small population (CSIR, 2010:ii). If the relatively small population is taken into account, South Africa is one of the three largest emitters per capita: South Africa emits 10.80 tons per capita, just after United States (16.90 tons per capita) and the Russian Federation (7.49 tons per capita) (Maia, Giordano, Kelder, Bardien, Bodibe, Du Plooy, Jafta, Jarvis, Kruger-Cloete, Kuhn, Lepelle, Makaulule, Mosoma, Neoh, Netshitomboni, Ngozo & Swanepoel, 2011:13). South Africa's high carbon emission is mainly the result of its dependence on fossil fuel, particularly coal (CSIR, 2010:ii). South Africa's energy sector uses coal to generate electricity. The effects hereof will be subsequently discussed.

#### 2.7.1.1 . The South African energy sector

It is one of the objectives of this study to determine a list of products which have a decreasing greenhouse intensity effect on the economy (see section 1.3). The only sector that has a high potential to reduce the greenhouse gasses is the sector '*Renewable Energy Plant*' as identified by the IISD (see table 3.1). Literature on mitigation policies also focuses on transforming the energy sector towards renewable energy sources (see section 2.5.4). Given the magnitude of current greenhouse gas emissions, policies would first and foremost have to focus on certain fundamental changes in the way in which energy is produced (UN, 2004). The energy sector therefore plays a prime role in the transformation to a green economy (Cosbey, 2011).

In the latest National Inventory Report namely the Greenhouse Gas Inventory South Africa (2009), the Department of Tourism and Environment reviewed the sources of greenhouse gas emissions in

South Africa from 1990 to 2000. According to the National Inventory Report the energy sector emits 75,1% of the total carbon dioxide in 1990 and 78,3% in 1994 (DEAT, 2009a:3). Preliminary estimations on the percentage of greenhouse gasses emitted by the energy sector in 2000 are 79% (DEAT, 2009a:3). The second largest emitter, emitting about a tenth of the energy sector in 1994, was the agricultural sector emitting 9,3% of $CO_2$ –eq. (DEAT, 2009a:3).

It is clear that a significant reduction in total greenhouse gasses can be made by focusing on reducing greenhouse gas emissions in the energy sector. The energy sector in South Africa is dominated by coal usage as 70% of South Africa's energy comes from coal usage (Davidson, *et al.*, 2006:4). A distinction should be made between primary energy and energy transformation. Primary energy is energy contracted or harvested from a source but not yet useful and it should first be transformed into a usable form (Davidson *et al.*, 2006:45). Coal as energy source is highly inefficient because only 9.5% of primary energy is transformed into energy of a usable form; the other 90.5% is lost to various inefficiency in the energy transforming process (Lavins, 2005: 76).

South Africa is an energy-intensive economy. This means that the ratio of energy needed for economic output is high (Davidson *et al.*, 2006:4). To produce 1000 international dollars[10], 0.24 tons of oil equivalents were needed in South Africa, while 2.4 tons of oil equivalents is needed to generate energy in South Africa (Davidson *et al*., 2006:4). Increasing the energy efficiency in South Africa will decrease harmful anthropogenic emissions (Davidson *et al*., 2006:4). According to the IPCC global reductions in carbon dioxide–levels should be 40 to 60% of the 1990-levels by 2020 (Houghton, *et al.,* 1996). The implication hereof for South Africa means a reduction of 42 to 56% of the 1990 carbon dioxide-levels by 2050 (ASSAf, 2011:65 & World Bank, 2012). In order to reach reduction targets policies and law is necessary in order to decrease greenhouse gas emissions.

[10] International dollars is a fictional currency used for comparison; it has the same purchasing power parity (PPP) of Gross Domestic Product (GDP) in 2001 of the USA.

### 2.7.2. Policies and laws to mitigate anthropogenic climate change in South Africa.

Climate change gradually evolved on the South African political agenda since the late 1980's. After the founding of the IPCC, the South African Department of Environment Affairs and Tourism started a national discussion on environmental issues (ASSAf, 2011:63). Thereafter the National Committee on Climate Change (NCCC) was established and the South African government adopted an official agreement with the UNFCCC in 1997 (ASSAf, 2011:63). As research increased it was evident that South Africa had a dual role in climate change; as a significant victim and as a significant contributor to global warming (ASSAf, 2011:63).

The World Summit on Sustainability held in 2005 in Johannesburg delivered the Johannesburg Plan of Implementation, which stipulated the triangle between environment, trade obligations and sustainable development. Members agreed to offer support to both trade obligations, WTO-trade agreements and to maintain environmental integrity. South Africa's global responsibility towards climate change increased during the Johannesburg Summit on Sustainability, as the Kyoto Protocol was accepted (ASSAf, 2011:64). To mitigate the effects of global warming to a 2°C increase in global average temperatures, the Kyoto Protocol estimates at least a 40% reduction in greenhouse gasses of 1990-levels by 2020 (ASSAf, 2011:70).

To create low-carbon growth (see figure 1.2) economic growth and a lower greenhouse gas intensity is needed. Increasing the production and exports of products can drive economic growth. On the other hand, mitigation policies are needed to decrease the greenhouse gas intensity of the economy. In South Africa the energy sector is highly greenhouse gas intensive. A creative solution is needed simultaneously to achieve increased exports and to mitigate greenhouse gasses through the transformation of the energy sector in South Africa. This creative solution will be subsequently discussed.

## 2.8. Creative solution for both the environment and the economy.

It is clear that exports can have a significant potential to increase economic growth, job creation and more (see section 2.3). It is also clear that environmental pressure resulting from economic growth should be reduced. In order to achieve this, a reform of how energy is generated is necessary. The economic bias of decision making should be corrected to reduce pressure on the environment.

The philosopher C.A. van Peursen stated that creativity is the ability to make a new linkage between existing entities (Van Peursen, 1976). If economic growth is enhanced through increasing a country's exports, a creative link should be made to ensure that the higher exports, in some way, also have a positive environmental effect. To discover this creative link, the relationship between the environment and higher export will be discussed.

### 2.8.1. The relationship between the environment and exports

It is important to try to understand what the effect on greenhouse gasses will be if trade is fully liberated. A study by the World Trade Organisation and United Nations Environmental Program (UNEP) broke the effect of liberated trade on greenhouse gas emissions down into three effects; the scale effect, the composition effect and the technique effect (Tamiotti, *et al.,* 2009).

The scale effect is to what degree greenhouse gasses may increase as a result of increased economic activity (Tamiotti, *et al*., 2009). When certain production factors are not utilised, liberalisation in trade will utilise these untapped production factors which will increase production and energy use. If the South African energy sector stays mainly dependant on coal, the scale effect will increase greenhouse gas emissions with an increase in economic activity. Another aspect of the scale effect is the increased transportation across borders which will also increase greenhouse gas emissions (Tamiotti, *et al*., 2009).

The composition effect is to what degree the liberalisation of trade would change the relative prices of certain sectors, which in turn could affect the relative size of certain sectors and what total production consists of (Tamiotti, *et al.,* 2009). The composition effect would thus be the growth or decline in certain sectors once trade is liberated. Whether greenhouse gas emissions increases or decreases will depend on whether energy intensive sectors expanded or contracted (Tamiotti, *et al*., 2009). If sectors which are less-energy intensive expanded and replaced energy intensive sectors, greenhouse gas emissions would decline (Tamiotti, *et al*., 2009).

Last, the technique effect is the degree to which superior technologies will be adopted to reduce potentially the carbon intensity of the economy. This will happen in one of two ways (Grossman and Krueger, 1993). The first aspect of the technique effect is the potential reduction of greenhouse gas emissions in the production of goods and services, due to a higher availability of 'green goods'. This is especially important for countries that do not have access to 'green' technologies. The Doha Ministerial Round aims to liberalise environmental goods and services in order to increase the availability of 'green' technologies through the technique effect (Tamiotti, *et al*., 2009). The second aspect of the technique effect is based on the assumption that a healthy environment is a normal good; if trade is liberated and the average income increases, people would have a higher demand for a healthy environment (Grossman and Krueger, 1993).

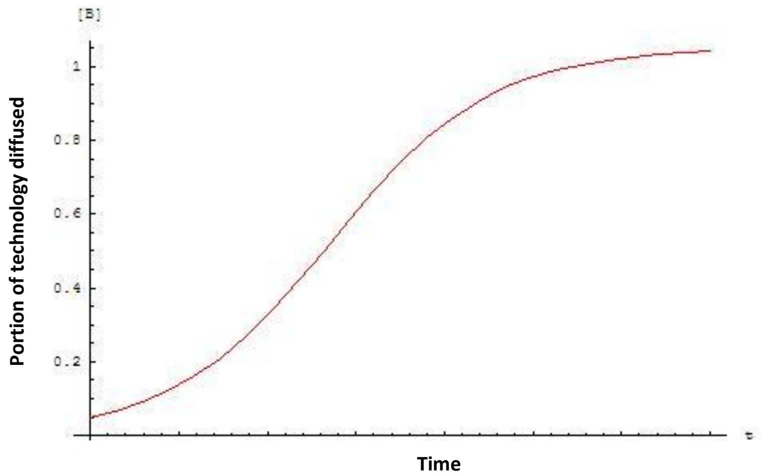
However the net effect of trade liberalisation on greenhouse gas emissions is difficult to estimate. While the scale effect shows an increase in greenhouse gasses, the composition effect shows a decrease in greenhouse gasses. Thus, the two effects work in opposite directions. The technique effect depends on the products traded and the country traded with. This study aims to identify environmental goods with a high potential to reduce anthropogenic greenhouse gas emissions (see section 2.2 and 3.2).

For the purposes of this study the technique effect would potentially reduce greenhouse gas emissions as the product traded, per definition, reduces greenhouse gasses in its end-use (see section 1.1.1). The composition effect for this study would potentially reduce greenhouse gas emissions; as the renewable energy sector, which is not greenhouse gas intensive, would expand and the current energy sector, which in South Africa is especially greenhouse gas intensive (see section 2.7.1.1), would potentially contract (Tamiotti, *et al*., 2009). By combining these three effects, the increase of the exports of low-carbon environmental goods could have a positive environmental effect globally and in South Africa by increasing environmental awareness, increasing the size of the low-carbon energy sectors and increasing income per capita. The acceptance of products into a society is not immediate, this will be discussed subsequently.

### 2.8.2. Liberalisation of low-carbon environmental goods

The acceptance of new technologies into a community is called the diffusion of technologies into the community. The diffusion of new technologies into a community never happens instantaneously but takes an S-shaped curve over time, also known as a sigmoid curve (Löschel, 2002:106). Figure 2.2 shows that the sigmoid curve has an initial slow diffusion rate called inception, which increases into a growth phase. Then it reaches maturity and diffusion starts decreasing in the decline phase (Löschel, 2002:106). The reason for the shape of the sigmoid curve is explained with the metaphor of a contagious virus infiltrating an uninfected community. Initially only a few people are infected and therefore only a few people have the ability to spread the disease to uninfected bodies. As they infect more people, the amount of people that are able to spread the disease increases, resulting in higher rates of infection, up to a point when only a small part of society is not infected and the rate of infection starts to decrease and tend to zero until everybody is infected (Löschel, 2002:106).

Figure 2.2: Diffusion of technologies over time




*Source*: Löschel (2002).

Technologies are diffused through various channels such as foreign direct investment, imitation, knowledge spillovers, the migration of skilled labour or international trade (Tamiotti *et al.*, 2009; Groizard, 2007:2). Of all the channels, trade consistently proves to be one of the most important channels (Groizard, 2007:2). Increased trade could potentially increase the rate of diffusion. In the past two decades removal of trade barriers have increased the diffusion of technologies in developing countries at a significant rate of about a 80% since 1994 (Mundial, 2008).

Trade liberalisation has therefore a key role to play in diffusing these technologies into developing countries or carbon intensive economies that can import low-carbon technologies for cheaper (Panitchpakdi, 2012). By liberating trade in these environmental goods, access to these goods is increased in the importing country but also indirectly in the exporting country(UN, 2004). Removing tariff and non-tariff measures increases international exposure to the specific goods. Openness to trade also increases per capita income and therefore the affordability of new technologies (see section 2.3.1.). Developing countries are also increasingly acceptant of new technologies in (Mundial, 2008). Not only environmental goods are diffused in an open economy but also knowledge, environmental best practice and general corporation over borders.

A faster rate of diffusion in low-carbon environmental goods will have a significant impact on greenhouse gas emissions. It is estimated that if current low-carbon technologies are fully diffused into a community, the decrease in greenhouse gasses in $CO_2$-eq. could be up to 2005 carbon-levels by 2050 (Tamiotti *et al.*, 2009).

Therefore, low-carbon environmental goods could serve as the creative link between the environment and the economy. The promotion of the production and exports of these goods could encourage economic growth and liberate trade in these goods possibly increasing the rate of diffusion which will potentially reduce global greenhouse gas intensity, the South African economy indirectly be less carbon intensive by increasing awareness in low-carbon energy, increasing the low-carbon energy sectors and therefore increasing local sales and an increase in per capita income can enable South Africans to make environmentally friendly decisions.

## 2.9. Conclusion.

To be able to achieve low-carbon growth, economic growth and lower greenhouse gas intensity should be simultaneously achieved. In order to encourage economic growth the National Development Plan identified export promotion as one of the key drivers. The problem however is that all economic activities emit some greenhouse gasses. It is therefore difficult to maintain a lower greenhouse gas intensive economy while growing economically. A major negative contribution to the greenhouse gas intensity of the South African economy is the energy sector. Revising the energy sector has the potential to reduce the carbon intensity of the economy as a whole. If the production, even carbon-intensive production, and exports of low-carbon environmental goods are encouraged, then an economy can potentially grow economically and achieve a lower greenhouse gas intensive economy.

The aim of this chapter was fourfold; the first objective was to discuss the term green growth in more detail. The term green growth was showed in figure 1.2, which showed the different aspects intersecting to create green growth. One of the sub-sets of green growth is low-carbon growth.

The second objective was to discuss the influence of increased exports on economic growth. Increased exports have various positive effects, which could potentially encourage economic growth. Increased exports increase the inflows into an economy; the efficiency of firms, increase the productivity of their workers and could decrease unemployment. The South African economy benefitted greatly from sudden trade liberation after democratisation. Since these benefits have stabilised, the government should intervene to encourage trade. The results of the DSM study (Cuyvers *et al.*, 2012) could support export strategic decision making to encourage trade further on a firm-level.

The third objective was to describe the current state of the environment, especially in terms of greenhouse gasses and to elaborate further on mitigation policies, both on a global and on a national level. Anthropogenic greenhouse gasses that have been accumulating in the atmosphere will increase the average global temperatures. Mitigation policies from the UN and the WTO have been focused on possible ways to reduce the greenhouse gas intensity of the global economy. South Africa, as a member of the UN and the WTO would also need to implement policies as South Africa is the fourteenth largest greenhouse gas emitter.

The fourth objective was to create a link between export promotion and decreasing the greenhouse gas intensity. This creative link was found in the technique effect, which explained the relationship between trade and greenhouse gas emissions. This can be positive if the product that is traded has the ability to decrease greenhouse gas emissions in end-use in the importing country. These goods are also known as low-carbon environmental goods. If the trade in low-carbon environmental goods are promoted, then the rate of diffusion of these goods could increase in the importing country.

Diffusion will also increase in the exporting country, South Africa, through three effects. First, the increase in renewable energy sector and the decrease in its current greenhouse gas intensive energy sector. Second, by producing more renewable energy products (even though the production process is not necessarily green) diffusion of these technologies into the South African economy will also increase via local sales and awareness. Third, the increase in per capita income of South Africans will increase the affordability of "green" technologies further.

Now that the potential of low-carbon environmental goods are identified, it is important to establish a list of goods that can be classified as low-carbon environmental goods. Chapter 3 will focus on establishing a list of low-carbon environmental goods.

# Chapter 3: Empirical study

## 3.1. Introduction

Traditionally decision-makers have prioritised economic concerns over environmental ones. This is especially true in the case with economic growth and greenhouse gas emissions; where a sustained increase in the economic growth rate can be closely associated with increasing greenhouse gas emissions (see section 1.1). Green growth aims to include various economic, environmental and social objectives in decision-making (see section 2.2). A sub-set of green growth, i.e. low-carbon growth, can be achieved by growing economically and decreasing the greenhouse gas intensity of the economy (see section 2.2). A potential creative solution to ensure low-carbon growth could be to encourage the production and exports of low-carbon environmental goods (see section 2.8). The problem however is that there is no universally accepted list of environmental goods. Various lists have been drawn up by various organisations but none has been accepted as the official list of environmental goods. Therefore, there is no official list of goods accepted as low-carbon environmental goods.

This chapter aims to first, identify which environmental goods have a high potential to reduce greenhouse gas emissions, named low-carbon environmental goods (see section 1.1.1). A list of low-carbon environmental goods on a Harmonized System level six (HS-6) code will firstly be identified. This will be done by comparing four existing lists of environmental goods from various sources. A list of low-carbon environmental goods will be derived for this study. Second, further classification of these products is necessary in order to create a priority list for South African decision-makers that are concerned with green growth. The final derived list of low-carbon environmental goods will be linked with the results of the DSM (see section 2.4.2). These goods will be ranked on three criteria: i) potential environmental benefits, ii) South Africa's production capacity for the specific good and iii) potential economic benefits. The three criteria will be taken together to create a final mark according to which the goods will be ranked.

This chapter will be structured as follows: section 3.2 will investigate the lists of environmental goods from the WTO (section 3.2.1), the WB (section 3.2.2), the ICTSD (section 3.2.3) and the FERDI (section 3.2.4) and derive a list of low-carbon environmental goods applicable to this study (section 3.2.5). Then the environmental goods will be ranked according to three criteria. In the first criterion consensus among role-players will be used as a proxy for the potential environmental benefits of each environmental good (see section 3.3). In the second criterion the revealed comparative advantage (RCA) of each product will be used as proxy for South Africa's production capacity (see section 3.4). In the third criterion the potential export value will be used as a proxy for the potential economic benefits of each environmental good (see section 3.5). A final mark, taking all three criteria into account, will then be allocated to each environmental good (see section 3.6).

## 3.2. Establishing a list of low-carbon environmental goods on HS-6 code.

According to Steenblik (2005:1) environmental goods and services (EGS) can be defined as goods and services that measure, prevent, limit, minimise or correct environmental damage to various environmental entities. On the other hand, low-carbon environmental goods are defined as goods that emit minimal or zero greenhouse gasses during end use (Solarpowernotes, n.d.). The identification of environmental goods is more complicated than to merely define the term environmental good or low-carbon technology.

Various methods to classify environmental goods exist, namely the request and offer approach, the end-use or project approach and the list approach (Cosbey, *et al.*, 2010). The request and offer approach, as proposed by Brazil, would mean that countries request the liberalisation of certain environmental goods from other countries which could agree or disagree with a specific tariff reduction (Cosbey, *et al*., 2010). The end-use approach aims to restrict the amount of environmental goods liberated on the grounds of various pre-approved environmental projects. The list approach, which will be used for the purpose of this study, classifies a list of environmental goods on a HS-6 code. The list approach is chosen for this study for its ease to compare global trade data on HS-6 code and because the HS-codes define and describe the products uniformly in all countries. The challenge with identifying a list of environmental goods is that some of these goods have multiple uses and some of these uses might be hazardous to the environment. Multiple uses of goods were not taken into consideration in identifying environmental goods in this study (see section 1.5).

Not all environmental goods have a high potential to reduce greenhouse gas emissions. Some environmental goods are useful to reach environmental objectives like increasing biodiversity, healthy habitats, water and air quality and more (see section 2.5.1). Although all environmental goods have an important role to play to ensure the quality of the environment, only a certain number of environmental goods are focused on reducing greenhouse gas emissions and are therefore low-carbon environmental goods.

Four lists of environmental goods are used for this study. The first list is from the World Trade Organisation (WTO). The list was submitted to the WTO by the *Friends of the EGS Group*, who submitted an informal document, consisting of 153 environmental goods, to the WTO's Committee on Trade and Environment Special Session (CTESS). The second list originates from the World Bank consisting of twelve environmental goods. The third list of 63 environmental goods originated from the International Centre for Trade and Sustainable Development (ICTSD) for the Programme on Trade and the Environment. The fourth list is from the Foundation for The Study and Research on International Development (FERDI) and consists of 26 environmental goods. Although most of the products on the lists overlap, there are also unique entries of environmental goods on each list and one list will be derived for purposes of this study. These four lists will subsequently be discussed.

### 3.2.1. First list: World Trade Organisation (WTO)

The following list, as submitted by the *Friends of the EGS Group* to the World Trade Organisation, categorises 153 environmental goods in twelve sub-groups. This is a particularly important list to include in the study as it is the first list to be used in environmental goods and services negotiations of the WTO negotiations (Wooders, 2009).

The focus in this study is only on environmental goods with a high potential to reduce greenhouse gas emissions (see section 1.5 and section 2.2). Only the sub-group number 4 in table 3.1, namely *Renewable Energy Plant* that has a high potential to reduce greenhouse gas emissions was used in this study. This subgroup contains 28 of 153 environmental goods. Although the WTO listed it as 28 goods, there are 30 different HS-6 codes because one of the entries in the list contains three goods[11] on HS-6 level.

Low-carbon environmental goods are goods that emit zero or minimal carbon dioxide or other greenhouse gasses during end use (see section 1.1.1). Of the total 153 goods in the lists of the WTO, only the thirty goods categorised under *Renewable Energy Plant* have been selected to be included in this study as it is the only sub-group that has a high potential to reduce greenhouse gasses. In other words, it is the only sub-group that can be defined as low-carbon environmental goods. Table 3.1 gives the categorisation of the World Trade Organisation's different categories of environmental goods.

[11] 841861, 841869 and 841581 are all grouped under one entry, namely 475 (Wooders, 2009) (see appendix A)

In table 3.1, the first column gives a short specification of the specific sub-group, the second column gives the quantity of goods that fall in this specific group and third column states the specific group's potential to reduce greenhouse gas emissions as ranked by the IISD. This ranking of the goods' potential to reduce greenhouse gas emissions will be used in subsequent lists.

Table 3.1: WTO: categories of environmental goods.

| Group specification | Quantity | Potential to reduce GHG |
|---|---|---|
| 1. Air pollution control | 13 | Negligible |
| 2. Management of solid and hazardous waste and recycling systems | 24 | Possibly some |
| 3. Clean up or remediation of soil and water | 4 | Negligible |
| **4. Renewable energy plant** | **28** | **High** |
| 5. Heat and Energy management | 6 | Possibly some |
| 6. Waste water management and potable water treatment | 29 | Negligible |
| 7. Environmentally preferable products, based on end use or disposal characteristics | 7 | Negligible |
| 8. Cleaner or more resource efficient technologies and products | 4 | Low |
| 9. Natural risk management | 3 | Negligible |
| 10. Natural Resource Protection | 3 | Negligible |
| 11. Noise and vibration abatement | 4 | Negligible |
| 12. Environmental monitoring analysis and assessment equipment | 29 | Low |
| **Total:** | **153** | |

*Source*: Wooders (2009:4)

Table 3.2 gives a list of the 30 low-carbon technologies as categorised under the *Renewable Energy Plant Group*. The second column gives the Harmonised System (HS) code on a six digit level and the third column gives a short specification of the product, as described by the United Nations Commodity Trade database (UN COMTRADE) (2010).

Table 3.2: WTO, sub-category: Renewable Energy Plant

| | **HS-6 code** | **Product specification** |
|---|---|---|
| 1. | 730820 | Towers and lattice masts, iron or steel |
| 2. | 761100 | Aluminium reservoirs, vats, tanks, etc., volume >300*l* |
| 3. | 840681 | Turbines not elsewhere specified *not elsewhere specified* (NES), of o <40mw |
| 4. | 840682 | Turbines NES, of o >40mw |
| 5. | 840690 | Parts of steam and vapour turbines |
| 6. | 841011 | Hydraulic turbines, water wheels, power < 1000 kW |
| 7. | 841090 | Parts of hydraulic turbines and water wheels |
| 8. | 841181 | Gas turbine engines NES of a power < 5000 kW |
| 9. | 841182 | Gas turbine engines NES of a power > 5000 kW |
| 10. | 841581 | Air conditioners NES with reverse cycle refrigeration |
| 11. | 841861 | Compression refrigeration equipment with heat exchange condensers are heat exchangers. |
| 12. | 841869 | Refrigerating or freezing equipment NES |
| 13. | 841919 | Instantaneous/storage water heaters, not electric NES |
| 14. | 841990 | Parts, laboratory/industrial heating/cooling machinery |
| 15. | 848340 | Gearing, ball screws, speed changers, torque converter |
| 16. | 848360 | Clutches, shaft couplings, universal joints |
| 17. | 850161 | AC generators, of an output < 75 kVA |

| | HS-6 code | Product specification |
|---|---|---|
| 18. | 850162 | AC generators, of an output 75-375 kVA |
| 19. | 850163 | AC generators, of an output 375-750 kVA |
| 20. | 850164 | AC generators, of an output > 750 kVA |
| 21. | 850231 | Wind-powered generating |
| 22. | 850239 | Electric generating sets |
| 23. | 850300 | Parts for electric motors and generators |
| 24. | 850440 | Static converters, NES |
| 25 | 850720 | Lead-acid electric accumulators except for vehicles |
| 26. | 853710 | Electrical control and distribution boards, < 1kV |
| 27. | 854140 | Photosensitive/photovoltaic/LED semiconductor devices |
| 28. | 900190 | Prisms, mirrors and optical elements NES, unmounted |
| 29. | 900290 | Mounted lenses, prisms, mirrors, optical elements NES |
| 30. | 903289 | Automatic regulating/controlling equipment NES |

*Source*: Wooders (2009)

### 3.2.2. Second list: World Bank (WB)

The list of the World Bank contains twelve environmental goods. It is important to include this list in the study as the World Bank is an important role player and stakeholder in the debate of environmental goods. The following table presents the twelve goods in four sub-categories namely, a) clean coal technologies, b) wind energy, c) solar photovoltaic system and d) energy efficient lighting as categorised by the World Bank.

The second column gives the HS-6 code of specific product, the third column gives a short product specification as described by UN COMTRADE (2010), the fourth column states whether the specific product overlaps with the list of the WTO and if it overlaps, the fifth column states how the IISD ranked the environmental goods in terms of its potential to reduce greenhouse gas emissions (Wooders, 2009).

Table 3.3: Environmental goods of the World Bank.

| | HS-6 | Product specification | Overlapping with the WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| **Clean Coal Technologies** | | | | |
| 1. | 840510 | Producer, water and acetylene gas generators | Yes | Negligible |
| 2. | 840619 | Steam and vapour turbine NES | No | N.A. |
| 3. | 841181 | Gas turbine engines NES of a power < 5000 kW | Yes | High |
| 4. | 841182 | Gas turbine engines NES of a power > 5000 kW | Yes | High |
| 5. | 841199 | Parts of gas turbine engines except turbo-jet/prop | No | N.A. |
| **Wind energy** | | | | |
| 6. | 848340 | Gearing, ball screws, speed changers, torque converter | Yes | High |
| 7. | 848360 | Clutches, shaft couplings, universal joints | Yes | High |
| 8. | 850231 | Generating sets, wind powered | Yes | High |
| 9. | 850239 | Generating sets (excl. wind-powered and powered by spark-ignition internal combustion piston engine) | Yes | High |
| **Solar photovoltaic system** | | | | |
| 10. | 850720 | Lead-acid electric accumulators except for vehicles | Yes | High |

| | HS-6 | Product specification | Overlapping with the WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| 11. | 853710 | Electrical control and distribution boards, < 1kV | Yes | High |
| 12. | 854140 | Photosensitive/photovoltaic/LED semiconductor devices | Yes | High |
| **Energy-efficient lighting** | | | | |
| 13. | 853931 | Fluorescent lamps, hot cathode | No | N.A |

*Source*: Wooders, 2009

The following can be observed from table 4.3:

i. The table shows thirteen environmental goods while the list of the World Bank only contains twelve. The reason for this inconsistency is:

   a. Table 3.3 is as specified under the HS 2002 Revision, while the list of the World Bank is under HS Revision 1996.

   b. Product HS-6: 850230 (Revision 1996), as indicated by the World Bank, was split in two goods HS-6: 850231 and HS-6: 850239 in the HS 2002 Revision, both of which is used in this study.

ii. Ten of the thirteen goods overlap with the WTO list,

   a. Nine[12] of these ten are in the sub-group *Renewable Energy Plant* and are already identified as low-carbon environmental goods.

   b. Only one good[13] of the ten identified by the WTO falls in another subgroup, namely *Air Pollution*, which has a negligible potential to reduce greenhouse gas emissions.

12 Entries 3, 4, 6, 7, 8, 9, 10, 11 and 12.

13 Entry 1

iii. Of the three goods[14] not included by the WTO, none will be included for purposes of this study as not one of these three goods are classified under a renewable energy plant (wind energy or solar photovoltaic system), as identified by the World Bank in table 3.3.

### 3.2.3. Third list: International Centre for Trade and Sustainable Development (ICTSD)

The third list was set up by Laborde and Lakatos in 2012 and aims to identify environmental goods that have a certain level of market accessibility (Laborde & Lakatos, 2012). This list is submitted by the ICTSD and is important for this study as it is the most recent list and the aim was to define environmental goods more clearly than in the Doha Mandate. Table 3.4 presents the environmental goods as proposed by the ICTSD. The second column presents the specific products HS-6 code, the third column gives a short product specification, as described by UN COMTRADE (2010), the fourth column states whether the specific good overlaps with the first list (WTO) and if it overlaps, the fifth column states how the IISD ranked it for potential reduction in greenhouse gas emissions.

The ICTSD categorised the goods in three sub-groups; a) renewable products and energy sources, b) environmental monitoring, analysis and assessment equipment and c) waste management, recycling and remediation.

14 Entries 2, 5 and 13

Table 3.4: Environmental goods of the ICTSD

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| **Renewable products and energy sources** | | | | |
| 1. | 730820 | Towers and lattice masts | Yes | High |
| 2. | 732111 | Solar cooking stoves | Yes | Low |
| 3. | 732190 | Stoves, parts | Yes | Low |
| 4. | 840682 | Steam turbines <40MW | Yes | High |
| 5. | 840690 | Parts of steam turbines | Yes | High |
| 6. | 841011 | Hydraulic turbines, micro (<1MW) | Yes | High |
| 7. | 841012 | Hydraulic turbines, small (1-10MW) | No | N.A |
| 8. | 841090 | Parts for hydraulic turbines | Yes | High |
| 9. | 841181 | Gas turbines, of a power >5000kW | Yes | High |
| 10. | 841182 | Gas turbines, of a power >5000kW | Yes | High |
| 11. | 841221 | Hydraulic power engines and motor cylinders | No | N.A |
| 12. | 841229 | Hydraulic power engines and motor others | No | N.A |
| 13. | 841581 | Air conditioner and heat pump | Yes | High |
| 14. | 841861 | Heat pumps | Yes | High |
| 15. | 841919 | Solar water heater | Yes | High |
| 16. | 841950 | Heat exchange units | Yes | Possibly some |
| 17. | 848340 | Gears | Yes | High |
| 18. | 848360 | Clutches | Yes | High |
| 19. | 850161 | AC generators <75kVA | Yes | High |

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| 20. | 850162 | AC generators 75 – 375kVA | Yes | High |
| 21. | 850163 | AC generators 375-750kVA | Yes | High |
| 22. | 850164 | AC generators >750kVA | Yes | High |
| 23. | 850231 | Wind-powered generation sets | Yes | High |
| 24. | 850300 | Parts of motors and generators | Yes | High |
| 25. | 850440 | Static converters | Yes | High |
| 26. | 850610 | Primary cells and batteries (manganese dioxide) | No | N.A. |
| 27. | 850630 | Primary cells and batteries (mercuric oxide) | No | N.A. |
| 28. | 850640 | Primary cells and batteries (silver dioxide) | No | N.A. |
| 29. | 850650 | Primary cells and batteries (lithium) | No | N.A. |
| 30. | 850660 | Primary cells and batteries (aird zinc) | No | N.A. |
| 31. | 850680 | Primary cells and batteries, other | Yes | Low |
| 32. | 850690 | Primary cells and batteries, parts | No | N.A. |
| 33. | 850720 | Lead acid | Yes | High |
| 34. | 853931 | Fluorescent, hot cathode lamps | No | N.A. |
| 35. | 854140 | PV semiconductor devices | Yes | High |
| 36. | 900190 | Mirrors (for solar energy) | Yes | High |
| 37. | 900290 | Glass mirrors (for solar energy | Yes | High |
| 38. | 902830 | Electricity meters | Yes | Possibly some |
| **Environmental monitoring, analysis and assessment equipment** | | | | |
| 39. | 853710 | Electrical control and distribution boards, < | Yes | High |

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| | | 1kV | | |
| 40. | 902780 | Equipment for physical or chemical analysis, NES | Yes | Low |
| 41. | 902790 | Microtomes, parts of scientific analysis equipment | Yes | Low |
| 42. | 903039 | Ammeters, voltmeters, ohm meters, etc, non-recording | Yes | Low |
| 43. | 903210 | Thermostats | Yes | Low |
| 44. | 903220 | Manostats | Yes | Low |
| 45. | 903289 | Other control instruments | Yes | High |
| **Waste management, recycling and remediation** | | | | |
| 46. | 392010 | Sheet/film not cellular/reinf polymers of ethylene | Yes | Possibly some |
| 47. | 392290 | Bathroom wares NES, of plastics | No | N.A. |
| 48. | 560314 | Nonwovens, man-made fila | Yes | Negligible |
| 49. | 701931 | Mats of glass fibre | No | N.A. |
| 50. | 701939 | Other glass-fibre insulation products | No | N.A. |
| 51. | 730630 | Pipes etc NES, iron/steel welded NES, diameter <406.4m | Yes | Negligible |
| 52. | 730640 | Pipes and tubing, stainless steel, welded | Yes | Negligible |
| 53. | 730650 | Pipes and tubing, alloy steel NES, welded | Yes | Negligible |
| 54. | 730660 | Hollow profiles/tubes,iron/steel,non-circular, welded | Yes | Negligible |
| 55. | 730690 | Tube/pipe/hollow profile, iron/steel,riveted/open sea | Yes | Negligible |

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis |
|---|---|---|---|---|
| 56. | 730900 | Reservoirs/tanks/vats/etc, iron/steel capacity >300l | Yes | Negligible |
| 57. | 731029 | Cans, iron or steel, capacity <50 litres NES | Yes | Negligible |
| 58. | 732690 | Articles of iron or steel, NES | Yes | Negligible |
| 59. | 761100 | Aluminium reservoirs, vats, tanks, etc. volume >300l | Yes | High |
| 60. | 840219 | Vapour generating boilers NES, hybrid boilers | Yes | Possibly some |
| 61. | 840290 | Parts of steam or vapour generating boilers NES | Yes | Possibly some |
| 62. | 840410 | Auxiliary plant for steam/vapour generating boilers | Yes | Possibly some |
| 63. | 841940 | Distilling or rectifying plant | Yes | Possibly some |

*Source*: Laborde & Lakatos (2012).

From table 3.4 the following can be observed:

i. Of the 63 environmental goods identified by the ICTSD, fifty goods overlap with the WTO list. Of the fifty goods which are in both lists of the ICTSD and the WTO;

   a. 26 goods[15] are already identified to fall in sub-group *Renewable Energy Plant* and therefore have a high potential to reduce greenhouse gas emissions.

   b. The other 24 products[16] fall in other sub-groups and falls outside the scope of this study.

ii. Of the thirteen products[17] not specified by the WTO;

15 Entries 1, 4, 5, 6, 8, 9, 10, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 33, 39, 35, 36, 37, 45 and 59

16 Entries 2, 3, 16, 32, 38, 40, 41, 42, 43, 44, 46, 48, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 62 and 63.

a. only nine[18] products are specified as *Renewable Products and Energy Sources* by the ICTSD, will be included in the final list with the exception of entry 34; HS-6: 853931. Product HS-6: 853931, 'fluorescent, hot cathode lamps' is specified under *renewable products and energy sources* by the ICTSD but falls under the second part of this sub-group, namely *energy sources* and is not part of renewable products.

### 3.2.4. Fourth list: Foundation for Education and Research on International Development of Education (FERDI)

The fourth list is a joint effort from representatives of Australia, Colombia, Hong Kong, China, Norway and Singapore to make a core list from the original 411 codes. The named countries narrowed down the list to 26 goods. This list is included in this study as it is a multinational attempt to create a list of environmental goods (Balineau & De Melo, 2011).

In table 3.5 the second column gives the specific products' HS-6 code, the third column gives a short product specification as described by UN COMTRADE (2010), the fourth column states whether the specific product overlaps with the first list (WTO) and if it overlaps, the fifth column states how the IISD ranked it for a potential reduction in greenhouse gas emissions. The sixth column gives the specific category or categories in which the product is specified by FERDI.

17 Entries 7, 11, 12, 26, 27, 28, 29, 30, 32, 39, 47, 49 and 50.

18 Entries 7, 11, 12, 26, 27, 28, 29, 30 and 32.

Table 3.5: Environmental goods of the FERDI

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis | Categories[19] |
|---|---|---|---|---|---|
| 1. | 460120 | Mats, matting and screens, vegetable plaiting material | No | N.A | WT/WM |
| 2. | 730820 | Towers and lattice masts, iron or steel | Yes | High | RE |
| 3. | 732111 | Cooking appliances for gas fuel, etc., iron or steel | Yes | Low | WT/WM, ET, CCS |
| 4. | 732490 | Sanitary ware and parts thereof, iron or steel, NES | Yes | Negligible | WT/WM, ET, CCS |
| 5. | 840290 | Parts of steam or vapour generating boilers NES | Yes | Possibly some | WM/WT, ET, CCS |
| 6. | 840410 | Auxiliary plant for steam/vapour generating boilers | Yes | Possibly some | WM/WT, ET, CCS |
| 7. | 840510 | Producer, water and acetylene gas generators | Yes | Negligible | APC, RE, WM/WT, ET, CCS |
| 8. | 840681 | Turbines NES, of o <40mw | Yes | High | RE |
| 9. | 840999 | Parts for diesel and semi-diesel engines | Yes | Negligible | APC, ET, CCS |
| 10. | 841011 | Hydraulic turbines, water wheels, power < 1000 kW | Yes | High | RE, ET, CCS |
| 11. | 841012 | Hydraulic turbines, water wheels, power 1000-10000 kW | No | N.A. | ET, CCS |
| 12. | 841090 | Parts of hydraulic turbines and water wheels | Yes | High | RE, ET, CCS |
| 13. | 841181 | Gas turbine engines NES of a power < 5000 kW | Yes | High | RE, ET, CCS, OTH |

[19] APC=Air Pollution Control, RE=Renewable Energy, ET=Environmental Energy, CCS=Carbon Capture and Storage, WM=Water Management, WT =Water Treatment, OTH=Other.

| | HS-6 | Product specification | Overlapping with WTO? | Potential to reduce GHG according to IISD analysis | Categories[19] |
|---|---|---|---|---|---|
| 14. | 841182 | Gas turbine engines NES of a power > 5000 kW | Yes | High | RE, ET, CCS, OTH |
| 15. | 841861 | Compression refrigeration equipment with heat exchange | Yes | High | RE |
| 16. | 841919 | Instantaneous/storage water heaters, not electric NES | Yes | High | RE |
| 17. | 841950 | Heat exchange units, non-domestic, non-electric | Yes | Possibly some | RE, ET, CCS |
| 18. | 847989 | Machines and mechanical appliances NES | Yes | Possibly some | APC, WM/WT, RE |
| 19. | 850231 | Wind-powered generating | Yes | High | RE |
| 20. | 850410 | Ballasts for discharge lamps or tubes | No | N.A. | ET, CCS |
| 21. | 853710 | Electrical control and distribution boards, < 1kV | Yes | High | RE |
| 22. | 854140 | Photosensitive/photovoltaic/LED semiconductor devices | Yes | High | RE |
| 23. | 900190 | Prisms, mirrors and optical elements NES, unmounted | Yes | High | RE |
| 24. | 900290 | Mounted lenses, prisms, mirrors, optical elements NES | Yes | High | RE |
| 25. | 902730 | Spectrometers, spectrophotometers, etc using light | Yes | Low | ET |
| 26. | 903210 | Thermostats | Yes | Low | ET, CCS |

*Source*: Balineau & De Melo 2011

The following can be observed from Table 3.5:

i. Of the core list of 26 goods there are 23 goods that overlap with the first list of WTO, of which:

   a. Thirteen goods[20] are categorised as *Renewable Energy Plant* in the list of the WTO (see table 3.2) and therefore have a high potential to reduce greenhouse gas emissions and are included in the final list;

   b. The other ten goods[21] that overlap with the list of the WTO fall in other sub-groups that either has a negligible, low or possibly some potential to reduce greenhouse gasses and are therefore not included in the final list of low-carbon goods.

ii. The three goods[22] that do not overlap with the list of the WTO are not specified by the IISD with a specific potential to reduce greenhouse gas emissions. These three goods will also not be included in the final list as not one of these three goods are categorised by FERDI as *renewable energy* in the list above (see table 3.5).

### 3.2.5. Derived list of low-carbon environmental goods.

For the purpose of this study, a combined list was derived from the various lists of the WTO, the WB, the ICTSD and the FERDI. The following table gives the derived list of low-carbon environmental goods and which will form the basis of the rest of the study. The second column gives the HS-6 code of the product and the third column a short description of the product as defined by UN COMTRADE (2010).

[20] Entries 2, 6, 10, 12, 13, 14, 15, 16, 19, 21, 22, 23 and 24.

[21] Entries 3, 4, 5, 6, 7, 9, 17, 18, 25 and 26.

[22] Entries 1, 11 and 20

Table 3.6: Derived list of low-carbon environmental goods

| | HS-6 code | Product description |
|---|---|---|
| 1 | 730820 | Towers and lattice masts, iron of steel |
| 2 | 761100 | Aluminium reservoirs, vats, tanks, etc., volume >300l |
| 3 | 840681 | Turbines NES, of o <40mw |
| 4 | 840682 | Turbines NES, of o >40mw |
| 5 | 840690 | Parts of steam and vapour turbines |
| 6 | 841011 | Hydraulic turbines, water wheels, power < 1000 kW |
| 7 | 841012 | Hydraulic turbines, small (1-10MW) |
| 8 | 841090 | Parts of hydraulic turbines and water wheels |
| 9 | 841181 | Gas turbine engines NES of a power < 5000 kW |
| 10 | 841182 | Gas turbine engines NES of a power > 5000 kW |
| 11 | 841221 | Hydraulic power engines and motors, cylinders |
| 12 | 841229 | Hydraulic power engines and motors, others |
| 13 | 841581 | Air conditioners NES with reverse cycle refrigeration |
| 14 | 841861 | Compression refrigeration equipment with heat exchange condensers and heat exchangers |
| 15 | 841869 | Refrigerating or freezing equipment NES |
| 16 | 841919 | Instantaneous/storage water heaters, not electric NES |
| 17 | 841990 | Parts, laboratory/industrial heating/cooling machinery |
| 18 | 848340 | Gearing, ball screws, speed changers, torque converter |
| 19 | 848360 | Clutches, shaft couplings, universal joints |
| 20 | 850161 | AC generators, of an output < 75 kVA |
| 21 | 850162 | AC generators of an output 75-375kVA |
| 22 | 850163 | AC generators 375-750kVA |

| | HS-6 code | Product description |
|---|---|---|
| 23 | 850164 | AC generators, of an output > 750 kVA |
| 24 | 850231 | Wind-powered generating |
| 25 | 850239 | Electric generating sets |
| 26 | 850300 | Parts for electric motors and generators |
| 27 | 850440 | Static converters |
| 28 | 850610 | Primary cells and batteries (manganese dioxide) |
| 29 | 850630 | Primary cells and batteries (mercuric oxide) |
| 30 | 850640 | Primary cells and batteries (silver dioxide) |
| 31 | 850650 | Primary cells and batteries (lithium) |
| 32 | 850660 | Primary cells and batteries (aird zinc) |
| 33 | 850690 | Primary cells and batteries, parts |
| 34 | 850720 | Lead-acid electric accumulators except for vehicles |
| 35 | 853710 | Electrical control and distribution boards, < 1kV |
| 36 | 854140 | Photosensitive/photovoltaic/LED semiconductor devices |
| 37 | 900190 | Prisms, mirrors and optical elements NES, unmounted |
| 38 | 900290 | Mounted lenses, prisms, mirrors, optical elements NES |
| 39 | 903289 | Automatic regulating/controlling equipment NES |

The thirty-nine products classified as low-carbon environmental goods (see table 3.6) are not all identical in terms of their ability to reduce greenhouse gasses, to encourage economic growth or South Africa's capacity to produce these environmental goods.  The three criteria in which the environmental goods will be ranked will be subsequently discussed.

## 3.3. First criterion: potential environmental benefits.

Further classification is required for the thirty-nine low-carbon environmental goods named in table 3.6 on three criteria namely i) the ability to reduce greenhouse gas emissions, ii) South Africa's production capacity and iii) potential economic benefits from export promotion (see section 2.3). The first criterion is each environmental goods' ability to reduce greenhouse gasses and as such its potential environmental benefit. This criterion will be based on the consensus of various role players (the WTO, the WB, the ICTSD and the FERDI), whether the specific product should be classified as a low-carbon environmental good. Table 3.7 shows the results of their first criterion.

In table 3.7 the second column states the HS-6 code of the derived low-carbon environmental goods. The third, fourth, fifth, sixth and seventh columns specify if the environmental good is included in the lists of the WTO, the World Bank, the ICTSD, the FERDI and whether the IISD categorised the good as a high potential to reduce greenhouse gasses. Each column either assigns a binary 1 or 0 to indicate an inclusion or exclusion in each column respectively and the last column allocates a mark to each low-carbon environmental good.

A maximum mark of five is assigned to products that are identified by all four lists and has a high potential to reduce greenhouse gasses according to the IISD. This total will be the first of three criteria used. Therefore, Table 3.7 shows the consensus among role-players if a specific good should be included in the final list of environmental goods. The consensus among role players to classify a specific good as an environmental good would serve as a proxy for the potential environmental benefit of each good.

Table 3.7: First criterion: consensus among role players as proxy for potential environmental benefits.

| | HS-6 code[23] | WTO | WB | ICTSD | FERDI | IISD | Criterion 1 |
|---|---|---|---|---|---|---|---|
| 1. | 730820 | 1 | 0 | 1 | 1 | 1 | **4** |
| 2. | 761100 | 1 | 0 | 1 | 0 | 1 | **3** |
| 3. | 840681 | 1 | 0 | 0 | 1 | 1 | **3** |
| 4. | 840682 | 1 | 0 | 1 | 0 | 1 | **3** |
| 5. | 840690 | 1 | 0 | 1 | 0 | 1 | **3** |
| 6. | 841011 | 1 | 0 | 1 | 1 | 1 | **4** |
| 7. | 841012 | 0 | 0 | 1 | 0[24] | 0 | **1** |
| 8. | 841090 | 1 | 0 | 1 | 1 | 1 | **4** |
| 9. | 841181 | 1 | 1 | 1 | 1 | 1 | **5** |
| 10. | 841182 | 1 | 1 | 1 | 1 | 1 | **5** |
| 11. | 841221 | 0 | 0 | 1 | 0 | 0 | **1** |
| 12. | 841229 | 0 | 0 | 1 | 0 | 0 | **1** |
| 13. | 841581 | 1 | 0 | 1 | 0 | 1 | **3** |
| 14. | 841861 | 1 | 0 | 1 | 1 | 1 | **4** |
| 15. | 841869 | 1 | 0 | 0 | 0 | 1 | **2** |
| 16. | 841919 | 1 | 0 | 1 | 1 | 1 | **4** |
| 17. | 841990 | 1 | 0 | 0 | 0 | 1 | **2** |
| 18. | 848340 | 1 | 1 | 1 | 0 | 1 | **4** |
| 19. | 848360 | 1 | 1 | 1 | 0 | 1 | **4** |

[23] For a description of each HS-6 code, see table 3.6.

[24] Environmental good 841012 was included in the FERDI list but was not classified by the FERDI as a renewable energy product and therefore gets a zero from the FERDI but a 1 from the ICTSD which did include it as a Renewable Products and Energy Sources.

| | HS-6 code[23] | WTO | WB | ICTSD | FERDI | IISD | Criterion 1 |
|---|---|---|---|---|---|---|---|
| 20. | 850161 | 1 | 0 | 1 | 0 | 1 | **3** |
| 21. | 850162 | 1 | 0 | 1 | 0 | 1 | **3** |
| 22. | 850163 | 1 | 0 | 1 | 0 | 1 | **3** |
| 23. | 850164 | 1 | 0 | 1 | 0 | 1 | **3** |
| 24. | 850231 | 1 | 1 | 1 | 1 | 1 | **5** |
| 25. | 850239 | 1 | 1 | 0 | 0 | 1 | **3** |
| 26. | 850300 | 1 | 0 | 1 | 0 | 1 | **3** |
| 27. | 850440 | 1 | 0 | 1 | 0 | 1 | **3** |
| 28. | 850610 | 0 | 0 | 1 | 0 | 0 | **1** |
| 29. | 850630 | 0 | 0 | 1 | 0 | 0 | **1** |
| 30. | 850640 | 0 | 0 | 1 | 0 | 0 | **1** |
| 31. | 850650 | 0 | 0 | 1 | 0 | 0 | **1** |
| 32. | 850660 | 0 | 0 | 1 | 0 | 0 | **1** |
| 33. | 850690 | 0 | 0 | 1 | 0 | 0 | **1** |
| 34. | 850720 | 1 | 1 | 1 | 0 | 1 | **4** |
| 35. | 853710 | 1 | 1 | 1 | 1 | 1 | **5** |
| 36. | 854140 | 1 | 1 | 1 | 1 | 1 | **5** |
| 37. | 900190 | 1 | 0 | 1 | 1 | 1 | **4** |
| 38. | 900290 | 1 | 0 | 1 | 1 | 1 | **4** |
| 39. | 903289 | 1 | 0 | 1 | 0 | 1 | **3** |

*Source*: Compiled by author

The potential environmental benefits of each good are shown in table 3.7; this table does not indicate whether South Africa has the capacity to produce the product or what the potential economic benefits of each product are. The production capacity of South Africa for the thirty-nine low-carbon environmental goods is subsequently discussed.

## 3.4. Second criterion: South Africa's production capacity.

In order to increase South Africa's exports, a study was undertaken by Steenkamp, Rossouw, Viviers & Cuyvers (2009) to identify export opportunities for South Africa by using the DSM (see section 2.4.2). The DSM identifies product-country combinations from a world demand perspective.

For the thirty-nine low-carbon environmental goods as identified for the purpose of this study (see table 3.6), the DSM results show 639 product-country opportunities (see Appendix B). South Africa's capacity to produce the thirty-nine environmental goods varies. Thus, it is important to also take South Africa's capacity to produce the products into consideration. To measure South Africa's production capacity the RCA will be used.

RCA measures whether a specific country exports more of a specific product in relation to its total exports relative to the total global exports of the product in relation to the total global exports of all products (Huberty & Zachmann, 2011). Using data provided by the ITC (2011), the RCA is calculated accordingly:

$$RCA_{i,RSA} = \frac{X_{i,RSA}/X_{RSA}}{X_{i,T}/X_T} \tag{3.1}$$

Where:

- $RCA_{i,RSA}$ is the revealed comparative advantage of product $i$ for South Africa;

- $X_{i,RSA}$ is South Africa's export of product $i$;
- $X_{RSA}$ is the value of South Africa's total exports;
- $X_{i,T}$ is the total world exports of product $i$ in; and
- $X_T$ is the total world exports.

In this section, the RCA of the thirty-nine identified environmental goods will be determined. The RCA of these products differs substantially. The average RCA can be used to see the relative advantage South Africa has in exporting a specific product relative to the rest of the world.

The RCA was taken over a five year period from 2006 to 2010. In order to lessen the effect of possible outliers; the average RCA for 2006 to 2010 of these products are given in Table 3.8. The first column gives a range of the average RCA's for 2006 to 2010 and the second column gives the amount of low-carbon environmental goods in the specific range.

Table 3.8: Average RCA for low-carbon environmental goods

| RCA | Amount of EG |
|---|---|
| $RCA_{2006\text{-}10}>1$ | 4 |
| $1< RCA_{2006\text{-}10}<0.8$ | 2 |
| $0.8< RCA_{2006\text{-}10}<0.6$ | 1 |
| $0.6< RCA_{2006\text{-}10}<0.4$ | 3 |
| $0.4< RCA_{2006\text{-}10}<0.2$ | 12 |
| $RCA_{2006\text{-}10}<0.2$ | 17 |
| **Total** | **39** |

*Source*: Compiled by author

The following can be observed from table 3.8:

I. Only four low-carbon environmental goods have a RCA greater than one (for more detail, see table 3.9).

II. Only two low-carbon environmental goods have a RCA smaller than 1 but greater than 0.8; these products show some potential in their RCA's.

III. The RCA's are not normally distributed. This skewed distribution of RCA's was an important motivation for the specific method[25] used to calculate the second criterion.

The four low-carbon environmental goods that have an RCA greater than one (as named in point (i) above) are shown in the following table. The first column gives the HS-6 code of the environmental goods, the second column states the product specification and the third column states the five year RCA average.

Table 3.9: Low-carbon environmental goods; RCA>1

| HS-6 | Product specification | RCA |
|---|---|---|
| 730820 | Towers and lattice masts, iron of steel | 9.72 |
| 761100 | Aluminium reservoirs, vats, tanks, etc., volume >300l | 3.15 |
| 850161 | AC generators, of an output < 75 kVA | 2.25 |
| 850630 | Primary cells and batteries (mercuric oxide) | 1.64 |

*Source*: Compiled by author

Two environmental goods have a RCA between 0.8 and 1 and show potential for production. Table 3.10 shows the HS-6-code, the product specification and the average five year RCA of the products.

[25] Methodology of ITC (ITC, 2012)

Table 3.10: Low-carbon environmental goods: 1<RCA <0.8

| HS-6 | Product specification | RCA |
|---|---|---|
| 854140 | Photosensitive/photovoltaic/LED semiconductor devices | 0.83 |
| 850162 | AC generators of an output 75-375kVA | 0.8 |

*Source*: Compiled by author

The following table assigns a mark out of five for each of the final low-carbon environmental goods and will be the second of the three criteria used to rank the low-carbon environmental goods for the purpose of this study. This mark is derived from the RCA of the products and serves as a proxy for South Africa's production capacity for the product. The first column of this table numbers the entries, the second column states the HS-6 code of the environmental good, the third column states the average five year RCA and the fourth column derives a mark out of five.

To ensure a more normal distribution of marks the ITC methodology is used (ITC, 2012). The mark out of five is calculated by giving a maximum mark of five to the products with a RCA in the highest 5%. The highest 5% is round up to two products. A mark of zero would be given to the two products with the lowest RCA. The other products will be marked in comparison to the products with the highest and lowest RCA; this is to ensure a more normal distribution of marks. The following formula is used:

$$x_{crit\_2} = \begin{cases} 5 \; if \; x_{RCA} \geq a \\ 0 \; if \; x_{RCA} \leq b \\ \left[\left(\frac{x_{RCA} - b}{a - b}\right) \times 5\right] \; if \; a < x_{RCA} < b \end{cases} \tag{3.2}$$

Where:

- $x_{crit\_2}$ is the mark out of 5 which will be allocated to the specific product.
- $x_{RCA}$ is the RCA of the specific product $x$

- $a$ is the RCA of the product with the second highest RCA and represents the upper threshold.
- $b$ is the RCA of the product with the second lowest RCA and represents the lower threshold.
- A mark of five is allocated if the $x_{RCA} \geq a$ is true, thus the product receives a mark of 5 if the RCA of the specific product is equal or greater than the second largest RCA.
- A mark of zero is allocated if the $x_{RCA} \leq b$ is true, thus the product receives a mark of 0 if RCA of the specific product is equal or less than the second smallest RCA.
- A mark calculated by $\left[\left(\frac{x_{RCA}-b}{a-b}\right) \times 5\right]$ is allocated if $(a < x_{RCA} < b)$, thus if the RCA of the specific product is not in the upper of lower threshold, a percentage of the maximum five marks will be given, depending on where the RCA of the specific products lies, relative to the RCA of the other goods.
- The mark is rounded to the second decimal.

Table 3.11: Second criterion: RCA as proxy for South Africa's production capacity.

| | HS-6 code | Average five year RCA | Criterion 2 |
|---|---|---|---|
| 1 | 730820 | 9.72 | **5.00** |
| 2 | 761100 | 3.15 | **5.00** |
| 3 | 840681 | 0.08 | **0.11** |
| 4 | 840682 | 0.09 | **0.13** |
| 5 | 840690 | 0.45 | **0.70** |
| 6 | 841011 | 0.34 | **0.53** |
| 7 | 841012 | 0.05 | **0.06** |
| 8 | 841090 | 0.11 | **0.16** |
| 9 | 841181 | 0.34 | **0.53** |
| 10 | 841182 | 0.01 | **0.00** |

| | HS-6 code | Average five year RCA | Criterion 2 |
|---|---|---|---|
| 11 | 841221 | 0.37 | **0.57** |
| 12 | 841229 | 0.64 | **1.00** |
| 13 | 841581 | 0.09 | **0.13** |
| 14 | 841861 | 0.17 | **0.25** |
| 15 | 841869 | 0.26 | **0.40** |
| 16 | 841919 | 0.2 | **0.30** |
| 17 | 841990 | 0.38 | **0.59** |
| 18 | 848340 | 0.46 | **0.72** |
| 19 | 848360 | 0.36 | **0.56** |
| 20 | 850161 | 2.25 | **3.57** |
| 21 | 850162 | 0.8 | **1.26** |
| 22 | 850163 | 0.31 | **0.48** |
| 23 | 850164 | 0.08 | **0.11** |
| 24 | 850231 | 0.01 | **0.00** |
| 25 | 850239 | 0.31 | **0.48** |
| 26 | 850300 | 0.21 | **0.32** |
| 27 | 850440 | 0.2 | **0.30** |
| 28 | 850610 | 0.05 | **0.06** |
| 29 | 850630 | 1.64 | **2.60** |
| 30 | 850640 | 0.07 | **0.10** |
| 31 | 850650 | 0.08 | **0.11** |
| 32 | 850660 | 0.09 | **0.13** |
| 33 | 850690 | 0.01 | **0.00** |

| | HS-6 code | Average five year RCA | Criterion 2 |
|---|---|---|---|
| 34 | 850720 | 0.52 | **0.81** |
| 35 | 853710 | 0.29 | **0.45** |
| 36 | 854140 | 0.83 | **1.31** |
| 37 | 900190 | 0.01 | **0.00** |
| 38 | 900290 | 0.03 | **0.03** |
| 39 | 903289 | 0.38 | **0.59** |

*Source*: Compiled by author

In section 3.3, the environmental goods were ranked according to their potential environmental benefits (as shown in table 3.7). In section 3.4, the RCA of a product is explained and the RCA was used as a proxy for South Africa's production capacity of the various environmental goods. In table 3.11, the mark for the second criterion was derived by using RCA as a proxy for South Africa's production capacity of the various environmental goods in South Africa. Further classification is needed for the potential economic benefits of each product for South Africa, which will be subsequently discussed.

## 3.5. Third criterion: potential economic benefits.

The third and last criterion evaluates the environmental goods potential economic benefits. Various factors, such as an increase in consumer spending, investment, government spending and export promotion have economic benefits. This study focuses on the economic benefits that are possible through export promotion (see section 2.3). To measure the potential economic benefits of increasing exports of these products only the potential export value will be taken into consideration. Secondary effects of consumer preference, government spending, investment and more will not be taken into consideration. Thus, potential export value can serve as a proxy for potential economic benefits.

To calculate potential export value, the size of the import demand (see section 3.5.1 and the number of countries supplying 80% of import demand (see section 3.5.2.) are taken into consideration when calculating potential export values in the DSM. Steenkamp (2011) used all these aspects to estimate the potential export value of each product-country combination. The potential export value is merely an estimation of the export potential for the specific product-country combination and not an objective that should be fulfilled. The potential export value is used to merely rank the export opportunities and to identify the most lucrative product-country combination. The aspects that are of importance for calculating potential export value, market share, market growth and export destinations will be subsequently discussed before the marks for the third criterion are calculated.

### 3.5.1. Market share and growth.

The DSM comprises four filters (see section 2.4.2). Filter 2 examines the size and growth of import demand of a specific country for the specific product and these results are combined with filter 4 that takes South Africa's share of the world market into consideration. Table 3.12 incorporates both filters 2 and 4. The size and growth of import demand, as determined by filter 2, is indicated in the rows of table 3.12. Import demand is divided into five categories: i) large market, ii) growing market (long and short term growth), iii) large market with short term growth, iv) large market with long term growth and v) large market with short and long term growth. The results of South Africa's share in each market, as determined by filter4, are indicated in the columns of table 3.12. South Africa's market share in each product-country combination is illustrated in four categories i) market share of South Africa relatively small, ii) intermediary small, iii) intermediary large and iv) relatively large. Cells 1 to 20, which are a combination of each product-country combination's respective growth and size of import demand (shown in the rows) and South Africa's market share (on the columns) are indicated.

The number of the 639 product-country combination of low-carbon environmental goods (see Appendix B) as identified by the DSM, that fall in each particular cell, is indicated.

Table 3.12: Categorisation of product-country export combinations of environmental goods in South Africa.

| | Market share of South Africa relatively small | Intermediary small | Intermediary high | Market share of South Africa relatively high | Total (percentile) |
|---|---|---|---|---|---|
| Large product/market | CELL 1<br>67 | CELL 6<br>27 | CELL 11<br>18 | CELL 16<br>3 | 115<br>(17,99%) |
| Growing (long and short term) product/market | CELL 2<br>329 | CELL 7<br>17 | CELL 12<br>3 | CELL 17<br>22 | 371<br>(58,06%) |
| Large product/market short term growth | CELL 3<br>33 | CELL 8<br>4 | CELL 13<br>10 | CELL 18<br>2 | 49<br>(7,67%) |
| Large product/market long term growth | CELL 4<br>26 | CELL 9<br>4 | CELL 14<br>6 | CELL 19<br>0 | 36<br>(5,63%) |
| Large product/market short and long term growth | CELL 5<br>56 | CELL 10<br>6 | CELL 15<br>5 | CELL 20<br>1 | 68<br>(10,64%) |
| Total (Percentile) | 511<br>(79,97%) | 58<br>(9,08%) | 42<br>(6,57%) | 28<br>(4,38%) | 639<br>(100%) |

*Source*: Cuyvers, 2004:13 and Steenkamp, 2010

The following can be derived from table 4.11:

I. South Africa has a relatively small market share in the majority (79.97%) of the low-carbon environmental product-country opportunities as indicated by cells 1 to 5.

II. South Africa has a relatively high market share in only 4.38% of low-carbon environmental product-country combinations as indicated by cell 16 to 20.

III. The biggest proportion, 58,06%, of the product-country combinations are in the ‘growing market (short and long term)’ category (cells 2, 7, 12, 17).

### 3.5.2. Destination identified by DSM for low-carbon environmental goods

The following 75 countries are destinations in the product-country opportunities identified by the DSM; Albania, Argentina, Armenia, Australia, Austria, Bahrain, Belarus, Belgium, Bosnia Herzegovina, Brazil, Bulgaria, Canada, Cape Verde, China, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, French Polynesia, Georgia, Germany, Ghana, Greece, Hong Kong, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kuwait, Latvia, Lithuania, Luxembourg, Macao, Malaysia, Malta, Mongolia, Netherlands, New Caledonia, New Zealand, Norway, Panama, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, United Arab Emirates, United Kingdom, United States, Uruguay, Vietnam and Zambia.

The thirty-nine environmental goods have potential export opportunities, in various combinations, to the seventy-five countries, named above. The list of all the product-country export opportunities is listed in Appendix B.

### 3.5.3. Calculating mark for third criterion.

Steenkamp (2011) calculated the potential export vale according to the following formula:

$$Potential\ export\ value = \frac{Z_{i,j}}{Countries_{Z^{0.8}i,j} + 1} \tag{3.3}$$

Where:

- $Z_{i,j}$ is the imports of product $i$ by country $j$; and
- $Countries_{Z^{0.8}i,j}$ is the number of countries responsible for 80% for the imports of that product into country $j$

The formula gives an indication of the size of the importing country's demand for a specific product. The plus one in the denominator is included to allow for South Africa as a potential contributor of the 80% imports of a specific product to a specific country (Steenkamp, 2011).

The potential export value per product-country combination is calculated (see table 3.13). The second column gives the particular HS-6 code. The third column is the sum of all the potential export values of a specific product, to various countries. The fourth column gives the number of export destinations the DSM have identified for the particular product. The fifth column provides the average potential economic benefit of each product per country; thus, the value in column three divided by the value in column four. The last column derives a specific mark out of five from the average potential export value (see column five), which was calculated as follows[26]:

$$x_{crit\_3} = \begin{cases} = 5 \; if \; x_{pot\_V} \geq a \\ = 0 \; if \; x_{pot\_V} \leq b \\ = \left[ \left( \frac{x_{pot\_V} - b}{a - b} \right) \times 5 \right] if \; a < x_{pot\_V} < b \end{cases} \tag{3.4}$$

Where:

- $x_{crit\_3}$ is the mark out of five given for product $x$ in criterion three.
- $x_{pot\_V}$ is the average potential export value of product $x$.
- $a$ is the value of the second highest average potential export value or the upper threshold.
- $b$ is the value of the second lowest average potential export value or the lower threshold.
- A mark of five is given if $x_{pot\_V} \geq a$; thus if the average potential export value falls in upper 5% a mark of five is allocated.

[26] Analogue to the ITC methodology (ITC, 2012).

- A mark of zero is given if $x_{pot\_V} \leq b$; thus if the average potential export value falls under the lowest 5% a mark of zero is given.
- If the potential export value falls in the inner 90%, thus if $(a < X_{pot\_V} < b)$ ; a percentage of five will be given by the formula $\left[\left(\frac{x_{pot\_V}-b}{a-b}\right) \times 5\right]$.

Table 3.13: Third criterion: potential export value as proxy for potential economic benefits

| | HS-6 | Total potential export value (USD 2010) | Number of export opportunities | Average potential economic benefit (USD 2010) | Criterion 3 |
|---|---|---|---|---|---|
| 1. | 730820 | 251,237 | 20 | 12,561.85 | 0.44 |
| 2. | 761100 | 13,130 | 5 | 2,626.00 | 0.07 |
| 3. | 840681 | 8,127 | 2 | 4,063.50 | 0.13 |
| 4. | 840682 | 112,885 | 9 | 12,542.78 | 0.44 |
| 5. | 840690 | 497,271 | 16 | 31,079.44 | 1.13 |
| 6. | 841011 | 1,539 | 7 | 219.86 | 0.00 |
| 7. | 841012 | 2,811 | 4 | 702.75 | 0.00 |
| 8. | 841090 | 51,150 | 13 | 3,934.62 | 0.12 |
| 9. | 841181 | 189,725 | 12 | 15,810.42 | 0.56 |
| 10. | 841182 | 221,958 | 4 | 55,489.50 | 2.03 |
| 11. | 841221 | 265,676 | 20 | 13,283.80 | 0.47 |
| 12. | 841229 | 229,648 | 21 | 10,935.62 | 0.38 |
| 13. | 841581 | 538,621 | 20 | 26,931.05 | 0.97 |
| 14. | 841861 | 282,847 | 17 | 16,638.06 | 0.59 |
| 15. | 841869 | 575,512 | 15 | 38,367.47 | 1.40 |
| 16. | 841919 | 73,881 | 18 | 4,104.50 | 0.13 |
| 17. | 841990 | 335,918 | 17 | 19,759.88 | 0.71 |

| | HS-6 | Total potential export value (USD 2010) | Number of export opportunities | Average potential economic benefit (USD 2010) | Criterion 3 |
|---|---|---|---|---|---|
| 18. | 848340 | 842,122 | 19 | 44,322.21 | 1.62 |
| 19. | 848360 | 223,496 | 21 | 10,642.67 | 0.37 |
| 20. | 850161 | 79,261 | 25 | 3,170.44 | 0.09 |
| 21. | 850162 | 52,024 | 22 | 2,364.73 | 0.07 |
| 22. | 850163 | 48,282 | 11 | 4,389.27 | 0.14 |
| 23. | 850164 | 220,449 | 12 | 18,370.75 | 0.66 |
| 24. | 850231 | 814,334 | 6 | 135,722.33 | 5.00 |
| 25. | 850239 | 519,907 | 13 | 39,992.85 | 1.46 |
| 26. | 850300 | 1,060,903 | 22 | 48,222.86 | 1.76 |
| 27. | 850440 | 2,499,571 | 20 | 124,978.55 | 4.60 |
| 28. | 850610 | 322,362 | 24 | 13,431.75 | 0.47 |
| 29. | 850630 | 3,625 | 6 | 604.17 | 0.00 |
| 30. | 850640 | 27,390 | 13 | 2,106.92 | 0.06 |
| 31. | 850650 | 374,500 | 28 | 13,375.00 | 0.47 |
| 32. | 850660 | 17,880 | 18 | 993.33 | 0.01 |
| 33. | 850690 | 66,129 | 18 | 3,673.83 | 0.11 |
| 34. | 850720 | 507,621 | 19 | 26,716.89 | 0.97 |
| 35. | 853710 | 1,761,196 | 23 | 76,573.74 | 2.81 |
| 36. | 854140 | 3,983,553 | 26 | 153,213.58 | 5.00 |
| 37. | 900190 | 1,426,253 | 13 | 109,711.77 | 4.04 |
| 38. | 900290 | 124,395 | 23 | 5,408.48 | 0.18 |
| 39. | 903289 | 1,406,776 | 30 | 46,892.53 | 1.71 |

*Source*: Compiled by author based on Steenkamp (2011)

## 3.6. Final ranking of low-carbon environmental goods.

Table 3.14 provides the final ranking of the low-carbon environmental goods according to the three criteria set for purposes of this study. The first criterion (tTable 3.7) was to rank the consensus of different role players for the inclusion of the specific good in an environmental goods list and this was used as a proxy for potential environmental benefits. The second criterion (Table 3.11) was to rank the RCA of the specific product in South Africa and this was used as a proxy for South Africa's production capacity. The third criterion was given in Table 3.13 by calculating the average potential export value of each product and this was used as a proxy for potential economic benefits. For each of these criteria a mark out of five was assigned. The first column of table 3.14 shows the original entry of the good as it is entered in the final list of low-carbon environmental goods (table 3.6). The second column provides the HS-6 code. Columns three to six indicates the respective mark out of five assigned to each product in each criterion. The last column derives the final mark which is calculated as follows:

$$Mark_{final} = crt_1 \times crt_2 \times crt_3 \tag{3.5}$$

The final mark is calculated by multiplying the three criteria. Multiplication is used rather than the sum of the three criteria in order to benefit products that have similar marks in all three criteria[27]. The last column shows the product of the marks in the three criteria in descending order.

[27] Analogue to the ITC methodology

Table 3.14 Ranked largest to smallest mark according to three criteria

| | HS-6 | Criterion 1 | Criterion 2 | Criterion 3 | Final Mark |
|---|---|---|---|---|---|
| 36 | 854140 | 5 | 1.31 | 5 | 32.75 |
| 1 | 730820 | 4 | 5 | 0.44 | 8.8 |
| 35 | 853710 | 5 | 0.45 | 2.81 | 6.32 |
| 18 | 848340 | 4 | 0.72 | 1.62 | 4.67 |
| 27 | 850440 | 3 | 0.3 | 4.6 | 4.14 |
| 34 | 850720 | 4 | 0.81 | 0.97 | 3.14 |
| 39 | 903289 | 3 | 0.59 | 1.71 | 3.03 |
| 5 | 840690 | 3 | 0.7 | 1.13 | 2.37 |
| 25 | 850239 | 3 | 0.48 | 1.46 | 2.10 |
| 26 | 850300 | 3 | 0.32 | 1.76 | 1.69 |
| 9 | 841181 | 5 | 0.53 | 0.56 | 1.48 |
| 15 | 841869 | 2 | 0.4 | 1.4 | 1.12 |
| 2 | 761100 | 3 | 5 | 0.07 | 1.05 |
| 20 | 850161 | 3 | 3.57 | 0.09 | 0.96 |
| 17 | 841990 | 2 | 0.59 | 0.71 | 0.84 |
| 19 | 848360 | 4 | 0.56 | 0.37 | 0.83 |
| 14 | 841861 | 4 | 0.25 | 0.59 | 0.59 |
| 12 | 841229 | 1 | 1 | 0.38 | 0.38 |
| 13 | 841581 | 3 | 0.13 | 0.97 | 0.379 |
| 11 | 841221 | 1 | 0.57 | 0.47 | 0.27 |
| 21 | 850162 | 3 | 1.26 | 0.07 | 0.26 |
| 23 | 850164 | 3 | 0.11 | 0.66 | 0.22 |
| 22 | 850163 | 3 | 0.48 | 0.14 | 0.20 |

| | HS-6 | Criterion 1 | Criterion 2 | Criterion 3 | Final Mark |
|---|---|---|---|---|---|
| 4 | 840682 | 3 | 0.13 | 0.44 | 0.17 |
| 16 | 841919 | 4 | 0.3 | 0.13 | 0.16 |
| 8 | 841090 | 4 | 0.16 | 0.12 | 0.08 |
| 31 | 850650 | 1 | 0.11 | 0.47 | 0.05 |
| 3 | 840681 | 3 | 0.11 | 0.13 | 0.04 |
| 28 | 850610 | 1 | 0.06 | 0.47 | 0.03 |
| 38 | 900290 | 4 | 0.03 | 0.18 | 0.02 |
| 30 | 850640 | 1 | 0.1 | 0.06 | 0.006 |
| 32 | 850660 | 1 | 0.13 | 0.01 | 0.0013 |
| 24 | 850231 | 5 | 0 | 5 | 0 |
| 37 | 900190 | 4 | 0 | 4.04 | 0 |
| 10 | 841182 | 5 | 0 | 2.03 | 0 |
| 6 | 841011 | 4 | 0.53 | 0 | 0 |
| 29 | 850630 | 1 | 2.6 | 0 | 0 |
| 33 | 850690 | 1 | 0 | 0.11 | 0 |
| 7 | 841012 | 1 | 0.06 | 0 | 0 |

*Source*: Compiled by author

The following can be observed from table 3.14:

I. Taking all three criteria into account the best five overall low-carbon environmental goods from a South African export potential perspective are:

a. Photosensitive/photovoltaic/LED semiconductor devices (HS-6: 854140);

b. Towers and lattice masts, iron or steel (HS-6: 730820).

c. Electrical control and distribution boards, < 1kV (HS-6: 853710).

d. Gearing, ball screws, speed changers, torque converter (HS-6: 848340).

e. Static converters (HS-6: 850440).

II. If the sum of the criteria was taken, the following environmental goods would have been included in the top five goods

a. Wind-powered generating; this good has zero in the second criterion (HS-6: 850231).

b. Aluminium reservoirs, vats, tanks, etc., volume >300*l*; this good has a negligible small mark in the third criterion (HS-6: 761100).

III. If the sum of the criteria was taken, the following environmental goods would not have been included in the top five goods

a. Gearing, ball screws, speed changers and torque converter (HS-6: 848340).

b. Static converters (HS-6: 850440).

IV. The export destinations of these environmental goods are not included in table 3.14 but will be discussed in more detail in chapter 4. Refer to Appendix B for a complete list of all the product-country export combinations.

## 3.7. Conclusion

Green growth aims to imply various economic and environmental objectives in decision-making. In chapter 2 it was argued that an increase in exports has a significant mechanism to ensure economic growth. It is therefore important to find a way in which increased exports could also benefit environmental objectives such as an economy with lower greenhouse gas intensity. A creative link between export promotion and lower greenhouse gas intensity was found in the technique effect (see section 2.8.1). The technique effect is one of three effects that define what happens to greenhouse gas emissions when trade is liberated. Through the technique effect, greenhouse gasses have the possibility to decrease when trade increases, but only if the product that is traded has a high potential to reduce greenhouse gas emissions in its end-use. These products can be defined as low-carbon environmental goods. However, there is no internationally accepted list of environmental goods.

This chapter aimed to create a list of low-carbon environmental goods drawn from four lists of different role players namely the World Trade Organisation, the World Bank, the International Centre of Trade and Sustainable Development and the Foundation for the Study and Research on International Development. These lists were chosen for specific reasons; WTO is one of the mayor role players in current negotiations regarding environmental goods and services, the World Bank is an important global economic role player, the ICSTD is the most recent list and the list of FERDI is compiled by representative of various countries. From these four lists and research undertaken by the International Institute of Sustainable Development one list of thirty-nine low-carbon environmental goods was derived. Not all these thirty-nine low-carbon environmental goods have the same capabilities; therefore further ranking of environmental goods was needed.

Three criteria were used to further rank the thirty-nine low-carbon environmental goods. In the first criterion the consensus among the WTO, the WB, the ICTSD and the FERDI to include the specific good as a low-carbon environmental good was used as a proxy to determine the potential environmental benefit of each good. In the second criterion the RCA of each environmental good was used as a proxy of South Africa's production capacity of the environmental good. In the third criterion the potential export value was used to indicate the potential economic benefit each environmental good might have. A final list was compiled to show which products had the best overall possibility in South Africa to address both environmental and economic objectives.

The low-carbon environmental goods with the 10% best final marks were chosen for further discussion. The fourth product (HS-6: 848340) and fifth product (HS-6: 850440) had similar marks; so the fifth product was also included in further discussion. The five low-carbon environmental goods according to the criteria are photosensitive semiconductors (HS-6: 854140), towers and lattice masts (HS-6: 730820), electrical control and distribution boards < 1kV (HS-6: 853710), gearing, ball screws, speed changers, torque converter (HS-6: 848340) and static converters (HS-6: 850440) (see section 3.6 and table 3.14).

For the top five environmental goods the criteria used in chapter 3 will be subsequently discussed in more detail. Attention will be given to the exact end-use of the environmental goods that will potentially improve the environment, the producers of the environmental goods in South Africa, further discussion on the RCA, market share, market growth and potential export value. Finally, the product-country export opportunities will be discussed in more detail.

# Chapter 4: Discussion of empirical results

## 4.1. Introduction.

Thirty-nine low-carbon environmental goods which potentially have both a positive effect on the economy and the environment were identified in the previous chapter. The low-carbon environmental goods identified differ in a) their respective ability to reduce greenhouse gas emissions, b) South Africa's ability to produce the products and c) their potential economic benefit.

Further discussion of the low-carbon environmental goods will only include the five environmental goods with the best final mark. In descending order the five products are photosensitive semiconductors (HS-6: 854140), towers and lattice masts (HS-6: 730820), electrical control and distribution boards less than 1kV (HS-6: 853710), gearing, ball screws, speed changers, torque converter (HS-6: 848340) and static converters (HS-6: 850440) (see table 3.6).

This chapter aims to discuss the five low-carbon environmental goods named above; both in terms of environmental and economic characteristics, especially their export potential. This chapter is structured accordingly; first, a short description of what each product would be able to contribute to the environment; second, a list of the current producers in South Africa is given; and third a description of the characteristics of environmental goods in more detail; the RCA of each product, its market share, market growth and potential export value. The fourth part will describe other economic characteristics of the products; South Africa's current exports of each environmental good, as well as an analysis of the identified possible export countries, according to existing markets (called intensive margin) and possible new markets(called extensive margin).

## 4.2. Environmental benefits of selected environmental goods

### 4.2.1. Photosensitive/photovoltaic devices (HS-6: 854140)

Photosensitive semiconductors are identified by all the role players as an environmental good. The IISD identified it as a good with a high potential to reduce greenhouse gasses. The CTESS identified photovoltaic cells, modules and panels as products of specific importance in the HS-6: 854140 code. Photovoltaic cells are used in solar energy which generates electricity directly from sun light. The CTESS also mentioned that photovoltaic cells should be included as environmental goods because of their ability to generate electricity without greenhouse gas emissions, other emissions, heat or noise (CTESS, 2007). Photovoltaic technologies are also important for generating electricity in isolated communities which are not connected to a grid system (CTESS, 2007).

### 4.2.2. Towers and lattice masts, iron or steel (HS-6:730820).

Towers and lattice masts are identified as environmental goods by the WTO, the ICTSD and the FERDI. The IISD also identified towers and lattice masts to have a high potential to reduce greenhouse gas emissions. The CTESS identified wind turbine towers as the main environmental good within the HS-6: 730820 code. Wind turbine towers are used to elevate and hold wind turbines, which generates energy from wind (CTESS, 2007). It is important to lift a wind turbine above surrounding obstacles such as houses and trees in order to reach unobstructed wind flows since unobstructed wind flows are stronger and more consistent (REUK, 2012). The mast or tower of a wind turbine can make up to 50% of the total costs of the turbine (REUK, 2012).

### 4.2.3. Electrical control and distribution boards, < 1kV (HS-6: 853710)

This HS-6: 853710 classification includes boards, panels, consoles, desks, cabinets and other bases for a voltage not exceeding 1000V. HS-6: 853710 has been identified by the WTO, the World Bank, the ICTSD and the FERDI as an environmental good. The IISD also identified these products to have a high potential to reduce greenhouse gasses. The CTESS identified photovoltaic system controllers, a devise that controls the photovoltaic system, as the main environmental good within the HS-6-853710 code:. A photovoltaic system controller will prolong the life of the battery. If batteries are overcharged, their life span shortens significantly (Solar Direct, 2011). Overcharging is specifically a risk with photovoltaic solar power (Solar Direct, 2011). The photovoltaic system controller ensures that the batteries do not overcharge by stopping or reducing voltage when it is too high (Solar Direct, 2011).

### 4.2.4. Gearing, ball screws, speed changers, torque converter (HS-6: 848340)

The HS-6: 848340 is described as gears and gearing, other than toothed wheels, chain sprockets and other transmission elements presented separately, ball or roller screws: gear boxes and other speed changers, including torque converters. The WTO, the WB and the ICTSD included HS-6: 848340 in their list of environment goods, the IISD also identified these products as having a high potential for reducing greenhouse gasses. The CTESS identified gearboxes in wind turbines as the specific environmental good within the HS-6:848340 code. Gearboxes are used in wind turbines to change the relatively slow pace of the turning blades of a wind turbine into the required speed needed to generate electricity (CTESS, 2007).

### 4.2.5. Static converters, NES (HS-6: 850440)

HS-6: 850440 is classified as static converters. Static converters are used in unison with electric generating sets (HS-6: 850239) or photovoltaic semiconductors (HS-6: 854140) (CTESS, 2007). Static converters are used to convert solar energy into electricity (CTESS, 2007). Wind turbines and solar panels capture energy on a three-phase basis, where energy for household use is usually on a one-phase basis (De Lange, 2012). Static converters convert three-phase energy into one-phase energy for household consumption. Industrial use of energy is often on a three-phase basis. Static converters could also convert one-phase energy into three-phase energy (De Lange, 2012).

## 4.3. Production of the top five environmental goods in South Africa

There are different ways to generate renewable energy. In section 4.2.1 to 4.2.5, the role of the top five low-carbon environmental goods that generate renewable energy is discussed. Environmental goods HS-6: 854140, HS-6: 853710 and HS-6: 850440 are used in solar harvesting while environmental goods HS-6: 730820 and HS-6: 848340 are used in wind farming. Therefore only the production of parts used in solar power plantations and wind farms will be discussed subsequently.

### 4.3.1. Production of components of solar power plantations

Solar power is fast becoming one of the major sources of renewable energy worldwide. There are three types of solar power which for purposes of this study, will all be categorised under solar power. According to Maia *et al.* (2011), the main producers for solar power components and major players in South Africa are Eskom, Kabi Energy, Solairedirect, Solar Total, Solar World Africa and Tenesol. Sasol, the Central Energy Fund and the University of Johannesburg investigated the possibility of producing a particular type of solar panel in Paarl in 2012 (Maia *et al.* 2011).

The South African production of solar parts is not yet highly competitive in the global solar power market, but there is potential. South Africa and Chile were identified by Greenpeace to have the best solar resources in the world (Maia *et al.* 2011). South Africa's main advantage with solar power lies in the abundance of minerals and an abundance of solar energy. South Africa has the potential to become a major role player in the later stage of the value chain, not only in the initial stage (Maia *et al.,* 2011).

### 4.3.2. Production of components of wind farms

International corporations like General Electric, Siemens and Mitsubishi and multinational oil companies are key players in the global wind power industry (Maia *et al.,* 2011). The production of wind turbines and various parts thereof in South Africa is still in its infancy (Maia *et al.,* 2011). However, potential exists for an increase in the production of wind turbines and other parts by established factories and various new comers (Maia *et al.,* 2011). The major role players in wind power in South Africa is Africa Wind Power, Dorbyl, General Electric, Green Power & Composites, Grinaker LTA, Isivunguvungu Wind Energy Converter (I-WEC), Iskhus Power, John Thomas Boilers, Kestrel, Palmtree Power and Siemens (Maia *et al,* 2011).

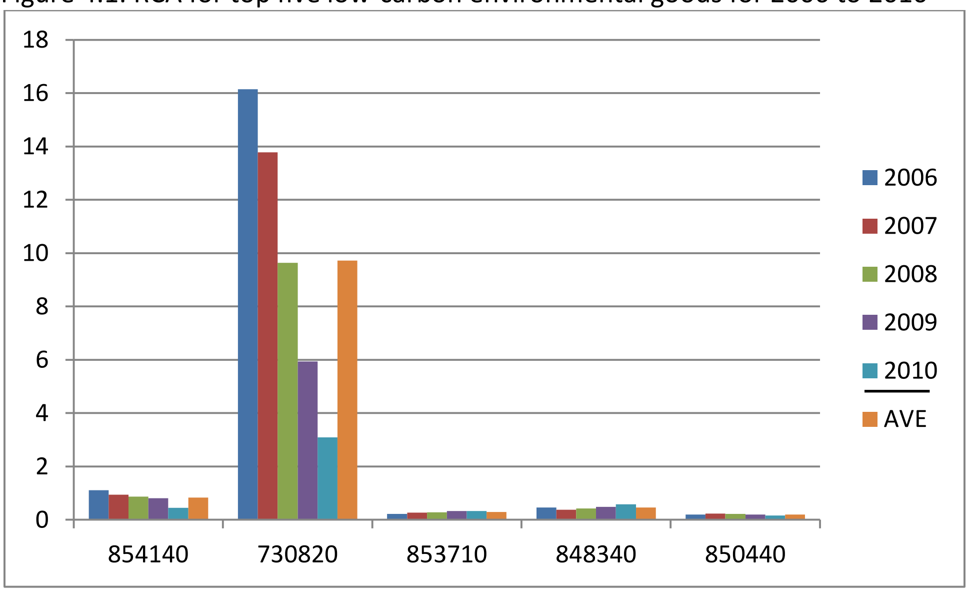
Other institutions such as Eskom, Industrial Development Corporation, Development Bank of Southern Africa, African Clean Energy Development, Macquarie, Genesis Eco-Energy, Mainstream, Electrawinds Belgium, The Oelsner Group, Umoya Energy, Safic/Accentuate, Suez, Investec and Inspired Evolution Investment Management, have demonstrated an interest to invest in wind power in South Africa (Maia *et al.,* 2011).

## 4.4. Further discussion of characteristics of top five environmental goods

### 4.4.1. Growth in RCA

In the second criterion the RCA of each product was used as a proxy for the study of South Africa's production of a specific product (see section 3.4). A five-year average of RCA was used in criterion 2 in order to minimise the effect of possible outliers. Figure 4.1 shows the top five low-carbon environmental goods for South Africa with their respective RCA's from 2006 to 2010 and the average RCA as used in the second criterion.

Figure 4.1: RCA for top five low-carbon environmental goods for 2006 to 2010

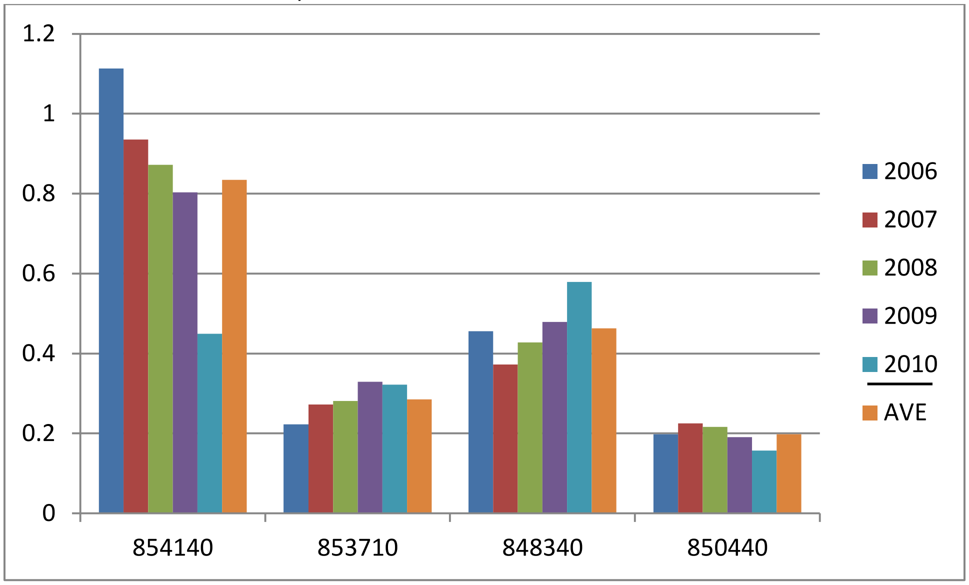



In figure 4.1 the following can be observed:

I. Product HS-6: 730820 (towers and lattice masts) had the highest RCA for every year but has been declining significantly.

II. In order to see the tendencies of the other products more clearly, another graph was drawn (see figure 4.2) which excluded HS-6: 730820 (towers and lattice masts).

Figure 4.2: RCA of top five low-carbon environmental goods for 2006 to 2010 (excluding HS-6: 730820, towers and lattice masts)




The following can be seen in figure 4.2:

I. The RCA of HS-6: 854140 (photosensitive/photovoltaic/LED semiconductor devices) steadily declined from 2006 to 2010.

II. The RCA of HS-6: 853710 (electric control and distribution boards, <1kV) is more stable over time but insignificant as the average RCA is smaller than 0.3 (see section 3.4)

III. The RCA of HS-6: 848340 (gearing, ball screws, speed changers, torque converters) is increasing since 2007 but currently the RCA average is still very small at 0.46 (see section 3.4)

IV. The RCA of HS-6: 850440 (static converters) is more stable over time but insignificant as the average RCA is 0.2 (see section 3.4)

The RCA of the top five low-carbon environmental goods is not ideal, if the RCA is not decreasing steadily, then it is insignificantly small. There are however, other factors that are also important characteristics of the importing markets of the low-carbon environmental goods, such as the market share and market growth which will be subsequently discussed.

### 4.4.2. Market share and market growth in cells.

The DSM methodology, results and the outline of the cells were discussed in section 3.5.1. In table 3.12 the 639 product-country combinations of the thirty-nine low-carbon environmental goods were presented. Table 4.1 outlines the 108 product-country combinations for the top five low-carbon environmental goods in the 20 cells.

Table 4.1 Cells for top five low-carbon environmental goods to various destinations

| | Market share of South Africa relatively small | Intermediary small | Intermediary large | Market share of South Africa relatively large | Total (percentile) |
|---|---|---|---|---|---|
| Large product/market | CELL 1<br>4 | CELL 6<br>9 | CELL 11<br>4 | CELL 16<br>0 | 17<br>(15,74%) |
| Growing (long and short term) product/market | CELL 2<br>56 | CELL 7<br>8 | CELL 12<br>2 | CELL 17<br>5 | 71<br>(65,74%) |
| Large product/market with short term growth | CELL 3<br>1 | CELL 8<br>1 | CELL 13<br>2 | CELL 18<br>0 | 4<br>(3,7%) |
| Large product/market with long term growth | CELL 4<br>3 | CELL 9<br>0 | CELL 14<br>3 | CELL 19<br>0 | 6<br>(5,56%) |
| Large product/market with short and long term growth | CELL 5<br>5 | CELL 10<br>2 | CELL 15<br>3 | CELL 20<br>0 | 10<br>(9,26%) |
| Total (Percentile) | 69<br>(63.89%) | 20<br>(18.52%) | 14<br>(12.96%) | 5<br>(4.63%) | 108<br>(100%) |

*Source*: Steenkamp (2011)

The following can be observed from table 4.1:

i. For the top five low-carbon environmental goods, South Africa’s market share of the global market is as follows:

a. 63,89% of the product-country combinations have a relatively small market share (cell 1 to 5).

b. 18,52% of the product-country combinations have a intermediary small market share (cell 6 to 10).

c. 12,96% of the product-country combinations have a intermediary large market share (cell 11 to 15).

d. 4,63% of the product-country combinations have a relatively large market share (cell 16 to 20).

ii. The growth of the respective markets can be described as follows:

a. 15,74% of the products can be exported to markets which is large (cells 1, 6, 11 and 16).

b. 65,74% of the product-country combinations are exported to markets which is relatively small with large long term and short term growth (cells 2, 7, 12 and 17).

c. 3,7% of the product-country combinations are exported to markets which are large and are experiencing short term growth (cells 3, 8, 13 and 18).

d. 5,56% of the product-country combinations are exported to markets which are large and are experiencing long term growth (cells 4, 9, 14 and 19).

e. 9,26% of the product-country combinations are exported to markets which are large and growing in the short and long term (cells 5, 10, 15 and 20).

iii. The single largest cell is cell 2 with fifty-six product-country combinations.

a. Cell two contains more than half of the product-country combinations.

b. It is important to note that this cell shows that South Africa has a relatively small market share compared to its six largest competitors of the specific product for a specific country. This does not mean that South Africa is not producing or exporting the product at all.

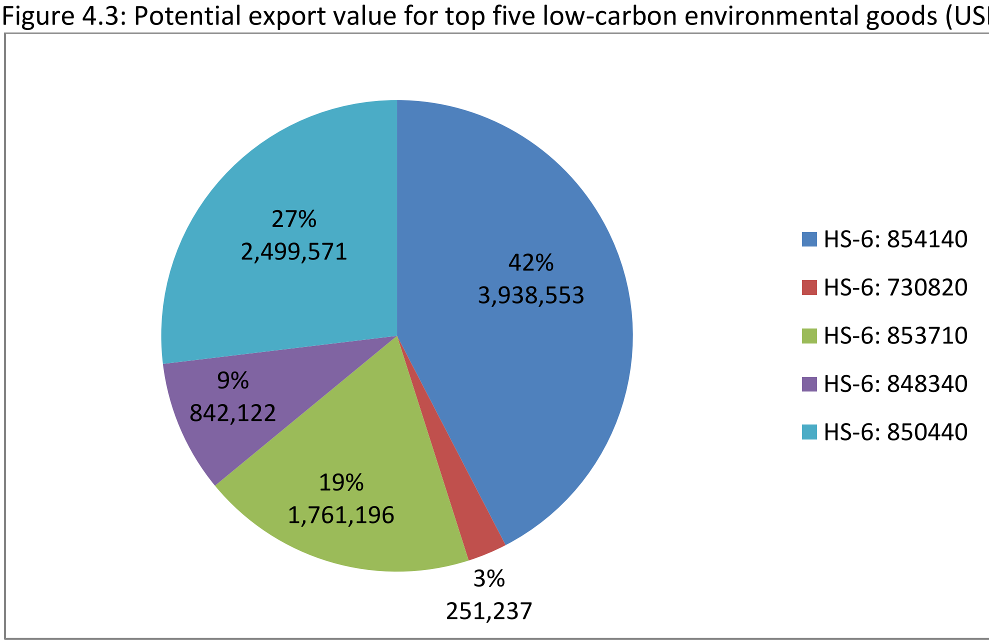
iv. There are no product-country combinations in cells 19 and 20, which are the cells that indicate a product-country combination with a large market share in a large and growing market.

Thus, the data supports statements made by Maia *et al*. (2011) that South Africa is not a major role player in the environmental goods market but there is potential. Although South Africa has a relatively small market share of the product-country combinations, there are indications of long and short term growth. Market share, market growth and potential export destinations will be subsequently discussed.

### 4.4.3. Potential export value

Figure 4.3 shows the total export potential of the top five low-carbon environmental goods and each product contribution. The percentages demonstrate the contribution to the total potential export value and the value indicated in brackets shows the export potential in 2010.

Figure 4.3: Potential export value for top five low-carbon environmental goods (USD)




Author's own calculation from Steenkamp (2011)

The following can be observed in figure 4.3:

I. Product HS-6: 854140 has the largest potential export value of USD 3,983,553 (2010); which is 42% of the total potential export value of the top five low-carbon environmental goods.

II. Product HS-6: 730820 ranks second on the overall criteria (see table 3.14) but has the smallest potential export value of the top five low-carbon environmental goods

III. Product HS-6: 853710 ranks third on the overall criteria (see table 3.14) and has the third largest export potential of USD 1,761,196.

IV. Product HS-6: 848340 ranks fourth in the overall criteria (see table 3.14) and has the fourth largest potential export value of USD 842,122 which is 9% of the potential export value of the top five low-carbon environmental goods.

V. Product HS-6: 850440 ranks fifth in the overall criteria (see table 3.14) and has the second largest potential export value of the top five products. Product HS-6: 850440 has a potential export value of USD 2,499,571 (2010) which is 27% of the total potential export value of the top-five products.

## 4.5. Intensive and extensive exports opportunities of the top five low-carbon environmental goods

Export decisions are frequently based on current export patterns, while the DSM identifies export opportunities in both existing and new markets. The intensive margin is classified in the World Bank's Trade Competitiveness Diagnostic Toolkit as the increasing of the exports of a current product-country combination (Reis & Farole, 2012:5). The extensive margin is defined as a new product-country combination - either by exploring the production and exports of a 'new' product or exporting a current product to 'new' countries (Reis & Farole, 2012:5).

Table 4.2 provides the intensive and extensive margins of the top five low-carbon environmental goods. Sub-headings indicate the current exporting value of each product-country combination, the potential export value and the percentage of the potential export value is currently utilised.

Table 4.2: Intensive and extensive export opportunities and differences between current and potential export opportunities for 'towers and lattice masts' (HS-6: 730820)

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Potential export value in thousands (USD 2010)** | **Current export value in thousands (USD 2010)** | **Percentage of potential export value utilised** | **Country** | **Potential export value in thousands (USD 2010)** |
| 1 | United States | 102,704 | 63 | 0.06 | Australia | 15,788 |
| 2 | Canada | 41,318 | 1 | 0.00 | Singapore | 12,307 |
| 3 | United Arab Emirates | 25,092 | 8 | 0.03 | Qatar | 9,111 |
| 4 | Tanzania | 10,441 | 10,441 | 100 | Germany | 7,100 |
| 5 | France | 3,274 | 185 | 5.65 | Bulgaria | 5,993 |
| 6 | United Kingdom | 1,879 | 8 | 0.43 | Norway | 5,744 |
| 7 | | | | | Kazakhstan | 3,278 |
| 8 | | | | | Saudi Arabia | 3,235 |
| 9 | | | | | Spain | 1,952 |
| 10 | | | | | Latvia | 580 |
| 11 | | | | | Egypt | 569 |
| 12 | | | | | Poland | 519 |
| 13 | | | | | Cape Verde | 287 |
| 14 | | | | | Austria | 66 |

*Source:* Steenkamp (2011), compiled by author

The following can be observed from table 4.2:

i. Towers and lattice masts (HS-6: 730820) have more extensive export opportunities (fourteen product-country combinations) than intensive export opportunities (six product-country combinations).

ii. With regard to the six intensive product-country export opportunities of towers and lattice masts (HS-6: 730820)

    a. South Africa is utilising 100% of the potential export value of this product to Tanzania.

    b. South Africa is utilising 5,65% of the total potential export value of this product to France.

    c. South Africa is utilising an insignificant amount (less than 1%) of the total potential export value of this product to Canada, United Arab Emirates, United Kingdom and the United States.

iii. With regard to the fourteen extensive product-country combinations: South Africa is currently not exporting HS-6: 730820 to Australia, Austria, Bulgaria, Cape Verde, Egypt, Germany, Kazakhstan, Latvia, Norway, Poland, Qatar, Saudi Arabia, Singapore and Spain. Of which the largest three new opportunities would be Australia, Singapore and Qatar in descending order.

iv. An extensive margin is a new product-country combination and has no current export value and South Africa is therefore, currently, not utilising any of the potential export value

Table 4.3: Intensive and extensive export opportunities and differences between current and potential export opportunities for 'gearing, ball screws, speed changers, torque converters' (HS-6: 848340)

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Potential export value in thousands (USD 2010)** | **Current export value in thousands (USD 2010)** | **Percentage of potential export value utilised** | **Country** | **Potential export value in thousands (USD 2010)** |
| 1 | China | 220,392 | 129 | 0.06 | Russia | 18,999 |
| 2 | United States | 220,195 | 2,012 | 0.91 | Spain | 11,999 |
| 3 | Canada | 77,216 | 71 | 0.09 | Tunisia | 5,486 |
| 4 | Germany | 61,132 | 1,550 | 2.54 | Kuwait | 1,432 |
| 5 | United Kingdom | 47,628 | 851 | 1.79 | Uruguay | 282 |
| 6 | Brazil | 45,568 | 23 | 0.05 | Panama | 266 |
| 7 | India | 41,355 | 15 | 0.04 | | |
| 8 | France | 34,512 | 56 | 0.16 | | |
| 9 | Italy | 32,864 | 10 | 0.03 | | |
| 10 | Norway | 16,835 | 33 | 0.20 | | |
| 11 | Kazakhstan | 3,405 | 185 | 5.43 | | |
| 12 | Qatar | 2,310 | 2,310 | 100 | | |
| 13 | Georgia | 11 | 243 | 4.53 | | |

*Source:* Steenkamp (2011), compiled by author

The following can be observed from table 4.3:

i. Gears, ball screws, speed changers, torque converters (HS-6: 848340) have more intensive export opportunities (thirteen product-country combinations) than extensive export opportunities (six product-country combinations).

ii. With regard to the thirteen intensive product-country export opportunities of ‘gears, ball screws, speed changers, torque converters’ (HS-6: 848340)

   a. South Africa is utilising 100% of the potential export value of this product to Qatar

   b. South Africa is utilising some (less than 6%) of the potential export value of this product in exports to Georgia, Germany, Kazakhstan and United Kingdom.

   c. South Africa is utilising an insignificant amount of the potential export value of this product to Brazil, Canada, China, France, India, Italy, Norway and the United States.

iii. With regard to the six extensive product-country combinations: South Africa is currently not exporting HS-6: 848340 to Kuwait, Panama, Russia, Spain, Tunisia and Uruguay. Of which the largest three new opportunities would be Russia, Spain and Tunisia in descending order.

Table 4.4: Intensive and extensive export opportunities and differences between current and potential export opportunities for ‘static converters’ (HS-6: 850440)

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Potential export value in thousands (USD 2010)** | **Current export value in thousands (USD 2010)** | **Percentage of potential export value utilised** | **Country** | **Potential export value in thousands (USD 2010)** |
| 1 | United States | 790,475 | 473 | 0.06 | Czech Republic | 92,705 |
| 2 | China | 546,884 | 12 | 0.00 | Poland | 78,762 |
| 3 | Japan | 346,731 | 158 | 0.05 | Kazakhstan | 5,094 |
| 4 | Germany | 281,620 | 246 | 0.09 | Belarus | 3,718 |
| 5 | Netherlands | 128,177 | 203 | 0.16 | Albania | 1,603 |
| 6 | France | 107,538 | 368 | 0.38 | Mongolia | 1,538 |
| 7 | India | 48,523 | 878 | 1.81 | Armenia | 643 |
| 8 | Spain | 33,917 | 61 | 0.18 | | |

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| Rank | Country | Potential export value in thousands (USD 2010) | Current export value in thousands (USD 2010) | Percentage of potential export value utilised | Country | Potential export value in thousands (USD 2010) |
| 9 | Indonesia | 11,364 | 24 | 0.21 | | |
| 10 | Greece | 10,718 | 19 | 0.18 | | |
| 11 | Zambia | 4,864 | 2,685 | 55.20 | | |
| 12 | Saudi Arabia | 4,758 | 15 | 0.32 | | |
| 13 | Uruguay | 479 | 39 | 8.14 | | |

*Source:* Steenkamp (2011), compiled by author

The following can be observed from table 4.4:

i. Static converters (HS-6: 850440) have more intensive export opportunities (thirteen product-country combinations) than extensive export opportunities (seven product-country combinations).

ii. With regard to the thirteen intensive product-country export opportunities of static converters (HS-6: 850440)

   a. South Africa is utilising 55.2% of the potential export value of this product to Zambia.

   b. South Africa is utilising some (less than 10%) of the potential export value of this product to India and Uruguay.

   c. South Africa is utilising an insignificant amount of the total potential export value of this product to China, France, Germany, Greece, Indonesia, Japan, the Netherlands, Saudi Arabia, Spain and the United States.

iii. With regard to the seven extensive product-country combinations: South Africa is currently not exporting HS-6: 850440 to Albania, Armenia, Belarus, Czech Republic, Kazakhstan, Mongolia and Poland. Of which the largest three new opportunities would be Czech Republic, Poland and Kazakhstan in descending order.

Table 4.5: Intensive and extensive export opportunities and differences between current and potential export opportunities for 'electric control and distribution boards less than 1kV'(HS-6: 853710)

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Potential export value in thousands (USD 2010)** | **Current export value in thousands (USD 2010)** | **Percentage of potential export value utilised** | **Country** | **Potential export value in thousands (USD 2010)** |
| 1 | United States | 838,671 | 1,352 | 0.16 | Russia | 41,890 |
| 2 | Canada | 273,184 | 119 | 0.04 | India | 22,923 |
| 3 | China | 248,574 | 17 | 0.01 | Indonesia | 5,813 |
| 4 | Germany | 162,870 | 1,509 | 0.93 | Vietnam | 4,624 |
| 5 | France | 73,317 | 291 | 0.40 | Macao | 4,395 |
| 6 | Saudi Arabia | 37,241 | 29 | 0.08 | French Polynesia | 1,632 |
| 7 | Kazakhstan | 16,903 | 783 | 4.63 | Mongolia | 1,631 |
| 8 | Kuwait | 8,756 | 36 | 0.41 | South Korea | 1,134 |
| 9 | Argentina | 8,128 | 6 | 0.07 | Cape Verde | 602 |
| 10 | Romania | 5,528 | 14 | 0.25 | Uruguay | 548 |
| 11 | Bahrain | 1,464 | 5 | 0.34 | | |
| 12 | Georgia | 966 | 2 | 0.21 | | |
| 13 | Ghana | 402 | 356 | 88.56 | | |

*Source*: Steenkamp (2011), compiled by author

The following can be observed from table 4.5:

i. ‘Electric control and distribution boards <1kV’ (HS-6: 853710) have more intensive export opportunities (thirteen product-country combinations) than extensive export opportunities (ten product-country combinations).

ii. With regard to the thirteen intensive product-country export opportunities of product HS-6: 853710 (electrical control and distribution boards less than 1kV)

   a. South Africa is utilising 88.56% of the total potential export value of this product to Ghana.

   b. South Africa is utilising some (less than 5%) of the total potential export value of this product to Kazakhstan

   c. South Africa is utilising an insignificant volume of the total potential export value of this product in eleven countries: Argentina, Bahrain, Canada, China, France, Georgia, Germany, Kuwait, Romania, Saudi Arabia and the United States.

iii. With regard to the ten extensive product-country combinations, South Africa is currently not exporting HS-6: 853710 to Cape Verde, French Polynesia, India, Indonesia, Macao, Mongolia, Russia, South Korea, Uruguay and Vietnam. Of these, the largest three new opportunities would be Russia, India and Indonesia in descending order.

Table 4.6: Intensive and extensive export opportunities and differences between current and potential export opportunities for 'photosensitive semiconductors' (HS-6: 854140)

| | Intensive margin | | | | Extensive margin | |
|---|---|---|---|---|---|---|
| **Rank** | **Country** | **Potential export value in thousands (USD 2010)** | **Current export value in thousands (USD 2010)** | **Percentage of potential export value utilised** | **Country** | **Potential export value in thousands (USD 2010)** |
| 1 | Germany | 922,362 | 2,143 | 0.23 | China | 953,255 |
| 2 | Spain | 647,886 | 54 | 0.01 | Hong Kong | 363,505 |
| 3 | United States | 307,954 | 73 | 0.02 | Czech Republic | 177,443 |
| 4 | Japan | 188,558 | 11 | 0.01 | Croatia | 55,907 |
| 5 | United Kingdom | 161,456 | 195 | 0.12 | Turkey | 4,738 |
| 6 | Italy | 115,731 | 9 | 0.01 | Ireland | 2,443 |
| 7 | France | 111,821 | 111,821 | 100 | Kuwait | 1,504 |
| 8 | Russia | 4,591 | 3 | 0.68 | Slovenia | 919 |
| 9 | Egypt | 1,740 | 17 | 0.98 | Bulgaria | 777 |
| 10 | Saudi Arabia | 1,307 | 344 | 26.32 | Poland | 727 |
| 11 | Tanzania | 841 | 39 | 4.64 | Lithuania | 607 |
| 12 | | | | | Kazakhstan | 543 |
| 13 | | | | | Cyprus | 358 |
| 14 | | | | | Georgia | 24 |
| 15 | | | | | Bahrain | 13 |

*Source:* Steenkamp (2011), compiled by author

The following can be observed from table 4.6:

i. 'Photosensitive semiconductors' (HS-6: 854140) have more extensive export opportunities (fifteen product-country combinations) than intensive export opportunities (eleven product-country combinations).

ii. With regard to the eleven intensive product-country export opportunities of photosensitive semiconductors (HS-6: 854140)

    a. South Africa is utilising 100% of the total potential export value of this product to France.

    b. South Africa is utilising 26,32% and 4,64% of the total potential export value of this product to Saudi Arabia and Tanzania respectively.

    c. South Africa is utilising an insignificant amount of the total potential export value of this product to Egypt, Germany, Italy, Japan, Russia, Spain, United Kingdom and the United States.

iii. With regard to the fifteen extensive product-country combinations: South Africa is currently not exporting HS-6: 854140 to Bahrain, Bulgaria, China, Croatia, Cyprus, Czech Republic, Georgia, Hong Kong, Ireland, Kazakhstan, Kuwait, Lithuania, Poland, Slovenia and Turkey. Of which the largest three new opportunities would be China, Hong Kong and Czech Republic in descending order.

Table 4.7 presents ten of the best intensive export opportunities as observed from table 4.2 to table 4.6. The first column ranks the intensive export opportunities according to their potential export value, the second column shows the specific product and the third column shows the export destination. The last column shows the potential export value.

Table 4.7: Top ten intensive export opportunities of the low-carbon environmental goods in terms of potential export value

| Rank | HS-6 code | Product specification | Export destination | Potential export value in thousands (USD 2010) |
|---|---|---|---|---|
| 1 | 854140 | Photosensitive semiconductors | Germany | 922,362 |
| 2 | 853710 | Electric control and distribution boards, smaller than 1kV | United States | 838,671 |
| 3 | 850440 | Static converters | United States | 790,475 |
| 4 | 854140 | Photosensitive semiconductors | Spain | 647,886 |
| 5 | 850440 | Static converters | China | 546,884 |
| 6 | 850440 | Static converters | Japan | 346,731 |
| 7 | 854140 | Photosensitive semiconductors | United States | 307,954 |
| 8 | 850440 | Static converters | Germany | 281,620 |
| 9 | 853710 | Electric control and distribution boards, smaller than 1kV | Canada | 273, 184 |
| 10 | 853710 | Electric control and distribution boards, smaller than 1kV | China | 248,574 |

Compiled by author

The following can be observed from table 4.7:

i. No export opportunities for towers and lattice masts (HS-6: 730820) and gearing, ball screws, speed converters, torque converters (HS-6: 848340) are in the top ten intensive export opportunities according to potential export value.
ii. Four of the top ten intensive export opportunities are for static converters (HS-6: 850440).
iii. Photosensitive semiconductors (HS-6: 854140) and electric control and distribution boards less than 1kV (HS-6: 853710) have each three intensive export opportunities which are in the top ten.

iv. United States is identified as the export destination for three products in the top ten.

v. Germany and China are both identified for two export opportunities in the top ten.

Table 4.8 presents ten of the best extensive export opportunities as observed from table 4.2 to table 4.6. The first column ranks the extensive export opportunities according to potential export value, the second column shows the specific product and the third column shows the export destination. The last column shows the potential export value.

Table 4.8: Top ten extensive export opportunities of the low-carbon environmental goods in terms of potential export value

| Rank | HS-6 code | Product specification | Export destination | Potential export value in thousands (USD 2010) |
|---|---|---|---|---|
| 1 | 854140 | Photosensitive semiconductors | China | 953,255 |
| 2 | 854140 | Photosensitive semiconductors | Hong Kong | 363,505 |
| 3 | 854140 | Photosensitive semiconductors | Czech Republic | 177,443 |
| 4 | 850440 | Static converters | Czech Republic | 92,705 |
| 5 | 850440 | Static converters | Poland | 78,762 |
| 6 | 854140 | Photosensitive semiconductors | Croatia | 55,907 |
| 7 | 853710 | Electric control and distribution boards, smaller than 1kV | Russia | 41,890 |
| 8 | 853710 | Electric control and distribution boards, smaller than 1kV | India | 22,923 |
| 9 | 848340 | Gears, ball screws, speed changers and torque converters | Russia | 18,999 |
| 10 | 730820 | Towers and lattice masts | Australia | 15,788 |

Compiled by author

The following can be observed from table 4.8:

i. All of the top five low-carbon environmental goods have at least one extensive export opportunity in the top ten extensive export opportunities.
ii. Photosensitive semiconductors (HS-6: 854140) to China Hong Kong has the highest and second highest potential value for an extensive export opportunity, respectively.
iii. There are two export opportunities for South Africa to both Czech Republic and Russia.

## 4.6. Conclusion.

The thirty-nine low-carbon environmental goods have different potentials for reducing greenhouse gas emissions or induce economic growth. The South African production capacities for each of the low-carbon environmental goods are also different. The focus of this chapter was on the environmental goods that had the best joint ability in the three criteria; a) potential greenhouse gas reduction in end-use, b) production capacity in South Africa and c) potential economic benefit. Of the thirty-nine low-carbon environmental goods, the final marks of the goods vary from 32.75 to zero (see table 3.14). The top 10% (four products) of the environmental goods were further discussed. The fourth product (HS-6: 848340) and the fifth product (HS-6: 850440) had similar final marks and therefore the fifth product was also included for further discussion.

Further analysis of the top five low-carbon environmental goods show that there is not one product that is clearly superior to the others with regard to different economic characteristics. Product HS-6: 730820 had the best RCA, which was used as a proxy for South Africa's production capacity. The RCA of product HS-6: 730820 was declining significantly. Product HS-6: 854140 has the best potential export value, which was used as a proxy for potential economic benefit. All of the goods had both intensive and extensive export opportunities. Extensive export opportunities are export opportunities to countries which South Africa has not yet exported that particular product to. The product-country export opportunities for the five identified low-carbon environmental goods were listed according to their potential export value. General observation of the intensive and extensive export opportunities for South Africa (see tables 4.2 to 4.6) is that South Africa is under utilising its total potential export value.

# Chapter 5: Conclusions and recommendations

## 5.1. Introduction

This study aimed to discuss the significance of low-carbon environmental goods for green economic growth. The empirical study aimed to identify low-carbon environmental goods and the export opportunities for these goods. The first part of this chapter summarises the main conclusions of each chapter and highlights significant results. The second part of this study stipulates the limitations of this study and recommendations for further studies.

## 5.2. Conclusions

Chapter two was a literature review about exports and the environment as separate entities and the interaction between the two entities. The chapter was structured as follows with the following conclusions:

i. Green growth is a relatively new term describing an economy that takes environmental, economic and social issues into account. This study focuses on a sub-section of green growth, namely low-carbon growth which consists of economic growth and lower greenhouse gas intensity.

ii. Various decision makers in South Africa, such as the New Development Commission, identified increased export as a viable method to encourage economic growth. Increased exports increases inflows of income, better efficiency and productivity and could have a positive impact on unemployment.

iii. The environment is a complex multifaceted entity; improving one aspect of the environment could deteriorate another. This study does not attempt to improve the environment as a whole but rather to solely focus on a decrease in greenhouse gasses in South Africa. Therefore the focus was exclusively on environmental goods that have a high potential to reduce greenhouse gasses in end-use, also known as low-carbon environmental goods.

iv. Various policies and laws, both international and national, require the South African economy to make changes. The South African economy is not only energy intensive but the energy generated in South Africa is greenhouse gas intensive. In order to reduce the greenhouse gas intensity of the economy, the energy sector of South Africa should adjust to utilise more renewable energy sources.

v. If a group of environmental goods can be scientifically determined, there has to be a way in which an increase in exports could lessen the greenhouse gas intensity of an economy.

vi. The relationship between exports and the environment is discussed in terms of three effects; the scale effect, the composition effect and the technique effect. The volume of greenhouse gas emissions can decrease when trade is liberated according to the composition and the technique effect. This can only be done if the product that is traded has a high potential to reduce greenhouse gasses and replace a product with high greenhouse gas intensity.

vii. By exporting low-carbon environmental goods South Africa can directly lessen greenhouse gas emissions globally. Local greenhouse gas emissions can also be decreased indirectly locally by increasing low-carbon energy sectors, which will increase local sales, increase awareness and increase income per capita which will make low-carbon energy further affordable.

viii. The Doha Mandate called for a reduction of tariffs and non-tariff measures for environmental goods. Even though this has not yet been made mandatory there is an increase in the trade liberation of environmental goods.

ix. Cheaper environmental goods can increase the rate of diffusion at every time period. Diffusion is the rate at which technologies spread in a community.

Chapter three accepts the premise in chapter two that export promotion of low-carbon environmental goods has a potential dual effect on economic growth and to decrease greenhouse gas emissions. The chapter was structured as follows with the following conclusions:

i. The Doha Mandate was vague on what environmental goods consists of. Three methods of identifying environmental goods were discussed and the list approach was chosen.
ii. In order to identify a list of low-carbon environmental goods, four existing lists of environmental goods were identified, studied and used to derive a list of low-carbon environmental goods to apply to this study.
iii. The first list is of the World Trade Organisation. It is an important list, as the WTO is an important role player and the particular list was the first used in EGS negotiations. The IISD also used that particular list and stipulated which of these products have a high potential for reducing greenhouse gasses. This list will be used for a comparison with other lists.
iv. The second list is of the World Bank; this list has been included because the World Bank is also an important role player.
v. The third list is from the International Centre of Trade and Sustainable Development. This list is included because it is not only the most recent list but research from the ICSTD has also focused on a dual solution for increasing trade and improving the environment.
vi. The fourth list is from the *Fondation Pour Les Etudes Et Recherches sur le Développement International,* which is an important list since it is a multi-national attempt to reach a consensus for a list of environmental goods.
vii. One list of environmental goods was derived from the four lists named above. However further ranking was necessary. Chapter 2 indicated environmental goods should have a potential for environmental and economic benefits, all within a South African context. Therefore three criteria were used to rank the products, namely environmental goods that have a high potential

to reduce greenhouse gasses, environmental goods with a high potential to increase economic benefits and environmental goods that South Africa can produce or manufacture.

viii. The first criterion used consensus among the WTO, the WB, the ICTSD, the FERDI and the IISD as a proxy for potential environmental benefits

ix. The second criterion used RCA as a proxy for South Africa's production capacity for the specific good.

x. The third criterion used potential export value as a proxy for the potential economic benefit a certain good has for South Africa.

xi. Finally, the study takes the three criteria into account and favoured products with similar marks for each criterion.

xii. The five goods that were identified as having both potential environmental benefits, can be produced in South Africa and have potential economic benefits were photosensitive semiconductors (HS-6: 854140), towers and lattice masts (HS-6: 730820), electrical control and distribution boards less than 1kV (HS-6: 853710), gearing, ball screws, speed changers, torque converter (HS-6: 848340) and static converters (HS-6: 850440). Further discussion of the characteristics and production of these products followed.

Chapter four discussed the top five low-carbon environmental goods as identified in chapter three. The top five goods were discussed in the following format:

i. Regarding criterion one, namely the potential environmental benefits, discussion followed what each of the five top low-carbon environmental good could contribute to reduce environmental pressure, specifically to reduce greenhouse gas emissions.

ii. Regarding criterion two, South Africa's production capacity of the various products were discussed on two grounds.

  a. First, the main producers of the top five low-carbon environmental goods were discussed.
  b. Second, the RCA's, which were used as a proxy for South Africa's production capacity, were discussed in more detail.

iii. Regarding criterion three, namely the potential economic benefits, it was also described further in two ways.
  a. First, the potential economic benefit each good had, relative to the other goods, was shown.
  b. Second, the product-country combination of the top five environmental goods was classified in 20 cells according to a representation of market share and market growth.

iv. Other economic characteristic, disregarding any of the three criteria, included a list of intensive and extensive export opportunities, including the estimated percentage of each export opportunity currently utilised.

v. Of the top five environmental goods, there is not one product that is best in all three criteria. Product HS-6: 854140 (photosensitive semiconductors) and product HS-6: 853710 (electric control and distribution boards) had the best potential to reduce environmental pressure. On the other hand, South Africa has the best capacity to produce product HS-6: 730280 (towers and lattice masts). Product HS-6: 854140 (photosensitive semiconductors) which shows the highest potential for economic gain.

## 5.3. Limitations of study, recommendations and further research

### 5.3.1. Holistic approach to green growth

This study only focused on low-carbon growth. Figure 1.2. (see section 1.5) shows other sub-sections of green growth as well, such as controlling climate change, valuing natural capital, strengthening communities and habitats and equitable growth. Each of these sub sections has a certain economic, environmental and social role to fulfil and each has a different relationship with trade. Low-carbon growth is therefore a necessary but partial movement towards green growth. Further studies can focus on the other aspects of a green economy.

### 5.3.2. Environmental benefits, development benefits and trade benefits

The Doha Mandate indicated a win-win-win situation, which consists of an environmental-win, a trade-win and a development-win. A shortcoming with this favourable win-win-win situation is that some countries benefit from the environmental-win, while other countries might carry an environmental-loss, but an economical-win. The win-win-win situation is not on a local level but rather on a global level. On a national level there could be certain losses such as the mining of steel for wind turbines which might be an economic-win but is also an environmental loss. Further studies can focus on the various losses that accompany the so called win-win-win situation.

### 5.3.3. Imperfect HS-6 detailing

The data used in this study is on a HS-6 level. HS-6 is the most detailed international trade code that is also internationally compatible. There is however a critique that HS-6 level is not detailed enough for the purpose of environmental good and service negotiations. For example, product HS-6: 730820 (towers and masts), includes various masts such as masts for street lights, towers for power cables and masts for wind turbine. The data for all types of masts are included in the HS-6: 730820 code but the others are not necessarily applicable to this study. The CTESS aimed to 'ex-out' the various environmental goods from their specific HS-6 code, by either creating a uniform HS-8 code (which is the national tariff line) or revising the HS-6 codes. Further studies could focus on the true significance of this problem; for example whether the production of masts, of any kind, can easily be transformed in the production of wind turbine masts.

### 5.3.4. Multiple uses and production

Even if a more detailed HS-8 code can be used to identify environmental goods, multiple uses of environmental goods still pose a problem. For example, product HS-6: 848340 (gearing, ball screws, speed changers, torque converter) include certain gears which can be used in wind turbines, to transform the relatively slow pace of the blades to faster speeds that can generate electricity. This same gear can potentially also be used in generating electricity from coal, which is particularly harmful to the environment. Multiple uses are not included in this study but further studies can investigate the other impacts of environmental goods on the environment.

The end-use of low-carbon environmental goods was the only consideration for an environmental impact of these goods. This is, however, a partial consideration. The environmental impact of the production of these products should also be taken into account. Further studies can focus on ways to encourage the 'green' production of environmental goods.

### 5.3.5. Proposed living document

A recommendation from Cosbey, Aguilar, Ashton and Ponte (2010) is that the list of environmental goods should be a living document. The flexibility of such a list will allow products to be included and removed from the list as new research and new products emerge from research and development.

#### 5.3.6. Green protectionism

Environmental taxation, tariffs or other measures are aimed at the discouragement of the production of goods that have a relatively high environmental impact and to favour goods that are environmentally preferable to other environmental goods. This, however, has resulted in protectionist policies that benefit local producers above foreign producers (Cosbey, 2011:27). Green protectionism might be a political constraint, which falls outside the scope of economic theory and practice but could potentially deliver interesting research topics.

## 5.4. Conclusion of chapter

This study investigated the potential effect of the production and export promotion of low-carbon environmental goods on the economy and environment from a South African perspective. This study could be used by governmental bodies, such as the DTI, that aim to diffuse 'green technologies' or national government which aims to grow economically and adhere to international mitigation policies. This study can also be used by any private enterprise that aims to invest in alternative renewable energy sources.

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## Appendix A: World Trade Organisation: list of environmental goods

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| **Air pollution** | | | |
| 209 | 840420 | Condensers for steam or vapour power units | Negligible |
| 210 | 840490 | Steam, vapour generating boiler auxiliary plant parts | Negligible |
| 211 | 840510 | Producer, water and acetylene gas generators | Negligible |
| 235 | 841410 | Vacuum pumps | Negligible |
| 237 | 841430 | Compressors for refrigerating equipment | Negligible |
| 238 | 841440 | Air compressors mounted on wheeled chassis for towing | Negligible |
| 239 | 841459 | Electric fans, motor > 125 watts | Negligible |
| 240 | 841480 | Air or gas compressors, hoods | Negligible |
| 241 | 841490 | Parts of vacuum pumps, compressors, fans, blowers, hoods | Negligible |
| 251 | 841960 | Machinery for liquefying air or other gases | Negligible |
| 252 | 841989 | Machinery for treatment by temperature change NES | Negligible |
| 259 | 842139 | Filtering or purifying machinery for gases NES | Negligible |
| 399 | 902610 | Equipment to measure or check liquid flow or level | Negligible |
| **Management of solid and hazardous waste and recycling systems** | | | |
| 68 | 392010 | Film and sheet etc, non-cellular etc, of polymers ofethylene | Possibly some |
| 193 | 761290 | Aluminium casks, drums, boxes etc., capacity <300 litre | Possibly some |
| 200 | 840219 | Vapour generating boilers NES, hybrid boilers | Possibly some |
| 206 | 840290 | Parts of steam or vapour generating boilers NES | Possibly some |
| 208 | 840410 | Auxiliary plant for steam/vapour generating boilers | Possibly some |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 244 | 841780 | Industrial or lab furnaces & ovens, inc incinerators non-electric NES | Possibly some |
| 245 | 841790 | Parts of industrial or laboratory furnaces/ovens | Possibly some |
| 249 | 841940 | Distilling or rectifying plant | Possibly some |
| 263 | 842220 | Machinery for cleaning/drying bottles/containers NES | Possibly some |
| 264 | 842290 | Parts of wash, filling, closing, aerating machinery | Possibly some |
| 271 | 842940 | Tamping machines and road rollers, self- propelled | Possibly some |
| 277 | 846291 | Hydraulic presses for working metal | Possibly some |
| 279 | 846596 | Splitting, slicing or paring machines for wood, etc. | Possibly some |
| 280 | 846599 | Machine tools for wood, cork or hard plastic, etc. NES | Possibly some |
| 281 | 846694 | Parts, accessories NES, metal shaping machine tools | Possibly some |
| 285 | 847420 | Machines to crush or grind stone, ores and minerals | Possibly some |
| 290 | 847982 | Machines to mix, knead, crush, grind, etc., NES | Possibly some |
| 291 | 847989 | Machines and mechanical appliances NES | Possibly some |
| 292 | 847990 | Parts of machines and mechanical appliances NES | Possibly some |
| 315 | 850590 | Electro-magnets NES and parts of magnetic devices | Possibly some |
| 322 | 851410 | Industrial electric resistance heated furnaces & oven | Possibly some |
| 323 | 851420 | Industrial & laboratory electric induction o dielectric furnaces & ovens | Possibly some |
| 324 | 851430 | Industrial/laboratory electric furnaces and ovens NES | Possibly some |
| 325 | 851490 | Parts of industrial/etc. electric furnaces/ovens NES | Possibly some |
| **Clean up or remediation of soil and water** | | | |
| 255 | 842119 | Centrifuges NES | Negligible |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 260 | 842191 | Parts of centrifuges, including centrifugal dryers | Negligible |
| 327 | 851629 | Electric space heating NES and soil heating apparatus | Negligible |
| 383 | 890790 | Buoys, beacons, coffer-dams, pontoons, floats NES | Negligible |
| | | **Renewable energy plant** | |
| 173 | 730820 | Towers and lattice masts, iron or steel | High |
| 192 | 761100 | Aluminium reservoirs, vats, tanks, etc., volume >300l | High |
| 212 | 840681 | Turbines NES, of o <40mw | High |
| 213 | 840682 | Turbines NES, of o >40mw | High |
| 214 | 840690 | Parts of steam and vapour turbines | High |
| 218 | 841011 | Hydraulic turbines, water wheels, power < 1000 kW | High |
| 221 | 841090 | Parts of hydraulic turbines and water wheels | High |
| 222 | 841181 | Gas turbine engines NES of a power < 5000 kW | High |
| 224 | 841182 | Gas turbine engines NES of a power > 5000 kW | High |
| 475 | 841581 | Air conditioners NES with reverse cycle refrigeration | High |
| 475 | 841861 | Compression refrigeration equipment with heat exchange | High |
| 475 | 841869 | Refrigerating or freezing equipment NES | High |
| 247 | 841919 | Instantaneous/storage water heaters, not electric NES | High |
| 253 | 841990 | Parts, laboratory/industrial heating/cooling machinery | High |
| 300 | 848340 | Gearing, ball screws, speed changers, torque converter | High |
| 301 | 848360 | Clutches, shaft couplings, universal joints | High |
| 305 | 850161 | AC generators, of an output < 75 kVA | High |
| 306 | 850162 | AC generators, of an output 75-375 kVA | High |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 307 | 850163 | AC generators, of an output 375-750 kVA | High |
| 308 | 850164 | AC generators, of an output > 750 kVA | High |
| 310 | 850231 | Wind-powered generating | High |
| 311 | 850239 | Electric generating sets | High |
| 313 | 850300 | Parts for electric motors and generators | High |
| 314 | 850440 | Static converters, NES | High |
| 457 | 850720 | Lead-acid electric accumulators except for vehicles | High |
| 456 | 853710 | Electrical control and distribution boards, < 1kV | High |
| 344 | 854140 | Photosensitive/photovoltaic/LED semiconductor devices | High |
| 384 | 900190 | Prisms, mirrors and optical elements NES, unmounted | High |
| 385 | 900290 | Mounted lenses, prisms, mirrors, optical elements NES | High |
| 435 | 903289 | Automatic regulating/controlling equipment NES | High |
| **Heat and energy management** | | | |
| 250 | 841950 | Heat exchange units, non-domestic, non-electric | Possibly some |
| 412 | 902810 | Gas supply/production/calibration meters | Possibly some |
| 413 | 902820 | Liquid supply, production and calibrating meters | Possibly some |
| 414 | 902830 | Electricity supply, production and calibrating meters | Possibly some |
| 415 | 902890 | Parts, accessories for gas, liquid, electricity meter | Possibly some |
| **Waste water management and potable water treatment** | | | |
| 116 | 560314 | Nonwovens, man-made filaments weighing >150g/m2 | Negligible |
| 146 | 691010 | Porcelain bathroom, kitchen & other sanitary fixtures | Negligible |
| 165 | 730300 | Tubes, pipes and hollow profiles, of cast iron | Negligible |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 167 | 730431 | Iron/non-alloy steel pipe, cold drawn/rolled, NES | Negligible |
| 167 | 730439 | Iron/non-alloy steel pipe or tubing, NES | Negligible |
| 167 | 730441 | Stainless steel pipe or tubing, cold rolled | Negligible |
| 167 | 730449 | Stainless steel pipe or tubing, except cold rolled | Negligible |
| 167 | 730451 | Alloy steel pipe or tubing, cold rolled | Negligible |
| 167 | 730459 | Tube, pipe & hollow profile, as (o/t stainless) smls, circ cross sect, NES | Negligible |
| 167 | 730490 | Iron or steel tubes, pipes or hollow profiles, NES | Negligible |
| 170 | 730630 | Pipes etc. NES, iron/steel welded NES, diameter <406.4m | Negligible |
| 170 | 730640 | Pipes and tubing, stainless steel, welded | Negligible |
| 170 | 730650 | Pipes and tubing, alloy steel NES, welded | Negligible |
| 170 | 730660 | Hollow profiles/tubes, iron/steel, non-circular, welded | Negligible |
| 170 | 730661 | Tubes and pipes and hollow profiles, welded, of square or rectangular | Negligible |
| 170 | 730669 | Tubes, pipes and hollow profiles, welded, of non-circular cross-section | Negligible |
| 170 | 730690 | Tube/pipe/hollow profile, iron/steel, riveted/open sea | Negligible |
| 174 | 730900 | Reservoirs/tanks/vats/etc., iron/steel capacity >300l | Negligible |
| 175 | 731010 | Tank, cask or container, iron/steel, capacity 50-300l | Negligible |
| 177 | 731029 | Cans, iron or steel, capacity <50 litres NES | Negligible |
| 185 | 732490 | Sanitary ware and parts thereof, iron or steel, NES | Negligible |
| 186 | 732510 | Cast articles, of non-malleable cast iron NES | Negligible |
| 188 | 732690 | Articles of iron or steel, NES | Negligible |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 229 | 841320 | Hand pumps not designed to measure flow | Negligible |
| 230 | 841350 | Reciprocating positive displacement pumps NES | Negligible |
| 231 | 841360 | Rotary positive displacement pumps NES | Negligible |
| 232 | 841370 | Centrifugal pumps NES | Negligible |
| 233 | 841381 | Pumps NES | Negligible |
| 248 | 841939 | Non-domestic, non-electric dryers NES | Negligible |
| 256 | 842121 | Water filtering or purifying machinery or apparatus | Negligible |
| 257 | 842129 | Filtering/purifying machinery for liquids NES | Negligible |
| 261 | 842199 | Parts for filter/purifying machines for liquid/gas | Negligible |
| 270 | 842833 | Continuous action goods conveyor or elevator belt type | Negligible |
| 294 | 848110 | Valves, pressure reducing | Negligible |
| 295 | 848120 | Valves for oleo hydraulic or pneumatic transmissions | Negligible |
| 295 | 848130 | Valves, check | Negligible |
| 297 | 848140 | Valves, safety or relief | Negligible |
| 295 | 848180 | Taps, cocks, valves and similar appliances, NES | Negligible |
| 299 | 848190 | Parts of taps, cocks, valves or similar appliances | Negligible |
| 346 | 854389 | Electrical machines and | Negligible |
| **Environmental preferable products based on end-use or disposal characteristics** | | | |
| 104 | 530310 | Jute and other textile bast fibres, raw or retted | Negligible |
| 106 | 530410 | Sisal and Agave, raw | Negligible |
| 107 | 530490 | Sisal textile fibres processed but not spun; tow & waste of sisal fibres | Negligible |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 117 | 560710 | Twine, cordage, ropes and cables, of jute or other textile bast fibres | Negligible |
| 118 | 560721 | Binder or baler twine, of sisal or agave | Negligible |
| 126 | 630510 | Sacks & bags, packing, of jute or other bast fibres | Negligible |
| **Cleaner or more resource efficient technologies and products** | | | |
| 183 | 732111 | Cooking appliances for gas fuel, etc., iron or steel | Low |
| 184 | 732190 | Parts for domestic non-electric thermic appliances | Low |
| 316 | 850680 | Primary cells & primary | Low |
| 318 | 850980 | Domestic appliances, with electric motor, NES | Low |
| **Natural risk management** | | | |
| 389 | 901540 | Photogram metrical surveying instruments, appliances | Negligible |
| 390 | 901580 | Surveying, etc. instruments NES | Negligible |
| 391 | 901590 | Parts and accessories for surveying etc. instruments | Negligible |
| **Natural resource protection** | | | |
| 121 | 560811 | Made up fishing nets, of manmade textile materials | Negligible |
| 122 | 560890 | Knotted netting, nets, of natural materials | Negligible |
| 440 | 950720 | Fish-hooks, whether or not snelled | Negligible |
| **Noise and vibration abatement** | | | |
| 88 | 450410 | Blocks, sheets, strip and tiles of agglomerated cork | Negligible |
| 216 | 840991 | Parts for spark-ignition engines except aircraft | Negligible |
| 217 | 840999 | Parts for diesel and semi-diesel engines | Negligible |
| 425 | 903110 | Machines for balancing mechanical parts, NES | Negligible |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| **Environmental monitoring, analysis and assessment equipment** | | | |
| 388 | 901530 | Surveying levels | Low |
| 400 | 902610 | Equipment to measure or check liquid flow or level | Low |
| 401 | 902620 | Equipment to measure or check pressure | Low |
| 402 | 902680 | Equipment to measure, check gas/liquid properties NES | Low |
| 403 | 902690 | Parts of equipment to measure or check fluid variable | Low |
| 405 | 902710 | Gas/smoke analysis apparatus | Low |
| 406 | 902720 | Chromatographs, electrophoresis instruments | Low |
| 407 | 902730 | Spectrometers, spectrophotometers, etc. using light | Low |
| 408 | 902740 | Exposure meters | Low |
| 409 | 902750 | Instruments NES using optical radiations | Low |
| 410 | 902780 | Equipment for physical or chemical analysis, NES | Low |
| 411 | 902790 | Microtomes, parts of scientific analysis equipment | Low |
| 418 | 903010 | Instruments to measure or detect ionising radiations | Low |
| 419 | 903020 | Cathode-ray oscilloscopes and cathoderay oscillographs | Low |
| 420 | 903031 | Electrical multi-meters | Low |
| 421 | 903039 | Ammeters, voltmeters, ohm meters, etc., non-recording | Low |
| 422 | 903083 | Recording electrical measurement instruments NES | Low |
| 423 | 903089 | Electrical measurement instruments NES | Low |
| 424 | 903090 | Parts & accessories, electrical measuring instruments | Low |
| 426 | 903120 | Test benches for measuring or checking equipment | Low |
| 427 | 903130 | Profile projectors, NES | Low |

| Entry | HS-6 | Product specification | Potential to reduce greenhouse gas emissions |
|---|---|---|---|
| 428 | 903149 | Optical instruments and appliances NES | Low |
| 429 | 903180 | Measuring or checking equipment, NES | Low |
| 430 | 903190 | Parts and access for measuring, checking equipment ne | Low |
| 432 | 903210 | Thermostats | Low |
| 433 | 903220 | Manostats | Low |
| 434 | 903281 | Hydraulic and pneumatic automatic controls | Low |
| 436 | 903290 | Parts and accessories for automatic controls | Low |
| 437 | 903300 | Parts/accessories NES for optical/electric instrument | Low |

## Appendix B: DSM results of derived low-carbon environmental goods.

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 730820 | Australia | 15,788 | 2 |
| 730820 | Austria | 66 | 2 |
| 730820 | Bulgaria | 5,993 | 2 |
| 730820 | Canada | 41,318 | 4 |
| 730820 | Cape Verde | 287 | 2 |
| 730820 | Egypt | 569 | 2 |
| 730820 | France | 3,274 | 4 |
| 730820 | Germany | 7,100 | 5 |
| 730820 | Kazakhstan | 3,278 | 2 |
| 730820 | Latvia | 580 | 2 |
| 730820 | Norway | 5,744 | 2 |
| 730820 | Poland | 519 | 2 |
| 730820 | Qatar | 9,111 | 3 |
| 730820 | Saudi Arabia | 3,235 | 2 |
| 730820 | Singapore | 12,307 | 5 |
| 730820 | Spain | 1,952 | 5 |
| 730820 | Tanzania | 10,441 | 7 |
| 730820 | United Arab Emirates | 25,092 | 1 |
| 730820 | United Kingdom | 1,879 | 5 |
| 730820 | United States | 102,704 | 10 |
| 761100 | Belgium | 60 | 4 |
| 761100 | Brazil | 776 | 2 |
| 761100 | Bulgaria | 87 | 2 |
| 761100 | France | 517 | 5 |
| 761100 | Germany | 361 | 4 |
| 761100 | Norway | 1,135 | 5 |
| 761100 | Russia | 2,164 | 4 |
| 761100 | Singapore | 387 | 2 |
| 761100 | Spain | 13 | 4 |
| 761100 | Thailand | 804 | 2 |
| 761100 | United Kingdom | 5,381 | 18 |
| 761100 | United States | 1,445 | 5 |
| 840681 | India | 6,277 | 3 |
| 840681 | Spain | 1,850 | 5 |
| 840682 | India | 28,992 | 4 |
| 840682 | Indonesia | 9,121 | 1 |
| 840682 | Ireland | 26 | 2 |
| 840682 | Italy | 29,356 | 5 |
| 840682 | Romania | 5,940 | 2 |
| 840682 | Singapore | 11,792 | 5 |
| 840682 | Thailand | 19718 | 5 |
| 840682 | United States | 6,990 | 1 |
| 840682 | Vietnam | 950 | 2 |
| 840690 | China | 177,154 | 4 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 840690 | France | 40,614 | 13 |
| 840690 | Germany | 24,671 | 4 |
| 840690 | Ghana | 334 | 2 |
| 840690 | Iceland | 308 | 2 |
| 840690 | India | 13,599 | 4 |
| 840690 | Japan | 42,399 | 1 |
| 840690 | Poland | 36,053 | 5 |
| 840690 | Qatar | 26,299 | 5 |
| 840690 | Russia | 17,391 | 2 |
| 840690 | Spain | 33,198 | 4 |
| 840690 | Sweden | 1,221 | 2 |
| 840690 | Switzerland | 25,925 | 5 |
| 840690 | United Kingdom | 7,659 | 9 |
| 840690 | United States | 38,460 | 1 |
| 840690 | Vietnam | 11,986 | 2 |
| 841011 | Canada | 172 | 2 |
| 841011 | France | 128 | 2 |
| 841011 | Italy | 146 | 3 |
| 841011 | Japan | 244 | 2 |
| 841011 | Singapore | 270 | 2 |
| 841011 | Spain | 317 | 5 |
| 841011 | Sri Lanka | 262 | 2 |
| 841012 | New Zealand | 657 | 5 |
| 841012 | Norway | 363 | 1 |
| 841012 | Sri Lanka | 1,296 | 5 |
| 841012 | United States | 495 | 1 |
| 841090 | Austria | 1,898 | 2 |
| 841090 | Bahrain | 428 | 2 |
| 841090 | Bulgaria | 5 | 2 |
| 841090 | China | 22,628 | 4 |
| 841090 | Denmark | 1,282 | 2 |
| 841090 | France | 3,870 | 5 |
| 841090 | Norway | 3,238 | 3 |
| 841090 | Panama | 883 | 2 |
| 841090 | Romania | 17 | 5 |
| 841090 | Singapore | 680 | 2 |
| 841090 | Switzerland | 8,742 | 5 |
| 841090 | Thailand | 129 | 2 |
| 841090 | United States | 7,350 | 6 |
| 841181 | Finland | 536 | 2 |
| 841181 | Germany | 20,904 | 16 |
| 841181 | Italy | 9,687 | 2 |
| 841181 | Japan | 50,730 | 5 |
| 841181 | Malaysia | 20,090 | 5 |
| 841181 | New Zealand | 1,234 | 2 |
| 841181 | Norway | 8,241 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 841181 | Russia | 5,474 | 2 |
| 841181 | Switzerland | 2,328 | 2 |
| 841181 | United Arab Emirates | 18,648 | 1 |
| 841181 | United Kingdom | 51,850 | 13 |
| 841181 | Zambia | 3 | 2 |
| 841182 | Belarus | 13,672 | 2 |
| 841182 | Belgium | 27,318 | 2 |
| 841182 | Italy | 125,534 | 3 |
| 841182 | United Kingdom | 55,434 | 1 |
| 841221 | Argentina | 4,833 | 2 |
| 841221 | Austria | 4,674 | 1 |
| 841221 | Belgium | 7,342 | 2 |
| 841221 | Brazil | 23,443 | 13 |
| 841221 | Canada | 32,620 | 1 |
| 841221 | China | 62,758 | 3 |
| 841221 | Cyprus | 3 | 2 |
| 841221 | Denmark | 1,214 | 2 |
| 841221 | Germany | 14,654 | 6 |
| 841221 | Ghana | 430 | 17 |
| 841221 | Japan | 11,514 | 1 |
| 841221 | Kazakhstan | 1,631 | 2 |
| 841221 | Malaysia | 259 | 2 |
| 841221 | Romania | 334 | 2 |
| 841221 | Saudi Arabia | 3,009 | 2 |
| 841221 | Singapore | 925 | 2 |
| 841221 | United Kingdom | 24,071 | 11 |
| 841221 | United States | 71,144 | 11 |
| 841221 | Uruguay | 156 | 2 |
| 841221 | Zambia | 662 | 17 |
| 841229 | Armenia | 14 | 2 |
| 841229 | Belarus | 4,806 | 2 |
| 841229 | Bulgaria | 22 | 2 |
| 841229 | Canada | 23,550 | 11 |
| 841229 | China | 62,37 | 1 |
| 841229 | Estonia | 19 | 2 |
| 841229 | France | 7,081 | 11 |
| 841229 | Germany | 22,052 | 6 |
| 841229 | Indonesia | 1,998 | 2 |
| 841229 | Italy | 19,217 | 6 |
| 841229 | Latvia | 14 | 2 |
| 841229 | Luxembourg | 256 | 2 |
| 841229 | Malta | 172 | 2 |
| 841229 | New Caledonia | 127 | 2 |
| 841229 | Panama | 78 | 2 |
| 841229 | Romania | 464 | 2 |
| 841229 | Singapore | 3,749 | 2 |
| 841229 | Tanzania | 863 | 17 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 841229 | United Kingdom | 18,762 | 11 |
| 841229 | United States | 62,681 | 11 |
| 841229 | Zambia | 986 | 17 |
| 841581 | Argentina | 4,369 | 2 |
| 841581 | Australia | 15,628 | 1 |
| 841581 | Austria | 9,391 | 2 |
| 841581 | France | 77,552 | 5 |
| 841581 | Germany | 21,995 | 1 |
| 841581 | Greece | 100,245 | 3 |
| 841581 | Iceland | 43 | 2 |
| 841581 | Indonesia | 1,106 | 2 |
| 841581 | Italy | 37,739 | 3 |
| 841581 | Kazakhstan | 6,754 | 2 |
| 841581 | Malaysia | 604 | 2 |
| 841581 | Poland | 4,001 | 2 |
| 841581 | Portugal | 4,690 | 3 |
| 841581 | Slovakia | 1,658 | 2 |
| 841581 | Spain | 191,899 | 1 |
| 841581 | Sweden | 18,671 | 5 |
| 841581 | Switzerland | 6,935 | 2 |
| 841581 | United Arab Emirates | 12,794 | 6 |
| 841581 | United Kingdom | 22,318 | 11 |
| 841581 | Zambia | 229 | 2 |
| 841861 | Armenia | 217 | 2 |
| 84186 | Bahrain | 517 | 2 |
| 841861 | Belarus | 2,930 | 2 |
| 841861 | China | 167,575 | 1 |
| 841861 | France | 11,212 | 3 |
| 841861 | Georgia | 695 | 2 |
| 841861 | Germany | 8,300 | 8 |
| 841861 | Japan | 67,954 | 1 |
| 841861 | Jordan | 587 | 2 |
| 841861 | Latvia | 102 | 2 |
| 841861 | Lithuania | 71 | 2 |
| 841861 | Malaysia | 2,291 | 2 |
| 841861 | New Zealand | 672 | 2 |
| 841861 | Portugal | 145 | 2 |
| 841861 | Saudi Arabia | 14,269 | 2 |
| 841861 | United Kingdom | 3,753 | 3 |
| 841861 | Vietnam | 1,557 | 2 |
| 841869 | Argentina | 9,086 | 2 |
| 841869 | Australia | 39,356 | 11 |
| 841869 | Belgium | 10,011 | 6 |
| 841869 | Brazil | 52,350 | 5 |
| 841869 | China | 227,939 | 5 |
| 841869 | France | 18,162 | 6 |
| 841869 | Germany | 18,040 | 4 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 841869 | Indonesia | 4,125 | 2 |
| 841869 | Italy | 20,173 | 6 |
| 841869 | Kazakhstan | 2,170 | 2 |
| 841869 | Qatar | 6,644 | 2 |
| 841869 | Russia | 12,652 | 2 |
| 841869 | Spain | 7,690 | 6 |
| 841869 | United Kingdom | 7,556 | 11 |
| 841869 | United States | 139,558 | 6 |
| 841919 | Austria | 2,293 | 1 |
| 841919 | Canada | 32,856 | 3 |
| 841919 | Cyprus | 196 | 2 |
| 841919 | France | 3,591 | 4 |
| 841919 | Georgia | 146 | 2 |
| 841919 | Germany | 13,148 | 1 |
| 841919 | Italy | 2,621 | 3 |
| 841919 | Lithuania | 142 | 2 |
| 841919 | Norway | 704 | 2 |
| 841919 | Portugal | 1,124 | 2 |
| 841919 | Romania | 254 | 2 |
| 841919 | Saudi Arabia | 15,548 | 2 |
| 841919 | Slovenia | 217 | 2 |
| 841919 | Spain | 4,748 | 5 |
| 841919 | Sweden | 982 | 2 |
| 841919 | Tunisia | 525 | 2 |
| 841919 | United Kingdom | 7,864 | 16 |
| 841919 | Uruguay | 70 | 2 |
| 841990 | Argentina | 11,570 | 2 |
| 841990 | Bahrain | 12,220 | 2 |
| 841990 | Bosnia Herzegovina | 1,897 | 2 |
| 841990 | Canada | 38,338 | 11 |
| 841990 | China | 38,407 | 6 |
| 841990 | Egypt | 9,808 | 2 |
| 841990 | Germany | 52,960 | 1 |
| 841990 | Iceland | 1,086 | 2 |
| 841990 | India | 15,331 | 2 |
| 841990 | Italy | 9,055 | 1 |
| 841990 | Japan | 33,069 | 1 |
| 841990 | Saudi Arabia | 30,510 | 4 |
| 841990 | Sweden | 5,768 | 5 |
| 841990 | Trinidad and Tobago | 8,419 | 2 |
| 841990 | United States | 62,220 | 1 |
| 841990 | Vietnam | 3,699 | 2 |
| 841990 | Zambia | 1,561 | 17 |
| 848340 | Brazil | 45,568 | 13 |
| 848340 | Canada | 77,216 | 6 |
| 848340 | China | 220,392 | 14 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 848340 | France | 34,512 | 11 |
| 848340 | Georgia | 243 | 2 |
| 848340 | Germany | 61,132 | 1 |
| 848340 | India | 41,355 | 12 |
| 848340 | Italy | 32,864 | 8 |
| 848340 | Kazakhstan | 3,405 | 2 |
| 848340 | Kuwait | 1,435 | 2 |
| 848340 | Norway | 16,835 | 7 |
| 848340 | Panama | 266 | 2 |
| 848340 | Qatar | 2,310 | 17 |
| 848340 | Russia | 18,999 | 2 |
| 848340 | Spain | 11,999 | 5 |
| 848340 | Tunisia | 5,486 | 2 |
| 848340 | United Kingdom | 47,628 | 13 |
| 848340 | United States | 220,195 | 11 |
| 848340 | Uruguay | 282 | 2 |
| 848360 | Albania | 44 | 2 |
| 848360 | Argentina | 1,978 | 2 |
| 848360 | Belgium | 4,420 | 3 |
| 848360 | Bosnia Herzegovina | 101 | 2 |
| 848360 | Brazil | 6,616 | 2 |
| 848360 | Canada | 26,830 | 6 |
| 848360 | China | 21,982 | 1 |
| 848360 | France | 10,811 | 1 |
| 848360 | Germany | 6,522 | 9 |
| 848360 | India | 12,481 | 10 |
| 848360 | Indonesia | 9,767 | 2 |
| 848360 | Italy | 21,553 | 6 |
| 848360 | Kuwait | 540 | 2 |
| 848360 | Malaysia | 22,482 | 5 |
| 848360 | New Caledonia | 209 | 2 |
| 848360 | Saudi Arabia | 2,730 | 2 |
| 848360 | Slovakia | 7,026 | 2 |
| 848360 | United Kingdom | 4,399 | 8 |
| 848360 | United States | 61,391 | 13 |
| 848360 | Vietnam | 882 | 2 |
| 848360 | Zambia | 732 | 17 |
| 850161 | Argentina | 526 | 2 |
| 850161 | Australia | 5,133 | 12 |
| 850161 | Austria | 154 | 2 |
| 850161 | Bulgaria | 14 | 2 |
| 850161 | Canada | 17,845 | 11 |
| 850161 | China | 3,185 | 7 |
| 850161 | Denmark | 917 | 2 |
| 850161 | Finland | 432 | 2 |
| 850161 | France | 10,584 | 10 |
| 850161 | Germany | 9,772 | 13 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850161 | Ghana | 1,064 | 2 |
| 850161 | India | 523 | 2 |
| 850161 | Ireland | 895 | 2 |
| 850161 | Italy | 2,003 | 1 |
| 850161 | Japan | 4,212 | 5 |
| 850161 | Kazakhstan | 319 | 2 |
| 850161 | Netherlands | 1,751 | 3 |
| 850161 | Poland | 730 | 7 |
| 850161 | Romania | 248 | 2 |
| 850161 | Saudi Arabia | 1,967 | 2 |
| 850161 | Singapore | 5,189 | 1 |
| 850161 | Spain | 4,714 | 4 |
| 850161 | United Kingdom | 5,733 | 3 |
| 850161 | Uruguay | 210 | 2 |
| 850161 | Zambia | 1,141 | 2 |
| 850162 | Argentina | 395 | 2 |
| 850162 | Brazil | 3,702 | 2 |
| 850162 | Cape Verde | 108 | 2 |
| 850162 | Cyprus | 58 | 2 |
| 850162 | Egypt | 1,970 | 2 |
| 850162 | France | 9,798 | 1 |
| 850162 | Germany | 2,606 | 11 |
| 850162 | Ghana | 202 | 2 |
| 850162 | Greece | 52 | 2 |
| 850162 | India | 760 | 2 |
| 850162 | Italy | 2,965 | 3 |
| 850162 | Jordan | 593 | 2 |
| 850162 | Latvia | 6 | 2 |
| 850162 | Poland | 130 | 2 |
| 850162 | Romania | 68 | 2 |
| 850162 | Russia | 2,338 | 2 |
| 850162 | Singapore | 4,506 | 1 |
| 850162 | Spain | 2,408 | 5 |
| 850162 | Sweden | 9,728 | 5 |
| 850162 | Tanzania | 512 | 2 |
| 850162 | Tunisia | 120 | 2 |
| 850162 | United States | 10,999 | 4 |
| 850163 | Argentina | 392 | 2 |
| 850163 | Brazil | 1,858 | 2 |
| 850163 | Finland | 549 | 1 |
| 850163 | France | 3,136 | 5 |
| 850163 | Italy | 879 | 5 |
| 850163 | Kazakhstan | 176 | 2 |
| 850163 | Poland | 23 | 2 |
| 850163 | Singapore | 9,108 | 3 |
| 850163 | Spain | 8,183 | 3 |
| 850163 | Tanzania | 192 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850163 | United States | 23,786 | 5 |
| 850164 | Argentina | 1,522 | 2 |
| 850164 | China | 16,673 | 1 |
| 850164 | Denmark | 2,712 | 1 |
| 850164 | Germany | 44,917 | 4 |
| 850164 | Hong Kong | 312 | 2 |
| 850164 | Kuwait | 8,495 | 2 |
| 850164 | Luxembourg | 0 | 2 |
| 850164 | Russia | 6,037 | 2 |
| 850164 | Saudi Arabia | 43,379 | 5 |
| 850164 | Sri Lanka | 526 | 2 |
| 850164 | United States | 95,432 | 3 |
| 850164 | Zambia | 444 | 17 |
| 850231 | Australia | 79,088 | 5 |
| 850231 | China | 123,985 | 5 |
| 850231 | Malaysia | 702 | 2 |
| 850231 | Thailand | 18,875 | 2 |
| 850231 | United Kingdom | 418 | 4 |
| 850231 | United States | 591,266 | 13 |
| 850239 | Bosnia Herzegovina | 116 | 2 |
| 850239 | Canada | 74,165 | 1 |
| 850239 | China | 71,835 | 3 |
| 850239 | Finland | 216 | 2 |
| 850239 | France | 28,936 | 20 |
| 850239 | Germany | 36,399 | 4 |
| 850239 | Malaysia | 11,828 | 2 |
| 850239 | Russia | 168,550 | 5 |
| 850239 | Saudi Arabia | 8,573 | 2 |
| 850239 | Slovenia | 246 | 2 |
| 850239 | Thailand | 116,598 | 5 |
| 850239 | Tunisia | 1,088 | 2 |
| 850239 | Zambia | 1,357 | 17 |
| 850300 | Armenia | 171 | 2 |
| 850300 | Bulgaria | 857 | 2 |
| 850300 | Canada | 90,467 | 9 |
| 850300 | China | 144,824 | 6 |
| 850300 | Czech Republic | 22,165 | 2 |
| 850300 | Denmark | 7,758 | 5 |
| 850300 | France | 35,299 | 13 |
| 850300 | Germany | 60,504 | 11 |
| 850300 | Hong Kong | 264,662 | 1 |
| 850300 | Italy | 21,614 | 3 |
| 850300 | Japan | 93,748 | 6 |
| 850300 | Kazakhstan | 7,416 | 2 |
| 850300 | Kuwait | 6,744 | 2 |
| 850300 | Latvia | 1,839 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850300 | Norway | 6,319 | 2 |
| 850300 | Panama | 1,954 | 2 |
| 850300 | Poland | 6,254 | 7 |
| 850300 | Russia | 14,543 | 2 |
| 850300 | Saudi Arabia | 18,771 | 2 |
| 850300 | Spain | 16,540 | 5 |
| 850300 | Tunisia | 5,990 | 2 |
| 850300 | United States | 232,464 | 6 |
| 850440 | Albania | 1,063 | 2 |
| 850440 | Armenia | 643 | 2 |
| 850440 | Belarus | 3,718 | 2 |
| 850440 | China | 546,884 | 15 |
| 850440 | Czech Republic | 92,705 | 2 |
| 850440 | France | 107,538 | 6 |
| 850440 | Germany | 281,620 | 6 |
| 850440 | Greece | 10,718 | 7 |
| 850440 | India | 48,523 | 17 |
| 850440 | Indonesia | 11,364 | 7 |
| 850440 | Japan | 346,731 | 6 |
| 850440 | Kazakhstan | 5,094 | 2 |
| 850440 | Mongolia | 1,538 | 2 |
| 850440 | Netherlands | 128,177 | 11 |
| 850440 | Poland | 78,762 | 2 |
| 850440 | Saudi Arabia | 4,758 | 12 |
| 850440 | Spain | 33,917 | 7 |
| 850440 | United States | 790,475 | 6 |
| 850440 | Uruguay | 479 | 2 |
| 850440 | Zambia | 4,864 | 17 |
| 850610 | Argentina | 9,192 | 2 |
| 850610 | Bahrain | 101 | 2 |
| 850610 | Belarus | 762 | 2 |
| 850610 | Belgium | 48,763 | 1 |
| 850610 | Bosnia Herzegovina | 755 | 2 |
| 850610 | Brazil | 17,000 | 2 |
| 850610 | Bulgaria | 188 | 2 |
| 850610 | China | 85,916 | 5 |
| 850610 | Czech Republic | 3,862 | 2 |
| 850610 | Egypt | 1,945 | 2 |
| 850610 | France | 25,229 | 1 |
| 850610 | Georgia | 76 | 2 |
| 850610 | Germany | 24,955 | 5 |
| 850610 | Ireland | 3,291 | 2 |
| 850610 | Jordan | 226 | 2 |
| 850610 | Kuwait | 1,252 | 2 |
| 850610 | Panama | 1,169 | 2 |
| 850610 | Qatar | 956 | 2 |
| 850610 | Romania | 3,989 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850610 | Singapore | 22,934 | 2 |
| 850610 | Slovakia | 1,064 | 2 |
| 850610 | Tunisia | 531 | 2 |
| 850610 | United States | 66,690 | 1 |
| 850610 | Uruguay | 1,516 | 2 |
| 850630 | France | 632 | 5 |
| 850630 | Norway | 60 | 5 |
| 850630 | Qatar | 315 | 3 |
| 850630 | United Arab Emirates | 130 | 1 |
| 850630 | United Kingdom | 1,575 | 10 |
| 850630 | United States | 913 | 3 |
| 850640 | Belgium | 3,460 | 1 |
| 850640 | Estonia | 3 | 2 |
| 850640 | France | 1,252 | 1 |
| 850640 | Germany | 2,211 | 1 |
| 850640 | Greece | 79 | 2 |
| 850640 | Hong Kong | 9,106 | 1 |
| 850640 | Italy | 522 | 1 |
| 850640 | Kuwait | 154 | 2 |
| 850640 | Latvia | 15 | 2 |
| 850640 | Romania | 27 | 2 |
| 850640 | Switzerland | 5,038 | 5 |
| 850640 | United Kingdom | 1,812 | 1 |
| 850640 | United States | 3,711 | 1 |
| 850650 | Australia | 4,746 | 2 |
| 850650 | Austria | 1,106 | 2 |
| 850650 | Belarus | 44 | 2 |
| 850650 | Brazil | 14,662 | 5 |
| 850650 | Bulgaria | 128 | 2 |
| 850650 | Canada | 13,027 | 4 |
| 850650 | China | 45,502 | 3 |
| 850650 | Czech Republic | 1,684 | 2 |
| 850650 | Egypt | 339 | 2 |
| 850650 | France | 6,636 | 1 |
| 850650 | Germany | 13,101 | 1 |
| 850650 | Ghana | 73 | 17 |
| 850650 | Hong Kong | 92,540 | 4 |
| 850650 | India | 1,506 | 2 |
| 850650 | Japan | 13,331 | 5 |
| 850650 | Kazakhstan | 232 | 2 |
| 850650 | Malaysia | 29,251 | 14 |
| 850650 | Netherlands | 6,649 | 2 |
| 850650 | Poland | 977 | 2 |
| 850650 | Saudi Arabia | 1,314 | 2 |
| 850650 | Singapore | 41,793 | 14 |
| 850650 | Slovakia | 1,057 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850650 | Slovenia | 305 | 2 |
| 850650 | Switzerland | 12,374 | 5 |
| 850650 | Thailand | 15,053 | 2 |
| 850650 | Tunisia | 122 | 2 |
| 850650 | United Kingdom | 19,755 | 15 |
| 850650 | United States | 37,193 | 14 |
| 850660 | Belgium | 1,590 | 1 |
| 850660 | Canada | 1,961 | 1 |
| 850660 | Cyprus | 15 | 2 |
| 850660 | Denmark | 185 | 3 |
| 850660 | Estonia | 0 | 2 |
| 850660 | France | 1,182 | 1 |
| 850660 | Germany | 833 | 1 |
| 850660 | Ireland | 122 | 2 |
| 850660 | Italy | 387 | 4 |
| 850660 | Latvia | 2 | 2 |
| 850660 | Luxembourg | 0 | 2 |
| 850660 | Malta | 0 | 2 |
| 850660 | Portugal | 31 | 2 |
| 850660 | Romania | 22 | 2 |
| 850660 | Spain | 137 | 3 |
| 850660 | United Kingdom | 3,432 | 1 |
| 850660 | United States | 7,956 | 4 |
| 850660 | Zambia | 25 | 17 |
| 850690 | Bahrain | 90 | 2 |
| 850690 | Belgium | 276 | 3 |
| 850690 | China | 3,570 | 1 |
| 850690 | Cyprus | 0 | 2 |
| 850690 | France | 478 | 2 |
| 850690 | Germany | 3,186 | 2 |
| 850690 | Hong Kong | 12,892 | 3 |
| 850690 | India | 985 | 2 |
| 850690 | Indonesia | 2,096 | 2 |
| 850690 | Japan | 3,705 | 2 |
| 850690 | Lithuania | 6 | 2 |
| 850690 | Malaysia | 25,386 | 5 |
| 850690 | Qatar | 213 | 2 |
| 850690 | Romania | 4 | 2 |
| 850690 | Singapore | 7,298 | 1 |
| 850690 | Tanzania | 318 | 17 |
| 850690 | United States | 5,317 | 3 |
| 850690 | Zambia | 309 | 17 |
| 850720 | Albania | 795 | 2 |
| 850720 | Argentina | 3,520 | 2 |
| 850720 | Armenia | 517 | 2 |
| 850720 | Belgium | 12,046 | 1 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 850720 | Bulgaria | 652 | 2 |
| 850720 | Canada | 91,498 | 1 |
| 850720 | Egypt | 6,232 | 2 |
| 850720 | France | 25,661 | 1 |
| 850720 | Germany | 22,398 | 4 |
| 850720 | Indonesia | 1,479 | 2 |
| 850720 | Italy | 90,899 | 5 |
| 850720 | Netherlands | 19,485 | 3 |
| 850720 | Qatar | 517 | 2 |
| 850720 | Singapore | 18,548 | 7 |
| 850720 | Slovakia | 4,902 | 2 |
| 850720 | Sweden | 49,288 | 1 |
| 850720 | Tanzania | 536 | 17 |
| 850720 | United Kingdom | 14,307 | 16 |
| 850720 | United States | 144,341 | 1 |
| 853710 | Argentina | 8,128 | 2 |
| 853710 | Bahrain | 1,464 | 2 |
| 853710 | Canada | 273,184 | 11 |
| 853710 | Cape Verde | 602 | 2 |
| 853710 | China | 248,574 | 10 |
| 853710 | France | 73,317 | 4 |
| 853710 | French Polynesia | 1,632 | 2 |
| 853710 | Georgia | 966 | 2 |
| 853710 | Germany | 162,870 | 6 |
| 853710 | Ghana | 402 | 17 |
| 853710 | India | 22,923 | 2 |
| 853710 | Indonesia | 5,813 | 2 |
| 853710 | Kazakhstan | 16,903 | 2 |
| 853710 | Kuwait | 8,756 | 7 |
| 853710 | Macao | 4,395 | 2 |
| 853710 | Mongolia | 1,631 | 2 |
| 853710 | Romania | 5,528 | 2 |
| 853710 | Russia | 41,890 | 2 |
| 853710 | Saudi Arabia | 37,241 | 7 |
| 853710 | South Korea | 1,134 | 2 |
| 853710 | United States | 838,671 | 6 |
| 853710 | Uruguay | 548 | 2 |
| 853710 | Vietnam | 4,624 | 2 |
| 854140 | Bahrain | 13 | 2 |
| 854140 | Bulgaria | 777 | 2 |
| 854140 | China | 953,255 | 1 |
| 854140 | Croatia | 5,907 | 2 |
| 854140 | Cyprus | 358 | 2 |
| 854140 | Czech Republic | 177,443 | 2 |
| 854140 | Egypt | 1,740 | 2 |
| 854140 | France | 111,821 | 17 |
| 854140 | Georgia | 24 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 854140 | Germany | 922,362 | 14 |
| 854140 | Hong Kong | 363,505 | 1 |
| 854140 | Ireland | 2,443 | 2 |
| 854140 | Italy | 115,731 | 15 |
| 854140 | Japan | 188,558 | 6 |
| 854140 | Kazakhstan | 543 | 2 |
| 854140 | Kuwait | 1,504 | 2 |
| 854140 | Lithuania | 607 | 2 |
| 854140 | Poland | 7,270 | 2 |
| 854140 | Russia | 4,591 | 7 |
| 854140 | Saudi Arabia | 1,307 | 2 |
| 854140 | Slovenia | 919 | 2 |
| 854140 | Spain | 647,886 | 15 |
| 854140 | Tanzania | 841 | 2 |
| 854140 | Turkey | 4,738 | 2 |
| 854140 | United Kingdom | 161,456 | 14 |
| 854140 | United States | 307,954 | 6 |
| 900190 | Belarus | 880 | 2 |
| 900190 | China | 858,417 | 5 |
| 900190 | Czech Republic | 15,484 | 2 |
| 900190 | Germany | 61,081 | 18 |
| 900190 | Hong Kong | 251,832 | 5 |
| 900190 | India | 5,036 | 2 |
| 900190 | Japan | 161,318 | 1 |
| 900190 | Lithuania | 1,432 | 2 |
| 900190 | Malaysia | 26,518 | 2 |
| 900190 | Romania | 57 | 2 |
| 900190 | Slovakia | 993 | 2 |
| 900190 | Turkey | 459 | 2 |
| 900190 | United States | 42,746 | 1 |
| 900290 | Argentina | 57 | 2 |
| 900290 | Belarus | 356 | 2 |
| 900290 | Brazil | 404 | 2 |
| 900290 | Bulgaria | 53 | 2 |
| 900290 | Canada | 5,644 | 2 |
| 900290 | China | 54,439 | 3 |
| 900290 | Czech Republic | 550 | 2 |
| 900290 | France | 4,646 | 2 |
| 900290 | Georgia | 57 | 2 |
| 900290 | Germany | 11,347 | 1 |
| 900290 | Ireland | 392 | 2 |
| 900290 | Israel | 2,729 | 2 |
| 900290 | Japan | 23,249 | 1 |
| 900290 | Latvia | 120 | 2 |
| 900290 | Lithuania | 122 | 2 |
| 900290 | Panama | 13 | 2 |
| 900290 | Poland | 521 | 2 |

| HS-6 | Destination | Potential export value (US thousands) | Cell classification |
|---|---|---|---|
| 900290 | Portugal | 1,716 | 2 |
| 900290 | Romania | 126 | 2 |
| 900290 | Slovakia | 150 | 2 |
| 900290 | United States | 16,725 | 6 |
| 900290 | Vietnam | 970 | 2 |
| 900290 | Zambia | 9 | 17 |
| 903289 | Argentina | 20,346 | 7 |
| 903289 | Belgium | 11,913 | 7 |
| 903289 | Brazil | 74,137 | 3 |
| 903289 | China | 200,967 | 15 |
| 903289 | Czech Republic | 10,973 | 2 |
| 903289 | Denmark | 6,156 | 2 |
| 903289 | France | 24,299 | 11 |
| 903289 | French Polynesia | 249 | 2 |
| 903289 | Germany | 91,258 | 10 |
| 903289 | Ghana | 1,650 | 2 |
| 903289 | India | 22,142 | 7 |
| 903289 | Indonesia | 7,902 | 2 |
| 903289 | Israel | 8,103 | 17 |
| 903289 | Italy | 10,331 | 8 |
| 903289 | Japan | 109,261 | 9 |
| 903289 | Kazakhstan | 7,849 | 2 |
| 903289 | Kuwait | 10,052 | 2 |
| 903289 | Latvia | 72 | 2 |
| 903289 | Lithuania | 2,533 | 2 |
| 903289 | Mongolia | 805 | 2 |
| 903289 | Netherlands | 23,491 | 7 |
| 903289 | Poland | 13,049 | 2 |
| 903289 | Saudi Arabia | 23,393 | 7 |
| 903289 | Tanzania | 1,532 | 17 |
| 903289 | Thailand | 83,904 | 5 |
| 903289 | United Kingdom | 51,682 | 13 |
| 903289 | United States | 584,931 | 6 |
| 903289 | Uruguay | 265 | 2 |
| 903289 | Vietnam | 2,173 | 2 |
| 903289 | Zambia | 1,358 | 17 |

# Appendix C: Contact Information

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