Indicators to measure the contribution of Energy Efficiency and Renewables to the Lisbon targets

Monitoring of Energy Efficiency in EU 27, Norway and Croatia (ODYSSEE-MURE)

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1 Executive Summary

In March 2000, EU heads of state and government agreed on an ambitious goal: making the EU "the most competitive and dynamic knowledge-based economy in the world by 2010, capable of sustainable economic growth with more and better jobs and greater social cohesion". In order to describe how energy efficiency and renewables as essential components of a sustainable development will improve the competitive position of European countries worldwide, it is necessary to develop tools that enable us to analyse such developments more quantitatively. This report focuses on the development of “Lisbon Indicators” (indicators for measuring competitiveness and innovation). Technological capability addresses a construct which is not directly measurable. It is therefore necessary to find indicators which at least come close to describing it. A widely accepted system to do so adapts indicators from various sub-fields of the innovation process, e.g. patents to measure R&D output (hence innovation capability). Foreign trade indicators focus more on the application and diffusion of technologies in R&D-intensive product markets.

In this report we develop and investigate for the three areas **Energy Efficiency, Renewables and Sustainable Mobility** the development and evaluation of the following concrete indicators:
(1) **Competitiveness indicators:** World Market Shares; Relative World Trade Shares or Revealed Export Advantage RWA (comparison of export structure of country to mean Worldwide export structure); Revealed Competitive Advantage RCA (comparison of the export/import relationship of a group of goods with the general export/import performance of the country.
(2) **Innovation Indicators:** Share in world patents for a given technology; Relative Patent Share = importance of patents of a country for a given technology as compared to the number of patents for the same technology in all countries

The three areas are split into Technology Groups and Technologies.

The focus in this report is on **developing the methodology for the indicators**. The indicators show in particular in how far the efforts to promote sustainable policies have translated into concrete industrial development. The results may be presented in an aggregate manner in **specialisation profiles** (Figure 1-1 and Figure 1-2) that **allow to judge on the position of a country in the two dimensions of competitiveness and innovation capability**. Dynamic aspects, especially the **success of demand-oriented policies to promote energy efficiency and renewables technologies and to develop strong industries behind** are clearly reflected in the indicators as illustrated by the case of wind energy converters in Germany and France (Figure 1-3).

Figure 1-1: Specialization profiles – Energy Efficiency (average 2000-2004)

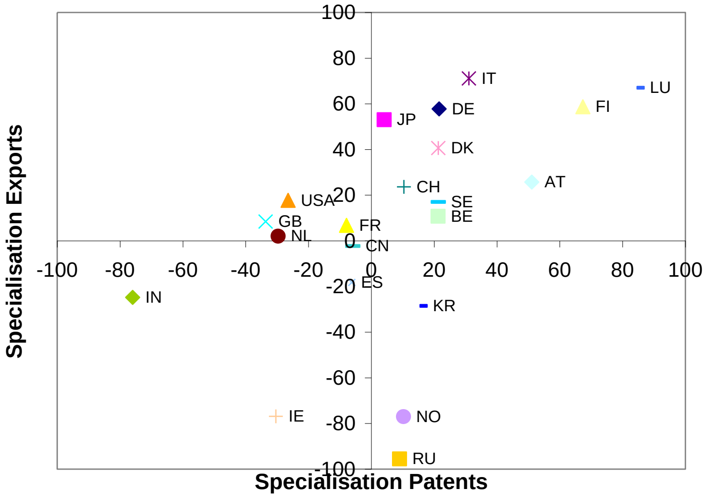


Figure 1-2: Specialization profiles – Renewables (average 2000-2004)

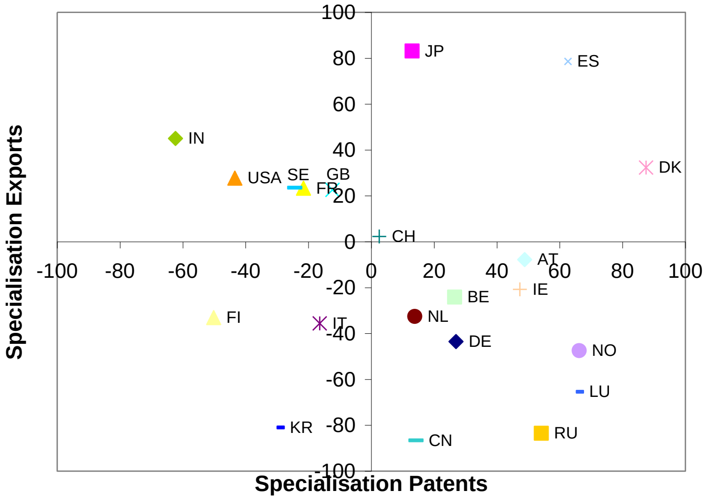
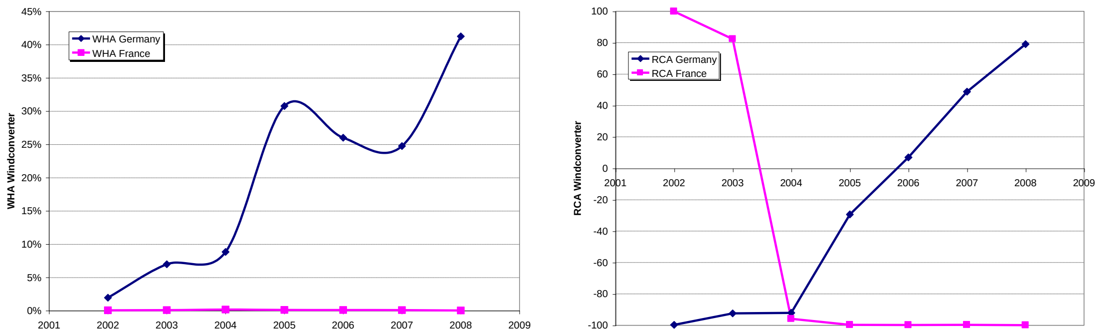


Figure 1-3: Dynamic aspects in world trade shares and export performance reflecting different policy environment in the case of wind converters (France and Germany)



2 Introduction

2.1 The Lisbon Targets

In March 2000, EU heads of state and government agreed on an ambitious goal: making the EU "the most competitive and dynamic knowledge-based economy in the world by 2010, capable of sustainable economic growth with more and better jobs[1] and greater social cohesion" (**Lisbon European Council March 2000**).

In particular, it was agreed that to achieve this goal, an overall strategy should be applied, aimed at:

- preparing the transition to a knowledge-based economy and society by better policies for the information society and R&D, as well as by stepping up the process of structural reform for competitiveness and innovation and by completing the internal market;
- modernising the European social model, investing in people and combating social exclusion;
- sustaining the healthy economic outlook and favourable growth prospects by applying an appropriate macro-economic policy mix.

Further important milestones in the path towards achievement of the Lisbon target were:

- The **Stockholm European Council (March 2001) + Barcelona Council (March 2002)** confirmed full employment goal and called for reinforced Employment Strategy in an enlarged EU.
- The **mid-term review of the Lisbon Strategy 2005 (Kok-Report):** new start for the Lisbon strategy refocusing efforts on two goals: delivering a stronger, lasting growth and more and better jobs.
- **Renewables/ Energy efficiency** were seen as important contributors to Knowledge and Innovation (SEC(2005) 981 - Common Actions for Growth and Employment: The Community Lisbon Programme).
- A June 2006 summit of EU leaders saw the adoption of a **renewed Sustainable Development Strategy (SDS)**. It addresses seven main challenges: climate change and clean energy; sustainable transport; sustainable consumption and production; conservation and management of natural resources; public health; social inclusion, demography and migration; and global poverty.

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[1] Aim: raise overall EU employment rate to 70% by 2010

- With its recently adopted climate and energy package (2008/2009), the EU has made a positive contribution to sustainable development, but "unsustainable trends persist in several areas".
- In 2009 the EU launched a reflection on how the EU Sustainable Development Strategy (SDS) should evolve in the future and how it could be better aligned with other cross-cutting EU strategies[2]. The Commission particularly stresses the need to find greater synergy with the Lisbon Strategy for growth and jobs, which will be reviewed in 2010. The report calls for better coordination and linkage between climate change, energy, financial and social sustainability - policy areas covered by both strategies. In parallel, the EU is starting to reflect on revising its 2000 Lisbon Strategy. 'Green growth' and environmental sustainability are likely to feature high among the strategy's new priorities.

In order to describe how sustainable development (and in particular energy efficiency and renewables) will improve the competitive position of European countries worldwide, it is necessary to develop tools that enable us to analyse such developments more quantitatively. This report focuses on the development of **"Lisbon Indicators"** in the frame of the Odyssee-MURE projects[3] which focus on energy efficiency indicators and the policies behind, and provide an understanding of how energy efficiency progresses. The indicators developed here may suitably complement the Odyssee indicators. **They represent, however, only two important tools out of the more general analysis of innovation and competitiveness.** Important aspects of such a more general analysis will be very briefly outlined in the next section. Carrying out such an analysis for technologies in the field of energy efficiency and renewables is a very valuable analysis but beyond the scope of this report.

2.2 The larger context of innovation analyses

The indicators presented here, constitute only two possible tools in the wider analysis of innovation and economic growth induced by energy efficiency and renewables. This section briefly touches upon this more general context of analysis.

Anchoring the idea of sustainability in the economic development process as early as possible is gaining enormous significance. Such technologies may give an enormous advantage to those who develop first these technologies (although it is not excluded that latecomers may have better strategies in the catch-up process.

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[2] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions: Mainstreaming sustainable development into EU policies: 2009 Review of the European Union Strategy for Sustainable Development. COM(2009) 400 final. Brussels, 24.7.2009

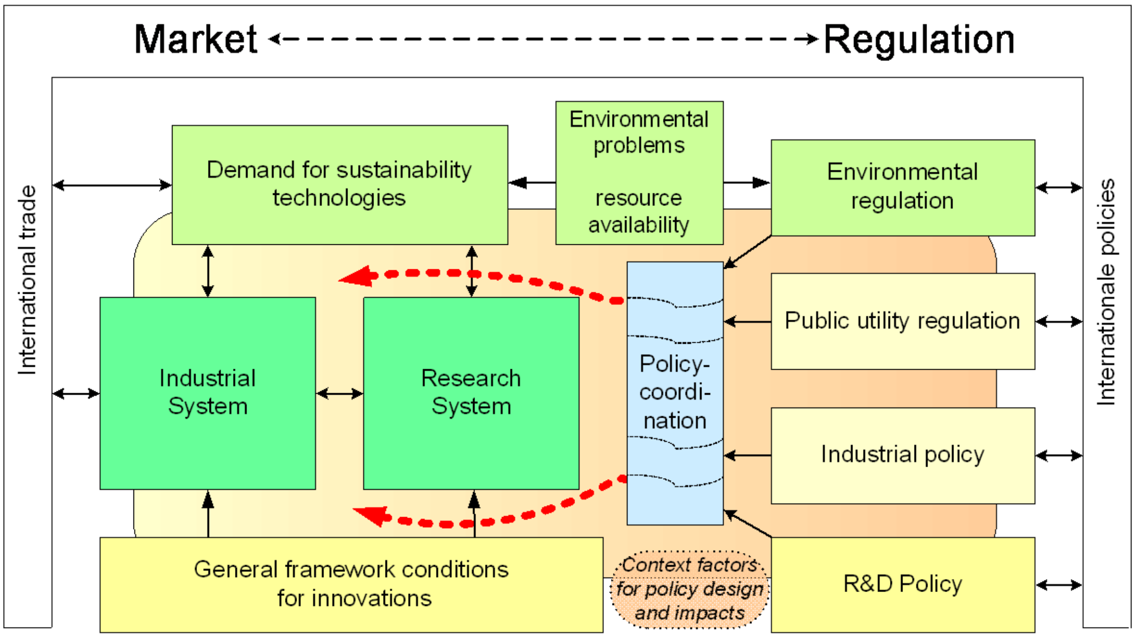
[3] see www.odyssee-indicators.org and www.mure2.com

In order to realise such first mover advantages, domestic suppliers must demonstrate long-lasting competitive advantages in the corresponding technologies. Here the conditions for establishing so-called **lead markets** play an important role. Establishing not easily transferable industrial clusters which consist in combining technological capability with demand that is open to innovations and favours early learning effects and their integration in differentiated production structures, are decisive pre-conditions for the success of a national innovation system (cf. Meyer-Krahmer 2004, Beise/Rennings 2005, Walz 2005; Jacob et al. 2005, Walz 2006). Besides the market-related factors and adaptable regulations, the technological capability of the technologies regarded and the competitiveness of complementary branch clusters are key conditions.

The discussion about setting up lead markets has concentrated up to now primarily on the industrialised countries. In the recent past, however, increases in technological capabilities have also been ascertained in the rapidly growing economies, in particular of the BRICS countries (Brazil, Russia, India, China, South Africa): With the prospect of lead markets for sustainability innovations emerging in the BRICS countries, the interest of these countries could change dramatically: sustainability technologies would not only become an element of technological modernisation and establishment of a domestic infrastructure, but also object of a world-market-oriented export strategy and would experience an enormous increase in importance within the catching-up strategy of the countries involved.

For both strategies – knowledge transfer and establishing lead market positions – it is necessary that corresponding competences are developed and a well functioning innovation system is founded. Thus the heuristic of the innovation system, which more recent innovation research calls on to explain innovation activity (cf. e. g. Carlsson et al. 2002; Lundvall et al. 2002, Edquist 2005), also gains relevance for the analysis of sustainability innovations in catching-up processes. Newer forms of the "systems of innovation approach" emphasise a disaggregated analysis on a sectoral or technological level (Malerba 2005), as well as consideration of the functions of an innovation system which could facilitate a comparative systematisation between the countries (Smits/Kuhlmann 2004; Hekkert et al. 2007). Main tenet of this concept is that the production and diffusion of new solutions depend crucially on the interplay of the different actors in the innovation process. With regard to sustainability innovations, a triple regulatory challenge exists (Walz 2007), because environmental policy and infrastructure specific needs must be accounted for in addition to the R&D needs. This results in a specific “systems of sustainability innovation” approach (see Figure 2-1). In the framework of this heuristic, soft context factors (e. g. situative conditions for policy design and impacts) and aspects of a demand-oriented innovation policy (ISI 2006) can be analysed.

Figure 2-1: Systems of Sustainability Innovation



In brief, the following elements constitute important building bricks in setting up a competitive sustainable economy and constitute important elements in a more generic investigation of competitiveness and innovation:

(1) The general framework conditions for innovations also influence the execution of sustainability innovations. Besides the **availability of human resources and other aspects of the knowledge base**, subjects like environmental regulations in the sense of a **demand-oriented innovation policy** play a role. Other themes such as receptiveness to new ideas, which in the wider sense can be classified as **social absorptive capacity**, can be added. Furthermore, the knowledge base and technology availability in general are very strongly influenced by **foreign direct investment**. This latter aspect is in particular relevant for emerging economies.

(2) **The research system and R&D policies** in the relevant sustainability fields are important components of the "system of sustainability innovations" in the countries investigated. Their prime function is to build up and continually improve a corresponding knowledge base in the countries.

(3) Developing technological competences in the sustainability fields being examined is a key indicator not only for the absorptive capacity of sustainability technologies, but also the starting situation with regard to building up lead market positions. In addition, **international patents and successes in foreign trade in particular indicate to what extent a country is already able to 'open up' internationally in the respective technology field.**

(4) A further topic of sustainability deals with the **acceleration of diffusion and innovation processes** as a cross-cutting question complex. The diffusion of sustain-

ability innovations depends to a great degree on political and societal framework conditions. Accordingly, social science sustainability research examines the institutional and actor constellations which contribute to, or hamper, sustainable development, as well as how societies deal with environmental risks. This field which is more strongly influenced by social sciences can also be interpreted as an activity to increase the absorptive capacity of new technologies in the own country. Therefore, performance in social science sustainability research needs to be investigated, using a publication analysis, to supplement the examination of performance in the technically defined sustainability fields.

(5) An **analysis of enterprises' experiences with cooperations** complements the analysis elaborated from the strongly indicator-based analyses from an actor's perspective. Due to the different methodological approaches and the highly disaggregated analysis level, this "corresponding perspective" must always remain cursory and cannot be statistically representative. On the other hand, it offers the possibility to capture all mentioned influential factors in their interplay/ interaction and to obtain, at least partially, qualitative estimates of how the innovation systems function. It offers an appropriate starting point to proceed beyond the quantitative, measurement-based perspective of the indicator-based analyses.

(6) Lastly, the analyses need to consider the **competences and operative capabilities for a sustainable development in the countries** investigated, each from a different viewpoint.

In this report, we will only focus on the third aspect of international patents and successes in foreign trade, and hence develop a partial analysis on methodologies how to measure the contribution of energy efficiency and renewables to the Lisbon targets.

3 Types of Indicators to Measure the Contribution of Energy Efficiency and Renewables to the Lisbon Targets

Technological capability addresses a construct which is not directly measurable. It is therefore necessary to find indicators which at least come close to describing it. A widely accepted system to do so adapts indicators from various sub-fields of the innovation process (see Grupp 1998). This section refers to **patents as R&D output** or intermediary indicators on the one hand, which are presumed to describe the direct result of the R&D process. At the same time they are assumed to be an **early indicator for future technological development**. On the other hand, **foreign trade indicators** are constructed which belong to the class of output indicators. They focus more on the **application and diffusion of technologies in R&D-intensive product markets**.

3.1 Competitiveness indicators

Main indicators measuring the competitiveness of a country for a given technology, hence also for energy efficiency and renewables technologies, are the following three:

- World Market Shares
- Relative World Trade Shares or Revealed Export Advantage RWA: comparison of export structure of country to mean Worldwide export structure (or to the export structure of a more limited entity like OECD countries).
- Indicators established in a Revealed Competitive Advantage RCA Analysis (comparison of the export performance of a group of goods with the general export performance of the country. Then compare the performance across the countries.

3.2 Innovation Indicators

Main Indicators measuring the innovative behaviour of a country for a given technology, hence also for energy efficiency and renewables technologies, are the following two:

- **Share in world patents** for a given technology
- **Relative Patent Share** = importance of patents of a country for a given technology as compared to the number of patents for the same technology in all countries

4 Definition of indicators

In this section we will use the generic word “technology” when we discuss the different indicators that could be defined to measures innovation and competitiveness, without explaning more in detail what we understand by this. It is clear that there are different aggregation levels for technologies, on which such indicators can be set up. A convenient definition may consider three levels, covering narrow to wider definitions of what a “technology”, generically spoken, is. This is exemplified with energy efficiency technologies:

- Technology: for example Condensing boilers;
- Technology group: Efficient conversion systems;
- Area: Efficient energy use

On these different levels, indicators may be defined in a hierarchical manner. This issue will be more discussed in section ??.

The indicators which we will develop in the following sections are:

- World trade shares (WHA)
- World patent shares (PA)
- Relative Patent Share (RPA)
- Revealed Comparative Advantage (RCA)
- Relative World Trade Shares or Revealed Export Advantage (RWA)

4.1 World trade shares / World patent shares

World trade shares

The simplest indicator for competitiveness is the world trade share for a given technology. By world trade we understand the sum of all exports. In other words it is the share of exports for a given technology and a country related to the sum of all exports for that given technology. These shares can then be compared for different countries but also for different technologies.

For each country i and each technology j the share in world trade is calculated with Equation 1.

In principle a high world trade share indicates a competitive position but other factors like the size of the country may influence this indicator and make country comparisons more difficult (see the discussion below on specialisation indicators.

$$WHA_{ij} = 100 * (a_{ij} / \overbrace{\sum_i a_{ij}}^{\text{World trade for technology j}})$$

Equation 1

World patent shares

The simplest indicator for competitiveness is the world patent share for a given technology and a given country. That is the ratio of the patents hold by a given country for a given technology compared to all patents for that technology. These shares can then be compared for different countries but also for different technologies.

For each country i and each technology/technology group or technology area j patent shares are calculated with Equation 2.

In analogy to the world trade share, high patent shares may indicate a strong innovation position but again other factors like the size of the country may influence this indicator and make country comparisons more difficult (see the discussion below on specialisation indicators.

$$PA_{ij} = 100 * (p_{ij} / \overbrace{\sum_i p_{ij}}^{\text{Patent volume for technology j}})$$

Equation 2

4.2 "Specialisation" patent and foreign trade indicators

"Specialisation" patent and foreign trade indicators

Patent shares and foreign trade shares are influenced by the size of the country and its general state of development. The larger a country, the larger will on average be the number of patents it publishes, or the larger the its foreign trade share, at least when looking at countries with a comparable development stage. Differences from this general pattern arises, if a country has, compared to its size and the general performance of the other countries, a better performance for a given technology. **The country is then said to have a specialisation for that technology**.

In order to measure better this specialisation, It is therefore common to calculate "specialisation" indicators. Specialisation indicators show the position of a given technology in relation to the average performance of all technologies in the country. Positive specialisation indicators show that the competence of the country in a given technology is over-proportional compared to all technologies. Negative specialisation indicators show that the country is performing underproportional.

The indicators are usually normalised so that they vary from -100 (extremely unfavourable specialisation) to + 100 (extremely high specialisation). The value 0 corresponds to an average specialisation.

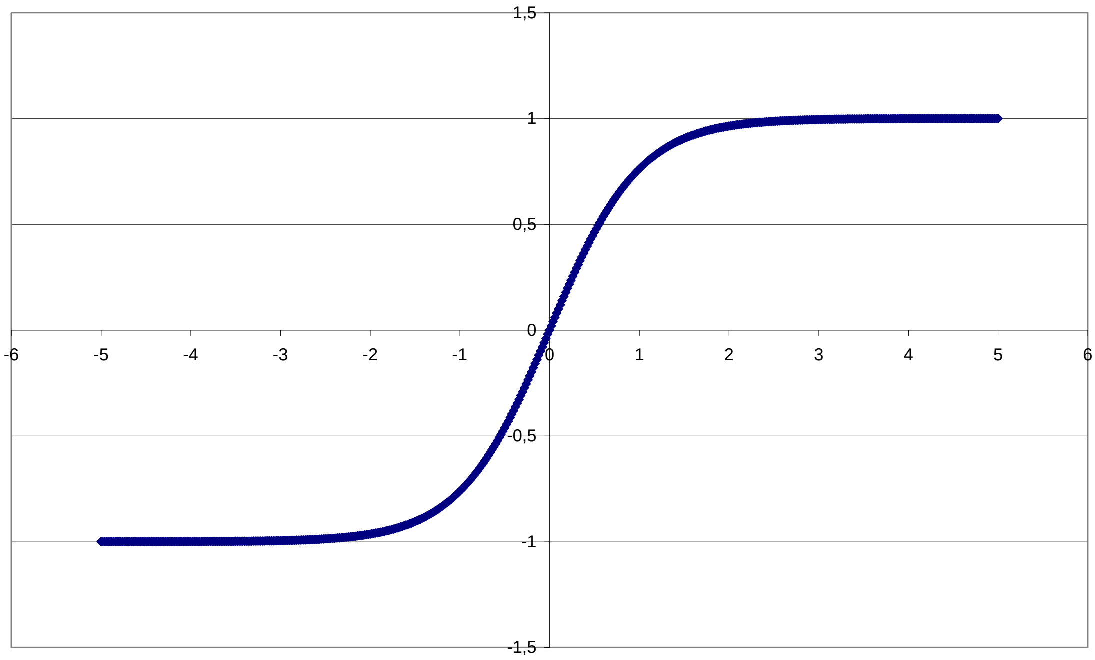
With these specialisation indicators the activities of the different countries can be compared independent from size effects.

Some mathematics

Normalisation to the range -100 to +100 is achieved by using the function tangens hyperbolicus or tanh in short (normalisation to range -1 to +1) and multiplication with the factor 100. In addition, the logarithmic function is introduced to allow to cover ranges that may differ by an order or magnitude.

The normalisation function is shown in Figure 4-1. It is nonlinear that is it differntiates more strongly the range between -1 and +1. In that range the normalisation function is essentially linear. Outside this range the curve flattens rapidly and the differentiation between the performances vanishes. It has to be realised that due to the use of the logarithmic function, the range up to 1 covers a ten times better performance while the range up to 2 would cover a hundred times better performance.

Figure 4-1: The normalisation function tangens hyperbolicus (tanh)



4.3 Revealed Comparative Advantage (RCA)

For foreign trade the RCA takes next to exports (a) also imports (e) into account. This indicator shows in how far the export/import ratio of a technology deviates from the general import/export ratio of the country.

For each country i and each technology j the RPA is calculated with Equation 3.

A positive sign indicates comparative advantages, hence a strong international competitive position for the technology in a country.

The RCA is difficult to interpret:

- if there is an import boom because the national capacities are limited compared to the demand or
- If there are extremely small imports due to import restrictions. For this reason one also uses the relative world trade share (RWA, see next section).

Equation 3

Export/Import performance of the country for all technologies

Export/Import performance for technology j

$$RCA_{ij} = 100 * \tanh \ \ln \left[(a_{ij}/e_{ij}) / \left(\sum_j a_{ij} / \sum_j e_{ij} \right) \right]$$

Examples:

If we assume that a country is exporting generally as much as it is importing but that an energy efficiency technology is exported five times more than it is imported then the RCA equals 100*tanh ln((5/1)/(1/1) = 92. The energy efficiency technology is performing much better than the rest of the industry. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is positive.

If we assume that a country is exporting generally five times more than it is importing and that an energy efficiency technology is also exported five times more than it is imported then the RCA equals 100*tanh ln((5/1)/(5/1) = 0. The energy efficiency technology is performing similar to the rest of the industry. It is performing good, as much more is exported than imported but it is not performing better than the rest of the industry. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is neutral. It benefits from the generally positive innovation environment in the country but other goods good benefit in a similar way.

If we assume that a country is exporting generally as much as it is importing but that an energy efficiency technology is exported five times less than it is imported then the RCA equals 100*tanh ln((1/5)/(1/1) = -92. The energy efficiency technology is performing much worse than the rest of the industry. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is negative.

4.4 Relative World Trade Shares or Revealed Export Advantage (RWA)

For foreign trade the RWA takes only exports (a) into account; imports are neglected. The Relative World Trade Shares or Revealed Export Advantage (RWA) corresponds in its logic to the Relative Patent Share RPA.

For each country i and each technology j the RWA is calculated with Equation 4.

A positive value shows here that the export share (world market share) of a given technology performs better in a country than the average export share (world market share) of all technologies from that country.

Equation 4

$$RWA_{ij} = 100 * \tanh \ \ln [(\overbrace{a_{ij} / \sum_i a_{ij}}^{\text{Foreign trade performance for technology j}}) / (\overbrace{\sum_j a_{ij} / \sum_{ij} a_{ij}}^{\text{Foreign trade performance of the country for all technologies}})]$$

Examples:

If we assume that a country is exporting generally as much as it is importing but that an energy efficiency technology has a world market share of 50%, while the country for all technologies has a world market share of 10% then the RWA equals 100*tanh ln((50%)/(10%) = 92. The energy efficiency technology is performing much better in the export than the rest of the industry. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is positive.

If we assume that a country is exporting five times more than it is importing, that further an energy efficiency technology has a world market share of 50%, while the country for all technologies has a world market share of 10% then the RWA equals again 100*tanh ln((50%)/(10%) = 92. The energy efficiency technology is performing much better in the export than the rest of the industry. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is positive. Hence, the difference in imports does not count for this indicator.

4.5 Relative Patent Share (RPA)

For patents the relative patent share (RPA) is calculated by putting the patent share of the country for the given technology in relation to patent shares of the country in all fields.

For each country i and each technology j the RPA is calculated with Equation 5.

If the patent share for a technology is over-proportionally large then the RPA takes a positive value. This implies that – compared to other technology – there is more national competence for innovation.

If a country is generally strong in patents it is more difficult for a technology to achieve a positive RPA.

Patent performance of the country for all technologies

Patent performance for technology j

$$RPA_{ij} = 100 * \tanh \ \ln [(p_{ij} / \sum_i p_{ij}) / (\sum_j p_{ij} / \sum_{ij} p_{ij})]$$

Equation 5

Examples:

If we assume that a country has patent share of 50% for a given energy efficiency technology, while the country for all technologies has a patent share of 10% then the RPA equals 100*tanh ln((50%)/(10%) = 92. The energy efficiency technology is performing much better in the patents than the rest of the technologies. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is positive.

If we assume that a country has patent share of 10% for a given energy efficiency technology, while the country for all technologies has a patent share of 10% then the RPA equals 100*tanh ln((10%)/(10%) = 0. The energy efficiency technology is performing equal in the patents than the rest of the technologies. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is neutral.

If we assume that a country has patent share of 2% for a given energy efficiency technology, while the country for all technologies has a patent share of 10% then the RPA equals 100*tanh ln((2%)/(10%) = -92. The energy efficiency technology is performing much worse in the patents than the rest of the technologies. In such a configuration the contribution of the energy efficiency technology to the Lisbon target is negative.

4.6 Combination of indicators

The discussion of the different indicators for competitiveness and innovation has shown they have partially drawbacks and advantages, which may be complementary to each other. Hence, the most suitable is to use combinations of these indicators to get a more complete picture of the situation. This is illustrated with the following examples:

> **Country 1: Large (over-proportional) World Trade Share for energy efficiency technology / Large Exports of energy efficiency technology**
>
> – World Trade Share of country for all technologies = 10%
>
> – World Trade Share of the country for specific technology = 20%
>
> – Export/import ratio for all technologies = 1
>
> – **Export/import ratio for specific technology = 2**
>
> – WHA = 20% + ; RCA = 60 + ; RWA = 60 +

> **Country 2: Large (but under-proportional) World Trade Share for energy efficiency technology / Very Large Exports of energy efficiency technology**
>
> – World Trade Share of country for all technologies = 10%
>
> – World Trade Share of the country for specific technology = 5%
>
> – Export/import ratio for all technologies = 1
>
> – **Export/import ratio for specific technology = 20**
>
> – WHA = 5% 0 ; RCA = 100 + ; RWA = -60 -

> **Country 3: Small (over-proportional) World Trade Share for energy efficiency technology/ Large Exports of energy efficiency technology**
>
> – **World Trade Share of country for all technologies = 1%**
>
> – World Trade Share of the country for specific technology = 2%
>
> – Export/import ratio for all technologies = 1
>
> – Export/import ratio for specific technology = 2
>
> – WHA = 2% - ; RCA = 60 +; RWA 60 +

The best case is country 1, followed by country 3 and then by country 2 (see Table 4-1). It shows that a country with a smaller share in world trade (country 3) may perform better in those indicators than a country with a larger share (country 2). The reason is that country 3 has, compared to its general world trade share an over-proportional contribution to the world trade for a given technology combined with excellent exports, while country 2 has also excellent exports but on an under-proportional part of the world trade share compared to its general performance.

Table 4-1: Synthesis of analysis for the three hypothetical cases for the analysis of competitiveness with foreign trade indicators

Country	**WHA** **All/specific technology**	**RCA**	**RWA**
Country 1: Large (over-proportional) World Trade Share / Large Exports	+ **10/20%**	+ **60**	+ **60**
Country 2: Large (but under-proportional) World Trade Share / Very Large Exports	**0** **10/5%**	+ **100**	- **-60**
Country 3: Small (over-proportional) World Trade Share, Large Exports	- **1/2%**	+ **60**	+ **60**

WHA: World Trade Share

RCA: Revealed Competitive Advantage (relative export/import performance compared to the average export/import performance of a country)

RWA: Relative World Trade Shares or Revealed Export Advantage RWA (relative export performance compared to the average export performance of a country)

5 Methodological Challenges

It goes without saying the setting up competition and innovation indicators in

- The largest challenge is the **identification of technologies and technology groups in foreign trade and patent statistics**.
  - In many cases an exact identification of technology groups is possible (e.g. electric motors or insulation materials).
  - In other cases it is possible to figure out important identifiable energy efficient components that represent well the overall technology (pars pro toto[4], for example, components of an energy management system.
  - In third cases, the technology groups represent rather a "potential" to manufacture energy efficiency technologies (e.g. a country that has a good world-wide position in car manufacturing has a good basis to manufacture and export energy efficient cars). However, in such cases some technology groups may need additional criteria (e.g. a definition what characterises an "energy efficient car").
- Very difficult is the challenge of **system innovations** ("Low energy house"). These are very important aspects in a sustainable energy system but are not directly reflected in patent or foreign trade statistics. Also in such a case it is necessary to identify important parts in the system that can be identified in the statistics,
- A third challenge is the **correct interpretation of the indicators**. This may require additional knowledge. There are dynamic aspects that may falsify the picture. An example is Germany in the field of renewables. The indicators for wind energy concerning foreign trade were bad at a moment because Germany was, due to its feed-in law, the largest market in the world representing half of the annual installations. In such a context it is clear that German companies had more limited possibilities to export wind converters while for foreign companies producing converters, the German market was the only one that was large enough.
- A fourth challenge is the interpretation of patent indicators: the **patent behaviour may vary** from country to country or from sector to sector. In some cases inventions are not patented in an early stage in order to avoid that competitors could receive too early information.

There are also particular methodological challenges, when **analysing the EU as a whole**:

- **Patents:** here the aggregation is easy as the sum of patent shares of Member States.
- **Foreign Trade:** the aggregation is more difficult due to the EU internal trade. Without this internal trade the world market share is smaller. The RCA values of the

[4] One part represents the total.

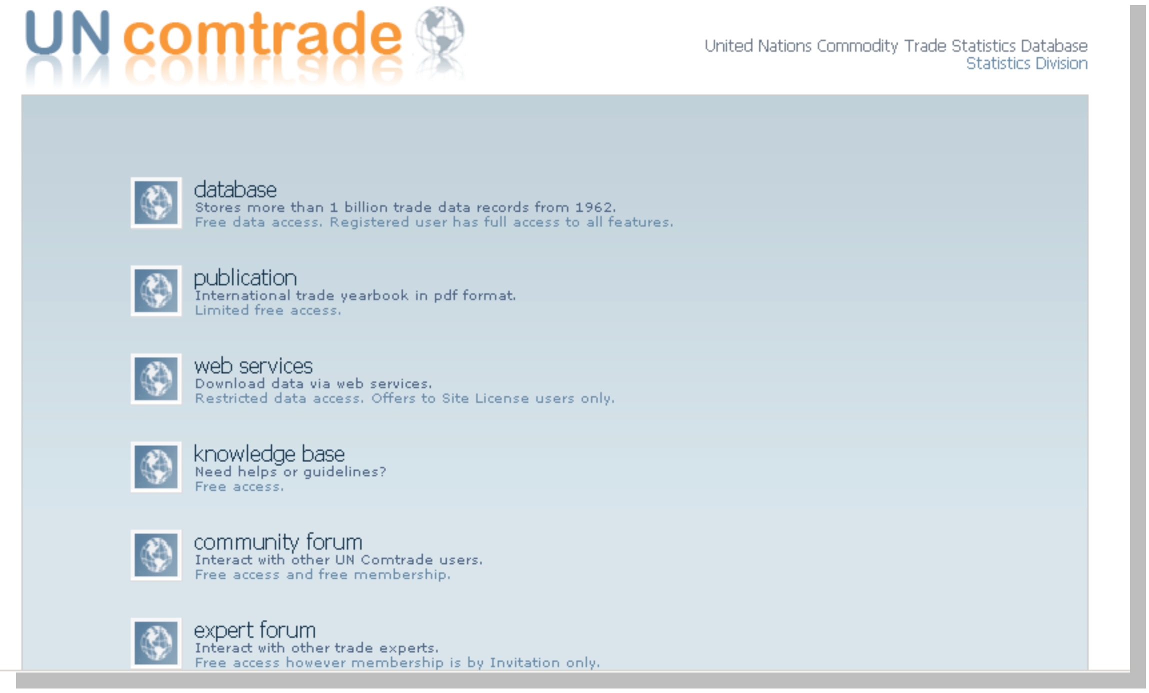
other countries outside the EU remain unchanged. The RCA of the EU as a whole may therefore increase or decrease compared to the weighted sum of the national performance. This depends whether the foreign trade for the technology is more or less directed towards countries outside the EU than for the total foreign trade of the EU.

6 Databases for indicators to measure the contribution of RUE/REN technologies to the Lisbon targets

This section presents briefly the two databases used for the analysis of competitiveness and innovation.

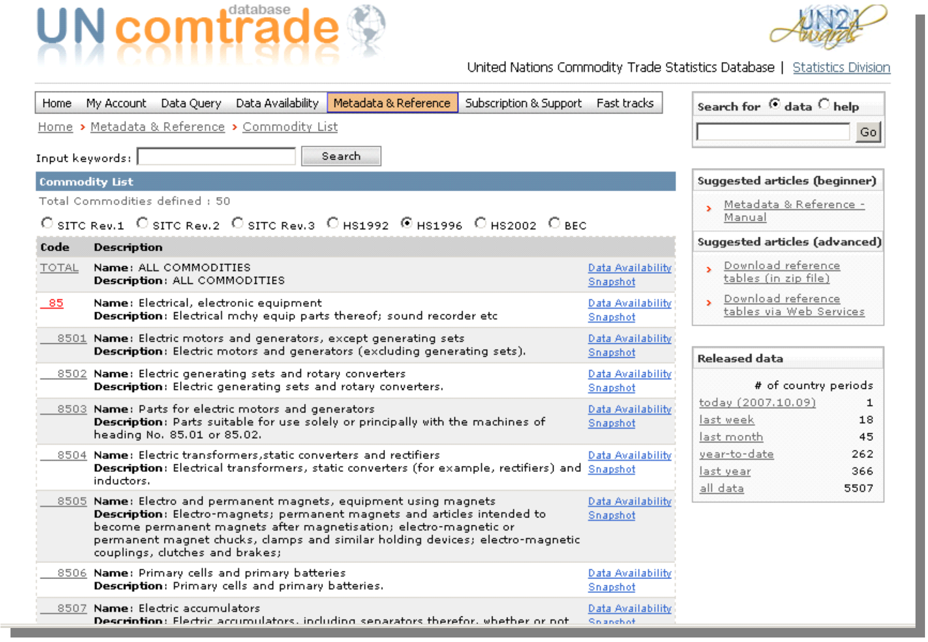
The database **UN COMTRADE** is referred to for foreign trade figures (see Figure 6-1 to Figure 6-3 for some snap shots). This is not limited to trade with OECD countries, but also covers South-South trade relations. In contrast to other analyses therefore, world trade is not only based on foreign trade flows in which OECD nations are involved, but encompasses the whole world. In addition, the classification of the technologies was structured according to the Harmonised System (HS) 2002. This foreign trade classification allows more detailed and thus more targeted disaggregation compared with the older classifications common in international comparisons (Standard International Trade Classification SITC). Nevertheless, this foreign trade classification still has many limitations in the level of disaggregation which make the application of the above sketched potential approach indispensable. The data are based on the year 2005.

Figure 6-1: UN Comtrade: Basis for the foreign trade indicators and analysis



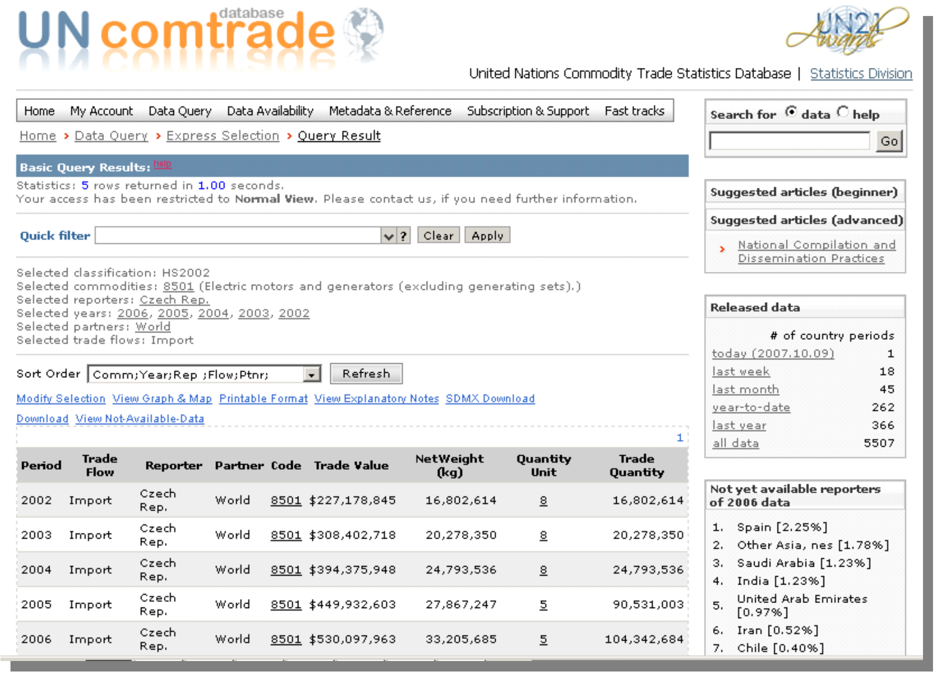
Source: UN Comtrade database

Figure 6-2: UN Comtrade: Classification in Foreign Trade



Source: UN Comtrade database

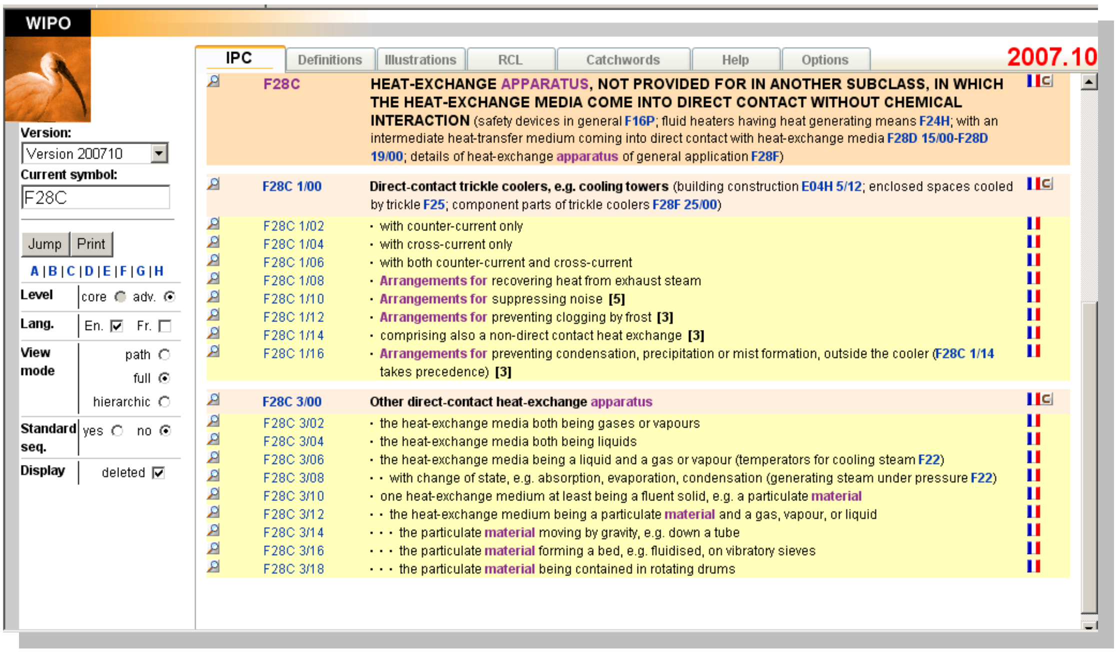
Figure 6-3: UN Comtrade: Type of results from data query



Source: UN Comtrade database

The patent searches primarily draw on patent applications at the World Intellectual Property Organization WIPO and thus international patents (Figure 6-4). In this way, a method of mapping international patents is employed which does not target individual markets such as Europe but is much more transnational in character and comparisons in innovation performance with outside Europe are possible. The years 2000-2004 were chosen as the period of study so that a statistically more reliable population is achieved in which chance fluctuations in individual years are evened out.

Figure 6-4: World Intellectual Property Organization WIPO: International Patent Classification



Source: World Intellectual Property Organization WIPO

More information on those databases is given in Legler et. al. (2006), DIW/ISI/Roland Berger Strategy (2007), and Walz (2008).

7 Technology Definition

As already mentioned previously the technologies investigated in the field of energy efficiency and renewables were hierarchised into areas, technology groups and technologies. The technologies were then associated with the corresponding classifications within the UN Comtrade and WIPO patent statistics. **Three areas were defined: Energy Efficiency Technologies, Renewables, Technologies for Sustainable Mobility**. The associated technology groups and technologies are given below.

Table 7-1: Definition of Energy Efficiency Technologies

Area	Technology Group	Technologies
Energy Efficiency Technologies	**Efficient building technology**	Efficient building components like insulation materials, insulation glassing, controlled air conditioning and ventilation, efficient conventional heating systems and heat pumps, building automation technologies. More difficult are system aspects in buildings such as low energy houses/passive houses
	Electricity in buildings	Energy efficient lighting and energy efficient appliances
	Energy efficient processes in industry	Iron/steel production, paper production etc.
	Energy efficient industrial cross-cutting technologies	Heat exchangers, efficient electric motors, pumps, ventilators etc., efficient industrial furnaces and driers

Table 7-2: Definition of Technologies for Renewables

Area	Technology Group	Technologies
Renewables Technologies	**Photovoltaics**	Different PV technologies
	Solarthermal energy	Different solar thermal technologies incl. Solarthermal power production and solar thermal hot water preparation
	Wind power	Different wind power technologies including on-shore/off-shore
	Hydro power	Different wind power technologies incl. wave and tidal power
	Geothermal energy	Different geothermal technologies
	Biomass/Biogas	Different biomass/biogas technologies

Table 7-3: Definition of Technologies for Sustainable Mobility

Area	**Technology Group**	**Technologies**
Technologies for Sustainable Mobility	**Propulsion technologies**	Hybrid systems for short term emission reduction + bridging technologies to electric propulsion technologies; Mobile fuel cells, production of H2/electricity with renewables + storage; continuous improvement of the efficiency of internal combustion engines (e.g. through the Homogeneous Charge Compression Injection HCCI) and of jet turbines.
	Vehicle technologies	Light construction Multi-functionality and attractivity of rail transport vehicles and their further compatibility with road traffic for the easier interconnection in logistic chains; Further improvement of the aerodynamics of air vessels as well as a general size increase of transport vessels.
	Transport infrastructure	Decoupling of passenger and goods transport on the rails; Extension of harbours and capacity increase of internal rail/water/road connections next to the harbours as well as in international corridors (Extension of Trans-European Networks/TEN), Traffic Demand Management in urban areas as well as IT supported information and mobility management to move demand to environmentally friendly energy carriers)
	Technologies for emission reduction	Further development of filters and catalysers and use for rail and water vessels; noise reduction technologies for all transport means.
	Biofuels	Production of high-value synthesis gas from biomass of varying composition in industrial scale
	Transport systems	-

8 Analytical Results

The results presented in this section are not meant to be exhaustive and a full scale analyses of the different technologies. The results should rather exemplify the different indicators for measuring competitiveness and innovation in the fields of energy efficiency and renewables.

8.1 Patent and World Trade Shares

Patent shares

Underlying the World Patent shares is the development of number of patents in a given field. While for renewables for example the number of patents grew exponentially and larger than the general growth in patens, energy efficiency technologies did not develop faster over time than the general growth in patents (Figure 8-1), except for one component concerning efficient electric appliances. Industrial process even underperformed. The reason may be that large demand stimulating programmes like for renewables were rare in the past for energy efficiency, although they grow in seize, partially also triggered by the EU Directive for Energy Efficiency.

Figure 8-1: Patent dynamics for the Area of Energy Efficiency

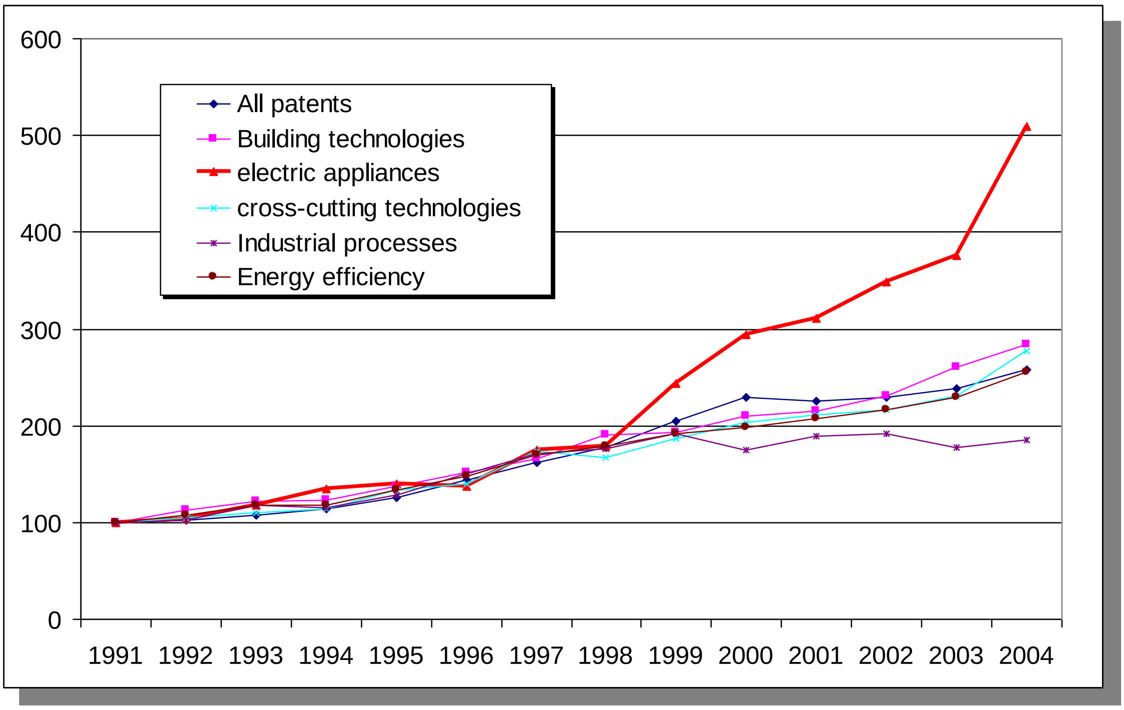


Figure 8-2: Patent share for the Area of Energy Efficiency

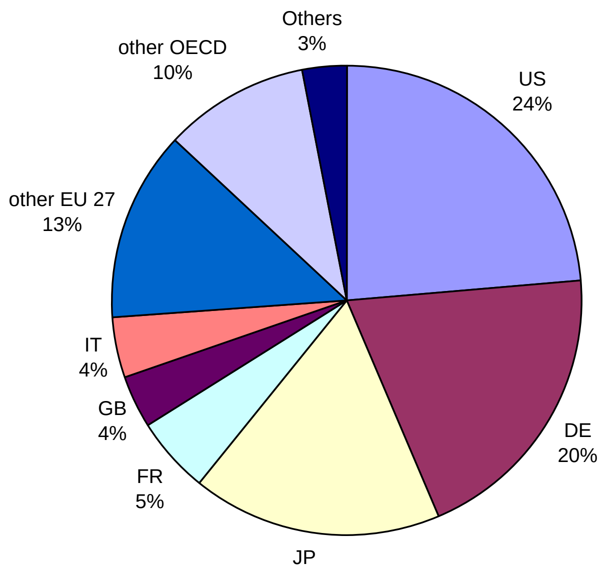


Figure 8-2 shows the predominance in the field of energy efficiency innovation which is mainly concentrated on three countries US, Germany and Japan. Partly this is caused by the size of these countries but to a large degree also to the importance that is attached to the issue in the policy sphere. The same picture can also be established for technology groups (see Figure 8-3 for the case of Energy Efficient Buildings) or technologies (Table 8-1), revealing thus more and more details. The dynamic development of patent shares (Figure 8-4) can also give hints to the position of a country as compared to competitors and how it evolves over time.

Figure 8-3: Patent shares for the Technology Group of Energy Efficient Buildings

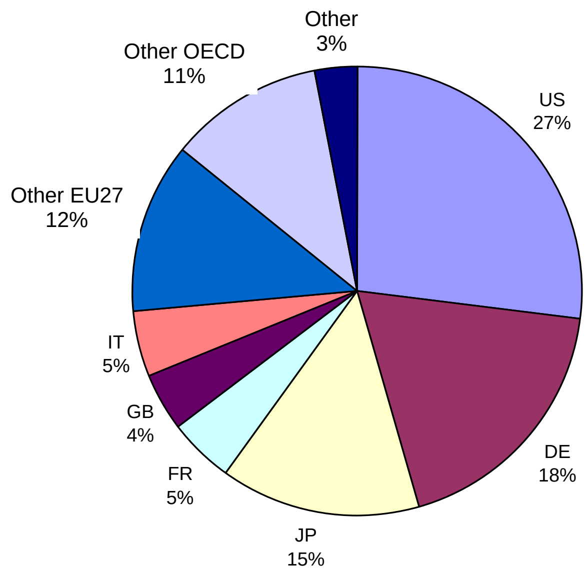
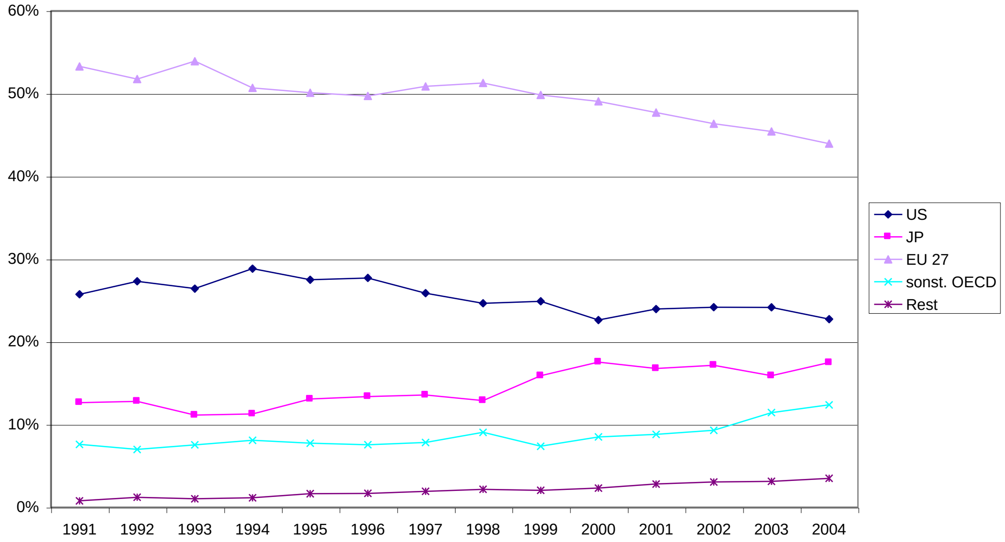


Table 8-1: Development of patents in the Technology Group Efficient Building Technologies

	Building management systems	Insulation glazing	Efficient heating systems	Air conditioning and ventilation	Total Technology Group
1991	214	98	201	79	25.922
1992	254	93	191	67	25.958
1993	259	124	228	112	26.894
1994	231	123	211	76	28.659
1995	253	108	203	82	30.144
1996	256	106	242	86	34.992
1997	307	104	277	105	39.116
1998	358	112	350	94	42.319
1999	347	159	310	107	45.665
2000	355	158	285	112	47.136
2001	354	134	312	114	46.117
2002	343	163	351	131	44.902
2002	212	89	233	67	17.048
2003	220	97	222	74	17.307
2004	259	90	256	76	16.901
2002	200	99	156	90	38.260
2003	218	93	163	80	39.365
2004	209	118	199	81	41.858

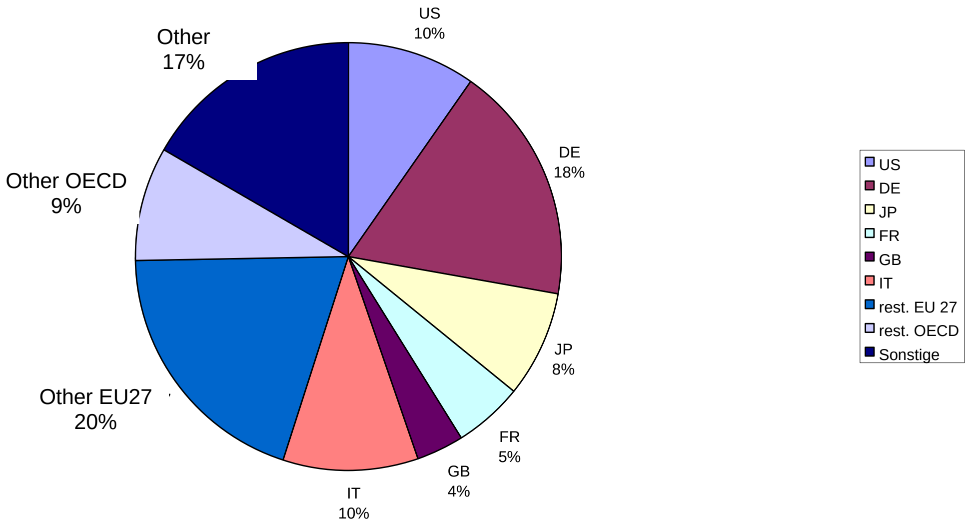
Figure 8-4: Development of patent shares for the Area of Energy Efficiency



World Trade shares

Similar to the patent shares in the innovation field, the shares in world trade for energy efficient products are presented in Figure 8-5. The dominance of the big three trading countries is here less expressed than for the patent shares discussed above.

Figure 8-5: Shares in world trade with energy efficient products

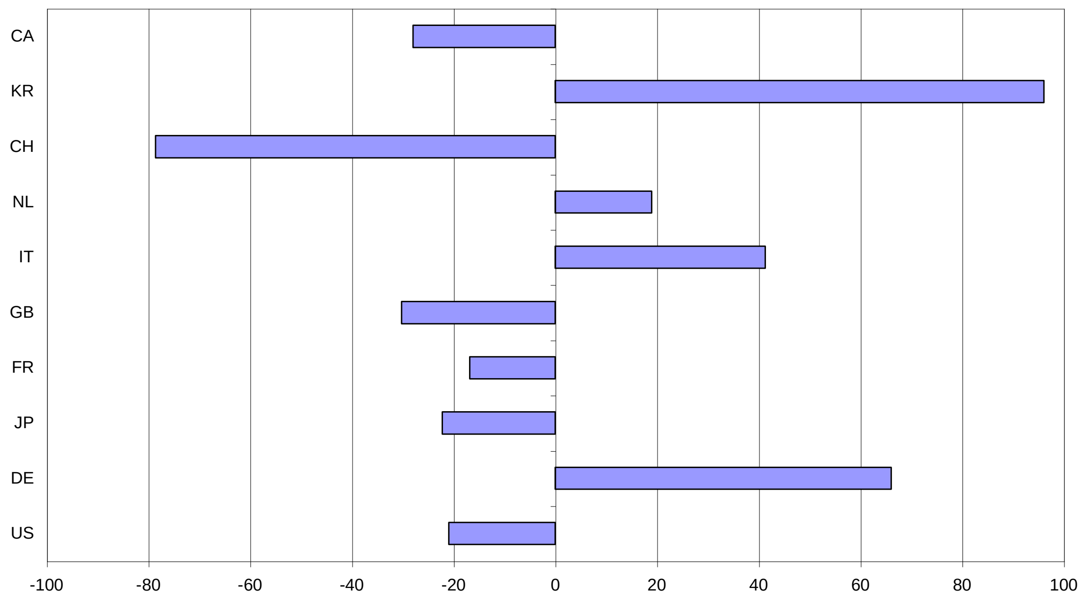


8.2 Specialisation indicators

Revealed Competitive Advantage RCA

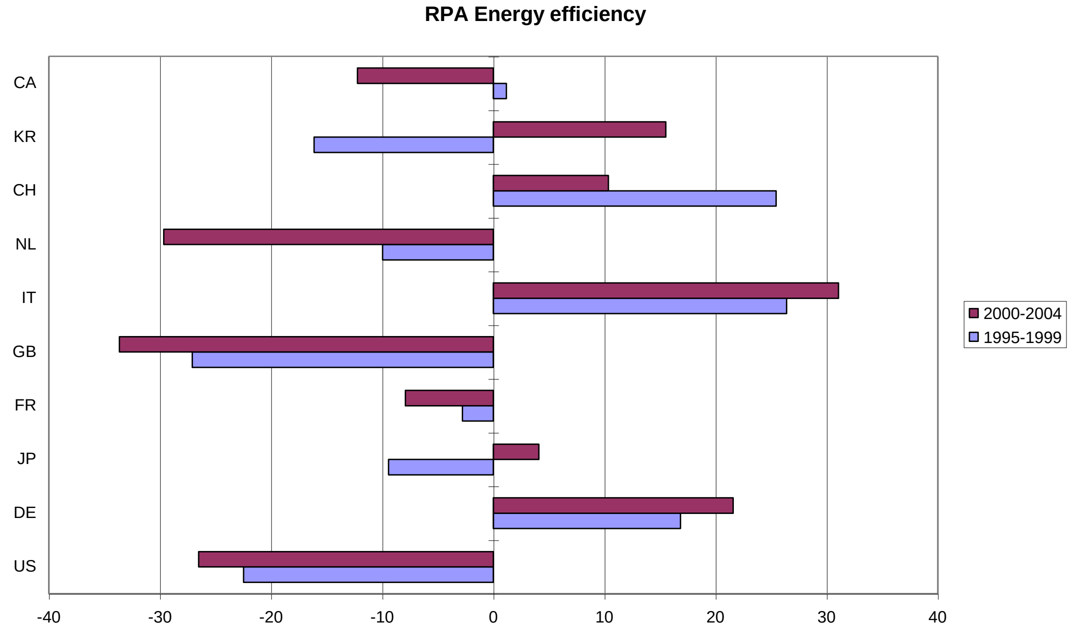
Specialisation indicators show whether a country has a positive or a negative specialisation with respect to a certain technology. Figure 8-6 shows the Revealed Competitive Advantage RCA for a variety of countries in the Buildings Technology Group. A larger number of negative specialisation that is the technologies perform less well in the export/import relation compared to the average of the technologies in the countries. There are, however, also countries such as Germany, Korea, Italy and the Netherlands where the energy efficient technologies contribute over-proportionally to improve the competitiveness of a country.

Figure 8-6: Revealed Competitive Advantage (RCA) - Building Technologies



A similar relative comparison can also be done to characterise the innovative behaviour (see Figure 8-7 the relative patent shares of the countries in the area of energy efficiency). This indicator characterises the relative performance of a technology in patents compared to the average performance of all technologies. This picture can also be followed up over time. If the number of patents is too small, especially for smaller countries, it may be necessary to average over several years in order to obtain a suitable data population for the indicators.

Figure 8-7: RPA: Relative Patent Analysis Energy Efficiency



9 Summing up Results

This section presents synthetic ways of how to convey the messages from the details of the indicator analysis, notably in the form of summary tables, specialisation profiles and SWOT analyses.

9.1 Summary tables

Summary tables have already been presented in Chapter 4.6 when comparing indicators for a hypothetical example with three countries. They summarise and weight the indicators for competitiveness and innovation in a synthetic table and compare the different countries (Area Energy Efficiency, Example of Germany, Table 9-1). The information may also be presented in a more qualitative way as in Table 9-2.

Table 9-1: Specialisation indicators (RPA and RCA) in the Area Energy Efficiency for the 10 most important countries

Area/ Technology Group	**Indi-cator**	**US**	**DE**	**JP**	**FR**	**GB**	**IT**	**NL**	**CH**	**KR**	**CA**	**CN**
Total area Energy Efficiency	RPA	-	+	0	0	-	+	-	+	+	-	0
	RCA	+	+	+	0	0	+	0	+	-	-	0
Energy efficient building technology	RPA	-	+	-	-	-	+	-	+	+	0	0
	RCA	-	+	-	-	-	+	+	-	+	-	+
Energy efficient appliances	RPA	-	+	+	-	-	+	0	-	+	-	+
	RCA	0	+	+	0	0	+	0	+	-	-	+
Industrial cross-cutting technologies	RPA	-	+	+	0	-	+	-	+	+	-	0
	RCA	+	+	+	0	+	+	0	+	-	-	-
Industrial proc-esses	RPA	-	+	0	0	-	0	-	0	-	0	-
	RCA	+	+	+	+	+	+	-	+	-	-	-

RPA: Relative Patent Share (relative importance of patents for a given technology in comparison with all patents)

RCA: Revealed Competitive Advantage (relative export/import performance compared to the average export/import performance of a country)

Source: adapted from ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

Table 9-2: Synthetic comparison of the performance of the different technology groups in the area Energy Efficiency (case of Germany)

Area/ Technology Group	**Patents**		**Foreign**	**JP**
	Relative position D	**Most important competitors**	**Relative position D**	**Most important competitors**
Total area Energy Efficiency	**High**	**IT, KR, CH**	**Very good**	**IT, JP**
Energy efficient building technology	Medium	IT, KR	Very good	KR, IT
Energy efficient appliances	High	KR, IT, JP	Good/very good	IT, JP, CH
Industrial cross-cutting technologies	High	KR, IT	Very good	IT, JP
Industrial processes	high	(CH, JP)	Good	IT, GB, JP, CH

Source: adapted from ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

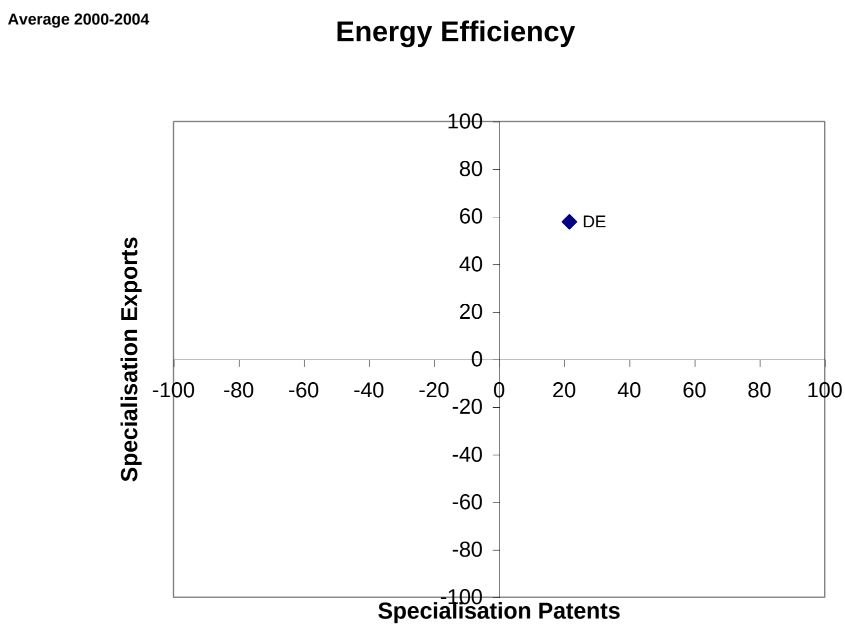
9.2 Specialization profiles

The relevance of the sustainability technologies in each respective country is revealed in a quantitative way in its specialisation profile. This shows the technological capability of the sustainability technologies for each country compared with the average of all technologies. Positive values indicate an above average activity of the country regarding sustainability-relevant technologies, negative values a situation below the average. This is a more quantitative way to visualise the results. Unfortunately, it is difficult to present in such a way additional parameters, such as world trade shares or patent shares; it would be necessary to present the results in three- or more- dimensional graphics, as in total there are at least five indicators to be presented (WHA, RCA, RWA for competitiveness issues, PA and RPA for the innovation aspects).

The most interesting dimensions to present together in one specialisation diagram are the RCA for the competitiveness issue and the RPA for the innovation aspects because they are less influenced by the size of the country (see Figure 9-1). A country which is strong in both innovation and competitiveness for a given area, technology group or technology would appear in the upper right quadrant. The better its position, the closer it would be to the upper right corner. A country which is weak in one of these two aspects would either appear in the upper left part (if it is weak in innovation but strong in competitiveness for a given technologies, which could indicate that it had made efforts in the past to be in front but that the future is badly prepared) or in the lower right part (if it is weak in competition but strong in innovation). This could indicate that a country is still a new comer in the field but is well preparing the future). The worst case is if a country is in the lower left quadrant; then neither the competitiveness is good, nor is innovation occurring for the given technology.

The case presented is the one of Germany for the overall area of energy efficiency. In this case the competitiveness looks good in the field. The innovation seems also occurring but to a weaker degree than would correspond to the present state of foreign trade. This could imply that Germany's position may weaken in the future if the competitors are stronger.

Figure 9-1: Specialization profiles – RCA versus RPA

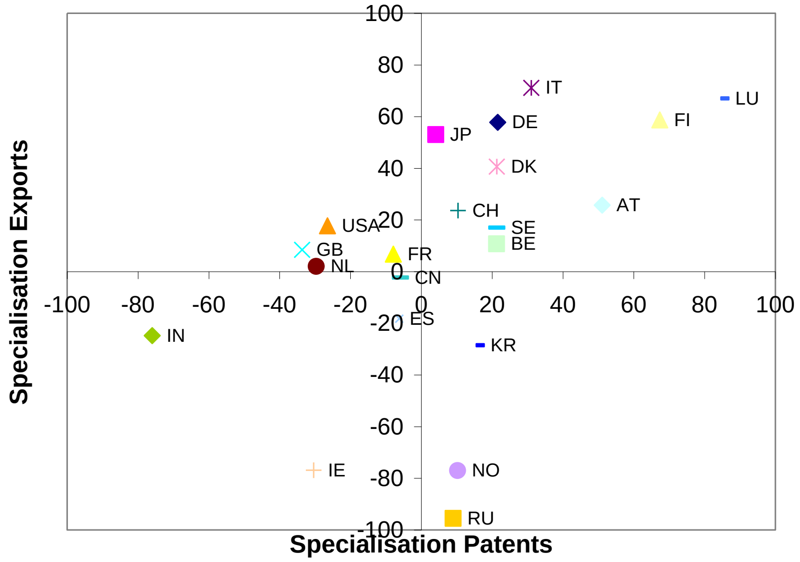


The results shown in the following sections for the three areas make appear clear differences between the countries. The results include also countries from outside of Europe because they are either major competitors (like USA, Japan, Canada or Korea), or could soon become competitors such as China or other BRICS countries.

Specialization profiles Energy Efficiency

Figure 9-2 compiles the specialisation profiles for the area of energy efficiency. There are a variety of countries with a relatively prominent position in the upper right part of the graphics hence with positive competitiveness and innovation behaviour in the field of energy efficiency. These are countries like Finland, Sweden, Denmark, Germany, Austria, Luxembourg, Italy and Switzerland). Some countries like France, Spain or the UK are rather in a neutral area where energy efficiency technologies are not playing a very prominent role. Countries with underperformance of energy efficiency technologies as compared to the average of the economy are rarer. They are found among transition countries like Russia or developing countries, although a country like China has already a good position in the middle of the graph.

Figure 9-2: Specialization profiles – Energy Efficiency (average 2000-2004)

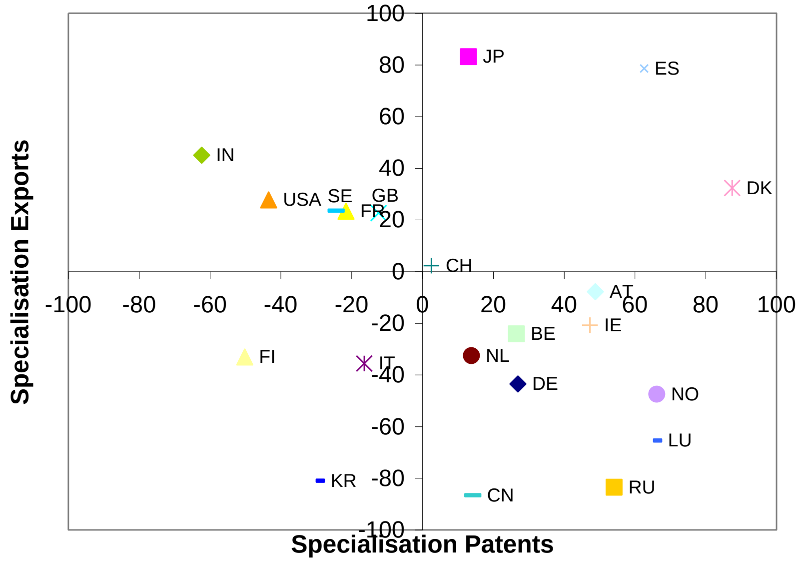


Note: country in upper right quadrant is strong in both innovation and competitiveness. Upper left: country weak in innovation but strong in competitiveness; lower right part: weak in competition but strong in innovation; lower left quadrant: neither good in competitiveness nor innovation

Specialization profiles Renewables

In the field of renewables there are clear champions appearing like Japan (due to photovoltaics) as well as Spain and Denmark (due to wind energy, see Figure 9-3)

Figure 9-3: Specialization profiles – Renewables (average 2000-2004)



A variety of countries appear as positive on the innovation side, with registration of patents but profit little in the time period considered in terms of competitiveness. Interesting is the position of India and China. While India has already activities in renewables in the field of wind energy, China had very little in 2000-2004. However, this has considerably changed over the past two to three years with China emerging increasingly as a player for renewable technologies.

9.3 Comparisons across different areas and countries

Another way to compare specialisation profiles (see previous section) is across the different areas. This provides information in which areas a country is strongest. Figure 9-4 and Figure 9-5 compare the three areas energy efficiency, renewables and sustainable mobility for France and Germany.

Figure 9-4: Comparison of specialization profiles across areas (France)

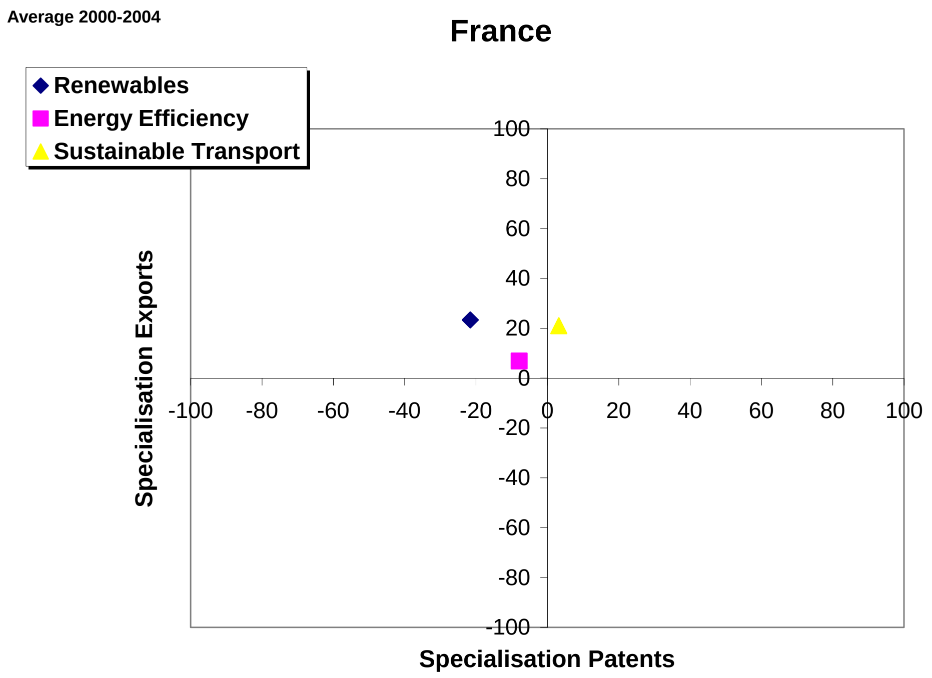
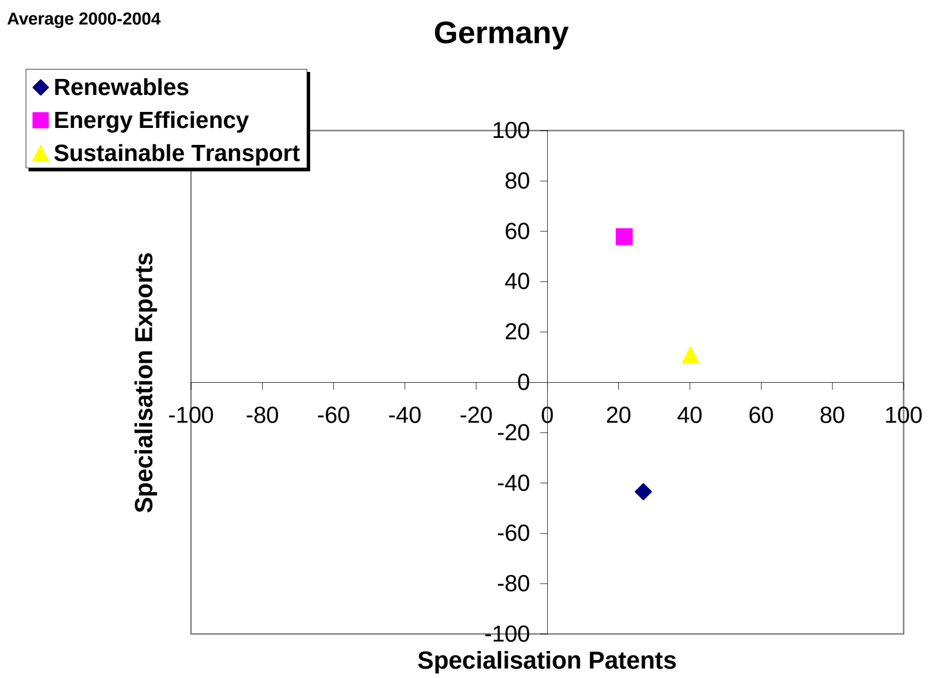


Figure 9-5: Comparison of specialization profiles across areas (Germany)



While the French points are rather centred on the middle, indicating that the technologies in those fields are on average not performing better than the rest of the economy.

None is really strongly in the upper right quadrant. This is different in Germany where the points deviate more strongly from the middle of the graphics with two points being quite strongly deviated towards the upper right (It has to be considered that there is a logarithmic scale in the formulas). Only the point for the renewables is considerably out in the negative concerning the foreign trade aspects. This issue will be discussed in its dynamic aspects in more detail in the next section.

9.4 SWOT Analysis summarising the indicators

Another suitable way to summarise the results of such an indicator analysis is in a more qualitative way by combining the results in a SWOT analysis. Examples are provided below for Germany and the three areas Energy Efficiency, Renewables and Sustainable Mobility (Table 9-3 to Table 9-5).

Table 9-3: SWOT analysis Energy Efficiency Germany

Strengths	**Chances**
• Good knowledge base and technological potential in important technology fields • Considerable international competitive successes of technology producers; high world market shares of domestic enterprises • Innovation and diffusion driven via energy and climate policy as well as issues of secure supply	• Strongly expanding world market • Re-investment needed in power station area which allows energy demand and supply to be newly balanced out • Use new policy instruments (emission trading, energy efficiency directive) to generate demand and use and orient towards innovations • Use price increases for energetic raw materials to drive innovations onwards
Weaknesses	**Challenges**
• Despite broad societal consensus on the role of energy efficiency activities uneven distribution over various technology lines • Enterprises clearly less well organized than in the renewable energy area • Lack of "visibility" of role of efficiency technologies in the public eye	• Use Energy Efficiency Directive more intensively to strengthen technology lines further • Take early account of competition from technology-strong developing countries • "Export" successful incentive policies to other countries to create larger markets for the products • More systematic integration of "new technology fields" like nano-/ biotechnologies in the development of more energy-efficient processes and products

Source: ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

Table 9-4: SWOT analysis Renewables Germany

Strengths	Chances
• Good knowledge base and technological potential in important technology fields • Considerable international competitive successes of technology producers; high world market shares of domestic firms as good starting position for further turnover growth in a number of technology lines • Energy and climate policy as well as security of supply are important innovation-drivers • Well organized enterprises in the area of renewable energies and power station technologies	• Strongly expanding world market • Re-investment required in power station sector, which allows renewable energies and CO2-low fossil fuel power stations to be utilized more • Discussion about new policy instruments for the generation of demand and use orientation towards efficient technology innovations • Use price increases for energetic raw materials to drive innovations onwards
Weaknesses	**Challenges**
• Markets for renewable energies are still too small in other countries compared with Germany. Therefore export opportunities are too small • Cost level of single technologies still too high • Societal consensus missing for CO2-low technologies for using coal and gas	• Use policy development like the EU Directive for renewable energies more intensively to strengthen technology lines further • Take early account of competition from technology-strong developing countries • "Export" successful incentive policies to other countries • More systematic integration of new technology fields like nano-/ biotechnologies

Source: ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

Table 9-5: SWOT analysis Sustainable Mobility Germany

Strengths	Chances
• Outstanding competitiveness in traditional sectors • Entry to world market in new technologies (e. g. hydrogen and fuel cells) • Approaches to support innovations in new technologies by progressive environment and transport policy • Advanced liberalization and standardization of the European markets in the area of road and air transport/ travel	• Massively expanding world market in the area of logistic services • New policy instruments (emission trading, road pricing) to generate demand and utilize direction to decentralized technology innovations • Cause early convergence of technology areas; build up existing competences in conventional vehicle technologies to enter new markets • Expansion and coalescence of the EU and promotion of a standardized railway areas/ network • Ambitious goals to promote renewable energies and to reduce climate gas emissions
Weaknesses	**Challenges**
• Technological deficits in single areas in some European countries (hybrid propulsion technology, alternative fuels, ship building and infrastructures) • No standard, widespread approach in the EU to create a market for highly efficient vehicles acc. to the zero-emission-vehicle program in California • Strongly national-state-oriented structures of railway enterprise prevent growth of rail traffic and intermodality in the European railways	• Increasing competition of catching-up countries also for technologically high quality products • Resistance from national railway firms against liberalization of access to the European railway network • Ageing of European society and dwindling demand in passenger transport • Increasing lack of well educated skilled staff in research and development as well as in transport services

Source: ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

10 Dynamic analysis of indicators: three case studies

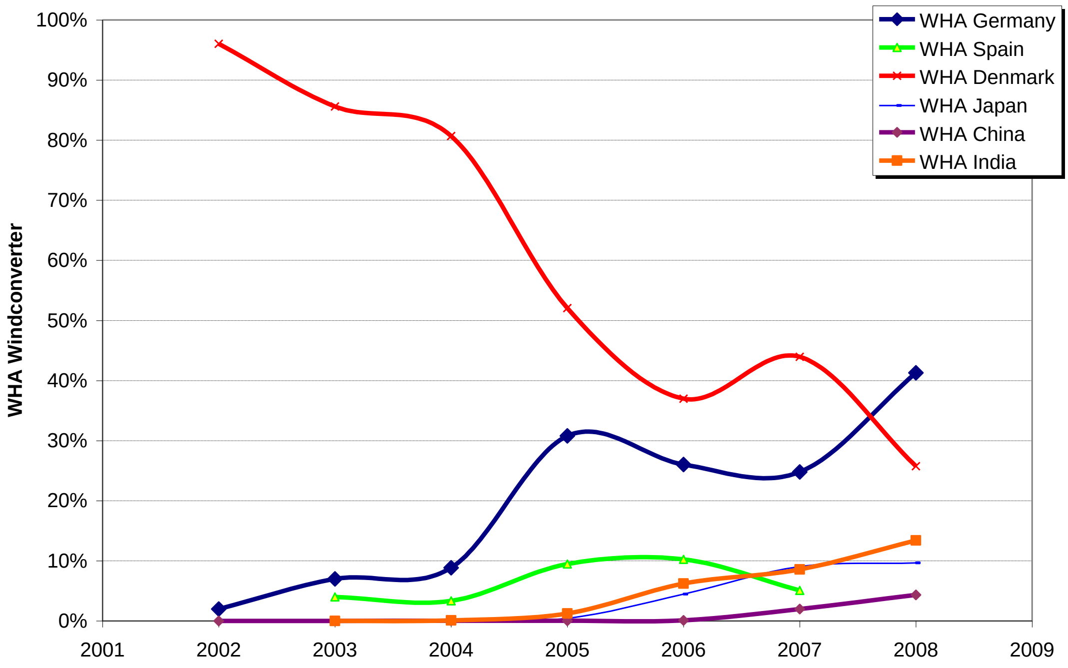
Dynamic aspects in the development of indicators for competitiveness and innovation are very important. A static picture may lead to a wrong conclusion. We will exemplify this in this section with three examples: wind energy, photovoltaics and small cogeneration. For each of these technology groups we try to identify countries with a strong position (top performers) and countries with a weak position (laggers).

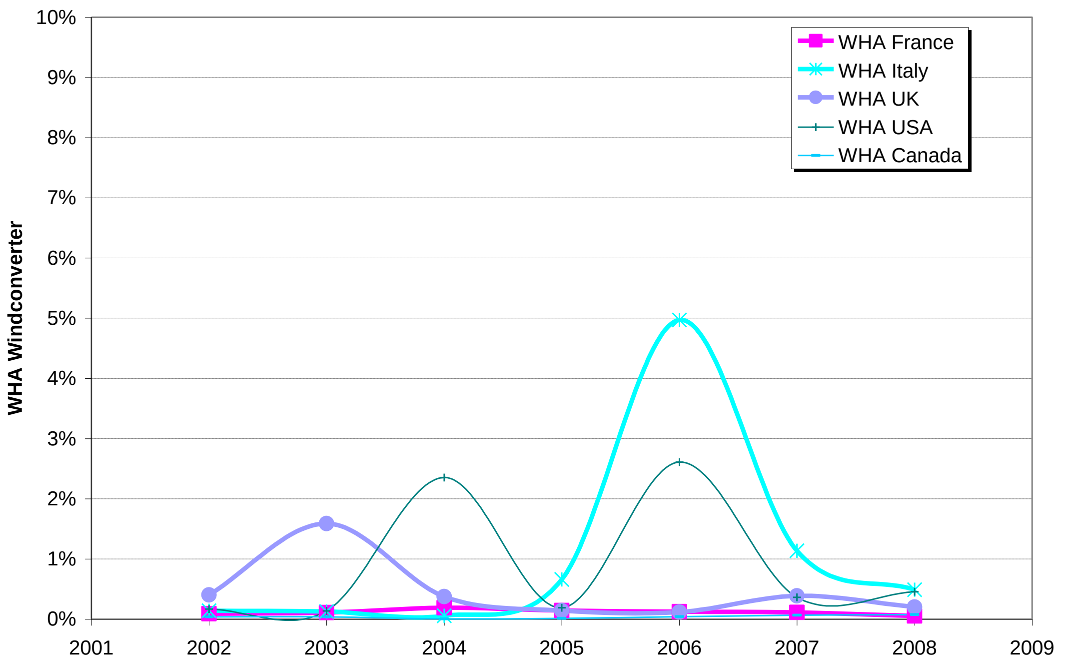
10.1 Case study on wind energy

Wind energy is an important technology group contributing to the area of Renewables. For this area Figure 9-5 has shown that for the period 2000-2004 Germany had not a very brilliant position despite tremendous efforts to promote renewables through feed-in tariffs fixed in the Renewable Energy Law. By looking closer to wind energy which largely dominates the results in 2000-2004, we will try to get a better understanding of what influences the indicators. We analyse each of the competitiveness indicators WHA, RCA and RWA for a variety of countries including Germany. Some of these countries such as France had a very weak policy on renewables and virtually no wind converters were installed before 2005. After that date wind energy installations got more consistent in those countries (the laggers). Other countries embarked (much more) earlier on wind energy (such as Denmark, Spain or India) or much more vigourously although late (such as China). They are designated as top performers in the following graphs although there is also a certain differentiation among them. Figure 10-1 to Figure 10-4 tell the dynamic story of the development in the different countries:

- **World Trade Shares (WHA,** Figure 10-1**):** The upper figures shows the group of countries with large markets shares for wind energy converters (that is, strong exporters): Denmark, Spain, Germany, Japan, China and India. The lower figure shows weak performing countries with low market share: France, Italy. UK, USA, Canada. The weakest country in the latter group is France; due to the lack of any demand oriented policy so far this country has up to now a consistently low share in the world market of around 0.1%. Initially, in Germany also the market share was low (around 2%) despite an already very strong demand oriented promotion policy. After 2004 the market share in Germany literally exploded: in 2008 Germany's market share reached 41% of the world market, which is 41% of all exports of wind converters worldwide. The historic market leader Denmark has continuously lost grounds due to the fact that the industrial basis of the country is too weak to serve the already very large worldwide wind market alone. Particular attention should be given to the market shares of India and China. The latter seems still lagging behind but this is rapidly changing (see the further discussion).

Figure 10-1: World Trade Shares (WHA) for wind converters exported from top performers (upper diagram) and laggers (lower diagram)

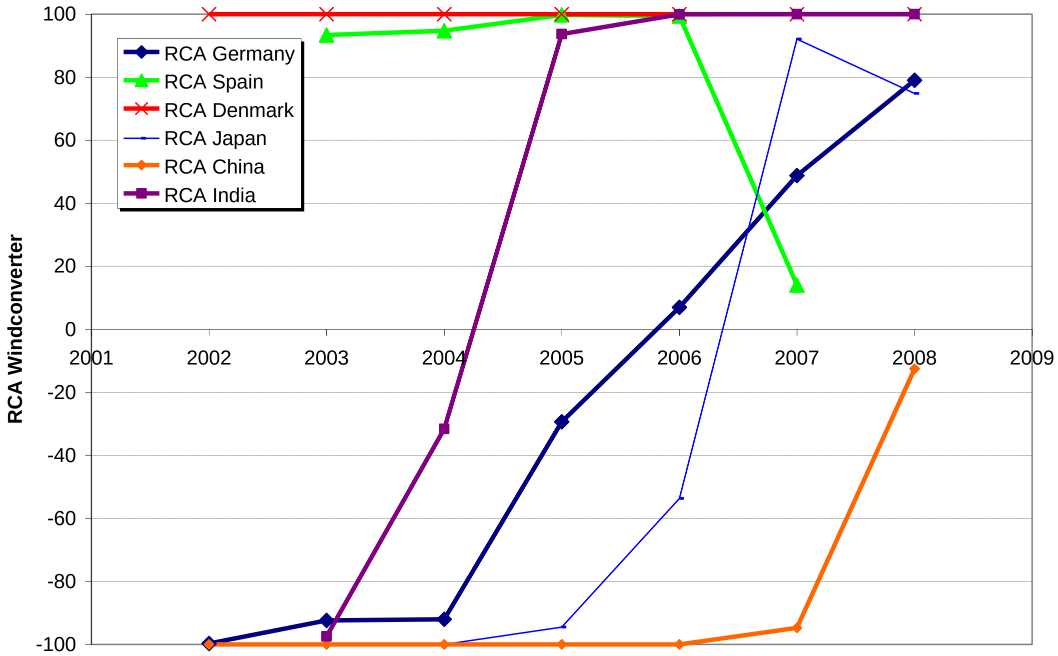




- **Revealed Competitive Advantage (RCA,** Figure 10-2**):** In the group of the laggers the case of France is representative for the other countries in that group. The RCA of France was initially very high but then fell rapidly after 2003 to negative values. However, this was not astonishing. The RCA compared imports and exports for wind converters. As France was not installing wind converters before 2005 not much was imported and hence, on a very low level, the indicator appeared as positive, as France was exporting some technology parts relevant for wind converters. As soon as France started to have success with its promotion system for renewables by changing it also to a feed-in system, it needed to import wind converters, as no national industry had been promoted by a demand-oriented policy. This is also the case for the other laggers. In the group of top performers Germany took the opposite path: while the RCA was strongly negative in the period before 2005 (we will explain this further below; this was the main reason for the negative RCA for the area of Renewables in Germany), the strongly increasing share in the exports boosted the performance of the German wind sector well beyond the general export performance of the country. It has to be realised that the RCA measures the performance of a technology as compared to all other technologies in a country. Given that Germany is a country which is strong in exports, wind energy had to perform even better to obtain the result below. France on the other end is a country which is generally weaker in exports; hence the wind energy in France is performing even worse than the average technology in France. It is by the way an interesting question whether an export-oriented general context in a country helps also a particular forthcoming technology. This touches upon the broader context of competitiveness and innovation as mentioned in section 2.2. The historic leader Denmark, despite the fact that it is losing market shares, is still performing excellent, when exports are compared to imports. Other top performers such as India and China follow a similar path as Germany; China with a few years delay as compared to India. Its RCA is still negative in 2008 but given the vigorous change observed so far it could be expected that by 2010/11 the RCA will have become positive for this country unless the present economic crisis slows down this development. Less because of slower economic growth in China but rather because of the economic slow-down of potential investors in wind energy in other countries.

- **Relative World Trade share (RWA,** Figure 10-3**):** The RWA of the countries in the group of laggers is continued very negative. As the RWA only considers exports and compares this with the general exports from the country, this shows that those countries performed always less well on wind energy exports than generally on exports. In difference, the RCA was positive for those countries at the beginning because the exports were overwhelming the imports but at a very low level. As soon, however, as promotion programmes in those countries spurred some own demand, the RCA turned negative. Germany started from a very low level (again the explanation will come further below), but the tremendous expansion in exports boosted at the same time the World Trade Share and the RWA. Similar trends are observed for the other top performers, except for Denmark where the development had started much earlier.

Figure 10-2: Revealed Competitive Advantage (RCA) for wind converters exported from and imported to top performers (upper diagram) and laggers (lower diagram)



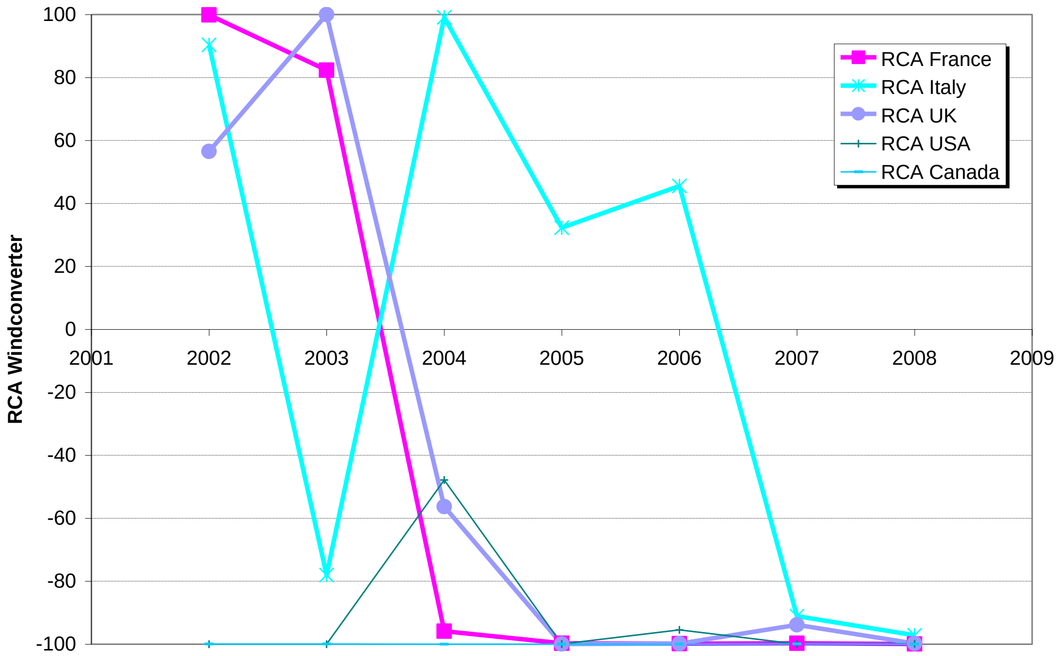
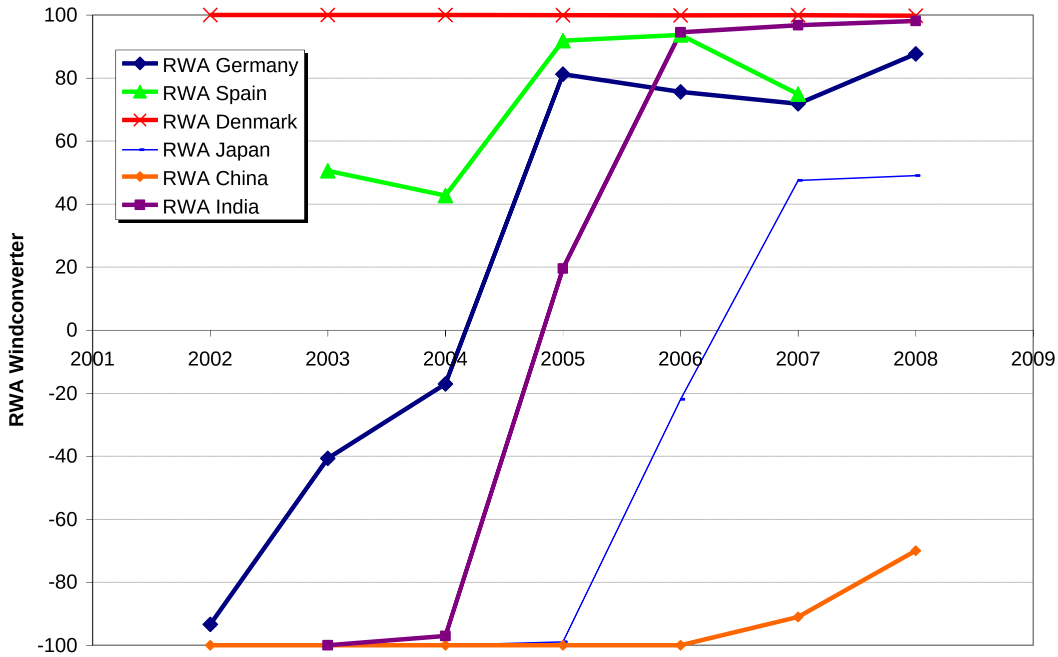


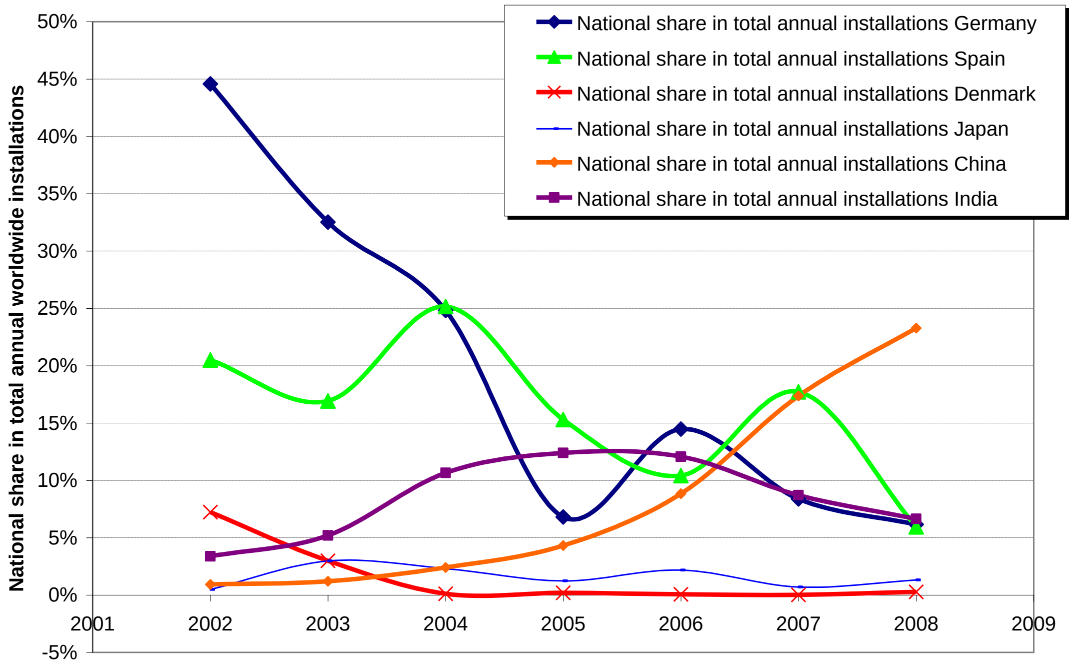
Figure 10-3: Relative World Trade share (RWA) for wind converters exported from top performers (upper diagram) and laggers (lower diagram)

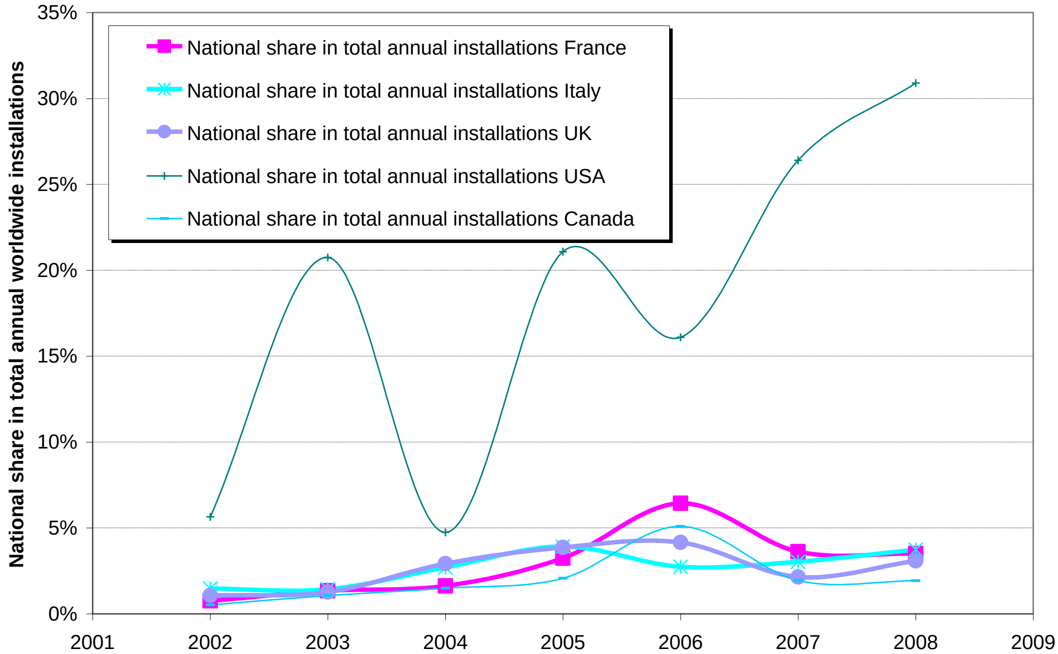


- **National annual share of wind converter installations compared to world-wide annual installations:** Figure 10-4 finally gives the explanation why Germany had in the period 2000-2004 so negative indicators for wind energy and hence for renewables. By that time Germany had the largest support programme for renewables worldwide. This programme was so large that nearly half of all annual installations were installed in Germany. This brought opportunities for producers in other countries. At the same time, the promotion scheme in Germany (and similar schemes in Spain and Denmark in parallel) have “bought down” the costs of wind energy for the whole remainder of the world. Suffering from the impact of high fossil fuel prices since 2005 and considering the growing evidence of climate change, other countries also started to promote renewables more strongly boosting even further the market. This has made that the annual installations of Germany represent only a mere 5% of the worldwide installations anymore. This value is very close to the French value in 2008 which is growing because France is far from realising its potential while installed wind power in Germany can only grow any more by repowering and wind offshore, although this still leaves some considerable margin. **So in summary, the price that Germany has initially paid and showed up in negative indicators in the early phase, was converted to a strong export-oriented industry which can compete on a worldwide level**. A similar development, with a delay of around 15 years may by the way also be ongoing on for solar cells (see next section) but the debate is still open given the fact that the general basis for wind energy, the machinery making industry, is traditionally very strong in Germany, while this is less true for the electronic industry, which is the home basis for solar cells. This industry was traditionally stronger in the US and Asian countries. Here other players such as China come more strongly into the game earlier, and analysing the indicators of competitiveness and innovation in such dynamic cases can give very important insights.

Interesting are the cases of China and the US where the home market has now become a substantial fraction of the world-wide installations, well beyond the home markets of the historic leaders. In the US the development was characterised by a stop-and-go policy over the past years. So far, this has led in this country to negative competitiveness indicators, while for China there is already some change visible towards a stronger competitive position. Both home markets promise to be much more giant than the home markets of Germany, Spain or Denmark in the past. It will be interesting to see, how this influences the development of the competitive position in both countries and how this will influence the development in the historic lead markets.

Figure 10-4: National annual share of wind converter installations in top performers (upper diagram) and laggers (lower diagram) compared to world-wide annual installations



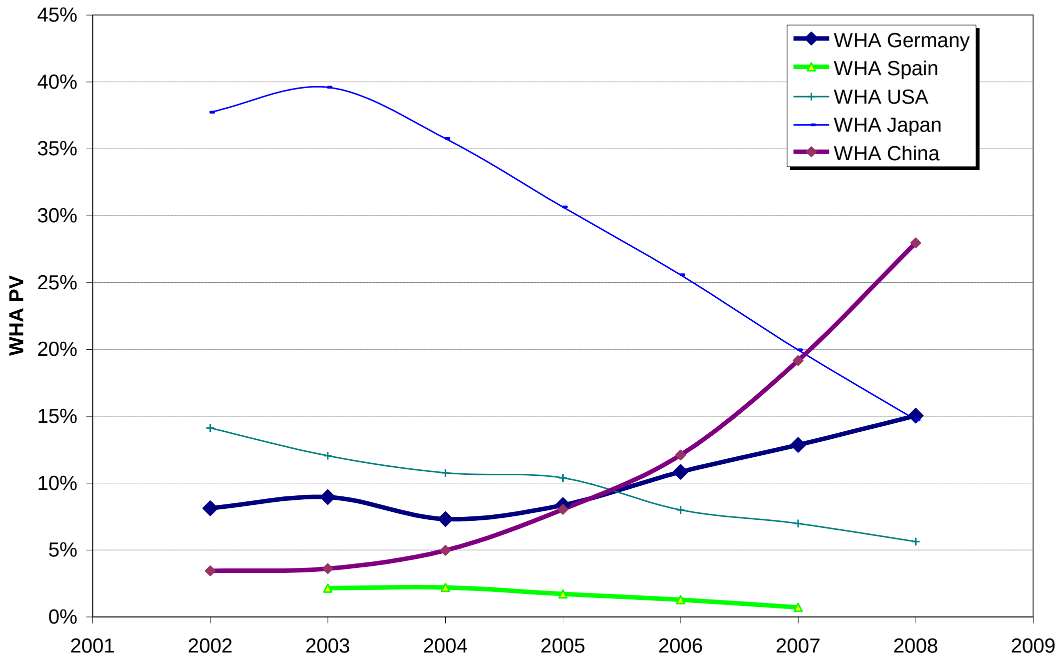


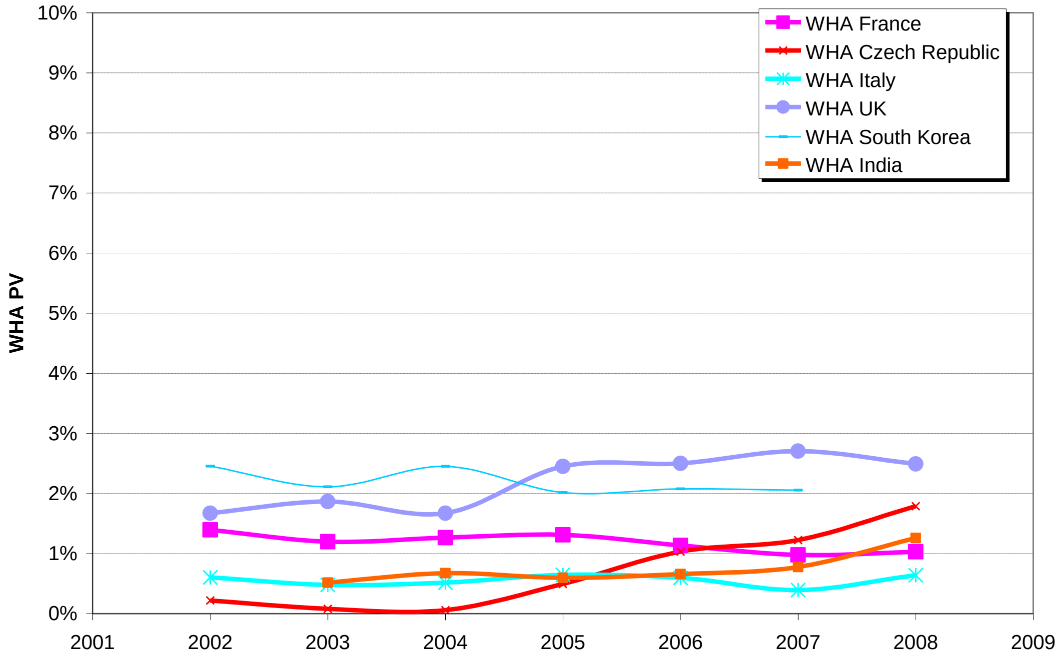
10.2 Case study on solar PV

Photovoltaics (PV) is a second important technology group contributing to the area of Renewables. Also here, we analyse each of the competitiveness indicators WHA, RCA and RWA for a variety of countries dividing them into the two groups of top performers (Japan, Germany, Spain, USA and China) and the laggers (France, Italy, UK, Czech Republic and India). The role of the historic leader which was Denmark in the case of wind energy was here taken by Japan and the US. Again, some of these countries such as France had a very weak policy on renewables and virtually no PV converters were installed before 2005. After that date PV installations got more consistent in some of those countries (the laggers). Interesting is the case of China which is at present still a very weak home market for PV installations. Figure 10-5 to Figure 10-8 tell the dynamic story of the development in the different countries:

- **World Trade Shares (WHA,** Figure 10-5**):** The upper figures shows the group of countries with large markets shares for PV (that is, strong exporters): Japan, US, Spain, Germany, China. It shows the decline of the market shares of the historic leaders, while two new players, Germany and in particular China have conquered larger market share. China is heading all other countries and Germany has just passed the historic leader. However the position of both countries is very different yet with respect to the home market. The lower figure shows weaker performing countries with low market share: France, Italy. UK, Czech Republic, India, South Korea. Interesting is in particular the case of the Czech Republic which seems to gain grounds although on low levels.

Figure 10-5: World Trade Shares (WHA) for PV exported from top performers (upper diagram) and laggers (lower diagram)





- **Revealed Competitive Advantage (RCA,** Figure 10-6**):** In the group of the laggers the changes are still not as dramatic as for wind energy because for most of these countries there is still not a very large demand on the home market. Therefore the RCAs are still fairly stable, although frequently at a negative level, that is the technology is underperforming with respect to the relative export/import ratio compared to other technologies. Notable are the changes in the Czech Republic towards more positive levels and the position of India and the UK, although all through starting from a very low level. In the group of top performers Japan and the US are still doing well despite losing market shares. In the US the RCA values for PV are even increasing but this reflects rather the general degradation of the export performance of the country and the fact that PV in relative terms shows a better level of exports. Germany is still in the negative region although since recently with an improving trend. The explanation will be given further on. China is outperforming all other countries while Spain is strongly aiming towards negative values. In Spain the problem was that the country has suddenly installed huge amounts of PV due to a very generous and not well-controlled promotion policy. This has led to massive imports of solar cells. This was, however, correct, one year ago and Spain has limited the amounts installed in order to master the expenses.

- **Relative World Trade share (RWA,** Figure 10-7**):** The RWA of the countries in the group of laggers is continued very negative although on the rise in some countries such as the Czech Republic. As the RWA only considers exports and compares this with the general exports from the country, this shows that those countries performed always less well on PV exports than generally on exports. In the group of top performers the figures for Japan, the historic leader, start to degrade (because the general exports perform better than PV) but are on the rise in the other countries except Spain for the reason mentioned above.
- **National annual share of wind converter installations compared to world-wide annual installations:** Figure 10-8 finally gives the explanation why Germany has still so negative indicators for PV. Germany has the largest support programme for PV worldwide. This programme was so large that at a given point in time 65% of all installtions occurred in Germany. This brought opportunities for producers in other countries. Similar to wind energy earlier, the promotion schemes in Germany, Spain, Japan and the US are currently buying down the costs for other countries although the cost of PV is still substantially higher than for wind energy. Very special is the case of China which was able, in the absence of any home market for PV to conquer a number one position in exports. This is possibly due to the strong position of China in electronics industries. It can be expected, however, from the present planning of installations that PV installations in China will grow much more substantially in the future. Germany's share in national installations has come down but this is partially due to the already mentioned overshooting of the Spanish market. It can be expected that due to the stop on the Spanish market last year the ratio will become higher again for Germany unless the new German government operates a radical reduction in PV installations by reducing considerably the national PV promotion scheme.

Figure 10-6: Revealed Competitive Advantage (RCA) for PV exported from and imported to top performers (upper diagram) and laggers (lower diagram)

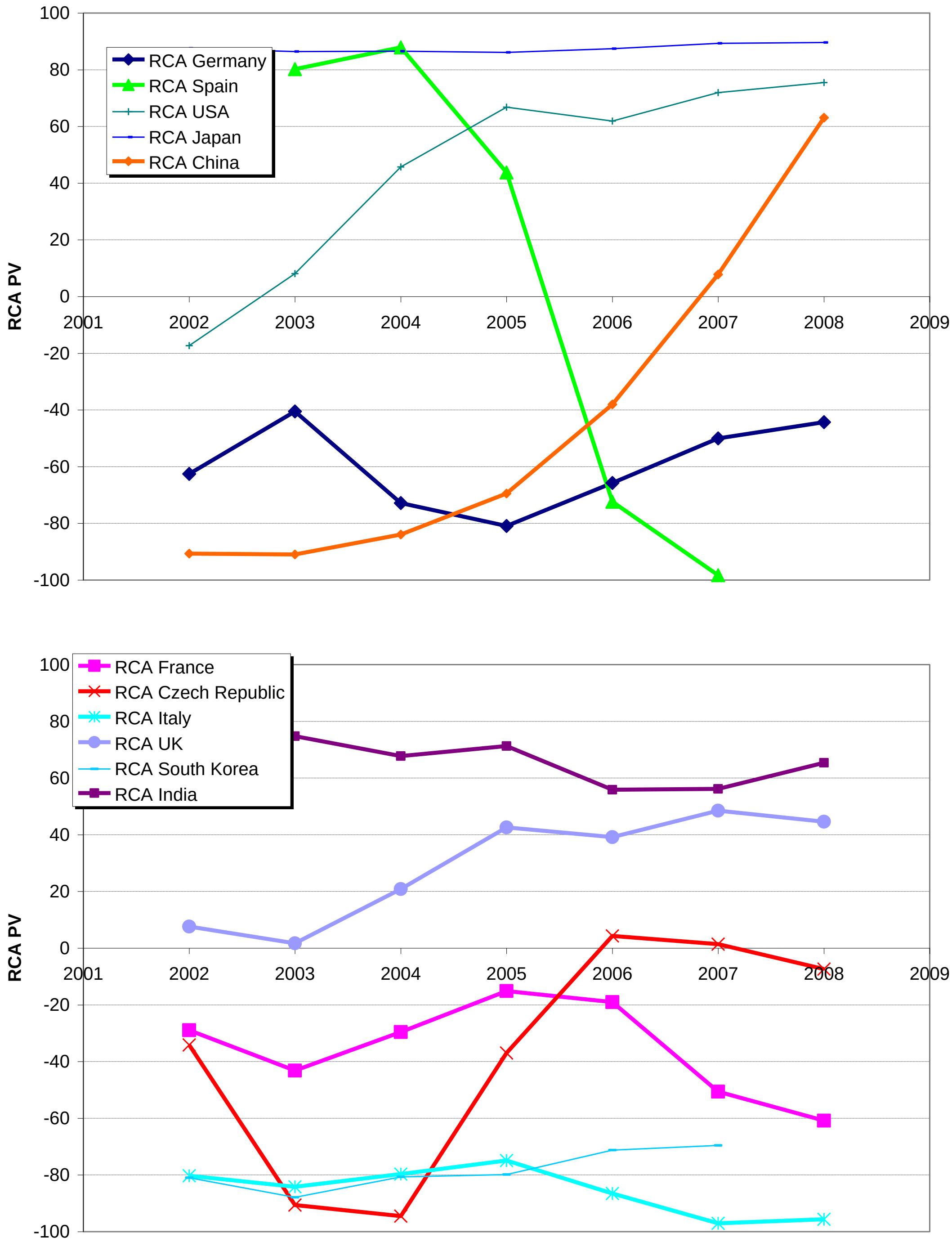
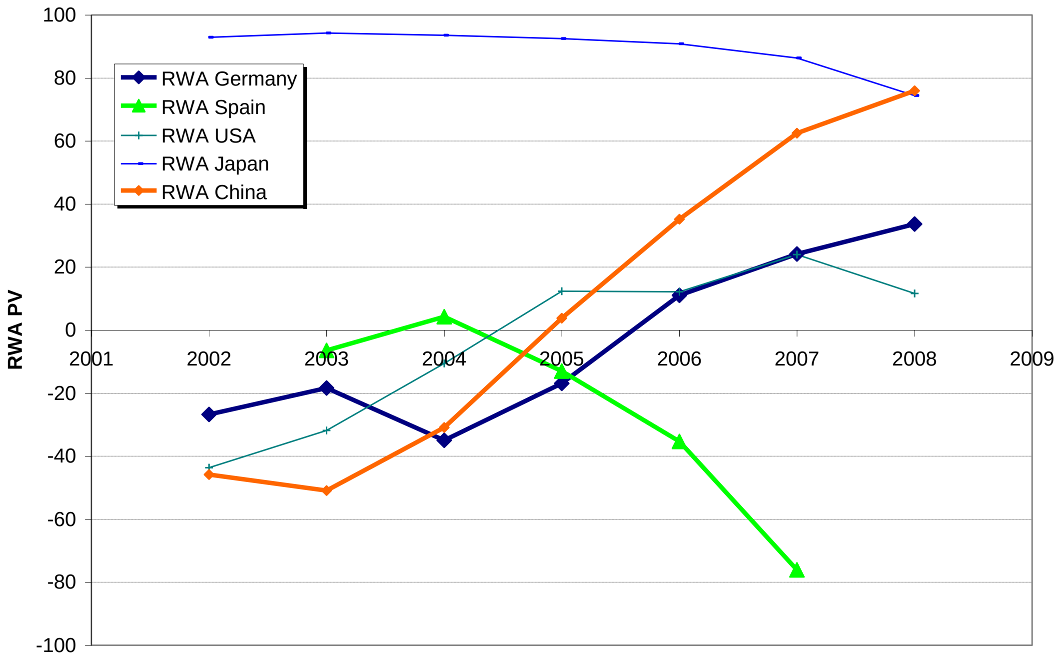


Figure 10-7: Relative World Trade share (RWA) for PV exported from top performers (upper diagram) and laggers (lower diagram)



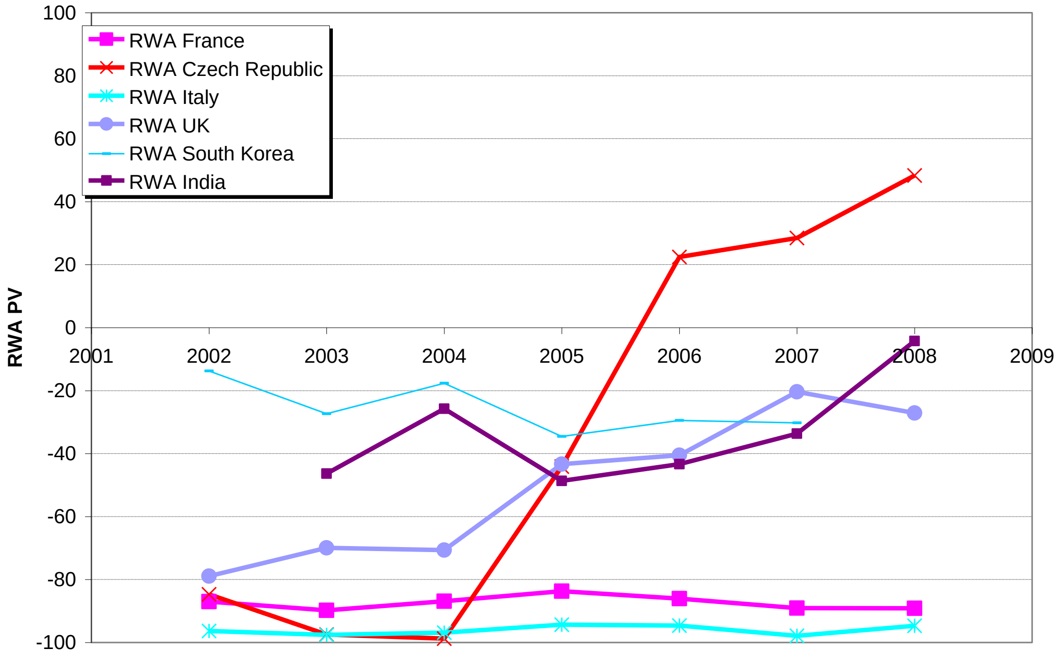
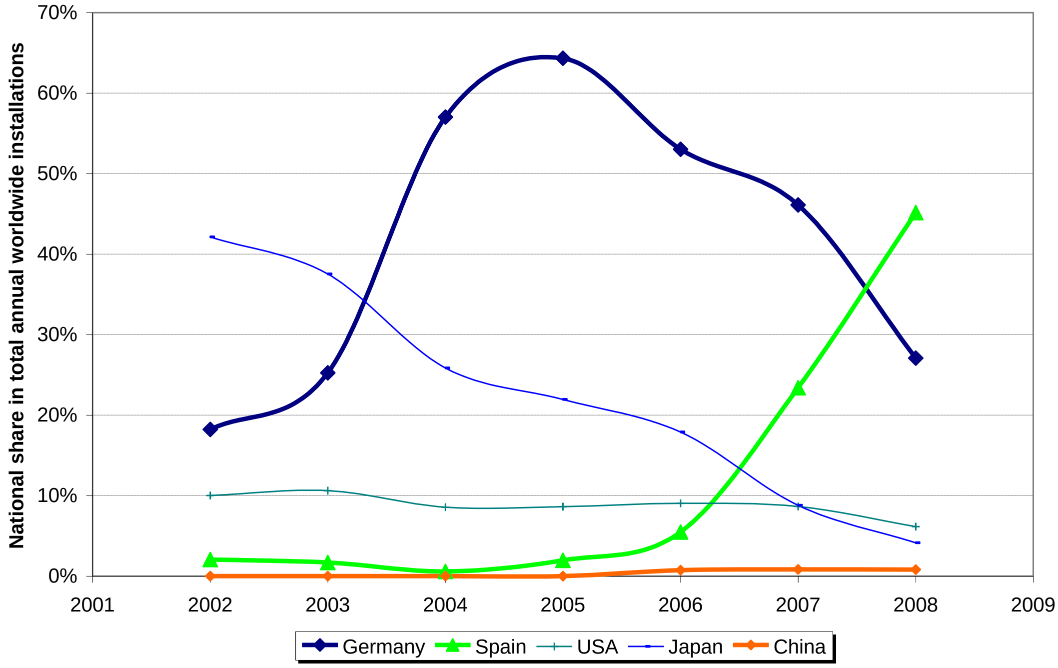
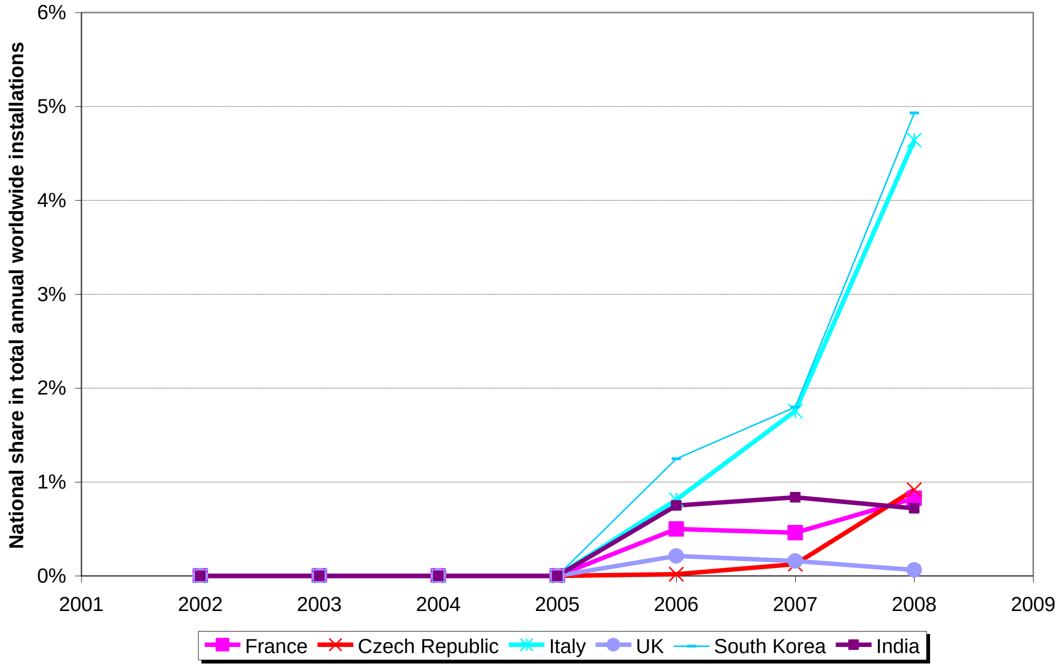


Figure 10-8: National annual share of PV installations in top performers (upper diagram) and laggers (lower diagram) compared to world-wide annual installations





10.3 Case study on small-scale CHP

Small-scale CHP is an important technology group contributing to the area of energy efficiency. We analyse each of the competitiveness indicators WHA, RCA and RWA for a variety of countries including Germany. Unfortunately, in the frame of this case study it was not possible to collect data on the installations of small-scale CHP in the different countries due to missing statistics. So the link to policies for the home market cannot be made and the interpretation of the indicators will require further work in the future. We therefore do not yet identify here groups of top performers and laggers and present results in one figure. Also, more dedicated work may be necessary to investigate whether the group of products identified contains still other products not related to small-scale CHP applications, e.g. equipment for emergency electricity generation. Figure 10-9 to Figure 10-11 tell the dynamic story of the development in the different countries:

- **World Trade Shares (WHA,** Figure 10-9**):** The market shares for the countries considered are fairly stable in the time period considered except for China where the share is strongly on the rise. Leaders in the market are the UK, US, Japan and Germany. Austria has also quite substantial market shares.
- **Revealed Competitive Advantage (RCA,** Figure 10-10**):**.Correspondingly the changes of the RCA were less dramatic than for wind energy or PV although one can clearly identify countries with positive RCA such as Austria and negative RCA such as Canada or Siwtzerland. China, India, the Netherlands and South Korea are on the increase. For the Netherlands this may be the effect of past CHP policies but the link needs to be further confirmed.
- **Relative World Trade share (RWA,** Figure 10-11**):** Also the RWA values that characterise the export performance of small-scale CHP compared to the general export performance are relatively stable although in some countries such as Denmark a degradation is observed.

Overall, it can be said that the link between policy and the development of the indicators in the field of small-scale CHP still requires further investigation and data concerning the home markets to go further in the interpretation.

Figure 10-9: World Trade Shares (WHA) for small-scale CHP exporter

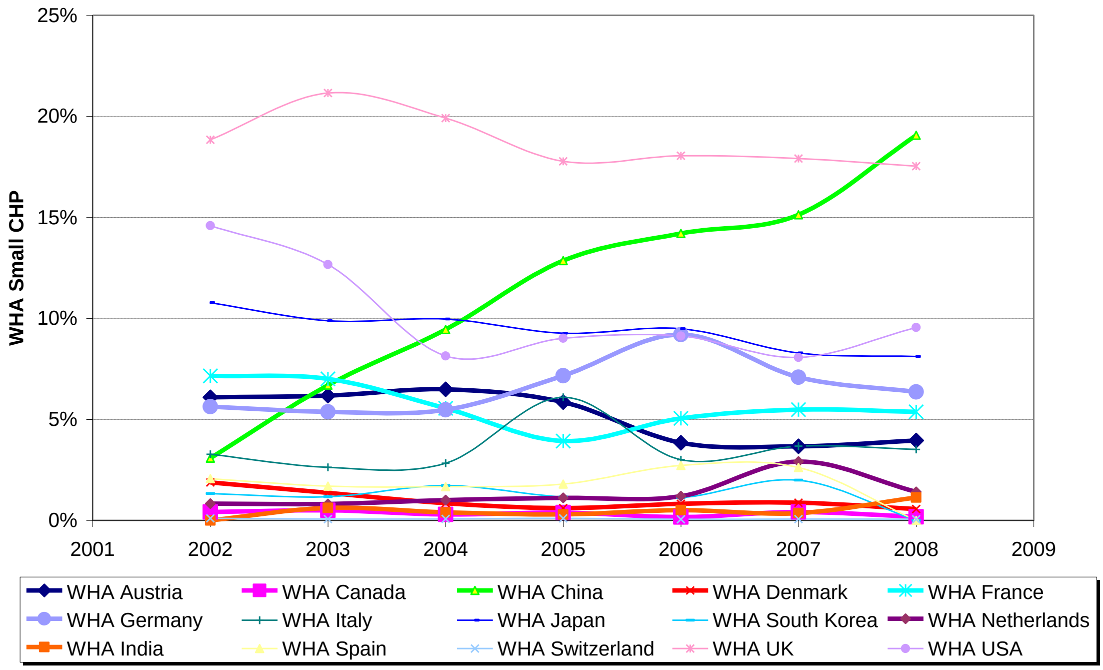


Figure 10-10: Revealed Competitive Advantage (RCA) for wind converters exported from and imported to top performers (upper diagram) and laggers (lower diagram)

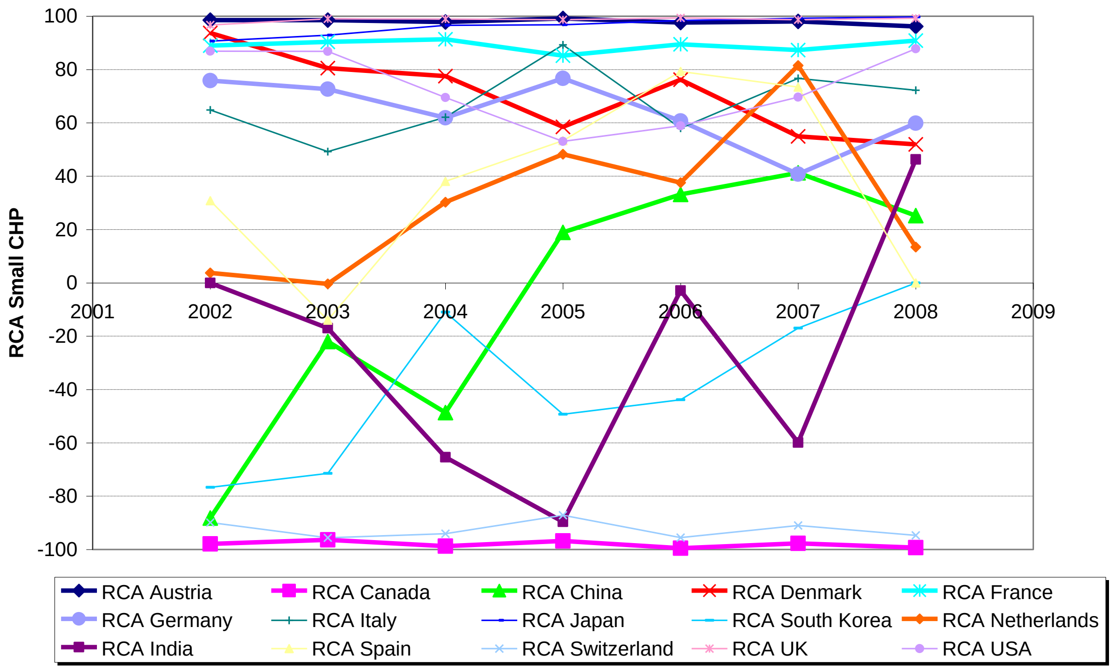
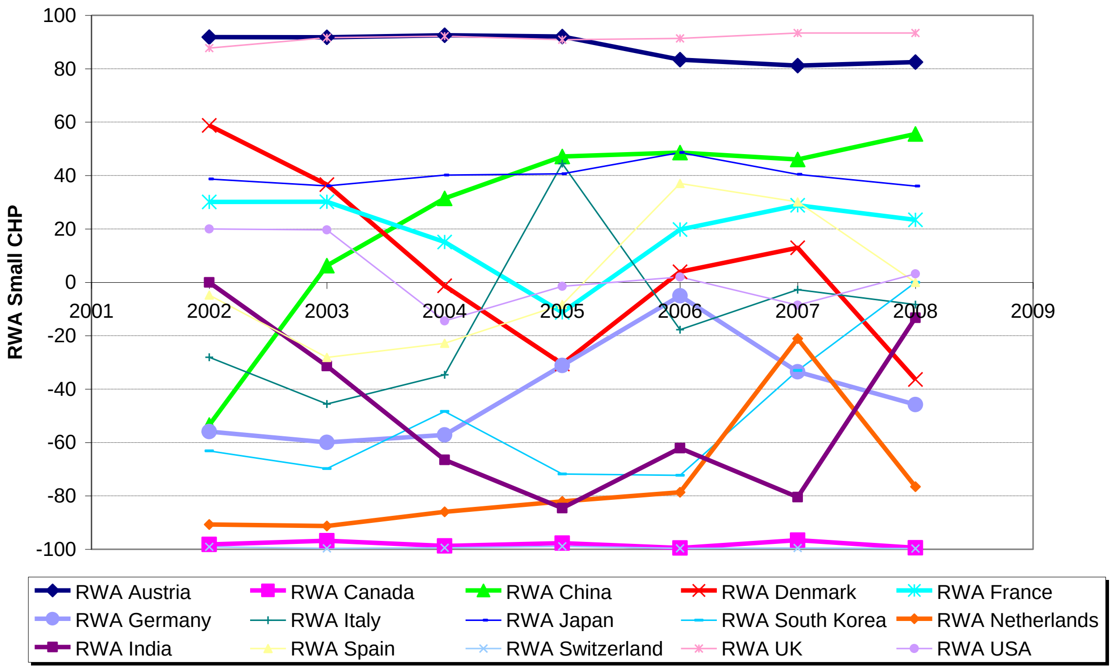


Figure 10-11: Relative World Trade share (RWA) for small-scale CHP exporters

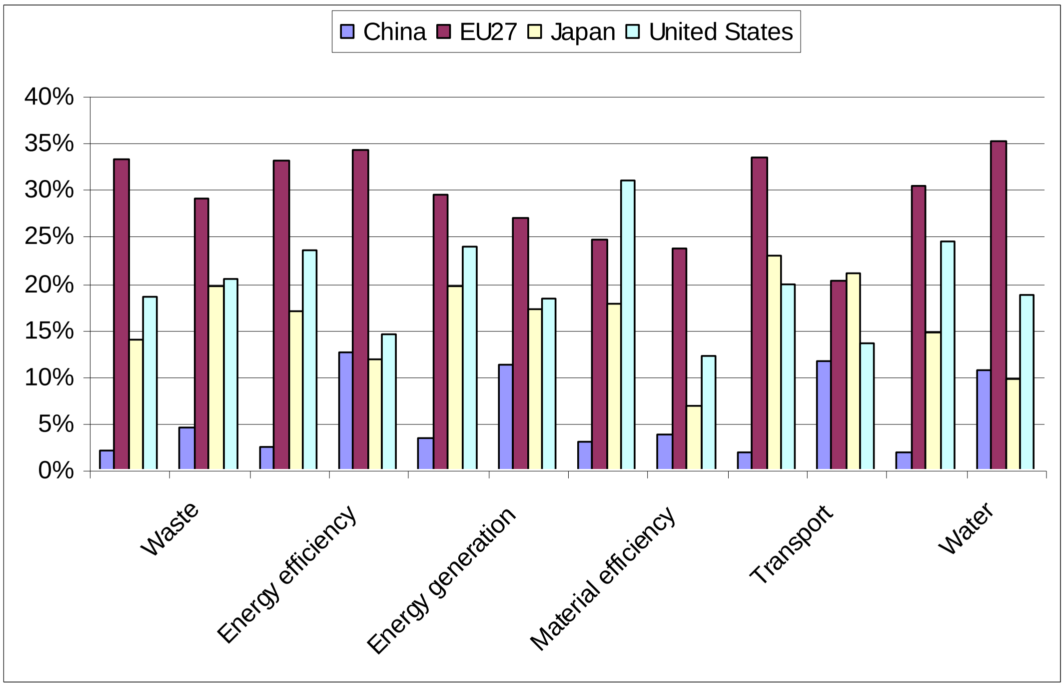


11 Outlook

The previous analyses have shown the usefulness and richness of the indicators of competitiveness and innovation when applied to fields like energy efficiency, renewables and sustainable mobility. There remain nevertheless a variety challenges which give rise to further research:

- Solving the **methodological issues** debated in chapter 5, in particular a continued effort in precisely linking patent and foreign trade statistics with the essence of technologies considered. In the case of patents this may even imply analysing the contents of the patents on a case by case basis to improve the data basis for the indicators.
- A second challenge is the aggregate presentation of the EU as a whole in the competitiveness indicators (Figure 11-1). In the patent indicators this is not a problem because it only comes to summing up the patents. For foreign trade, however, it is because one needs to **separate intra-EU effects and extra EU effects in the foreign trade indicators**.

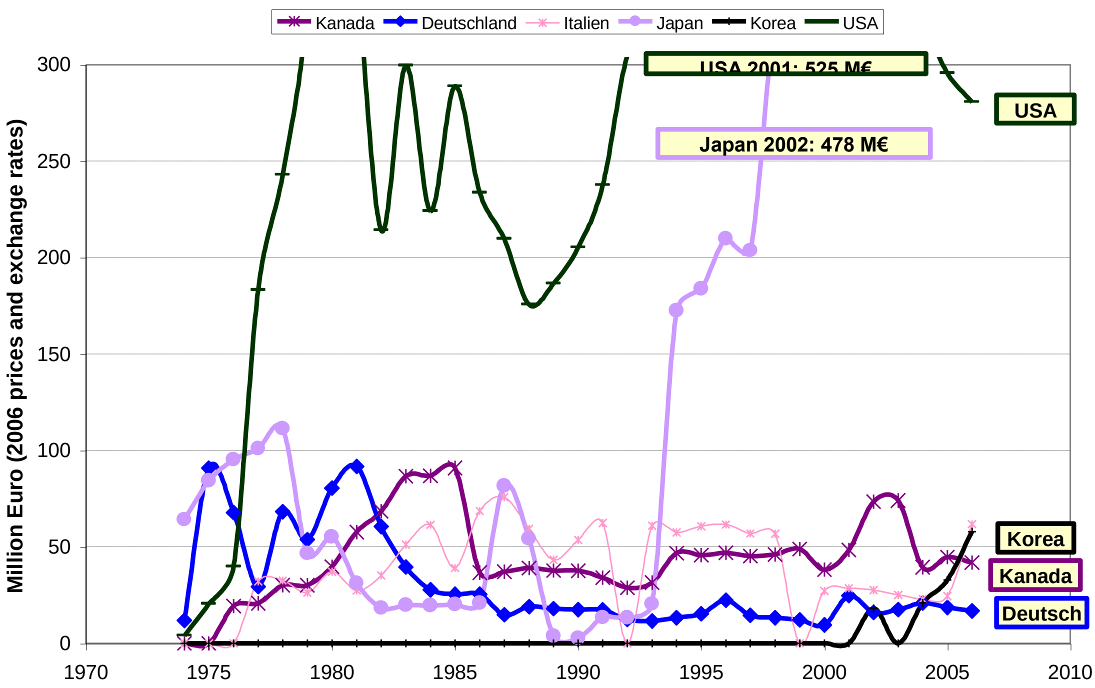
Figure 11-1: The challenge of reflecting properly the EU aggregate in competitiveness analyses



Source: ISI/Borderstep/ZTC/VDI Technologiezentrum GmbH (2008)

- An important effort needs also be made to **link the development of the indicators for competitiveness and innovation more closely to the underlying driving forces**. This is a common aim also for other indicators in the Odyssee-MURE project where one strives to explain the development of indicators in the Odyssee project with the policy developments in MURE. In a similar manner one has to link for example the development of foreign trade indicators for example to demand stimulating programmes. This was discussed in detail for wind energy in the cases of Germany and France in the report (section 10.1). However, this needs to be done much more broadly for other technologies also, in particular for energy efficiency technologies where this is more complex. A difficult area is also to link for example public R&D spending with the innovation indicators which are based on patents. In how far the public spending is influencing the development of indicators. In addition there may also be partially much larger private R&D spending that is much less well known but influences also the indicators.

Figure 11-2: Public R&D spending for energy efficiency



Source: IEA Energy R&D spendings (various years)

- Finally, as already said in section 2.2, the partial analyses presented here based on patent statistics and foreign trade needs to be complemented by a **broader analysis of the context for innovation and competitiveness**, notably the impact of aspects of the system of innovation.

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