Energy research Centre of the Netherlands

EU Standards for Energy Security of Supply

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Clingendael International Energy Programme

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Abstract

In a review process to assess the energy security of supply (SoS) for the EU and individual Member States, standards can provide a common and objective framework in EU energy policy. In particular, they could be useful in the context of the Strategic EU Energy Review as proposed by the European Commission in its recent Green Paper on EU energy policy. Standards should be based on security of supply indicators. This report elaborates the proposed concept of energy security of supply standards. It explains the role of (novel) indicators in the standards and the process for using and developing them. Also the use of SoS standards in a review process of energy supply security is elucidated. The report describes the development of two quantitative indicators that can be used in EU security of supply standards.

The first one is the Supply/Demand Index, which is based on a Member State’s energy system covering not only the supply of primary energy sources but also the conversion and transport of secondary energy carriers and the final energy demands. The S/D Index is particularly well suited for assessing today’s energy security as well as energy security in the medium and longer term. The use of this indicator is illustrated with examples for the EU-25 and for the Member States the Netherlands, Poland, Spain, and the United Kingdom. Today’s index values for these examples vary from 51 to 78, on a scale of 0 to 100. Indicative 2020 values for these five cases range from 48 to 72, based on the EC Trends to 2030 scenarios published in 2003. The S/D Index is based largely on objective information contained in energy balances combined with weighing factors and scoring rules, using existing indicators to the extent possible. The most important uncertainties are addressed by sensitivity analyses.

The second indicator is the Crisis Capability Index. With this indicator the capability of a Member State or the EU as a whole to manage and mitigate short-term supply interruptions can be assessed.

Finally, the standard includes qualitative considerations concerning the multilateral measures to secure overall producer/consumer relations and safeguarding vulnerable transport routes for oil and gas.

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Executive Summary

Increasing awareness of the EU's growing energy import dependency has put the issue of energy supply security high on the policy agenda again. The other two main goals of energy policy are facilitating properly functioning energy markets and minimising the environmental impact of energy use. These latter two goals both have an EU framework for defining and assessing policy instruments. Such a framework is largely absent for energy supply security, which, over time, has remained a national policy of the Member States. Some partial frameworks do exist, but only on an energy sector basis, such as an oil supply emergency framework and to a lesser extent for natural gas. Yet, there is no overall framework for the full energy balance.

In a 2004 study on Energy Supply Security and Geopolitics, prepared for the European Commission's DG TREN, CIEP recommended developing an EU standard for energy supply security. Such a standard, if adopted by all Member States (MS), could facilitate a more objective review and assessment of the supply security of the entire EU and the individual MS' medium and longer term energy balances. It would help to reinforce coherence and efficiency of EU and MS' energy policies through a process of consultation and coordination, while acknowledging the asymmetries among the Member States. The underlying study was performed by ECN and CIEP and aims to provide a model, based on standards, for the EU and its Member States to assess energy supply security. Based on this model the MS can discuss, review and adapt their underlying national energy policies where necessary. The standards could in time develop into a policy instrument that not only allows the MS to optimise their national energy security of supply policies, but also help streamline policy instruments among MS to produce an improved EU security level. The model could be particularly useful in the context of the Strategic EU Energy Review, as proposed by the EU Commission in its 2006 Green Paper on EU energy policy.

From a consumer's point of view it is less relevant what causes a supply shortage or supply disruption and which part of the supply chain is causing the trouble. Therefore, the starting point of this study is that an assessment of energy supply security should include all possible causes of supply shortages and disruptions and comprehend the total supply chain. Furthermore, a Member State's energy security relates to the short-term risks as well as the changes of these risks in the longer term. Such a distinction in the model is relevant because of the different types of policies concerned (e.g. emergency measures to mitigate sudden supply interruptions in the short term and fuel mix changes to reduce security of supply risks in the longer term).

The model developed in this study focuses on a process that is based on a common and objective framework for reviewing and assessing energy supply security on the basis of pre-agreed criteria. The model uses two quantitative indicators and includes some qualitative considerations:

1. The first quantitative indicator is covering full energy supply and demand balances, both present and future ones. This is the Supply/Demand Index or S/D Index.
2. The second indicator deals with the risk of sudden unforeseen short-term supply interruptions and the capability to manage them. This is the Crisis Capability or CC Index.
3. The qualitative considerations concern the multilateral measures for securing overall producer/consumer relations and safeguarding vulnerable transport routes for oil and gas.

The S/D Index covers final energy demand, energy conversion and transport and primary energy supply. It uses four types of inputs, two objective types and two types of a more subjective nature. The objective inputs concern the shares of different supply and demand types (i.e. for demand: industrial use, residential use, tertiary use and transport use; for supply: oil, gas, coal, nuclear, RES and other) and the values characterizing capacity and reliability in conversion and transport. The subjective inputs concern the weights that determine the relative contribution of

the different components in the Index (such as the relation between supply and demand outputs in the Index, or the relation between EU imports and non-EU imports) and the scoring rules for determining various Index values reflecting different degrees of perceived vulnerabilities. The use of the S/D Index is illustrated with examples for the EU-25 and for the Netherlands, Poland, Spain, and the United Kingdom. Today's Index values for these examples vary from 51 to 78, on a scale of 0 to 100. Indicative 2020 values for these five cases range from 48 to 72, based on EC baseline scenarios published in 2003. The examples are based largely on objective information contained in energy balances combined with weighing factors and scoring rules, using existing indicators where possible. The most important uncertainties are scrutinised by some sensitivity analyses.

The Crisis Capability Index combines the risk of a country to be confronted with sudden supply interruptions and its potential impact (the Risk Assessment, RA) and the capability of that country to manage and mitigate these impacts (the Mitigation Assessment, MA). Each country is invited to make its own RA and MA on the basis of a checklist with some simple scoring values. If RA is higher than MA, the CC Index gets a value of less then 100. The study did not develop any further examples for this Index. The qualitative factor is dealing with multilateral policies and makes a distinction between the willingness of a MS to participate in multilateral approaches and programmes and its capabilities to follow through on these intentions. Here again, the Member State is invited to develop a policy document with these two elements, in which all kinds of energy diplomacy dealing with producer/consumer relations is discussed, together with participations in joint projects supporting these relations. A more controversial element might be the actions of a more military nature, securing vulnerable transport routes of oil and gas.

Finally, one could consider combining the S/D Index and the CC Index into an EU Security of Supply Index (SoS Index). This could be done by simply aggregating the two outcomes, either by giving them similar weights or not. This SoS Index would then result in a value on a 0-100 scale, leaving room for arguing about a value for an EU standard. In such a political process, one could take account of the qualitative multilateral actions as well.

If the SoS Index (or the S/D Index and CC Index individually) is used in a process to assess the security of energy supply in the EU and individual Member State, the indicator can evolve into a benchmark and ultimately into a criterion indicating a minimum level of energy supply security or a policy target for a level of energy supply security in the future. The Security of Supply Index is then used as a measure to indicate a desired state and has become the Energy Security of Supply Standard.

Four final comments should be made:

1. Firstly, companies and consumers will remain primarily responsible for the (short-term) security of their own energy supplies, making sure that they invest and contract for energy in a timely manner. Governments are responsible for national energy balances and fuel mixes. The use of a shared framework for assessing the energy situation in MS will also uncover the impact of national policy choices on the EU energy market.
2. Secondly, it is important to stress that compatibility and compliance with existing emergency arrangements and commitments under the IEA Treaty remain part of this proposed policy review and assessment process.
3. Thirdly, the use of standards for security of supply provides a tool that allows for explicitly addressing trade offs between security of supply, mitigation of (CO_2) emission and cost.
4. Lastly, if the EU wishes to embark on a review process based on standards, it is recommended that the whole process be provided with a legal basis that would set procedures, define inputs and data, determine responsibilities and boundary conditions and procedures and periodicity. Such a legal basis could help to maintain the required level of compatibility and transparency and is perhaps best structured in a Council regulation.

1. Introduction

The increasing import dependency in the European Union (EU), the growing concentration of oil and gas supplies in a limited number of net-exporting countries/regions in the world and the growing competition among consuming countries for scarce supplies has put security of energy supply high on the political agenda again. This change in the international energy balances has raised concerns in the EU because the energy markets of the EU Member States (MS) are at the same time involved in a process of liberalisation and making the energy balances more environmentally sustainable. Security of supply concerns are matched by security of demand concerns in producer countries. Debates among producer and consumer countries focus on required levels of investments, market access and diversity of demand and supply. Current investment, market and regulatory uncertainties have recently resulted in a switch from a buyer's to a seller's market, further emphasizing the security of supply fears in consumer countries.

The competency of the EU in energy policy-making does not cover all three main goals, i.e. the market, the environment and security of supply. Both the internal energy market and the environment policies are based on a EU policy framework. Such a policy framework is nearly absent for security of supply, where the MS have largely maintained their national competence or have agreed to share their competence in the International Energy Agency (oil market emergencies).

Security of energy supply policies or policy initiatives are characterized by the fuel-by-fuel and top-down approaches often proposed by the European Commission (EC). The history of energy policy-making in the EU entails a large series of attempts to formulate an EU-wide energy policy, including security of supply (Van der Linde and Lefeber, JWT 1988). The existence of two sectoral treaties (ECSC and Euratom) have further emphasized the sectoral and top-down approach, thus preventing the capture of synergies and efficiencies in combining the strengths of different policy approaches. Particularly the development of the internal gas and electricity market will stimulate more bottom-up approaches among increasingly integrated neighbouring and integrated regional markets within Europe. These spontaneous developments can efficiently be used to improve EU energy policy-making and translated into a certain standard of Security of Supply (SoS). Such a standard would improve transparency and confidence among the MS in each other's energy policy-making.

In the study on 'Energy Supply Security and Geopolitics' which was prepared for the European Commission's directorate for transport and energy (DG TREN), CIEP recommended developing standards for EU and Member States (MS) energy supply security because "more efficient, more flexible and tailor-made choices for Member States and their specific energy security needs and their specific dependencies are possible." (CIEP, 2004, p.27) Such a standard would allow for an integrated and bottom-up approach to energy security rather than the fuel-by-fuel and top-down approach prevailing in current energy policy-making. Rather, the use of standards could help overcome the lack of a common security of supply framework because it creates transparency about national energy balances, exposure to certain risks and the policies that attempt to avert these risks at a national level. Thus, it could show the MS the advantages of cooperation and perhaps harmonisation of certain security of supply policies. Until now, these discussions were immediately set in a context of transferring competency to the EU level. Instead, the standards could facilitate the review and assessment of the supply security of the entire EU's as well as MS' individual medium and long-term energy balances. Such a review process has recently been proposed in the Commission's Green Paper (EC, 2006).

In the last two years ECN has published several studies in the field of quantifying supply security aspects (Jansen et al., 2004; Scheepers et al., 2004; Van Werven et al., 2005; Van Oostvoorn (ed.) 2003; Kessels and Bakker, 2005). Based on this earlier work, in July 2005 CIEP and

ECN were invited by the Dutch Ministry of Economic Affairs to further elaborate their ideas on a system of energy supply security standards. In October 2005, CIEP and ECN presented an outline for the development of such a system and the ministry subsequently commissioned CIEP and ECN to carry out this study, which should include both the standards as well as the procedures to implement them. The objective of the development of security of supply standards is to reinforce the coherence and efficiency of the EU and MS' energy policies through a process of consultation and coordination between MS and the European Commission on the basis of a set of agreed upon standards.

This study aims to provide an instrument to help the EU and MS shape and adapt their energy policies with a view to supply security. More particularly, it could be a useful instrument to realize the Strategic EU Energy Review as proposed by the EU Commission in its recent Green Paper on EU energy policy (EC, 2006). This is further discussed in Section 2 of this study. Section 3 then elaborates on the proposed concept of energy security of supply standards. It explains the role of indicators in the standards, followed by a description of the process for developing them. Moreover, the use of SoS standards in a review process of energy supply security is elucidated. The model that has been developed for the Supply/Demand Index (S/D Index) by which the medium and long-term security of supply can be assessed is presented and discussed in Section 4. In Section 5, the use of the S/D Index is illustrated with some examples. Section 6 discusses the other indicator to be used in SoS standards: the Crisis Capability Index, while Section 7 continues with the more qualitative issue of multilateral action. The study concludes with some final remarks in Section 9.

The Appendices A to C provide additional details on the S/D Index model, its data and quantification.

2. The EU context

The recent Green Paper from the EU Commission is again drawing attention to the fact that energy import dependencies for the EU as a whole are increasing. The increasing import dependency has contributed to the recent elevation of energy on the political agenda of both the EU and the MS. Figure 2.1 gives an indication of these developments, with overall energy import dependency rising as much as up to 60% in the next 25 years.

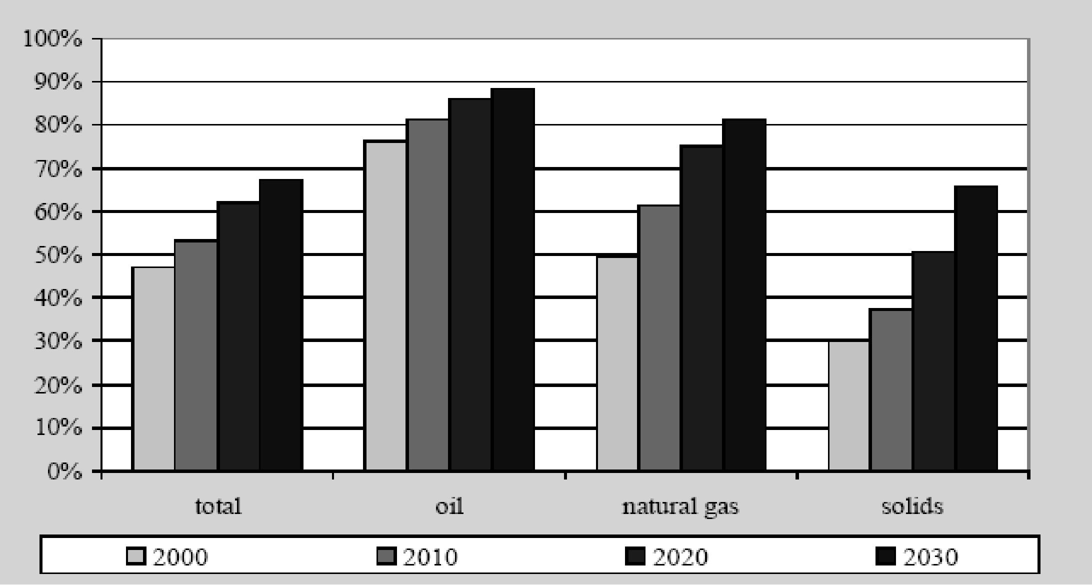

Figure 2.1 *EU energy import dependencies*
Source: Green Paper, EC (2006).

Taking a closer look at the various elements of the EU's energy policy, a number of observations can be made. EU energy policy basically has three objectives, i.e. securing energy supply continuity, securing properly functioning energy markets and promoting energy efficiency, energy savings and the promotion of new and renewable energy sources. This latter objective must also be seen in the context of the environmental impacts of energy production and energy consumption. Two of these three objectives are based on a more concrete setting and legal framework. EU energy markets find this setting not only in the EU Treaty itself and its articles on competition, but also in the 2003 Energy Directives and its further implementing building blocks. The same can be noted for the environmental policy setting, with the Kyoto commitments and the ETS as major implementing devices together with various directives and EU policy instruments for regulating emissions, energy efficiency and renewable energy.

It should be noted that, so far, a consistent set of instruments for the overall energy supply security, as well as a procedure for consultation and discussion is absent. On a sector basis there are some important legal and policy commitments, such as for an oil supply emergency and to a lesser extent for natural gas. However, an overall framework for the full energy balance is lacking. It would therefore be appropriate to consider developing a framework in order to effectively assess supply security policies for the EU as a whole and to improve their consistency and coherency with the other two main objectives of EU energy policy without immediately having to address the competency issue. The recent EU Green Paper seems to propose such a framework with its Strategic EU Energy Review. This review would "offer a clear European framework for national decisions on the energy mix, analysing advantages and drawbacks of different sources of energy…. and the knock-on effects of these changes for the EU as a whole."

Standards could be a useful instrument for this EU policy review process because it can found the process on a common and objective framework of analysis. National policies could be assessed using common pre-agreed criteria in the context of an overall outcome for energy supply security. The process would take place on a country-by-country basis, where each MS should use the standard reporting for their national situation. Outcomes then should be assessed in a common peer process, not only for the Member States concerned but also for their impact on the EU as a whole. The process could then lead to policy adjustments and if needed or desired, be guided by quantitative targets. Though the standards for supply security will basically focus on energy supply issues, it will be possible to link them to environmental standards as well, such as CO_2 emission reduction targets.

Security of Supply (SoS) standards can be based on quantitative indicators reflecting the energy supply security situation of the EU and its Member States. This study describes the development and use of a security of supply indicator that is based on a MS' or the EU's supply and demand structure and can be used for assessing today's energy security as well as energy supply security in the medium (10 years) and longer term (20 years). Furthermore, in a review process the capability of the EU and Member States to accommodate short-term supply interruptions can also be included in the assessment. Therefore, SoS standards should include a Crisis Capability indicator that can be developed in a similar way as the Supply/Demand indicator, but that is based on other attributes.

3. The concept of energy supply security standards

3.1 Energy Supply Security Risks

A security of supply risk refers to a shortage in energy supply, either a relative shortage, i.e. a mismatch in supply and demand inducing price increases, or a partial or complete disruption of energy supplies. The supply shortage or disruption affects the energy consumers that were supposed to receive the supplies. From the consumer's point of view it is less relevant what causes the supply shortage or disruption and which part in the supply chain is giving the trouble. Therefore, a review of energy supply security should include all possible causes of supply shortages and disruptions and comprehend the total supply chain.

Security of supply risks can be managed in the short term and the long term. A sudden shortage in energy supply or disruption can be overcome by measures such as emergency stocks, fuel switching, demand rationing and reserve capacities. The probability of an energy supply risk and the impact on economy and society depends to a large extent on the structure of the energy system (fuel mix, origin of primary energy sources, energy transport infrastructure, conversions into secondary energy, energy demand, etc.). Changes in the energy system structure will influence a Member State's security of supply risk, i.e. in the future the probability and impact of a sudden shortage can be different from today. A review of a Member State's energy security should relate to the short-term risks as well as the changes of these risks in the longer term.

3.2 The Standard

In an EU energy policy SoS indicators can be used as a measure to indicate a desired state. This desired state could be determined for individual Member States or the EU as a whole. Through the normative use of a SoS indicator, it becomes a SoS standard. In an EU SoS policy, standards can be used to discuss, review, assess and where necessary adapt, the energy SoS of individual MS. The SoS standard is used as criterion or benchmark for assessing the security of energy supply in the EU and individual MS. Such an SoS standard can, for example, indicate a minimum level of energy supply security of an individual EU Member State relative to the average level of security of supply of all EU Member States. In this way it can be used to stimulate Member States with a relatively poor energy supply security situation to implement additional policy measures. Another option is to use the standard as a policy target for a future situation compared to a historical situation. The EU can for example decide that the level of SoS in the future should not become lower than the level of SoS in the past. In contrast with these relative approaches, the SoS standard can be used in an approach where an absolute value for the SoS standard is determined on the basis of a cost-benefit analysis. In case of a supply crisis, the social costs (e.g. high energy prices, loss of economic growth etc.) will become high if the level of SoS is poor. On the other hand, increasing the SoS level will also imply costs. An optimal SoS level can be determined by the balance of, on the one hand, the estimated avoided social costs and the risk of a supply crisis and, on the other hand, costs for enhancing SoS (Mulder, 2003).

3.3 The Process

The concept proposed here is one that is focussing on a process, i.e. a process for a strategic EU policy review, for discussion, evaluation, assessment and review adaptation wherever necessary. A process, moreover, which is based on a common and objective framework where national policies could be assessed using shared pre-agreed criteria in the context of an overall outcome for energy supply security. The concept consists of two quantitative indicators and some qualitative considerations. Because demand and supply structures cannot be changed overnight, one quantitative indicator is dealing with the energy demand and energy supply structure in the medium and longer term (the Supply/Demand Index or S/D Index). The other indicator deals with the capability of an energy system to manage short-term interruptions (this is the Crisis Capability Index or CC Index). The more qualitative considerations include securing long-term supplier/consumer relations between different states by effective energy diplomacy, participation in joint projects on political, economic and energy cooperation and joint actions to protect and safeguard vulnerable transport routes for oil and gas. Willingness and/or capability of a Member State could be included as a notion for participation in these multilateral actions.

The two quantitative indicators, the Supply/Demand Index and the Crisis Capability Index, will be based on a number of objective and subjective criteria. This is discussed in more detail for the S/D Index in Section 4 and in Section 6 for the CC Index. In order to use the two quantitative indicators, a procedure should be followed that consists of two phases. In the first conceptual phase, EU Member States will discuss the different quantitative factors on which the indicators are based. Both indicators can be used in separate standards for medium and long-term energy supply security and for crisis capability. Alternatively, both indicators can be combined into one SoS Index (with a certain weight for each indicator) and be used in one SoS standard. In this phase, the impact of the more qualitative considerations could also be examined. This conceptual phase will be characterised by negotiations with political and policy-oriented considerations resulting in the establishment of the SoS standard(s) as a new policy instrument.

In the second operational phase, the new tool will be applied and used in a review process. The SoS standard(s) can be used at the EU level, for EU Member States individually, but also to assess the supply security situation for a sub-region of a few EU Member States. Both the current energy supply security as well as future situations using energy scenarios such as the EU Trends to 2030 can be assessed (EC, 2003). Moreover, specific policies can be assessed with use of the SoS standard(s), for example: can the supply security be improved by a certain change in fuel mix? Such a 'what-if' type approach can be done both on a national and on a European level. It is in this phase that the SoS standards could be applied in the context of the wider EU Strategic Energy review, as announced in the Commission's Green Paper.

However, it is stressed that companies and consumers will remain primarily responsible for the (short-term) security of their own energy supplies, making sure that they invest and contract for energy in a timely manner. Governments are responsible for national energy balances and fuel mixes. The use of a shared framework for assessing the energy situation in MS will also uncover the impact of national policy choices on the EU energy market. Moreover, it is also important to stress that compatibility and compliance with existing emergency arrangements and commitments under the IEA Treaty remain part of this proposed policy review and assessment process.

Lastly, if the EU wishes to embark on a review process based on standards, it is recommended that the whole process be provided with a legal basis; a basis that would set procedures, define inputs and data, determine responsibilities and boundary conditions and procedures and periodicity. Such a legal basis could help to maintain the required level of compatibility and transparency and is perhaps best structured in a Council regulation. The Commission could set the values that are employed after a comitology procedure. But again, before starting a process of legalising the idea, an in-depth consultative process is recommended, where various inputs, attributes and rates are analysed and tested.

4. The Supply/Demand Index

4.1 Security of Supply Indicators

Quantitative indicators describing energy supply security are often focusing on the energy supply of one or several primary energy sources (Jansen et al., 2004). An assessment of energy supply security should however also include energy demand. Energy security may be affected by strong increase of energy demand due to economic growth, whereas energy-saving policies may improve the energy security situation. Furthermore, the end-use of energy is to a large extent based on secondary energy carriers such as electricity, transport fuels and heat. The supply security of end users also depends on the capacity and reliability of energy conversion installations (e.g. power stations, refineries, etc.) and energy transmission and distribution networks.

The S/D Index for review and assessment of energy security of supply in the medium and longer term should therefore include all three parts of the energy system: final energy demand, energy conversion and transport and primary energy supply.

4.2 The S/D Index Model

For the calculation of the S/D Index a computer model has been developed including a database for input parameters. The model represents the energy demand and supply structure of an EU Member State, the whole EU or a sub-region of the EU. Figure 4.1 shows the model structure. Transparency of the model is essential for the discussions in the conceptual phase (see Section 3.3). Therefore, on the one hand sufficient relevant aspects have been included, but on the other hand the development of a too complex model has consciously been avoided.

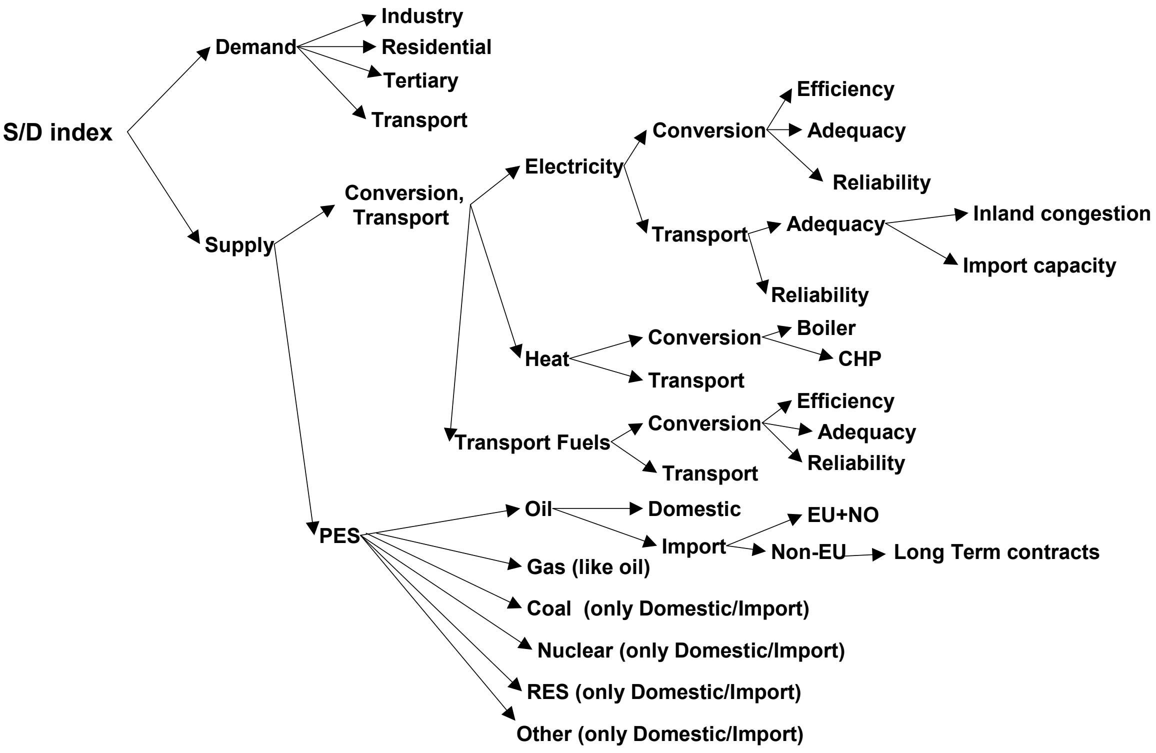

Figure 4.1 *The Supply/Demand Index Model Structure*

The S/D Index Model uses four types of inputs:

1. *shares* of different types of supply and demand,
2. *values* characterising capacity and reliability,
3. *weights* determining the relative contribution of different branches of the model,
4. *scoring rules* determining the index value of each individual aspect contributing to the S/D index.

The first two types of inputs are objective and based on physical parameters of the energy system. Shares have been used for energy demand and for primary energy sources, resulting from the energy balances. These can be taken from statistical data or scenario forecasts. The values used are further explained for demand in Section 4.3, for primary energy sources in 4.4 and, for conversion and transport, in 4.5. The latter two, weights and scoring rules, are of a more subjective nature and based on expert judgement. Weights are used for the relations between the supply and demand outputs and for the relations between conversion & transport and primary energy sources. In addition, a weight factor has been given to the relation between long-term and short-term non-EU imports for oil and gas. The weights parameters have been approached in relation to the perceived vulnerability: more weight with increasing vulnerability. Scoring rules are also further explained in Sections 4.3, 4.4 and 4.5 and in Appendix A. All these parameters can be varied to a certain extent and will be subject of discussion in the conceptual phase. However, one should realize that the degree in which parameters can be varied is limited by rational argumentations. In Section 5.3 a sensitivity analysis is therefore discussed showing to which extent differences in expert judgement can influence the S/D Index.

Each individual aspect used in the model (i.e. at the end of the branches) will have an index value between 0 and 100. The next sections discuss in more detail the calculation method of the individual indexes for each of the three parts of the model (energy demand, conversion and transport, primary energy sources). Default values for weights determining the relative contributions of the individual index values to the overall S/D Index are listed in Figure 4.2. Objective shares are coloured in red, and subjective weight factors are coloured in blue.

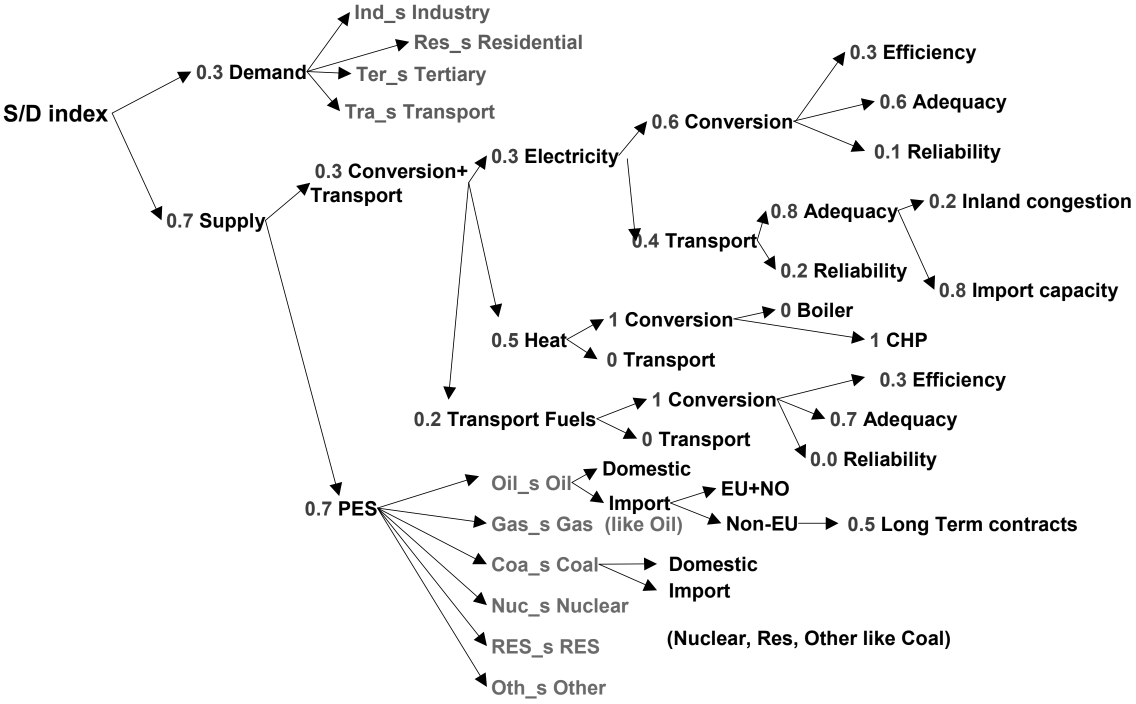

Figure 4.2 *Weights (defaults) and shares used in the Supply/Demand Index Model*

4.3 Essential Energy Demand Needs

As explained above the S/D Index Model takes into account the final energy demand, i.e. the amount of electricity, heat and transport fuels used by energy consumers. For assessments of energy supply security in the future the energy demand in a business-as-usual scenario could be used in the model. However, the index should in particular value the degree in which the energy demand is kept as low as possible, i.e. the energy demand level should be compared to the 'essential energy demand needs' warranted by the energy supply. As parameter to indicate the essential energy demand needs the energy intensity factor has been chosen. Energy intensity, either in terms of energy used per capita or per € GDP is gradually declining over time, both EU-wide as well as in most Member States. It is an indication of increasing energy efficiency, a trend that is expected to continue in the future (see Figure 4.3). This factor could also be regarded as an indicator for the effect of continuing energy conservation programmes.

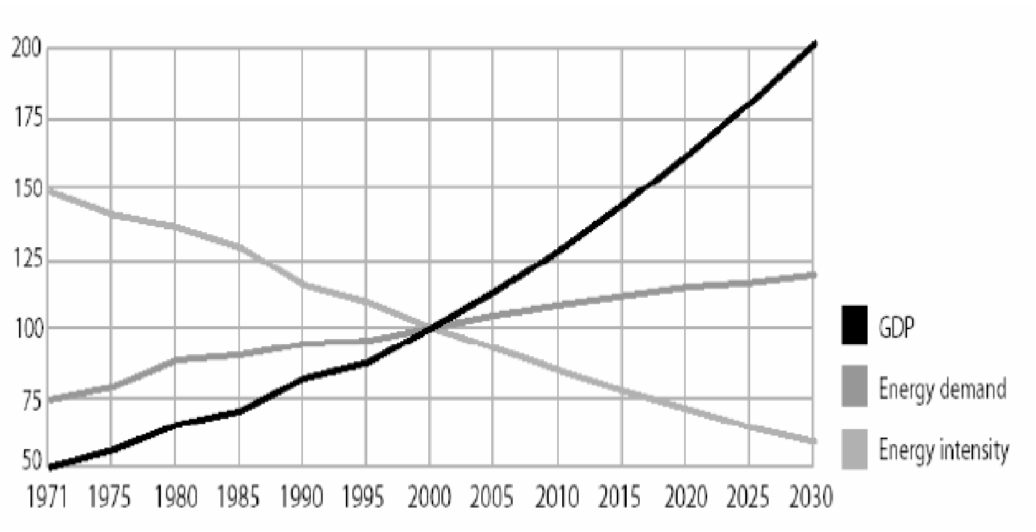

Figure 4.3 *Long term EU development of GDP, energy demand and energy intensity (2000=100)*

Source: (EC, 2006).

The S/D Index Model uses four energy intensity factors to allow for differences in Member State demand structures:

1. Energy intensity of the residential sector (ton-oil-equivalents/capita).
2. Energy intensity on added value for the industrial sector (ton-oil-equivalents /M€).
3. Energy intensity on added value for the tertiary sector (ton-oil-equivalents /M€).
4. Energy intensity for the transport sector (ton-oil-equivalents /M-ton-km for goods and ton-oil-equivalents /M-passenger-km for passengers).

For the essential energy demand needs benchmark values are used per energy demand sector. The benchmark is the average figure of energy intensities of the 5 best performing EU Member States. Corrections are not made for climate differences (residential sector), differences in energy intensive industries (industrial sector) and population density (transport sector), because the index should indicate the vulnerability of energy demand sectors for energy supply constraints. It will also keep the model simple and more transparent.

The index value for each energy demand sector is calculated from the ratio between the EU's or Member States' energy intensity and the benchmark figure. Weighing the four sectoral indices with the shares of each demand sector relative to total final energy demand results in an index value for energy demand.

Some consideration could be warranted for alternative approaches, such as using Kyoto commitments or energy conservation targets as a reference for essential energy demand needs. With Kyoto, it is possible to determine total energy demand based on fossil energy supplies. There would be some political advantage as these commitments are the product of a wider and more global negotiated context, but they would have to be supplemented by a factor for non-fossil fuels. This could be done on the basis of production targets for renewable energy and, where appropriate, for nuclear energy. Moreover, the development of CCS (Carbon Capture & Storage) would bring additional complexities. The other idea would be to use targets for energy conservation, which would cover all energy demand and make no difference as to how it is met by supply. Using targets in the two alternatives would create numerous flaws based on a variety of interpretations and definitions. Therefore, due to these many practical limitations, the energy intensity approach is the preferred one.

4.4 Primary Energy Sources

For assessing the security of primary energy supply, the S/D Index Model distinguishes a number of factors:

- Domestic primary energy production versus imports from other EU Member States.
- Imports from the EU (including Norway[1]) versus imports outside of the EU.
- Imports from outside of the EU warranted by long-term contracts versus short-term contracts.

It could be argued that in terms of energy supply security no distinction should be made between domestic energy supplies and those coming from other EU countries, since the internal market should assure non-discriminatory trade and respect of import contracts. However, it has to be noted that political and public perceptions differ from formal legality. As a consequence, for instance, questions are raised whether existing import contracts for gas or power should always be honoured, even in times of immediate shortfalls. Although in response to these questions politicians assured not to interfere in existing contracts when there are short-term supply interruptions, the model allows for making a slight difference in rating supply relations that are purely national versus those that are intra-EU based.

Energy trade relations for imports from outside the EU will also be based on contracts, i.e. on the rule of law, and sometimes on multilateral or bilateral treaties. EU energy imports are basically covering crude oil, oil products, gas (including LNG), coal, uranium and renewables (mainly biomass). It would seem that the last three energy sources do not ask for a specific assessment because of a sufficiently diverse supply base from a number of secure sources. With respect to oil and gas the S/D Index model distinguishes between import from EU Member States and supply from outside the EU. This does not only arise from heavy geographic concentrations of these energy sources, but also from the increasing awareness of geopolitical concerns that are adding to supply risk perceptions. Although several methods are available allowing for differences in geopolitical circumstances in supply regions, it was decided not to make further refinements in this respect, because of the poor data availability on future supply origins and in order to avoid a too high degree of complexity. On the other hand, it could be argued that oil and gas supplies based on long-term contracts will give higher assurances of interrupted supply in comparison to short-term contracts. Oil and especially gas that is coming from areas where national oil or gas companies together with international energy companies have made some heavy long-term investments, and thus have created strong economic interests in secure and reliable long-term energy flows, could be considered as more secure because it is mitigating supply risks for consumers and demand risks for producers. These contracts usually have some re-

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[1] Norway is since 1994 legally committed through the Agreement on the European Economic Area (EEA) to apply the EU's energy market rules. This being the case, there is no reason to treat energy imports from Norway different from imports from within the EU.

lation with government involvement, possibly as part of multilateral actions as described in Section 7. Therefore, the model allows for this type of differentiation.

The factors above are included in the calculation of the index for primary energy sources. For the six primary energy sources the following calculation rules apply (see also Figure 4):
- Nuclear energy will have a value of 100 irrespective of the supply origin because supply risks for uranium are relatively low.
- Because coal, renewables (mainly biomass) and other energy supplies will be sufficiently diversified, the index has a minimum value of 70 if the total supply is imported and will increase proportionally with decreasing imports. Some may argue that coal is at least as good for the security of supply as nuclear; in that case the minimum score for coal would be 100. In the case for the Netherlands, a specific sensitivity analysis has been performed and reported in Appendix C.
- The index for gas and oil will be zero until the net share of domestic supplies exceeds a level of 30%. Above this level the index will increase proportionally with increasing domestic supplies. The threshold of 30% will become lower when the share of long-term contracts in non-EU imports increases (i.e. in Figure 4.4 the point of intersection of the gas/oil line with the x-axis will move to the left).

The index value for primary energy sources is calculated on the basis of the index value and the relative share in the total primary energy supply of each of the primary energy sources.

It should be noted that the establishment of the minimum levels mentioned above are also part of the conceptual phase of the process for a strategic review. The levels reported here should be considered as illustrative. Section 5.3 presents sensitivity analyses that include changes to these levels.

From a supply security perspective it could be argued that the domestic energy reserve situation should be included in the S/D Index. An adequate energy resource management may be a contributing factor to a Member State's energy security. Furthermore, if a Member State makes natural resources available for other EU Member States the energy supply security of the EU will benefit. However, including energy reserves and resource management policies will result in a higher complexity and less transparency of the model. Alternatively, national energy reserves and resource management policies may become visible in the S/D Index when the model is used in a scenario approach with different time frames (see also Section 5.2).

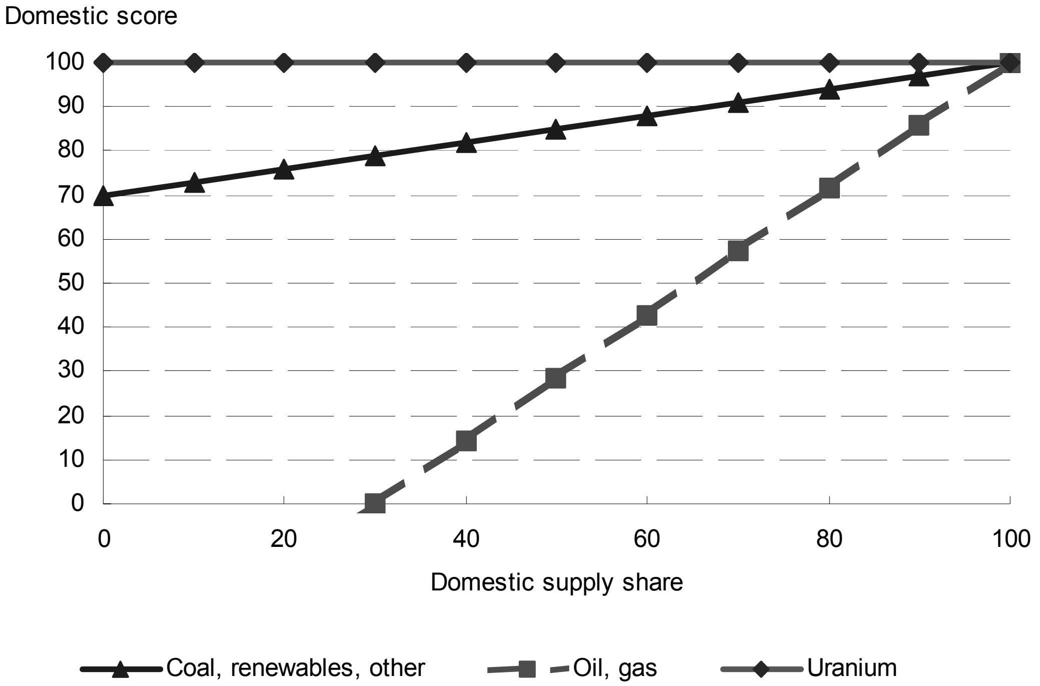


Figure 4.4 *Index values for primary energy sources as a function of the net share of domestic supply*

4.5 Energy Conversions and Transport

Whether final energy demand can be covered by primary energy sources depends on the adequacy and reliability of energy conversion and transport infrastructures. The S/D Index Model distinguishes three secondary energy carriers: electricity, heat and transport fuels (see also Figure 4.1). Moreover, the efficiencies of energy conversion are taken into account, since higher efficiencies will reduce the supply requirements. For rating indices for energy conversion and transport aspects a number of rules have been developed. However, for some aspects reliable data is lacking, in particular in future energy scenarios, or the aspects are seen to be affecting energy supply security to a lesser extend. For reasons of consistency these aspects are kept in the model, but the default value is set to 100. These aspects are: power generation reliability, adequacy for the inland electricity network, electricity network reliability, heat transport, refinery reliability and fuel transportation.

The index value for energy conversion and transport aspects are rated as follows:

- *Efficiency power generation*: if the average electricity generation park efficiency is less than 35% the index value is zero. The index value is 100 if the average efficiency is 50% or above. Between 35% and 50% the index value is proportional. These values are based on the present state of the technology.
- *Power generation adequacy*: the index value is based on the so-called reserve factor, i.e. the power generation capacity exceeding the level of peak demand. If the reserve factor is 1.2 or above the index value is 100. The index value is zero when the reserve factor is less than 1 and proportional if the reserve factor is between 1 and 1.2. These values reflect present industry practices, including the role of mothballing.
- *Power generation reliability*: The default index value is 100, assuming that on average the reliability of power plants is sufficient. Alternatively, the power generation reliability can also be included in power generation adequacy.

- *Electricity network adequacy*: The index value for import capacity consists of combining a value relating import capacity to domestic capacity and one including a reserve factor including both domestic and import capacity. The import capacity value is proportional to a ratio between 0 en 5%, and the value for the ’combined’ reserve factor is proportional if its value lies between 1 and 1.2. Instead of the 5%, one could also choose the so-called ‘Barcelona target’ (EC, 2003b) according to which interconnection should cover at least 10% of a Member State’s installed capacity. The value of 5% has also been subject of the NL/UK sensitivity analyses reported in Section 5.3. For the Netherlands it appears not to be important (as the import factor is about 19%), while for the UK it is somewhat more important (as the import factor is only 3%).
- *Electricity network reliability*: For this component statistics on network reliability in terms of the average time of outages per year can be used. However, data on future network reliability is not available. For the moment the default index value is 100.
- *Heat generation efficiency:* The boiler efficiencies are not used here because of lacking information on this aspect. But even more relevant for efficiency of heat production is the share of heat generated by combined heat and power (CHP). However, since these figures are difficult to acquire, the share of CHP in electricity generation is used instead. The index value is proportional to this share and will reach the value of 100 when 25% of national annual electricity production is generated by CHP, a figure reflecting national practice in the Netherlands and Denmark.
- *Refineries efficiency:* The efficiency of refineries is determined by the ratio of the energy value of transport fuels and those of crude oil and biofuels, due to the importance of oil products for the transport sector.. The fuel efficiency in terms of crude oil (and biofuels) input versus oil products output is relatively high (typically about 94%) and not really discriminating. Moreover, supporting data cannot be obtained easily; therefore, a score of 100 is assigned in all cases. Otherwise, a similar rule such as for power generation efficiency could be applied.
- *Refineries adequacy:* The index value is 100 if the refinery capacity in use is 80% or lower compared to the total domestic refinery capacity. If this figure exceeds the value of 95% the index value is dropping to zero. Between these two figures, which again reflect industry practice including mothballing, the index value is proportional to the ratio of refinery capacity in use.
- *Fuel transportation:* The capacity for transporting automotive fuels will seldom be constrained, because there are several alternatives (by truck, ship, train or pipeline). Therefore the default index value is 100.

5. Use of the Supply/Demand Index: some examples

5.1 Today's energy supply security

For an assessment of today's energy supply security the S/D Index Model has been applied for a selected number of Member States (Spain, United Kingdom, The Netherlands, Poland) as well as the EU-25. For this analysis input data from basically 2002/2003 was used from the following sources:

- *Energy demand intensities* were taken from the Odyssee database (Odyssee, 2006) and Eurostat (Eurostat, 2004; 2006).
- Data on *energy conversion and transport aspects* were taken from a variety of sources including UCTE (UCTE, 2005a;b), the Dutch TSO (TenneT, 2005), EC scenarios (EC, 2003; 2004), EC Benchmarking reports (EC, 2005b) and IEA (IEA, 2005).
- Statistical data from Eurostat (Eurostat, 2004; 2006) and from the most recent EC scenarios (EC, 2003; 2004) was used for the *primary energy sources*.

Results of the analysis are presented in Table 5.1. For the four Member States and the EU two columns are shown. The first column lists weights (see also Table 5.1) and shares of final demand and the primary energy mix explaining the contributions of sub-indices to the overall S/D Index value. The second column shows the S/D Index and the major sub-indices. For a review of energy security supply the sub-indices for demand, supply, energy conversion and transport (C+T) and primary energy sources (PES) are at least as important as the S/D Index (the bold figures in Table 5.1). Appendix A and B give a further description and explanation of the methodology and data used.

Table 5.1 Today's *S/D Index for energy supply security for a number of selected EU MS and the EU*

	Spain		The Netherlands		UK		Poland		EU-25	
	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index
S/D Index		**51.1**		**68.3**		**77.5**		**65.2**		**53.9**
Demand	0.3	**75.2**	0.3	**58.1**	0.3	**66.8**	0.3	**49.2**	0.3	**67.9**
Industry	0.33	47	0.27	45	0.24	64	0.30	17	0.28	65
Residential	0.15	100	0.20	56	0.30	47	0.33	75	0.27	58
Tertiary	0.11	70	0.24	53	0.13	67	0.20	14	0.15	67
Transport	0.41	90	0.29	76	0.34	85	0.16	100	0.30	80
Supply	0.7	**40.8**	0.7	**72.7**	0.7	**82.0**	0.7	**72.0**	0.7	**47.9**
C+T	0.3	**63.1**	0.3	**96.0**	0.3	**45.6**	0.3	**84.0**	0.3	**60.2**
Electricity	0.3	88	0.3	90	0.3	59	0.3	86	0.3	64
Heat	0.5	47	0.5	100	0.5	35	0.5	100	0.5	55
Tr. Fuels	0.2	67	0.2	94	0.2	51	0.2	40	0.2	67
PES	0.7	**31.2**	0.7	**62.7**	0.7	**97.7**	0.7	**66.9**	0.7	**42.7**
Oil	0.50	0	0.38	10	0.34	100	0.22	0	0.37	0
Gas	0.16	0	0.46	100	0.38	100	0.11	6	0.24	24
Coal	0.15	81	0.11	70	0.16	85	0.62	100	0.18	89
Nuclear	0.12	100	0.01	100	0.10	100	0.00	100	0.14	100
RES	0.07	100	0.02	100	0.01	100	0.05	100	0.06	100
Other	0.00	100	0.02	100	0.00	100	0.00	100	0.00	100

Of all selected countries the S/D Index value for *Spain* is the lowest. This is mainly caused by large import dependencies for oil (with a 50% PES-share) and natural gas, but some energy conversion and transport aspects also contribute negatively to the value of the S/D Index. In contrast with the low figures at the supply side, the Spanish sub-index for demand is the highest of the selected countries, due to low energy intensity of the residential and transport sectors.

The S/D Index for *The Netherlands* has a moderate value. Indigenous natural gas production and a good score on energy conversion (e.g. electricity generation efficiency, CHP share) and energy transport (e.g. electricity import capacity) have a positive influence on the sub-index value for supply, whereas the import dependency for oil and coal contributes negatively to this sub-index value. On the demand side the value for the industrial sector is relatively low.

The high score of the sub-index for the primary energy sources results in a relatively high S/D Index for the *United Kingdom*. Much weaker are the index values for energy conversion and transport aspects and the energy intensity of the residential sector and with that reducing the UK's S/D index.

At the supply side *Poland* profits from the indigenous coal production (with a PES-share of 62%). The sub-index value for primary energy sources is reduced, however, by the strong dependency of oil and gas imports. A relative poor score at the demand side (industry and tertiary sectors) negatively influences the overall S/D Index value for Poland though.

The calculated S/D Index of the *European Union* (EU-25) is only slightly higher than the index value of Spain. This is explained by the composition of contributing factors: the sub-index for demand shows a quite reasonable value, but the sub-index for supply reduces the overall S/D Index value, in particular the sub-index value for primary energy sources due to the strong import dependencies for oil and natural gas. Also the sub-index for energy conversion and transport has a relatively low value.

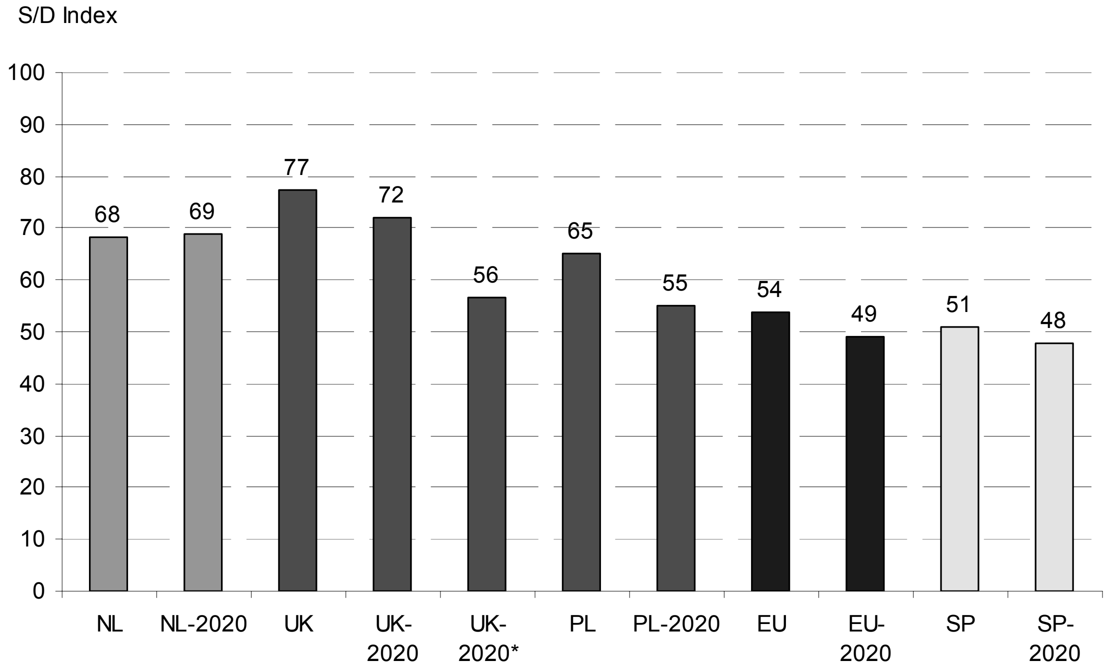
5.2 S/D Index in a scenario approach

An essential element in the whole idea about the standards is to look forward. This is especially the case with respect to the development of energy balances, as they will evolve over time. For the UK it is quite clear for instance that its domestic oil and gas production will decrease and that imports from outside the EU will have to increase, with strong impacts for the UK's S/D Index. As another example, it could be questioned to what extent Poland will be able to continue its large domestic coal production, considering economic and environmental sustainability.

The use of the S/D Index in a scenario approach is illustrated in Table 5.2 and in Figure 5.1, which shows the more aggregated results and a comparison with today's values. On the basis of scenario data taken from the base case scenario of EU Trends to 2030 (EC, 2003) S/D Index values have been calculated for the selected Member States and the European Union (EU-25). According to the scenario the S/D Index for *Spain* decreases with 3.2 points compared to the today's index value due to an increased import dependency for gas and oil, and lower sub-index values for energy intensity. The S/D Index for *The Netherlands* increases slightly, mainly due to an increase of the domestically produced gas in the fuel mix. In 2020 the *United Kingdom* will become import dependent for natural gas. It is assumed that 50% of these imports will originate from outside the EU and Norway. The sub-index for PES drops with 16.3 points resulting in 4.5 lower S/D Index for the UK. Figure 5.1 also shows a sensitivity case for the UK with a 75% import dependency for oil and gas in 2020, based on new insights (FCO, 2004; DTI, 2006), see also Appendix C.3. The PES index also drops for *Poland*. Due to an increasing import dependency - indigenous coal is replaced by imported gas - the sub-index for PES drops with 19.8 points and results in a decrease of the overall S/D Index with 10.2 points. Also the import dependency of the *European Union* is the main cause of a decrease of the PES sub-index with 11.9 points and a decrease of the overall S/D Index with 4.9 points.

Table 5.2 *S/D Index for energy supply security for a number of selected EU MS and the EU in 2020 on the basis of EC baseline scenarios*

	Spain		The Netherlands		UK		Poland		EU-25	
	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index	Weight/ share	Index
S/D Index		**47.9**		**68.7**		**72.0**		**55.0**		**49.0**
Demand	0.3	**70.0**	0.3	**57.7**	0.3	**67.1**	0.3	**46.1**	0.3	**66.7**
Industry	0.30	45	0.24	44	0.24	65	0.24	25	0.28	65
Residential	0.17	82	0.21	51	0.28	45	0.34	44	0.25	52
Tertiary	0.12	68	0.24	54	0.14	66	0.20	18	0.15	67
Transport	0.40	85	0.31	75	0.34	87	0.23	95	0.32	80
Supply	0.7	**38.5**	0.7	**73.5**	0.7	**74.1**	0.7	**58.8**	0.7	**41.3**
C+T	0.3	**69.8**	0.3	**91.5**	0.3	**57.1**	0.3	**86.3**	0.3	**66.1**
Electricity	0.3	95	0.3	100	0.3	66	0.3	94	0.3	72
Heat	0.5	56	0.5	85	0.5	54	0.5	100	0.5	62
Tr. Fuels	0.2	67	0.2	94	0.2	51	0.2	40	0.2	67
PES	0.7	**25.1**	0.7	**65.7**	0.7	**81.4**	0.7	**47.1**	0.7	**30.8**
Oil	0.45	0	0.36	10	0.34	100	0.28	0	0.36	0
Gas	0.29	0	0.52	100	0.47	64	0.25	0	0.32	0
Coal	0.06	80	0.06	70	0.07	77	0.42	100	0.13	85
Nuclear	0.10	100	0.00	100	0.07	100	0.00	100	0.11	100
RES	0.10	100	0.04	100	0.04	100	0.05	100	0.08	100
Other	0.00	100	0.02	100	0.01	100	0.00	100	0.00	100



*) With 75% import dependency for oil and gas.

Figure 5.1 *S/D Index for today and 2020, EU-25 and four Member States*

5.3 Sensitivity analysis

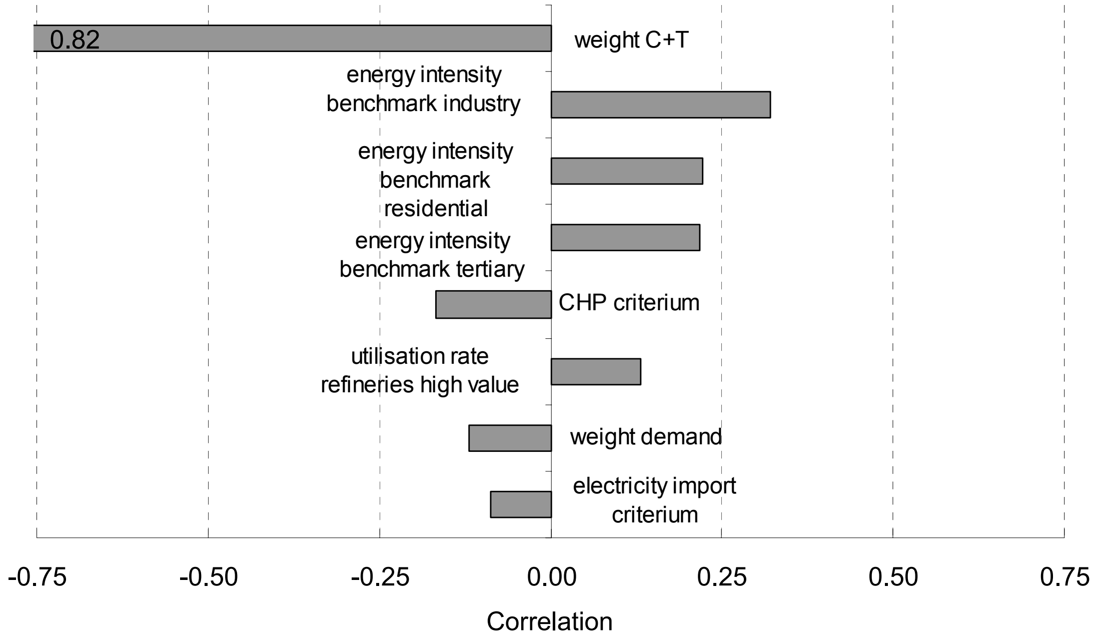
As has been indicated in Section 4.2, the S/D Index Model uses parameters that have to be determined by expert judgement. With use of a multi-variate sensitivity analysis the impact of changes in these more subjective parameters have been investigated for the S/D indices of today's energy supply security for The Netherlands and United Kingdom. Assuming uniform intervals for expert judgement the parameters for weights and criteria in the scoring rules were varied:

- Weights have been raised and reduced with 0.1.
- Benchmark criteria for energy intensities were changed +/- 20%.
- Parameters in scoring rules for determining sub-index values have been changed between -3% and +10%.

The number of parameters varied in this way amount to almost 30.

The uncertainty range for the S/D index for The Netherlands and the United Kingdom has a bandwidth of +/- 7 points, i.e. a range of about +/- 10%. The analysis gave also insight in the relative contributions of different aspects to this uncertainty. Figure 5.2 shows the correlations between the most important varied parameters and the S/D index. The parameters with the highest correlations are the most important ones. It should be noted that some weights do not appear graphically in Figure 5.2 although they are important. This applies to some of the weights that sum up to 1 in combination with other weights. E.g. the weight for PES (w_pes) is equal to '1 - w_c+t', so w_pes is dependent of the weight for conversion and transport, w_c+t. The w_c+t parameter has been varied and with the use of the relationship 'w_pes = 1 - w_c+t ' the PES weight parameter is varied accordingly. For both The Netherlands and United Kingdom the factors that had the highest impact were the weights between energy conversion and transport (0.3) versus primary energy sources (0.7) and the benchmark values for final energy intensities. Other relatively important factors were for The Netherlands the criterion for oil and for the UK the CHP criterion.

For discussions in the conceptual phase on the quantification of the model parameters (see Section 3.3) it is important to note that when a specific country has a low sub-index score the choice for the corresponding attribute is of particular importance for that country. In this phase there are all sorts of risks of strategic behaviour by Member States. The quality of the negotiating process in this phase could be further enhanced when the various vulnerabilities would be made more explicit. Sensitivity analyses could therefore be an important element during conception and negotiation. Appendix C presents additional sensitivity analyses.



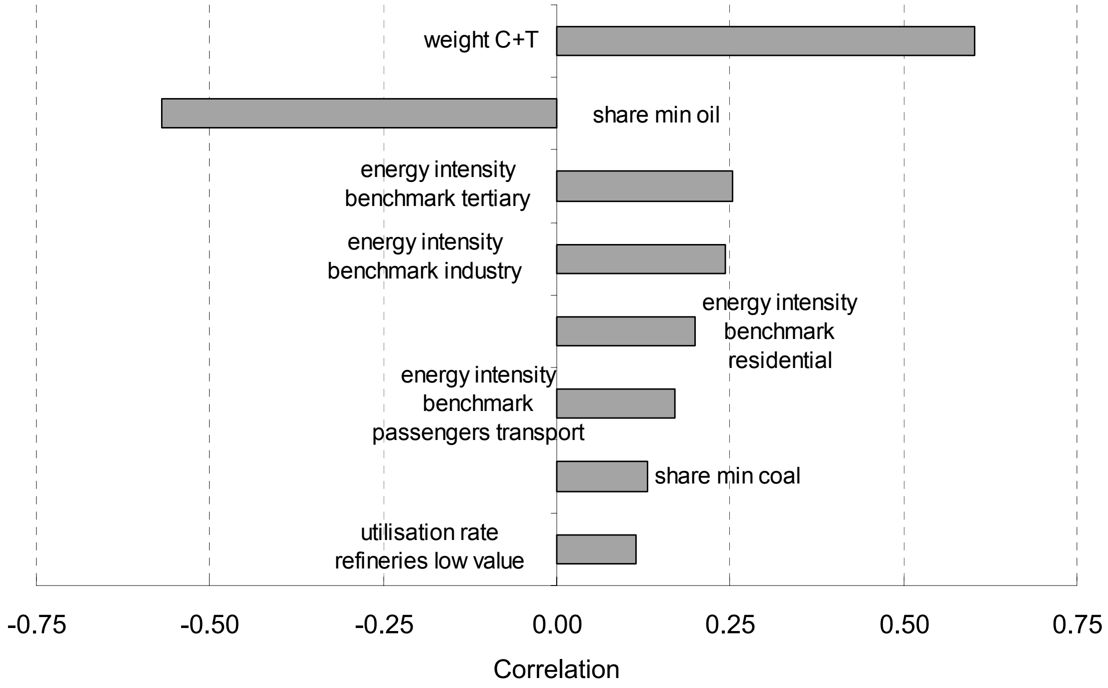


Figure 5.2 *Sensitivity analysis for United Kingdom (top) and The Netherlands (bottom)*

6. The Crisis Capability Index

The second indicator to be used in the SoS standards deals with crisis capability. Short-term actions and short-term results are the main items to be addressed, being more a question of weeks than one of months. The index combines an assessment of a Member State's risk to be confronted with sudden supply interruptions and its potential impacts (Risk Assessment: RA) and the capability of that country to mitigate these impacts (Mitigation Assessment: MA). If the risk is high, more weight should be put on effective crisis capabilities than when this risk is low.

6.1 The Risk Assessment

Assessing risks of sudden and unforeseen supply interruptions will be done along the same lines as used in the S/D Index in Section 4. Domestic production, imports, conversion and transport will all be assessed for their different risks of short-term interruptions. Primary domestic energy production (oil, coal, gas and others), could have various degrees of risks for interruptions. Production could take place in difficult and remote areas, or with installations that are becoming obsolete or meeting operational problems for whatever reason. Environmental restrictions or accidents could be part of the assessment. Import risk assessments could be more specific, dealing with politically inspired interruptions for oil and gas, with sea transport risks when choke points are passed. Political interventions, but also accidents could create sudden supply interruptions. Transit routes over land, both for gas and electricity also have their vulnerabilities, where again both political and accidental causes could create interruptions.

Power generation as such could also be subject to unforeseen shortfalls. A large dependence on climate based intermittent sources such as wind or hydro, but also environmental restrictions for using open surface cooling waters could lead to these interruptions. Technology risks could also play a role, especially if several units are deploying the same specific new technological devices and a serious incident occurs in one of them. This could be specifically relevant for nuclear power plants. Similar events could happen in oil refineries or in LNG-terminals and regas-facilities. Here again, climate factors could trigger activity interruptions, such as have happened with the 2005 hurricanes Rita and Katrina in the US Gulf. Energy transmission and distribution networks could also add to the risk of supply interruptions, where maintenance (including wood management) or poorly managed operational procedures could be determining factors.

Table 6.1 shows a checklist for risk assessment for sudden supply interruptions. Each individual cause for a sudden supply interruption risk listed in the checklist should be assessed on the basis of the probability of such a risk and the impact of this risk on the energy system and on society. The risk can be valued with a figure indicating no (0), low (1), medium (2) or high risk (3). Adding the individual values together and dividing the total by 1,11 results in the Risk Assessment sub-index (a value between 0 and 100).

Table 6.1 *Checklist risk assessment for sudden supply interruptions*

			Value[*]
Domestic primary energy production	Oil	Technical constraint	
		Environmental constraint	
	Natural gas	Technical constraint	
		Environmental constraint	
	Coal	Technical constraint	
		Environmental constraint	
	Renewable (e.g. wind, hydro)	Technical constraint	
		Environmental constraint	
Energy conversion	Power plants	Technical constraint	
		Environmental constraint	
	Refineries	Technical constraint	
		Environmental/safety constraint	
Inland energy transport	Gas pipelines	Operational failures	
		Vulnerability nodes	
	Electricity lines	Operational failures	
		Vulnerability nodes	
Energy import	Supply constraints oil	Political risks	
		Environmental constraints	
		Technical constraints	
	Supply constraints natural gas	Political risks	
		Environmental constraints	
		Technical constraints	
	Supply constraints electricity	Political risks	
		Environmental constraints	
		Technical constraints	
	Sea transport routes oil	Political risks	
		Environmental constraints	
		Technical constraints	
	Sea transport routes gas	Political risks	
		Environmental constraints	
		Technical constraints	
	Land transport routes gas	Political risks	
		Environmental constraints	
		Technical constraints	
	Land transport routes electricity	Political risks	
		Environmental constraints	
		Technical constraints	
Total score:			Max. 111

* no risk: 0; low risk: 1; medium risk: 2; high risk: 3.

6.2 Mitigation & Emergency measures

Measures to handle or to manage short-term sudden supply interruptions are in place in many MS. This is partly due to international commitments such as the IEA Treaty and partly due to national contingency planning. The measures should be summarised in four groups, i.e. strategic or emergency stocks, demand restraint (including rationing), fuel switching capabilities and reserve and/or locked-in production capacities. Describing measures is one thing: testing and verifying them is another one, where a distinction should also be made between national and international test runs (including the IEA[2]). Here again, the MS should come with an informed de-

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[2] Not all EU-25 members are member of the IEA (Poland, Slovenia, Slovakia, the 3 Baltic states, Malta and Cyprus), so some provision has to be taken into account for this.

scription of its Mitigation Package, where the various measures should be listed on the basis of an ex ante set checklist.

With respect to oil emergency stocks, there is the EU requirement to maintain strategic stocks covering 90 days of oil consumption[3]. With respect to other emergency stocks, there is no international commitment for gas, but there may be specific national provisions for short-term interruptions. However, there is an EU-procedure requiring consultation and eventually common action in case of sudden gas supply interruptions[4] and there are also proposals from the Visegrad-countries[5] to establish a regional scheme for securing gas supplies in a crisis situation With respect to coal, there have been EU-rules in the past, requiring power plants to hold a minimum level of 30 days of coal stocks, but this requirement was terminated in the mid 1980's. With respect to uranium there have been attempts in the past to set up strategic stocks for (enriched) uranium, but this has never been accepted by MS.

With respect to demand restraint & rationing devices, IEA members have the option to use these measures in the case of an oil emergency. In addition, the IEA has provided a menu for options to introduce short-term conservation measures, especially during an oil emergency[6]. Restraining demand in an emergency situation is very complex in modern societies. Leaving this to the market could be the most economic option, but from a political viewpoint this is highly unlikely. Measures that were effective in the past, such as Sunday driving bans or restraining electricity use, would create numerous difficulties. Rationing schemes or pro rata obligatory delivery cuts could still be feasible, but would need political choices as to priority setting. An alternative might be the use of interruptible contracts (e.g. gas, electricity), where both the supplier and the consumer could use the option to interrupt or restrain deliveries and either lay down their activities or make use of alternative energy options. In essence, effective demand restraint measures could help secure energy supply at the level of the consumer market, by fair allocation of available supplies for all consumers.

Fuel switching capabilities could be seen as an alternative to demand restraint. Switching from one energy source to another for the same installation could then mitigate further supply shortfalls. This could especially be the case for large energy users that have dual-firing capabilities. Partly or temporarily softening environmental restrictions could be necessary to make effective use of these options. A country may either have policy in place to promote or enforce fuel switching, but practical realities and technological boiler specifications that are limiting broad quality ranges of fossil fuel usages are increasingly restricting short-term fuel switching in a number of countries. Here again, the country concerned could indicate in its standard the option of fuel switching capacity, however not in terms of theory, but in proven practicable terms.

As to production capacity, a distinction is made between reserve capacity available in the subsurface energy supply system and (underground) locked-in energy production. Reserve capacities for electricity could be found in power generation capacity (including mothballed capacity or allowing more flexible use by softening environmental limits) and in interconnections with additional import capacity (for instance by allowing more imports when temporarily operational safety limits are softened). For gas, reserve capacity could also be found in transmission lines, allowing temporarily more flexibility. For oil products, refinery runs could be changed allowing for instance more production of transport fuels. Increasing locked in energy production, using system flexibility or other various forms of spare domestic production capacities could be very interesting as well. These additional productions have to exist, however, which is becoming less likely in tightening overall supply situations. If they do exist, they will very often require special conditions, both in economic and in environmental terms. Under the IEA emergency scheme,

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[3] EU Directive 68/414 as amended in 1998.

[4] EU Directive 2004/67.

[5] Poland, Hungary, Slovakia and the Czech Republic.

[6] Saving oil in a hurry; IEA/OECD, Paris 2005.

oil producers such as Norway and the UK were allowed to use these options in meeting their emergency obligations. The same was true for the US with their Naval Petroleum Reserves. Gas production might also be increased in the short term, as is still the case in Norway or the Netherlands. But here again, decreasing gas production in the medium term will put further limits on these options as well.

Table 6.2 shows the checklist that can be used to assess the Mitigation Program. If a measure is implemented this measure will be rated with '1'; if it is not available the value will be '0'. The value will become '2' if the measure is implemented and tested, i.e. the measure should have been demonstrated in practice or procedures should have been tested. The value of this Mitigation Assessment (MA) sub-index can be calculated when the total score of the checklist is divided by 0.3, resulting in an index value between 0 and 100.

Table 6.2 *Checklist for assessment of measures to mitigate sudden supply interruptions*

			Value*
Emergency stocks	Oil	Oil stocks	
	Gas	Gas reserves (LNG and UGS)	
Demand restraint and rationing	Electricity	Demand response contracts	
		Rationing procedures	
	Gas	Interruptible contracts	
	transport fuels	Rationing procedures	
Fuel switch capabilities	Electricity	Multi fuel capacity (i.e. oil/gas) power plants	
	Heat	Multi fuel capacity (i.e. oil/gas) industrial boilers	
	Transport fuels	Multi fuel engines (e.g. petrol vs. LPG or CNG, petrol or diesel vs. biofuels)	
Reserve capacity	Electricity	Import capacity	
		Generation reserves	
	Gas	Reserve capacity transmission pipelines	
	Refineries	Spare capacity for production transport fuels	
Locked-in production	Oil	Domestic oil production	
	Gas	Domestic gas production	
		Total score:	Max. 30

* not available: 0; implemented: 1; implemented and tested: 2.

Whether a country has an adequate capability to handle sudden energy supply interruptions can be judged by comparison of the Mitigation Assessment (MA) sub-index to the Risk Assessment (RA) sub-index. Although this comparison does not say anything about the capability of a country to mitigate specific supply interruptions, it gives an overall indication of how well a country is prepared in comparison to its risk exposure. If the RA sub-index is much higher than the MA sub-index the country may be vulnerable for sudden supply interruptions, i.e. the Crisis Capability (CC) Index should have value of less than 100. The CC Index can be calculated with the formula:

$$\text{If RA} > \text{MA: CC-Index} = \text{MA}/\text{RA} \times 100$$

If the RA sub-index is similar to or lower than the MA sub-index the crisis capability of a country may be sufficient in comparison to the probability and impact of sudden supply interruptions. In that case the CC Index will be 100. It should be note that if the MA sub-index is much higher than the RA sub-index the costs associated with crisis capability measures may be exceeding the probability and costs of sudden supply interruptions.

6.3 Using the CC Index with some examples

It would be very interesting if the CC Index could be further explained and examined with some examples. However, this would require some further discussion on the basis of concrete case studies, both with respect to risk assessments and to mitigation programs. These studies would also have to be scrutinised on the basis of practical applications, either in the case of reality applications or in the case of test runs. Test runs for mitigation programs are frequently done in the context of the IEA emergency plans and could provide relevant input for the CC Index. In the context of his study, however, suitable case studies or peer reviews have not been sought/provided. It would be more appropriate to exercise these in the conceptual phase with some volunteering Member States. This the more so, as such a CC Index test run would touch all sorts of aspects of internal EU solidarity and which should probably be more appropriate to consider in the wider context of the EU energy balance as such.

7. Multilateral actions

Assessing and describing the third input to the SoS standards, a more qualitative approach will be followed for multilateral actions. With these policy actions national and/or European energy supply security will be promoted and enhanced. A distinction is made between the willingness of a MS and its capability, i.e. willingness to take, support or participate in actions together with other EU MS, be it in the context of a 'coalition-of-the-willing' or in a more formal EU context. Capabilities are based on the question if the MS has effective policy options or instruments at hand or not. Here again, this input will be based on a policy document to be submitted by each MS. This document will be subjected to a peer review. The multilateral actions could be further elaborated, with a distinction between three categories: effective energy diplomacy, participation in joint projects and actions and participation in military protection of vulnerable transport routes.

Effective energy diplomacy could be used to build stable relations with major energy suppliers. Such relations would probably require wider packages of mutual benefits and could even go beyond energy relations and programmes. Effective energy diplomacy would also mean periodical contacts and exchanges of views and information on issues that are of mutual interest. They could cover not only direct bilateral relationships, but also relevant issues in ongoing or forthcoming multilateral discussions elsewhere. Mutual trust, understanding and respect are keywords for the effectiveness of these actions, accepting that it may not always be possible to make public statements on them. Examples in the EU context could be seen in the producer-consumer dialogues that the EU is pursuing with OPEC, with Russia and with the Gulf states, but many MS are also using their own contacts and relations supporting overall energy supply security. The recent Green Paper from the Commission suggests the development of an EU external energy policy. If this were to be developed, it could be a strong tool of the multilateral actions as mentioned in this context. It could also be counterproductive, however, and limit effective national or regional actions. There is also a relation between the outcome of the S/D and CC Indexes, both nationally and for the EU as such. They could for instance have a positive or negative effect on the arguments for designing and agreeing upon effective multilateral actions. These indexes would then have a wider impact than just being inputs into a system of standards for EU energy SoS.

Participation in joint projects and more direct actions is a group of activities that could go beyond 'just talking'. Energy supply security could be part of wider packages of political, economic and/or energy cooperation, ranging from direct government financial involvements, including financial guarantee schemes, to political backing of private industry participations. The EU as such or within EU-coalitions could then secure energy supplies via long-term contracts embodied in political agreements. Such political umbrellas could be very effective, also using wider options for economic cooperation under multilateral frameworks such as the World Bank or relevant EU schemes.

Joint actions to protect or safeguard vulnerable transport routes for oil and gas are to be considered as a form of more direct intervention. Oil and gas, either as LNG or in pipelines, are crossing a number of choke points on their way to consumer markets. These points are critical and vulnerable for terrorist attacks and could require various forms of monitoring and protection in order to add to supply security. Police and or more pronounced military action could be considered necessary and this would probably necessitate joint actions by a number of countries. Coalitions of the willingness, actions in NATO or even in UN-frameworks would then probably be most appropriate, as the EU as such does not have a framework for this type of interventions. Willingness to support or even participate in these actions will always be related to explicit and sometimes controversial national political decision-making processes. Willingness is one thing;

capability is another thing, where various ranges of contribution could be foreseen, including monetary or direct military support actions.

As part of the standards process, each MS should be invited to prepare a policy statement on the three categories of multilateral actions. In this statement the MS will indicate its (un)willingness to participate in these actions, and if so under what conditions. Secondly, the statement should indicate, if applicable, the abilities of the MS to contribute to the actions. In addition, the statement should also discuss the impact the actions might have on the supply security situation of the MS itself and on other MS. On this basis synergies of actions could be assessed, national abilities could be benchmarked and further development of an effective external energy supply policy for the EU as a whole could be facilitated. One aspect of these actions has been translated in the S/D Index, giving a higher weight factor to non-EU imports based on long-term contracts. On the other hand, it should be realised that many of these actions might have a highly political nature and may be rather too sensitive for an open and transparent process. This could also mean that it would be difficult or inappropriate to develop a set of objective criteria for MS' policy assessments. It is important, however, to include the concept of multilateral actions in the standards-process and at least national policy documents should be prepared as inputs into the wider review and assessment procedures.

8. Towards an EU standard?

The previous chapters discussed the two more quantitative indexes and a more qualitative factor. The next question is whether or not to integrate these two inputs into a combined standard or to use them as separate ones for inputs into the policy discussions in the context of the strategic energy review process. In addition, one could also consider adding the qualitative factor when it comes to wider political assessments. Although this last factor could be translated into some quantitative factor[7], the political judgement about multilateral action would always have to prevail.

If the first option were to be chosen, the standard would probably have to result in a normative process, culminating in a single EU norm for energy supply security. The energy policy of the individual MS and of the EU as a whole is then to be assessed in relation to the norm that is set. A less far-reaching approach would be to use the SoS standards in a benchmark process. The standards are then used for defining the EU average or some best policy practice outcome, after which national standards are assessed in relation to this average or best practice outcome. Policies could then be designed aimed at meeting the benchmark. The policy review option would maximise the political assessment process and could give room for further discussion and negotiations.

What direction is chosen, using combinations of EU standards for supply security for the assessment of the energy security situation, could have strong spin offs for related EU policies. Internal EU solidarity, either in the situation of an energy crisis, or in a more structural energy policy sense, could be further enhanced or challenged when the outcomes of the standards are discussed. Energy synergies or energy cost-efficiencies and their wider implications for economic structures in the EU could also play a role. Improving the energy supply security in one Member State could for instance be more effectively done by structural measures in another Member State. In the same context, mitigation policies for climate change could also be assessed. More generally, supply security standards could be further enhanced by linkage to Kyoto targets or even wider sustainability targets. This could ultimately evolve into standards for EU energy sustainability, which would help to come to a more balanced and integral approach for developing energy and environmental policies. It would be interesting to dedicate further research and studies to these wider issues.

If one would choose for a simple arithmetic approach, the two indexes could easily be combined. In arithmetic terms the S/D- and CC-Indexes are set as follows:

$$\textit{S/D Index} = (0{,}3)\ \textit{demand value} + (0{,}7)\ \textit{supply value}$$
$$\textit{CC Index} = \textit{MA/RA} \times 100 \qquad (\textit{if RA} \leq \textit{MA CC-Index} = 100)$$

Both indexes would never be higher than ‘one hundred’ and it should therefore be no problem to combine them in an SoS value. It could be done on a 50/50 basis, when considering both indexes as equally important. It seems to be more appropriate, however, to give a higher rating to the S/D Index than to the CC Index. This could reflect the importance of longer-term S/D balances in comparison with the much more short-term issues of sudden supply shortfalls. This higher rating could be done for instance on a one-to-two basis. This would then mean that the SoS value could be calculated accordingly:

$$\textit{SoS Index} = 2/3\ \textit{S/D Index} + 1/3\ \textit{CC Index}$$

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[7] This could be done by some simple arithmetic, on the proposed policy document, indicating degrees of discussion about it. (No document: zero, document with comment, 1 and with no comment 2).

The SoS Index would then result in a 0-100 scale, leaving room for choosing or arguing about a value for a standard. In this much more politically oriented process, the qualitative factor could be taken into account as well.

9. Concluding remarks

This report introduced the concept of SoS standards including a procedure, two quantitative indicators and possibly a qualitative one to be used in a broad assessment of energy supply security in EU MS and the EU as a whole. This broad assessment could be used as part of the wider EU Strategic Energy Review as proposed in the recent Green Paper. Although the use of one indicator was illustrated with some examples, the value of the procedure and indicators for EU energy policy should be demonstrated in practice. Practical experience will learn how the concept, the procedure, the quantitative model and the checklists can be further improved. However, it is unquestionable that a review process with assessments of EU MS' energy supply security in a well-structured way will become a valuable asset for a better understanding of the energy security of supply issue and factors that play a role in it. A good insight in the different factors and aspects is a precondition for the consultation between the Member States and the Commission with a view on the shaping of adequate EU policies on European energy security of supply.

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Abbreviations

CC	Crisis Capability
CCS	Carbon Capture and Storage
CIEP	Clingendael International Energy Programme
CHP	Combined Heat and Power
DG TREN	Directorate-General Transport and Energy
EC	European Commission
ECN	Energy research Centre of the Netherlands
ETS	Emission Trading System
EU	European Union
GDP	Gross Domestic Product
GE	Global Economy, one of the new baseline scenarios for the Netherlands. The scenario has a high economic growth, and assumes no post-Kyoto climate policy.
IEA	International Energy Agency
LNG	Liquefied Natural Gas
MA	Mitigation Assessment
MS	Member State
NATO	North Atlantic Treaty Organisation
OPEC	Organisation of Petroleum Exporting Countries
PES	Primary Energy Sources
PL	PoLand
POWERS	Model for the Dutch electricity market and electricity production
RA	Risk Assessment
S/D	Supply/Demand
SoS	Security of Supply
SP	SPain
TSO	Transmission System Operator
UCTE	Union for the Co-ordination of Transmission of Electricity
UK	United Kingdom
UN	United Nations

Appendix A Scoring rules

This appendix provides more details on the scoring rules of the Supply/Demand Index Model that have been described qualitatively in Chapter 4 (Sections 4.3, 4.4 and 4.5). The scoring rules are shown as formulas (mathematical expressions), with the symbols explained.

With the various weights, sub-indices and scoring rules at the end of the S/D Index tree (see Figure 4.2, also the sub-index values can be computed. The formulas for the ‘top-level’ indices are given below:

S/D index = w_dem × sc_dem+w_sup × sc_sup
w_dem = weight of Demand (default 0.3)
w_sup = weight of Supply (default 0.7)
w_dem + w_sup = 1
sc_dem = sub-index Demand
= w_ind × sc_ind + w_res × sc_res + w_ter × sc_ter + w_tra × sc_tra
sc_sup = sub-index Supply
= w_ct × sc_ct+w_pes × sc_pes
w_ct = weight of Conversion and transport (default 0.3)
w_pes = weight of Primary Energy Sources (default 0.7)
w_ct + w_pes = 1
sc_ct = Sub-index Conversion and transport (secondary energy carriers)
sc_pes = Sub-index Primary Energy Sources

The scoring rules at the lower levels are explained in the next sections.

A.1 Final energy demands

The scoring rules for the final energy demands have been qualitatively described in Section 4.3 of Chapter 4. This section will describe the scoring rules in their mere mathematical formulation.

A.1.1 Definitions

Symbol	Description
w_res	Weight for residential (households) in Final Energy Demand (equal to relative share in final energy Final Energy Demand mix)
w_ind	Weight for industry in Final Energy Demand (equal to relative share in final energy Final Energy Demand mix)
w_ter	Weight for tertiary sector in Final Energy Demand (equal to relative share in final energy Final Energy Demand mix)
w_tra	Weight for transport sector in Final Energy Demand (equal to relative share in final energy Final Energy Demand mix) w_res + w_ind + w_ter + w_tra = 1
f_tra_goo	Fraction of transport goods demand
f_tra_pas	Fraction of transport passenger demand f_tra_goo + f_tra_pas = 1

Symbol	Description	Unit short
ei_res	Energy intensity of the residential sector	toe/capita
ei_ind	Energy intensity on added value for the industrial sector	toe/M€
ei_ter	Energy intensity on added value for the tertiary sector	toe/M€
ei_tra_goo	Energy intensity for the transport sector, goods	toe/Mtkm
ei_tra_pas	Energy intensity for the transport sector, passenger	toe/Mpkm
ei_res_bm	Benchmark value for energy intensity of the residential sector	toe/capita
ei_ind_bm	Benchmark value for energy intensity on added value for the industrial sector	toe/M€
ei_ter_bm	Benchmark value for energy intensity on added value for the tertiary sector	toe/M€
ei_tra_goo_bm	Benchmark value for energy intensity for the transport sector, goods	toe/Mtkm
ei_tra_pas_bm	Benchmark value for energy intensity for the transport sector, passenger	toe/Mpkm

toe = ton-oil-equivalents
Mtkm = M-ton-km
Mpkm = M-passenger-km

A.1.2 Benchmark values and scoring rules

The benchmark values have been deduced from the Odyssee database (2003 values) or Eurostat databases (2002 or 2003 values). The next table shows the values used. Lacking readily available data for the new Member States, the Odyssee data that cover the EU-15 plus Norway have been used as approximation in most cases. Moreover, in case of clear outliers, a more representative selection of a ‘top-5’ average as benchmark value has been chosen.

Symbol	Value	Value	Remarks
ei_res_bm	0.35	toe/cap	Average of the top-5 EU-25 value (Eurostat, 2005)
ei_ind_bm	76.0	toe/M€	Average of the top-5 EU-15 value (Odyssee, 2005)
ei_ter_bm	15.2	toe/M€	Average of the top-2 to 5 MS, EU-15 value (Odyssee, 2005). Luxembourg (1st) omitted as outlier, and not that representative.
ei_tra_goo_bm	46.2	toe/Mtkm	Average of the top-2 to top-5 MS, EU-15 value (Odyssee, 2005). Austria (1st) omitted as outlier.
ei_tra_pas_bm	30.5	toe/Mpkm	Average of the top-2 to top-5 MS, EU-15 value (Odyssee, 2005). Finland (1st) omitted as outlier.

It should be noted that the selection of the benchmark values inherently has some subjectivism. In the numerical examples presented in Chapter 5 and in Appendix C, all estimates but in particular the weighing factors and scoring criteria should be considered as illustrative and indicative only. Therefore, these types of parameter values have been subject to multi-variate sensitivity analyses in the first (preliminary) calculations (see also Section 5.3).

The scoring rule for each of the final energy demand sectors is:

Score = Minimum (ei_*Sector*_bm / ei_*Sector*, 1) × 100
With *Sector* = either res, ind, ter, tra_goo, or tra_pas

So, the index value for each energy demand sector is calculated from the ratio between the EU’s or Member States’ energy intensity and the benchmark figures. So, the maximum index value will be 100 if the energy intensity is less (i.e. better) than the benchmark value.

Weighing the four sectoral indices with the shares of each demand sector relative to total final energy demand results in the sub-index value for energy demand.

The transport sub-index value is calculated from the fractions of the goods and passenger demand and the two separate scores.

A.2 Primary energy sources

A.2.1 Definitions

w_*pri* = Weight for the primary energy source *pri*
ds_*pri* = (Net) domestic share for for the primary energy source *pri*
pri = either oil, gas, coa, nuc, ren, or oth (first three letter are used as symbolic representation)

Symbol	Value	Description
Weights		
w_oil	MS-spec	Weight of oil (products) in primary energy sources (equal to relative share in PES mix)
w_gas	MS-spec	Weight of gas in primary energy sources (equal to relative share in PES mix)
w_coa	MS-spec	Weight of coal (solids) in primary energy sources (equal to relative share in PES mix)
w_nuc	MS-spec	Weight of nuclear fuel in primary energy sources (equal to relative share in PES mix)
w_ren	MS-spec	Weight of renewable energy sources (biomass and other sources) in primary energy sources (equal to relative share in PES mix)
w_oth	MS-spec	Weight of other sources in primary energy sources (equal to relative share in PES mix)

The weights above are equal to the relative fractions in the PES mix (gross inland consumption, (Eurostat, 2006; year 2003 data)), and hence sum up to 1:
w_oil + w_gas + w_coa + w_nuc + w_ren + w_oth = 1.

Symbol	Value	Description
Domestic, all		
ds_oil	MS-spec	(Net) domestic share for the primary energy source oil
ds_gas	MS-spec	(Net) domestic share for the primary energy source gas
ds_oil_min	30	Minimum (Net) domestic share for the primary energy source oil in order to get positive score on domestic part
ds_gas_min	30	Minimum (Net) domestic share for the primary energy source gas in order to get positive score on domestic part
ds_coa	MS-spec	(Net) domestic share for the primary energy source coal
ds_nuc	MS-spec	(Net) domestic share for the primary energy source nuclear
ds_ren	MS-spec	(Net) domestic share for the primary energy source renewables
ds_oth	MS-spec	(Net) domestic share for the primary energy source 'others'
sc_min_coa	70	Minimum score for domestic/import criterion coal
sc_min_nuc	100	Minimum score for domestic/import criterion nuclear
sc_min_ren	70	Minimum score for domestic/import criterion renewables
sc_min_oth	70	Minimum score for domestic/import criterion 'others'
Import, oil and gas		
EU+NO_s_oil	MS-spec	(Crude) oil import share coming from within EU+NO
EU+NO_s_gas	MS-spec	Natural gas import share coming from within EU+NO
sc_EU_min_oil	30	Minimum import oil from within EU+NO to get positive score on EU+NO/non-EU criterion [%]
sc_EU_min_gas	30	Minimum import gas from within EU+NO to get positive score on EU+NO/non-EU criterion [%]
sh_lt_oil	MS-spec	Share for long term 'secure' oil contracts in non-EU import part (0-1)
sh_lt_gas	MS-spec	Share for long term 'secure' gas contracts in non-EU import part (0-1)
w_lt_oil	0.5	Weight for long term 'secure' oil contracts in non-EU import part (0-1)
w_lt_gas	0.8	Weight for long term 'secure' gas contracts in non-EU import part (0-1)

A.2.2 Oil and gas

The scoring rules for all PES use the net import shares and net domestic share (ds), to score the domestic part. In addition for oil and gas, the shares originating from EU+Norway, from non-EU, and a (weighted) part from the non-EU share governed by long-term contracts are used in a combined rule to score the import part.

Domestic

Domestic production will only result in a positive score if the domestic share is above a certain minimum, ds_min. The score is proportional to the domestic share in the interval (ds_min, 100).

In a formula, the domestic score equals:
$\text{Max}\ (0\ ;\ -\ \text{ds\_min\_oil} \times 100\ /\ (100-\text{ds\_min\_oil}) + 100\ /\ (100-\text{ds\_min\_oil}) \times \text{ds\_oil})$
$\text{Max}\ (0\ ;\ -\ \text{ds\_min\_gas} \times 100\ /\ (100-\text{ds\_min\_gas}) + 100\ /\ (100-\text{ds\_min\_gas}) \times \text{ds\_gas})$

This scoring rule is depicted graphically in Figure 4.4 in Chapter 4.

Import

The import part will only get a positive score if the import share from EU+Norway (EU+NO_s) and a weighted (weight: w_lt_) share from non-EU governed by long term contracts (sh_lt_) is above a certain minimum threshold (sc_EU_min_).

In a formula, the import score equals for oil (gas similar):
$\text{Max}\ (0\ ;\ -\ \text{sc\_EU\_min\_oil} \times 100\ /\ (100-\text{sc\_EU\_min\_oil}) + 100\ /\ (100-\text{sc\_EU\_min\_oil}) \times (\text{EU+NO\_s\_oil} + \text{w\_lt\_oil} \times \text{sh\_lt\_oil})$
In essence, this formula is similar to the domestic part with the ‘ds_min_’ part replaced by ‘sc_EU_min_’ and ‘ds_’ replaced by ‘EU+NO_s_ + w_lt_ × sh_lt_’.

Moreover, the score for import is normalised with the domestic score, by multiplying it:
(import score) × (100 - domestic score) /100.

This ensures that the total PES sub-index value (score) will not be higher than 100, using the net domestic share and import dependency as weighing factors.

The import scoring rules are depicted graphically in the next Figure A.1 In the default situation the credit for long-term contracts is zero. In addition, two cases are shown for which the imports from outside the EU and Norway are secured by 50% or 100% long-term contracts.

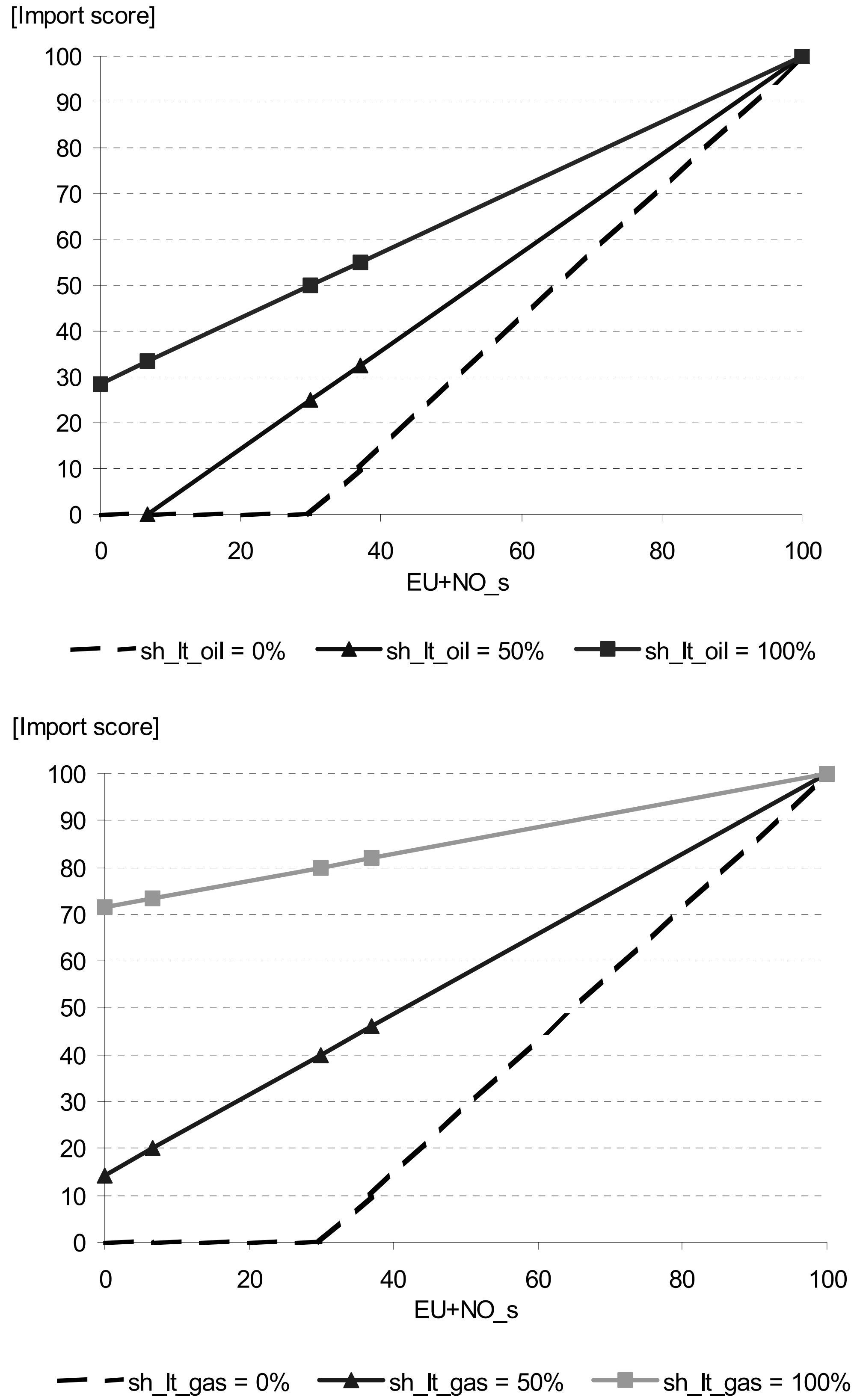

Figure A.1 *Scoring rules for imports of oil (top) and gas (bottom)*

A.2.3 Coal, Nuclear, Renewable sources, Other

Nuclear energy will have a value of 100 irrespective of the supply origin because supply risks for uranium are relatively low.

Because coal, renewables (mainly biomass) and other energy supplies will be sufficiently diversified, the index has a minimum value of 70 (sc_min) if the total supply is imported. The score will increase proportionally with decreasing shares of imports (and increasing domestic shares).

In a formula, the domestic score equals:
$\text{sc\_min\_}pri + (100-\text{sc\_min\_}pri) \times \text{ds\_}pri / 100$,
with *pri* = either coa, nuc, ren or oth (coal, nuclear, renewables or ‘other’).

These scoring rule is depicted graphically in Figure 4.4.

Some may argue that coal is at least as good for the security of supply as nuclear; in that case the minimum score for coal would be 100. In the case for the Netherlands, a specific sensitivity analysis has been performed and reported in Appendix C.

A.3 Energy conversion and transport

A distinction is made between electricity, heat and transport fuels. For each a further subdivision is made between conversion and transport, and depending on secondary energy carrier, a further delineation, see also Figure 4.2 in Chapter 4.

A.3.1 Definitions

Symbol	Value	Description
Weights		
w_ele	0.3	Weight electricity (as secondary energy carrier)
w_hea	0.5	Weight heat (as secondary energy carrier)
w_trf	0.2	Weight transport fuel (as secondary energy carrier)
Electricity		
eff_e	MS-spec	Average conversion efficiency thermal electricity production
eff_e_min	0.35	Minimum value average conversion efficiency thermal electricity production
eff_e_max	0.50	Maximum value average conversion efficiency thermal electricity production
res_fac	MS-spec	Reserve (margin) factor domestic production for the electricity system, without import capacity and assumptions on (unplanned) availability
res_fac_cri	1.20	Criterion value reserve margin factor domestic production for the electricity system
imp_cap	MS-spec	Import capacity interconnection, expressed as percentage of domestic production capacity
imp_cap_cri	0.05	Criterion value for import capacity interconnection, expressed as fraction of domestic production capacity
Heat		
ele_CHP	MS-spec	Fraction of electricity produced by combined heat and power (CHP)
ele_CHP_cri	25%	Criterion value fraction of electricity produced by CHP
Transport fuels		
ref_cap_uti	MS-spec	Refinery capacity utilisation rate (IEA, 2005, p. 89)
low_uti	80%	Low value for criterion for refinery capacity utilisation rate
hig_uti	95%	High value for criterion for refinery capacity utilisation rate

A.3.2 Electricity

Conversion

If the *efficiency* of thermal electricity production is higher, a higher score results. An efficiency of 35% or less, leads to a score of 0; an efficiency of 50% or more leads to a 100 score. In between, a proportional score applies. E.g. an efficiency of 42% leads to a score of 47 (=100 × (42-35)/(50-35)).

The *adequacy* score is related to the domestic capacity compared to peak demand. A ‘reserve factor’, res_fac, is defined as the percentage of the available capacity in excess of the peak demand. If the reserve factor is more than a certain level, res_fac_cri (20%) the score is 100. Otherwise, the score is res_fac/res_fac_cri.

The default score value for *reliability* is 100, assuming that on average the reliability of power plants is sufficient. Alternatively, the reliability of power generation capacity could also be included in power generation adequacy.

These scoring rules are summarised in the table below.

Attribute	Weight	Values	Scoring rule
Efficiency	0.3	eff_e e.g. from energy balance eff_e_max = 50% eff_e_min = 35%	100, if eff_e > eff_e_max 0, if eff_e < eff_e_min 100 × (eff_e-eff_min) / (eff_e_max - eff_e_min), in between
		Score, eff_e = 42%	Score: 47 (= (47-35) / (50-35))
Adequacy	0.6	res_fac_cri = 20%	100, if res_fac > res_fac_cri Min (100; 100 × res_fac / res_fac_cri)
		Score, res_fac = 10%	Score: 50 (= 10/20)
Reliability	0.1		100 (Reliability of plants considered sufficient)

Transport

The *adequacy* attributes are associated with *inland congestion* (weight 0.2) and the import capacity (weight 0.8). The default score for inland congestion is 100. Member States with inland congestion problems may have a lower score.

The score on the *import capacity* is a combination of a score related to the share of import, expressed as % of the domestic capacity (imp_cap_fac), and a criterion value (imp_cap_cri), and sum of the domestic and import capacity compared to peak demand (see also Electricity, Conversion, Adequacy).

The import capacity criterion valuee (imp_fac_cri) is tentatively set to 5%, so lower and less stringent than the 'Barcelona' goal of 10% set out in (EC, 2003b).

A product type of rule is needed for Member States with very high import capacities (e.g. Luxembourg) in comparison with domestic capacity. The sum of domestic and import capacity in relation to peak demand is then relevant as well. Otherwise, the value of import capacity could be overrated. In the product scoring rule, the same criterion value as for domestic capacity only has been used (res_fac_cri).

Note that different sources may use different definitions of 'domestic capacity', 'reserve factor', 'reserve margin', or 'import capacity' as a result of which the shares or criteria may (slightly) differ (UCTE, 2005; TenneT, 2005). For MS comparison purposes, a clear and uniquely determined and consistent definition should be used.

For the transport *reliability* attribute, statistics on network reliability in terms of the average time of outages per year could be used or a value for the total minutes per year without supply. Such values could be compared to a criterion value below which the score would be 100 (reliable enough). If the values are higher than such criterion values, the score would be less than 100. However, data on future network reliability is not available. For the moment the default index value is 100.

These scoring rules are summarised in the table below.

Attribute	Weight		Weight	Scoring rule
Adequacy	0.8	Inland congestion	0.2	100
		Import capacity	0.8	Min (100; 100 × imp_cap_fac / imp_fac_cri) × Min (100; 100 × (res_fac + imp_cap_fac/ res_fac_cri) / 100
Reliability	0.2		n/a	100 (Reliability of network considered sufficient)

A.3.3 Heat

Conversion

The type of scoring rules and attributes for heat are different from the ones for electricity.

The boiler efficiencies are not used here because of lacking information on this aspect (weight set to 0, see Figure 4.2 in Section 4.2). But even more relevant for efficiency of heat production is the share of heat generated by combined heat and power (CHP). Because of the complex (or even impossible) way to compute heat generated and the final heat from existing statistical information, these figures are not used. Instead, the share of CHP in electricity generation (ele_CHP) is used. Both statistics and scenario results usually report this CHP indicator for electricity. The index value is proportional to this share and will reach the value of 100 when 25% (ele_CHP_cri) of national annual electricity production is generated by CHP, a figure reflecting national practice in the Netherlands and Denmark.

In a formula, the scoring rule equals: Min(100; ele_CHP/ele_chp_cri × 100).

Transport

The weight of the transport branch in the S/D Index model has been set to 0. Hence, no scoring rule has been developed.

A.3.4 Transport fuels

Conversion

Efficiency: The fuel efficiency in terms of crude oil (and biofuels) input versus oil products output is relatively high (typically about 94%) and not really discriminating. Moreover, supporting data cannot be obtained easily; therefore, a score of 100 is assigned in all cases. Otherwise, a similar rule such as for Electricity, Efficiency could be applied (see Section A.3.2).

Adequacy: The index value is 100 if the refinery capacity in use is 80% or lower compared to the total domestic refinery capacity. If this figure exceeds the value of 95% the index value is dropping to zero. Between these two figures, which again reflect industry practice including mothballing, the index value is proportional to the ratio of refinery capacity in use.

Attribute	Weight	Values	Scoring rule
Efficiency	0.3		100
Adequacy	0.7	ref_cap_uti MS-spec low_uti = 80% hig_uti = 92%	100, if ref_cap_uti <= low_uti 0, if ref_cap_uti >hig_uti 100 - (ref_cap_uti-low_uti)/(hig_uti-low_uti) × 100, otherwise
Reliability	0.0		n/a (weight 0)

Transport

The capacity for transporting automotive fuels will seldom be constrained, because there are several alternatives (by truck, ship, train or pipeline). Therefore the default index value is 100.

Appendix B Quantification details

This part of the appendix reviews in more detail issues with regard to quantification of the S/D model, viz. data sources, specific data requirements, additional assumptions, limitations and other issues.

B.1 Data sources

Both the conceptual model as outlined in Chapter 4 and the illustrative quantified examples of the model in Chapter 5 indicate that the model needs a variety of data in order to quantify it. To the extent possible, objective data sources have been used:

1. *Energy demand intensities* from (Odyssee, 2005) and (Eurostat, 2004; 2006).
2. Data on *energy conversion and transport aspects* from a variety of sources including (UCTE, 2005), the Dutch TSO (TenneT, 2005), EC scenarios (EC, 2003; 2004), EC Benchmarking reports (EC, 2005b) and (IEA, 2005).
3. Data on *primary energy sources:* from Eurostat data and the EC scenarios.

Since energy balances play a crucial role in providing the more objective information, one example from Eurostat and one from the baseline EC scenarios is presented here, see Table B.1 for the EU-25 energy balance 1990-2003 and Table B.2 for the energy balance 1990-2030 of the 'old' baseline scenario for Netherlands.

From the inland consumption data, the *relative shares of the primary energy supply* mix can be computed. From the final energy demand, the *relative shares of the sectoral final energy demand* can be computed. These two types of shares provide the 'objective' weighing factors in the S/D model.

In addition, Table B.3 presents the summary indicators some of which have been used in the quantification of the S/D model.

For reasons of convenience, the most recent energy balances (April 2006) that were readily and easily available through the Eurostat website have been used. These data are made publicly available in Excel formats, which facilitates the various quantification steps. Therefore, the 2003 data of (Eurostat, 2006) have been used primarily. Moreover, information on the final energy intensities is largely based on the Odyssee database.

It should be noted that some parts of the Eurostat 'Monthly tables' include more recent data on the primary supply and imports. Data for 2004 (complete) and partially for 2005 are included in these tables. Such information is only made publicly available in PDF format.

Table B.1 *Example of summary energy balance, EU-25, 1990-2003*

[Mtoe]	1990	1995	2000	2001	2002	2003
Production	877.84	896.80	896.60	897.55	895.86	888.17
Solid fuels	351.75	264.46	203.20	201.53	200.59	*196.64*
Oil	120.33	162.35	163.77	152.66	155.87	*145.12*
Gas	139.63	174.17	196.66	197.22	193.27	*189.39*
Nuclear	196.95	215.32	237.66	246.03	248.40	*251.16*
Renewables	67.52	78.18	92.62	97.07	94.51	*103.11*
Other	1.67	2.34	2.68	3.04	3.22	*2.74*

[Mtoe]	1990	1995	2000	2001	2002	2003
Net Imports	708.96	701.17	801.54	827.27	826.24	875.47
Solid fuels	75.25	73.92	94.31	103.48	101.33	*111.30*
Oil	507.99	490.73	518.22	540.31	525.22	*547.29*
Gas	123.39	134.80	186.46	182.01	197.39	*216.16*
Electricity	2.18	1.37	2.14	1.04	1.86	*0.41*
Renewables	0.14	0.34	0.40	0.43	0.43	*0.30*
Derived heat			0.00	0.00	0.00	0.00
Inland Consumption	1553.01	1571.44	1652.15	1686.83	1676.89	1726.03
Solid fuels	431.53	345.42	305.60	307.14	305.53	*314.38*
Oil	593.65	621.11	634.76	648.04	638.00	*645.85*
Gas	259.14	307.34	376.29	383.97	384.92	*408.08*
Nuclear	196.95	215.32	237.66	246.03	248.40	*251.16*
Renewables	67.89	78.53	93.01	97.56	94.94	*103.40*
Other	3.85	3.71	4.83	4.09	5.10	*3.16*
Elec. Generation [TWh]	2379.96	2630.76	2928.49	3004.58	3018.03	3120.53
Coal	887.51	909.12	887.27	897.57	895.43	960.38
Oil	214.04	217.16	176.40	170.18	185.69	162.39
Gas	180.91	275.75	503.21	508.53	542.63	581.60
Nuclear	780.21	864.56	921.36	953.76	964.12	973.67
Renewables*	293.79	335.58	404.17	430.28	386.67	398.60
Other	23.50	28.60	36.09	44.26	43.49	43.89
Final Energy Demand	1010.46	1023.74	1068.86	1093.97	1080.07	*1131.56*
by fuel/product						
Solid fuels	123.93	81.52	58.20	56.94	52.45	51.16
Oil	428.58	447.22	469.39	480.81	475.16	476.43
Gas	202.89	231.62	257.05	262.35	258.11	275.17
Electricity	176.46	187.82	211.35	216.32	218.33	224.55
Renewables	33.78	38.01	43.58	45.44	45.24	48.16
Other	44.82	37.56	29.28	32.10	30.77	56.10
by sector						
Industry	331.64	304.89	309.89	309.86	307.01	*317.18*
Transport	273.14	295.01	333.38	335.74	338.09	*344.38*
Households	259.33	274.58	274.11	290.24	274.09	*300.53*
Commerce & other	146.35	149.26	151.47	158.13	160.87	*169.48*
Non-Energy Uses	94.31	103.55	105.94	102.45	100.31	100.82
CO_2 emissions** [Mt]	3775	3655	3692	3749	3750	3853
Energy intensity [toe/M€95]	246	230	212	212	209	208
CO_2 intensity [tCO2/toe]	2.43	2.33	2.23	2.22	2.24	2.23
Import dependency [%]	44.6	43.6	47.3	47.8	48.0	49.5
Energy per capita [kgoe/cap]	3524	3507	3648	3714	3682	3773
CO_2 per capita [kg/cap]	8566	8157	8152	8255	8233	8428

* not including pumping

** without maritime bunkers

Source: (Eurostat, 2006)

Data indicated in italics have been used for the ‘2003’ quantification.

Table B.2 *Summary energy balance EC baseline scenario, the Netherlands, 1990-2030*

[Mtoe]	1990	1995	2000	2005	2010	2015	2020	2025	2030
Primary Production	60.29	65.95	56.91	62.18	65.55	60.30	*55.12*	50.11	48.18
Solids	0.00	0.00	0.00	0.00	0.00	0.00	*0.00*	0.00	0.00
Oil	4.03	3.56	2.37	2.86	2.90	2.33	*1.75*	1.32	0.99
Natural gas	54.61	60.46	51.90	56.02	60.00	55.00	*50.00*	45.00	43.00
Nuclear	0.88	1.04	1.01	0.94	0.00	0.00	*0.00*	0.00	0.00
Renewable energy sources	0.77	0.90	1.62	2.35	2.65	2.97	*3.37*	3.80	4.19
Hydro	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Biomass	0.54	0.60	1.01	1.35	1.59	1.76	2.06	2.31	2.44
Waste	0.22	0.26	0.52	0.68	0.68	0.77	0.81	0.81	0.81
Wind	0.00	0.03	0.07	0.29	0.34	0.39	0.45	0.61	0.85
Solar and others	0.00	0.00	0.01	0.02	0.03	0.04	0.05	0.05	0.09
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Imports	17.39	16.34	34.24	29.65	30.82	39.29	48.20	57.03	64.07
Solids	9.52	8.90	8.17	5.38	5.64	5.22	*4.96*	7.82	12.54
Oil	30.88	32.83	41.63	41.15	42.47	44.85	*47.28*	49.40	51.48
- Crude oil and Feedstocks	47.96	59.28	60.93	73.78	78.40	83.39	*88.95*	93.51	98.38
- Oil products	-17.08	-26.45	-19.30	-32.63	-35.93	-38.54	*-41.67*	-44.11	-46.90
Natural gas	-23.80	-26.37	-17.19	-18.56	-19.01	-12.52	*-5.80*	-1.96	-1.73
Electricity	0.79	0.98	1.63	1.68	1.71	1.74	1.76	1.77	1.77
Gross Inland Consumption	66.82	73.32	75.36	76.72	80.03	82.21	85.01	87.76	91.75
Solids	9.15	9.08	7.98	5.38	5.64	5.22	*4.96*	7.82	12.54
Oil	24.42	27.24	28.41	28.91	29.03	29.80	*30.72*	31.33	31.98
Natural gas	30.81	34.09	34.71	37.46	40.99	42.48	*44.20*	43.04	41.27
Nuclear	0.88	1.04	1.01	0.94	0.00	0.00	0.00	0.00	0.00
Electricity	0.79	0.98	1.63	1.68	1.71	1.74	1.76	1.77	1.77
Renewable energy forms	0.77	0.90	1.62	2.35	2.65	2.97	*3.37*	3.80	4.19

[Mtoe]	1990	1995	2000	2005	2010	2015	2020	2025	2030
as % in Gross Inland Consumption									
Solids	13.7	12.4	10.6	7.0	7.1	6.3	*5.8*	8.9	13.7
Oil	36.5	37.2	37.7	37.7	36.3	36.2	*36.1*	35.7	34.8
Natural gas	46.1	46.5	46.1	48.8	51.2	51.7	*52.0*	49.0	45.0
Nuclear	1.3	1.4	1.3	1.2	0.0	0.0	*0.0*	0.0	0.0
Renewable energy forms	1.2	1.2	2.2	3.1	3.3	3.6	*4.0*	4.3	4.6
Electricity Generation [TWh_e]	71.82	81.05	89.60	96.62	114.25	128.46	141.41	153.50	164.33
Nuclear	3.50	4.02	3.93	3.66	0.00	0.00	0.00	0.00	0.00
Hydro & wind	0.14	0.41	0.97	3.55	4.13	4.76	5.38	7.27	10.38
Thermal (incl. biomass)	68.18	76.63	84.70	89.41	110.11	123.70	136.03	146.23	153.95
Fuel Inputs for Thermal Power Generation	16.70	18.87	19.41	19.18	21.64	22.43	23.59	25.10	27.53
Solids	5.77	5.92	5.15	2.26	1.94	1.45	1.10	3.90	8.59
Oil (including refinery gas)	1.22	1.36	0.92	0.46	0.66	0.58	0.59	0.61	0.60
Gas	9.20	10.96	12.08	14.85	17.67	18.88	20.29	18.92	16.69
Biomass - Waste	0.52	0.63	1.26	1.62	1.38	1.53	1.62	1.67	1.65
Geothermal heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydrogen - Methanol	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel Input in other transformation proc.	72.28	83.70	85.03	98.93	103.29	107.39	111.98	116.06	120.13
Refineries	68.77	80.01	82.16	95.74	99.08	103.11	107.36	111.20	115.15
District heating	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biofuels and hydrogen production	0.00	0.00	0.00	0.18	0.66	0.79	1.07	1.30	1.45
Others	3.51	3.69	2.87	3.01	3.55	3.50	3.56	3.56	3.53
Energy Branch Consumption	5.41	6.25	5.48	5.45	5.54	5.65	5.78	5.91	6.06
Non-Energy Uses	9.33	9.33	9.45	9.33	9.32	9.29	9.21	9.14	9.08
Final Energy Demand	42.64	47.16	49.59	52.86	55.93	58.48	*61.12*	63.21	65.32

[Mtoe]	1990	1995	2000	2005	2010	2015	2020	2025	2030
by sector									
Industry	12.89	12.43	13.60	13.66	13.97	14.37	*14.63*	14.86	15.11
- energy intensive industries	9.90	8.78	9.48	9.39	9.37	9.43	9.42	9.39	9.33
- other industrial sectors	2.99	3.65	4.12	4.27	4.61	4.94	5.21	5.47	5.77
Residential	9.77	11.12	10.28	10.94	11.67	12.24	*12.68*	13.01	13.42
Tertiary	9.66	11.20	11.89	12.62	13.41	13.98	*14.57*	15.14	15.65
Transport	10.32	12.40	13.82	15.64	16.88	17.88	*19.24*	20.19	21.13
by fuel									
Solids	1.64	1.39	1.25	1.19	1.18	1.19	1.14	1.10	1.06
Oil	12.60	14.20	16.20	18.34	19.46	20.55	21.93	22.81	23.76
Gas	19.70	21.02	19.99	20.17	20.67	20.91	21.08	21.27	21.62
Electricity	6.32	7.14	8.42	8.93	10.33	11.44	12.45	13.37	14.19
Heat (from CHP and District Heating)	2.14	3.17	3.45	3.97	4.03	4.12	4.24	4.36	4.39
Other	0.24	0.24	0.28	0.26	0.26	0.28	0.28	0.30	0.30
CO_2 Emissions (Mt of CO_2)	152.9	167.2	165.6	164.6	174.0	178.4	184.4	194.9	211.5
Electricity and Steam production	48.7	54.0	52.3	45.5	51.5	52.2	54.1	62.1	75.3
Energy Branch	13.6	15.8	13.1	12.9	12.9	13.0	13.2	13.4	13.6
Industry	22.4	19.9	21.3	20.5	20.4	20.6	20.5	20.2	20.2
Residential	19.2	20.6	18.9	19.9	20.9	21.6	22.1	22.3	22.5
Tertiary	19.0	20.7	19.5	20.2	20.1	20.0	20.0	20.3	20.6
Transport	30.0	36.2	40.5	45.5	48.2	51.0	54.4	56.7	59.2
CO_2 Emissions Index (1990=100)	100.0	109.3	108.3	107.7	113.8	116.7	120.6	127.5	138.3

Source: (EC, 2003), based on PRIMES calculations.
Data indicated in italics have been used for the 2020 quantification.

Table B.3 *Summary indicators EC baseline scenario, the Netherlands, 1990-2030*

	1990	1995	2000	2005	2010	2015	2020	2025	2030
Main Energy System Indicators									
Population [Million]	14.95	15.46	15.92	16.45	16.82	17.13	*17.40*	17.66	17.86
GDP [in 000 MEuro'00]	301.4	334.8	401.1	446.9	503.1	564.0	630.3	702.5	780.1
Gross Inl. Cons./GDP [toe/MEuro'00]	221.7	219.0	187.9	171.7	159.1	145.8	134.9	124.9	117.6
Gross Inl. Cons./Capita [toe/inhabitant]	4.47	4.74	4.73	4.67	4.76	4.80	4.88	4.97	5.14
Electricity Generated/Capita [kWh/inhabitant]	4805	5243	5627	5875	6793	7501	8125	8694	9203
Carbon intensity [t of CO_2/toe of GIC]	2.29	2.28	2.20	2.15	2.17	2.17	2.17	2.22	2.31
CO_2 Emissions/Capita [t of CO_2/inhabitant]	10.23	10.81	10.40	10.01	10.35	10.42	10.59	11.04	11.85
CO_2 Emissions to GDP [t of CO_2/MEuro'00]	507.3	499.3	412.9	368.4	345.9	316.4	292.5	277.5	271.2
Import Dependency [%]	22.4	19.3	38.6	32.3	32.0	39.5	46.6	53.2	57.1
Energy intensity indicators (1990=100)									
Industry (Energy on Value added)	100.0	88.2	85.1	80.0	74.8	69.5	*64.3*	59.5	55.0
Residential (Energy on Private Income)	100.0	105.4	80.2	*75.3*	71.2	66.5	61.4	56.5	52.4
Tertiary (Energy on Value added)	100.0	103.7	89.7	*83.7*	77.9	71.9	*66.5*	61.7	57.1
Transport (Energy on GDP)	100.0	108.2	100.7	102.3	98.0	92.6	89.2	84.0	79.2
Carbon Intensity indicators									
Electricity and Steam production [t of CO_2/MWh]	0.43	0.39	0.35	0.28	0.29	0.26	0.25	0.27	0.32
Final energy demand [t of CO_2/toe]	2.12	2.07	2.02	2.01	1.96	1.94	1.91	1.89	1.88
Industry	1.73	1.60	1.57	1.50	1.46	1.44	1.40	1.36	1.34
Residential	1.96	1.85	1.84	1.82	1.79	1.77	1.74	1.71	1.68
Tertiary	1.97	1.85	1.64	1.60	1.50	1.43	1.37	1.34	1.32
Transport	2.91	2.92	2.93	2.91	2.85	2.85	2.83	2.81	2.80
Electricity and steam generation									
Generation Capacity [GW_e]		21.02	22.75	26.55	28.15	32.61	36.53	39.69	43.08
Nuclear		0.54	0.54	0.48	0.00	0.00	0.00	0.00	0.00
Hydro (pumping excluded)		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

	1990	1995	2000	2005	2010	2015	2020	2025	2030
Wind and solar		0.29	0.46	1.05	1.24	1.64	2.14	2.26	3.38
Thermal		20.15	21.72	24.99	26.87	30.94	34.34	37.40	39.67
of which cogeneration units		6.85	8.87	10.05	9.60	9.22	8.65	7.44	8.51
Open cycle (incl. biomass-waste)		15.05	13.26	13.19	11.41	7.84	6.28	6.75	9.95
Supercritical Polyvalent/Clean Coal and Lignite		0.00	0.00	0.00	0.00	0.00	0.00	2.81	4.89
Gas Turbines Combined Cycle		4.49	7.96	11.30	15.14	19.95	23.80	23.10	19.81
Small Gas Turbines		0.61	0.50	0.50	0.33	3.15	4.26	4.74	5.02
Fuel Cells		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal heat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indicators									
Efficiency for thermal electricity production [%]		36.3	36.9	42.2	45.5	49.1	*51.3*	51.7	50.0
Load factor for gross electric capacities [%]		44.0	45.0	41.5	46.3	45.0	44.2	44.1	43.5
CHP indicator [% of electricity from CHP]		36.3	44.1	43.5	31.7	23.9	*21.3*	16.5	20.7
Non fossil fuels in electricity generation [%]		8.1	10.4	12.3	7.1	6.9	6.8	7.3	8.6
- nuclear		5.0	4.4	3.8	0.0	0.0	0.0	0.0	0.0
- renewable energy forms		3.1	6.0	8.5	7.1	6.9	6.8	7.3	8.6
of which waste		1.0	1.9	1.8	1.6	1.4	1.2	1.1	1.0
Transport sector									
Passenger transport activity [Gpkm]	169.7	179.0	193.3	210.9	232.7	258.8	*285.5*	312.8	340.8
public road transport	11.1	11.8	12.6	15.5	16.0	16.9	17.9	18.8	19.6
private cars and motorcycles	141.4	145.3	154.3	167.0	183.8	203.6	223.6	243.7	264.0
train transport	12.3	15.4	16.2	15.6	16.8	18.7	20.2	21.9	23.5
Aviation	4.1	5.8	9.6	12.3	15.4	18.8	22.9	27.3	32.5
inland navigation	0.8	0.7	0.6	0.6	0.7	0.8	0.9	1.0	1.1
travel per person [km per capita]	11351	11577	12139	12824	13837	15113	16403	17715	19088
Freight transport activity [Gpkm]	70.5	80.7	90.8	103.2	117.1	130.0	*142.8*	155.7	168.8
Trucks	31.8	42.2	45.7	55.1	64.8	73.9	83.5	93.7	104.6

	1990	1995	2000	2005	2010	2015	2020	2025	2030
train transport	3.1	3.1	3.8	3.7	4.0	4.2	4.4	4.5	4.6
inland navigation	35.7	35.5	41.3	44.5	48.4	51.9	54.9	57.5	59.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
freight activity per unit of GDP [tkm/000 Euro'00]	234	241	226	231	233	231	227	222	216
Energy demand in transport [Mtoe]	10.32	12.40	13.82	15.64	16.88	17.88	19.24	20.19	21.13
public road transport	0.10	0.07	0.09	0.11	0.11	0.11	0.11	0.10	0.10
private cars and motorcycles	5.04	5.55	5.29	5.69	5.74	5.70	6.01	6.07	6.00
trucks	2.90	3.33	4.25	5.12	6.01	6.77	7.34	7.86	8.20
train transport	0.11	0.16	0.18	0.16	0.16	0.15	0.14	0.13	0.14
aviation	1.61	2.60	3.35	3.85	4.09	4.33	4.78	5.15	5.81
inland navigation	0.56	0.70	0.67	0.72	0.78	0.83	0.87	0.88	0.89
Efficiency indicator (activity related)									
passenger transport [toe/Mpkm]	40.4	46.8	46.0	*46.4*	43.3	39.7	*38.7*	36.6	35.4
freight transport [toe/Mtkm]	49.0	49.8	54.3	*56.6*	58.0	58.4	*57.4*	56.1	53.8

Source: (EC, 2003), based on PRIMES calculations.

Data indicated in italics have been used for the 2020 quantification.

Table B.4 *Gross inland consumption, EU-25 and Member States, 2003*

[Mtoe]	All fuels	Solid fuels	Oil	Natural gas	Nuclear	Renewables
EU-25	*1 726.0*	*314.4*	*645.8*	*408.1*	*251.2*	*103.4*
EU-15	1 513.4	222.5	596.0	366.1	231.7	92.1
BE	55.8	6.2	21.2	14.4	12.2	1.1
CZ	43.7	20.7	8.6	7.8	6.7	1.2
DK	20.7	5.7	8.3	4.7	0.0	2.7
DE	344.5	85.0	125.3	79.2	42.6	11.6
EE	5.5	3.4	1.0	0.7	0.0	0.5
EL	30.2	8.9	17.5	2.0	0.0	1.5
ES	*134.1*	*20.2*	*67.1*	*21.4*	*16.0*	*9.4*
FR	270.6	13.8	92.0	39.4	113.8	17.3
IE	15.3	2.5	8.7	3.7	0.0	0.3
IT	181.8	14.9	88.3	63.4	0.0	10.8
CY	2.5	0.0	2.5	0.0	0.0	0.0
LV	4.4	0.1	1.2	1.3	0.0	1.5
LT	9.0	0.2	2.4	2.4	4.0	0.7
LU	4.2	0.1	2.7	1.1	0.0	0.1
HU	26.7	3.7	6.8	11.9	2.8	0.9
MT	0.9	0.0	0.9	0.0	0.0	0.0
NL	*80.5*	*8.7*	*31.2*	*36.0*	*1.0*	*2.0*
AT	32.7	4.0	13.8	7.6	0.0	6.7
PL	*94.1*	*57.7*	*20.4*	*11.3*	*0.0*	*5.1*
PT	25.3	3.3	14.9	2.6	0.0	4.3
SI	6.9	1.5	2.5	0.9	1.3	0.7
SK	18.9	4.6	3.6	5.7	4.6	0.6
FI	37.1	8.2	10.4	4.1	5.9	7.9
SE	50.9	2.7	15.5	0.8	17.4	13.4
UK	*229.8*	*38.4*	*79.3*	*85.9*	*22.9*	*3.1*

Source: (Eurostat, 2006)
Data indicated in italics have been used for the ‘2003’ quantification.

Table B.5 *Import dependencies, EU-25 and Member States, 2003*

[%]	All fuels	Solid fuels	Oil	Gas
EU-25	*49.5*	*35.4*	*76.6*	*53.0*
EU-15	51.8	55.1	79.2	49.2
BE	78.8	86.2	100.9	98.9
CZ	24.9	-17.4	95.8	98.2
DK	-31.7	98.3	-98.0	-55.7
DE	61.1	29.1	98.0	78.8
EE	27.4	6.8	73.7	100.0
EL	67.4	4.7	96.1	98.8
ES	*76.4*	*63.4*	*99.6*	*99.1*
FR	50.5	86.0	99.4	95.5
IE	87.1	65.8	96.3	85.2
IT	84.0	97.7	82.9	80.3
CY	99.1	94.7	100.6	-
LV	58.7	93.7	101.5	104.4
LT	45.3	98.9	89.5	100.0
LU	98.7	100.0	100.2	100.0
HU	61.1	26.8	71.0	83.6
MT	100.0	-	100.0	-
NL	*37.6*	*104.6*	*91.7*	*-45.0*
AT	69.8	83.8	93.5	78.7
PL	*14.3*	*-23.0*	*96.5*	*66.6*
PT	85.3	99.7	103.1	100.3
SI	53.4	20.4	101.4	99.4
SK	64.6	79.9	90.6	96.8
FI	59.2	80.6	102.1	100.0
SE	42.9	92.7	106.3	100.0
UK	*-5.9*	*52.2*	*-33.2*	*-8.2*

Source: (Eurostat, 2006)

Data indicated in italics have been used for the '2003' quantification. Negative numbers indicate that a MS is a net exporter. In that case, the 'net' domestic share (ds_*pri*, see Section A.2) used in the quantification of the S/D Index has been set to 1 (see also Table C.1 where the import dependencies have been set to 0 in such cases)

B.2 Additional assumptions and data requirements for future scenarios

For the 2020 quantification, the summary energy balances in (EC, 2003) and (EC, 2004) have been used as information sources. In particular, the demand and PES scores are based on data from these scenario studies. It should be noted that these scenarios do not always provide the data required for the S/D model. Additional but plausible assumptions have therefore been made to fill this data gap, see the examples outlined in Section C.3.

B.2.1 Final energy demand

The energy intensity development for industry and the tertiary sector is given as an index value in the EC scenarios. The changes in index values for 2005 and 2020 are used for calculation of the absolute energy intensities in 2020 (expressed as toe/M€), together with the absolute current (i.e. 2003) figures.

The EC scenarios provide explicit data for the transport energy intensities (toe/Mtkm and toe/Mpkm, for goods and passenger kilometres, respectively). Since the Odyssee transport data are not always consistent with the Eurostat or scenario data due to differences in definitions, the differences of the '2003' Odyssee data and the Eurostat data or '2005' scenario data are used as proxy to correct the '2020' scenario data.

The future toe/capita values for the residential final energy demand can be deduced from the projected size of the population and the final residential energy demand.

B.2.2 Energy conversion and transport

For the C+T part of the model, mainly the efficiency indicator (electricity branch of C+T tree) and CHP indicator (heat branch of C+T tree) of the scenarios have been used. All other parameters have not been changed, principally due to a lack of data in the public documentation of these scenarios. This applies to import capacities of electricity, reserve factors, and the transport fuel data. In theory, such information could be made available from details on the scenarios. An example of such detailed information is a more recent baseline scenario for the Netherlands, see Section C.3. For this Global Economy scenario estimates for the reserve factor for electricity production and the import capacity factor have been derived from the detailed POWERS calculations. POWERS is the electricity market simulation model used for the Reference Projections (ECN/MNP, 2005). The model calculates wholesale electricity prices, capacity allocation and the resulting fuel mix, with the projected electricity demands and the actual production park including investments in new capacity as exogenous inputs. The model takes into account scenario parameters like fuel prices, CO_2 prices and economic growth that is reflected in the development of the electricity demand. A description of the model can be found in (Seebregts et al., 2005).

B.2.3 Primary energy sources

The primary energy mix and the import dependencies can be directly retrieved from the summary energy balances.

B.3 Limitations and flexibility

B.3.1 Limitations

The quantification of the S/D index has some limitations that have been already addressed but are here summarised for convenience.

1. The assessments on the basis of the S/D Index model are partly subjective. However, it should be noted that any assessment of this type will be subjective.
2. Comparison of index values with other Member States or some EU benchmark may lead to undesired ‘wishful’ weighing and scoring in order to get a good mark.
3. Depletion of fossil reserves is an aspect sometimes included in indicators for long-term security of supply, see e.g. the indicators developed in (Jansen et al., 2004). Depletion has been intentionally left out in the S/D index. Remaining reserves, either domestic or from countries of origin is an important aspect in an overall assessment. Within the procedure outlined in this report, depletion could be dealt with in the scenario application of the S/D index, or the aspect could be added to the S/D model, once reserves really become an issue of concern.
4. Definitions, accuracy and incompleteness in ‘objective’ data sources must be carefully considered
5. The usual Eurostat energy statistics are always somewhat delayed: ‘now’ may be 2-3 years ago. National statistics usually have more recent data if necessary.
6. When applying the S/D index model for a future energy system, it should be noted that the larger the time horizon, the larger the future uncertainties are. Different future scenarios for one Member State may show quite diverging energy images, with quite differently emerging values for the S/D index. In that case, comparisons are still meaningful. On the contrary, S/D Index values comparisons between Member States should at least be based on the same common ‘EU’ scenario in order to let the comparison be meaningful.

B.3.2 Flexibility

The detail of the energy system model that forms the basis for scoring the security of supply has therefore been carefully selected in order to arrive at a model that:

1. Is still transparent and simple enough to understand the results relatively easy, given the data and other assumptions
2. Enables sensitivity and uncertainty analyses on key assumptions and data parameters
3. Depicts the entire energy system in one (graphical) figure.
4. Can be quantified without the need for detailed data mining, as it is based on existing energy system data and existing other indicators.

On the other hand, the model has been defined such that it enables flexibility in terms of:

1. Increasing the level of detail, e.g. one could make a distinction in imports coming from outside the EU and Norway, and add the country or regional detail to those imports with also different weights.
2. Modifying the existing weights and scoring criteria, which has been demonstrated in a few sensitivity analyses in Section 5.3 and Appendix C.
3. Modifying the nature of the scoring rules.

The parameter and data uncertainties, either with respect to the weighing factors in the model or with respect to selected criteria used in the scoring rules, have been analysed in sensitivity analyses. These analyses have shown which uncertain parameters have the largest impact on the S/D index value, and which should therefore receive special attention.

Appendix C Additional quantitative results

In addition to the results reported in Chapter 5, this Appendix provides more quantification results. Additional and illustrative sensitivity analyses are presented to show the impact of the most important weighing factors, and the use of alternative scenarios for the Netherlands and the UK.

C.1 Focusing at sub-indices

The overall S/D index value is just one figure that indicates the level of energy security of supply in the medium and long term. The advantage of the modelling and quantification approach is that it enables focusing at the sub-indices and sub-scores as well. The next Table C.1 shows all relevant figures in one view. These cases have largely been reported in Chapter 5 (Sections 5.1 and 5.2) but the import dependencies of the primary energy sources and the fraction of the imports coming from outside the EU/Norway are presented too in this table. This helps in explaining and understanding the PES score. Due to the weights of Supply and the PES herein, the total S/D index is usually largely determined by the PES sub-index. In that sense, the PES sub-index could be compared to other (long-term) security of supply indicators that often are restricted to the supply of PES only (see e.g., Jansen et al., 2004).

It is important to note that Table C.1 also shows the sub-indices of the branches: Demand, Supply, Conversion+Transport, and Primary Energy Sources. In this way, comparisons, either intertemporal (now and 2020) or between countries can be made at the underlying parts of the energy system.

Table C.1 *Summary of results, default values*

	Netherlands		NL-2020		UK		UK-2020		UK-2020-75%		Poland		PL-2020		EU-25		EU-25-2020		Spain		SP-2020	
S/D Index		**68.3**		**68.7**		**77.5**		**72.0**		**56.5**		**65.2**		**55.0**		**53.9**		**49.0**		**51.1**		**47.9**
Demand	0.3	**58.1**	0.3	**57.7**	0.3	**66.8**	0.3	**67.1**	0.3	**67.1**	0.3	**49.2**	0.3	**46.1**	0.3	**67.9**	0.3	**66.7**	0.3	**75.2**	0.3	**70.0**
Industry	0.27	45	0.24	44	0.24	64	0.24	65	0.24	65	0.30	17	0.24	25	0.28	65	0.28	65	0.33	47	0.30	45
Residential	0.20	56	0.21	51	0.30	47	0.28	45	0.28	45	0.33	75	0.34	44	0.27	58	0.25	52	0.15	100	0.17	82
Tertiary	0.24	53	0.24	54	0.13	67	0.14	66	0.14	66	0.20	14	0.20	18	0.15	67	0.15	67	0.11	70	0.12	68
Transport	0.29	76	0.31	75	0.34	85	0.34	87	0.34	87	0.16	100	0.23	95	0.30	80	0.32	80	0.41	90	0.40	85
Supply	0.7	**72.7**	0.7	**73.5**	0.7	**82.0**	0.7	**74.1**	0.7	**51.9**	0.7	**72.0**	0.7	**58.8**	0.7	**47.9**	0.7	**41.3**	0.7	**40.8**	0.7	**38.5**
C+T	0.3	**96.0**	0.3	**91.5**	0.3	**45.6**	0.3	**57.1**	0.3	**57.1**	0.3	**84.0**	0.3	**86.3**	0.3	**60.2**	0.3	**66.1**	0.3	**63.1**	0.3	**69.8**
Electricity	0.3	90	0.3	100	0.3	59	0.3	66	0.3	66	0.3	86	0.3	94	0.3	64	0.3	72	0.3	88	0.3	95
Heat	0.5	100	0.5	85	0.5	35	0.5	54	0.5	54	0.5	100	0.5	100	0.5	55	0.5	62	0.5	47	0.5	56
Tr. Fuels	0.2	94	0.2	94	0.2	51	0.2	51	0.2	51	0.2	40	0.2	40	0.2	67	0.2	67	0.2	67	0.2	67
PES	0.7	**62.7**	0.7	**65.7**	0.7	**97.7**	0.7	**81.4**	0.7	**49.7**	0.7	**66.9**	0.7	**47.1**	0.7	**42.7**	0.7	**30.8**	0.7	**31.2**	0.7	**25.1**
Oil	0.38	10	0.36	10	0.34	100	0.34	100	0.34	56	0.22	0	0.28	0	0.37	0	0.36	0	0.50	0	0.45	0
Gas	0.46	100	0.52	100	0.38	100	0.47	64	0.47	29	0.11	6	0.25	0	0.24	24	0.32	0	0.16	0	0.29	0
Coal	0.11	70	0.06	70	0.16	85	0.07	77	0.07	77	0.62	100	0.42	100	0.18	89	0.13	85	0.15	81	0.06	80
Nuclear	0.01	100	0.00	100	0.10	100	0.07	100	0.07	100	0.00	100	0.00	100	0.14	100	0.11	100	0.12	100	0.10	100
Ren. ES	0.02	100	0.04	100	0.01	100	0.04	100	0.04	100	0.05	100	0.05	100	0.06	100	0.08	100	0.07	100	0.10	100
Other	0.02	100	0.02	100	0.00	100	0.01	100	0.01	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100	0.00	100
Import dependencies	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU	Import	Non-EU
Oil	0.91	0.63	1.00	0.63	0.00	0.31	0.00	0.31	0.75	0.31	0.97	0.99	0.98	0.99	0.77	0.73	0.93	0.73	1.00	0.90	1.00	0.90
Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.50	0.75	0.50	0.66	1.00	0.90	1.00	0.53	0.85	0.75	0.85	0.99	1.00	1.00	1.00
Coal	1.00		1.00		0.49		0.76		0.76		0.00		0.00		0.35		0.50		0.63		0.68	
Nuclear	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Ren. ES	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.01		0.00		0.00	
Other	0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	

C.2 Additional sensitivity analyses on most important weights

The main sources of uncertainty which effects the value of the overall S/D index are the weighing factors that are based on expert judgment. These importance measures factors have been quantified and illustrated for two cases in Section 5.3, in combination with the various scoring criteria, and based upon a multi-variate sensitivity analysis. For these two cases/countries, it appeared that the S/D index varied about 10% when the weights varied by +/- 0.1.

The main overall important factors are the weighing factors up front in the model, viz. the weight of supply (w_sup) versus demand (w_dem), and within the supply part, the weight of the primary energy sources (w_pes) versus conversion and transport (w_ct).
w_sup + w_dem = 1
w_pes + w_ct = 1

If the other weights at lower sub-branches and the scoring criteria remain unaltered, the impact of changing the upfront weights can be easily quantified and displayed by changing only the two weights w_sup and w_pes.

For a more extreme case, the weights for supply and PES have been changed from 0.7 to 0.9 (hence, decreasing demand and C+T weights from 0.3 to 0.1). The results with these weights are displayed in Table C.3. The overall S/D index value changes in this case. The scores more resemble the sub-index value of the Supply/Primary Energy Sources.

Table C.2 *Summary of results, with 0.9 instead of 0.7 weights for supply and primary energy sources (demand and C+T 0.1 instead of 0.3)*

	Netherlands	NL-2020	UK	UK-2020	UK-2020-75%	Poland	PL-2020	EU-25	EU-25-2020	Spain	SP-2020
Changed (0.9)	65.2	67.2	89.9	77.7	52.1	66.7	50.5	46.8	37.5	38.5	33.6
Default (0.7)	68.3	68.7	77.5	72.0	56.5	65.2	55.0	53.9	49.0	51.1	47.9
Difference	-3.1	-1.5	12.4	5.8	-4.4	1.5	-4.5	-7.2	-11.4	-12.6	-14.4
[%]	-4	-2	16	8	-8	2	-8	-13	-23	-25	-30

The (baseline) scenarios reported in (EC, 2003) and (EC, 2004) are outdated to some extent. Examples of more recent baseline scenarios are those from the Netherlands (ECN/MNP, 2005) or new insights for future energy situation of the United Kingdom (DTI, 2006). Some general notions on assumptions and data requirements for quantifying the S/D index for future energy systems are described in Section B.2.

The results of these other scenario studies give an indication of both the effect of using another scenario - quite different in some respect compared to the old baseline and of effects on the long term (2040 in the Dutch case). In particular, noteworthy effects are visible with respect to the fuel mix of the electricity production (increasing role of renewables or coal at the expense of natural gas), and the import dependency of natural gas and oil.

C.3 More recent baseline scenarios NL and UK

C.3.1 The Netherlands - Global Economy scenario - 2020 and 2040

The Reference Projections Energy and Emissions 2005-2020 (ECN/MNP, 2005) are the most recent baseline scenarios for the Netherlands. It concerns two scenarios, Global Economy (GE) and Strong Europe (SE), which differ mainly with respect to future economic growth (and hence future energy demand) and to post-Kyoto climate policy. These scenarios are ‘policy free’, so based on existing policies and instruments as of 2004. An assumption in the GE scenario is that the global and EU climate policy ends after 2020 (CO_2 price of 0), while in the SE scenario more stringent climate policy will emerge with CO_2 price levels of more than 80 €/ton in 2040.

A further expansion of these and two other scenarios to the very long term (2040) has just been finalised (CPB/MNP/RPB, 2006; ECN, 2006). ECN was responsible for the theme ‘Energy’ in those scenarios.

The Global Economy is a scenario with a relatively high economic growth and hence a relatively increase in energy demand is the scenario which is currently the reference scenario for energy and climate policy making in the Netherlands.

The results for the three cases are presented in Table C.2 and in Figure C.1. The S/D index is only slightly less in 2020 compared to the old baseline. The decrease is mainly caused by a worse score on PES, despite a higher share of coal and lower share of gas. If the minimum score for coal would be 100, similar as for nuclear, the PES score would be 63.7 instead of 59.5. In that case, the baseline PES score would be 67.5 (instead of 65.7). The overall S/D score would then be 69.6 compared to 68.7 for the NL baseline 2020. Changes in PES scores propagate with a factor 0.49 (=0.7 x 0.7) in the total S/D index.

Note that the share of imported oil coming from outside EU or Norway has been assumed to be equal to the 2003 value (63%, with crude oil assumed to be a proxy for all oil i.e. crude oil and oil products).

The demand score remains equal, while the C+T score improves somewhat due to a higher share of CHP (35% in GE-2020, 21% in NL 2020 baseline). It is important to note that the scores on Industry, Tertiary and Transport have been assumed equal to the baseline case. Only the relative shares have been changed. The same holds for these demand sectors in 2040.

In GE-2040 the S/D index is 10 points less than in GE-2020. The main cause is that the Netherlands becomes a net importer of gas and hence more dependent of gas imports (42% dependency), which are assumed to originate for 50% outside the EU and Norway. Moreover, the share of oil (with 100% import dependency) increases. As a result the PES sub-index value drops almost 20 points, from 60 to 42.

Table C.3 *S/D index for the Netherlands, 2020 and 2040, impact of other scenarios*

	NL-2020 (Baseline from (EC, 2003)		NL-GE-2020 (ECN, 2006)		NL-GE-2040 (ECN, 2006)	
S/D index		**68.7**		***66.7***		**57.1**
Demand	0.3	**57.7**	0.3	**57.7**	0.3	**56.9**
Industry	0.24	44	*0.29*	44	0.32	44
Residential	0.21	51	*0.20*	*55*	0.19	51
Tertiary	0.24	54	*0.21*	54	0.19	54
Transport	0.31	75	*0.30*	75	0.31	75
Supply	0.7	**73.5**	0.7	***70.6***	0.7	**57.2**
C+T	0.3	**91.5**	0.3	***96.4***	0.3	**93.3**
Electricity	0.3	100	0.3	*92*	0.3	81
Heat	0.5	85	0.5	*100*	0.5	100
Tr. Fuels	0.2	94	0.2	94	0.2	94
PES	0.7	**65.7**	0.7	***59.5***	0.7	**41.7**
Oil	0.36	10	*0.39*	10	0.43	10
Gas	0.52	100	*0.38*	100	0.32	58
Coal	0.06	70	*0.14*	70	0.21	70
Nuclear	0.00	100	*0.01*	100	0.00	100
Ren. ES	0.04	100	*0.06*	*84*	0.02	
Other	0.02	100	0.02	100	0.03	100
	Import dep.	Non-EU	Import dep.	Non-EU	Import dep.	Non-EU
Oil	1.00	0.63	*0.98*	0.63	1.00	0.63
Gas	0.00	0.00	0.00	0.00	0.41	0.50
Coal	1.00		1.00		1.00	
Nuclear	1.00		1.00		1.00	
Ren. ES	0.00		*0.52*		0.26	
Other	0.00		0.00		0.00	

Notes:

1) The changes for the GE scenario in 2020 compared to the old baseline are marked in *italic.*

2) The changes for the GE scenario in 2040 compared to GE 2020 are underlined.

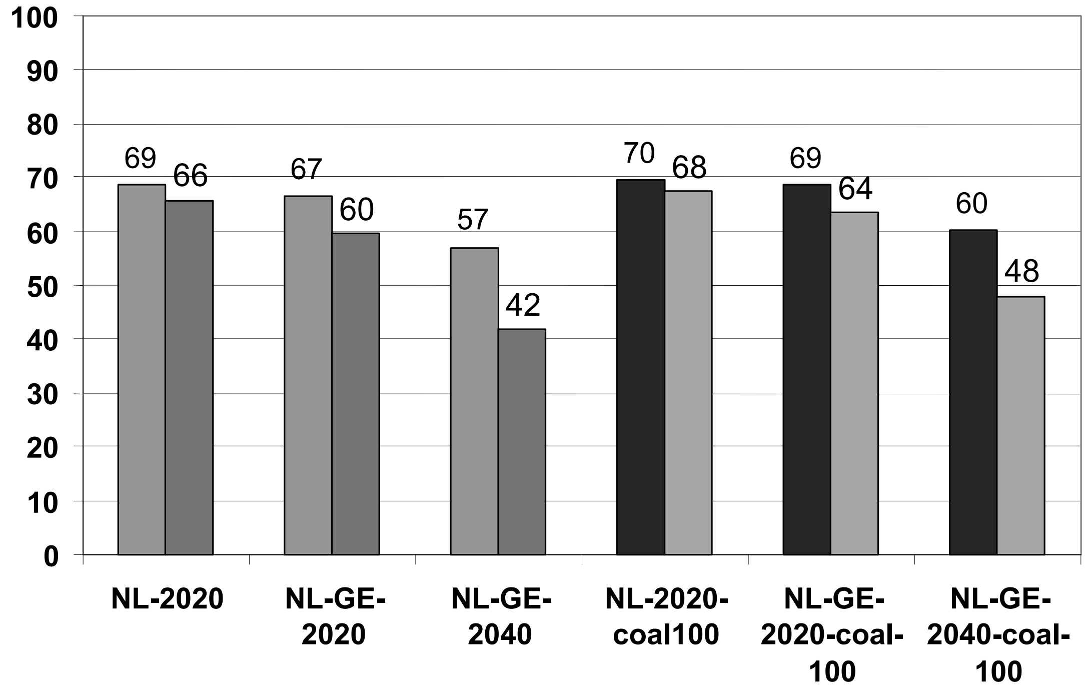

Figure C.2 *S/D Index the Netherlands, another future scenario (GE) and sensitivity on coal criterion (coal 100)*

C.3.2 The United Kingdom - In 2020 import dependencies of 75%

The decline of its indigenous energy supplies (oil and gas) makes the energy security of supply a major issue in the UK (DTI, 2006). The security of supply issue is one of the main reasons for the recent plea for new nuclear power plants in the UK. In (FCO, 2004) it is stated: “It is likely that the UK will become a net importer of gas annually by around 2006 and of oil by around 2010. By 2020, the UK is expected to be importing around 75% of its primary energy needs." So, this is quite different from the old UK baseline reported in (EC, 2003) in which the UK was still a net exporter of oil in 2020 and the import dependency for gas was only 36%. For nuclear fuel the import dependency was 76%.

As sensitivity to the UK-2020 baseline case, the following assumptions have therefore been made:

1. The import dependency for oil and gas is 75% in 2020, instead of 0% and 36%, respectively.
2. All other parameters have been based on and are equal to the original UK-2020 case, e.g. from the imported gas, 50% is assumed to come from outside the EU or Norway. In 2003, the natural gas imports came from Belgium (17%) and Norway (83%).

These changes effect the PES sub-index value that drops from 81 to 50, see Table C.1. As a result the total S/D Index value then drops from 72 to 56.5.


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