Is the German Energy System Sustainable? An Analysis Based on the UNCSD Theme-based Sustainability Approach

Holger Schlör*, W. Fischer, J.-F. Hake

Institute of Energy Research, IEF-STE

Forschungszentrum Jülich, Jülich, Germany

*e–mail: h.schloer@fz-juelich.de

* Corresponding author

I Abstract

The World Summit on Sustainable Development (WSSD) in Johannesburg 2002 reaffirmed the conclusions of the 1992 UN Conference on Environment and Development in Rio and of the Brundtland Report that sustainable development is a crucial element for the future of the world and a keystone of the international agenda.

Since the publication of the Brundtland Report, the sustainability concept and its implementation have been discussed by the science community and society. Sustainability is regarded as a solution for society's present and future problems. To determine whether we are working in a sustainable way, we need information about the condition of the human and natural system. Sustainable development indicators describe and define issues and circumstances which characterize sustainable development. They measure the difference between current conditions and a reference situation defined as sustainable. The availability of indicators is a precondition for the conversion of the model of sustainable development into specific policies. Energy already plays an important role for sustainable development in the Brundtland Commission's report. The use of energy facilitates, on the one hand, economic development and prosperity but, on the other hand, the production and consumption of energy has negative consequences for the environment. The German Government has developed a sustainability indicator set for its Sustainability Strategy based on the UN theme-based approach, which also includes indicators for the energy system. The Government thereby defined a sustainable order for Germany.

The Index of Sustainable Development (ISD) developed by the authors calculates the degree to which sustainable development has been achieved or not. This measurement of sustainable development will start by measuring the single indicators of the sustainable strategy, then we will analyse the single pillars and finally the whole energy system. This technique has the advantage that it provides information for the public and also political decision makers at every level of sustainability: the single indicators, the four themes of the SD Strategy and the total system. The index shows whether Germany is on a sustainable energy path according to the goals set by the German Government in its strategy. The index enables us to compare the sustainability order of the German Government’s goals with the actual behaviour of German society. The index enables us to answer the question of whether the German energy sector is “better off” in sustainable categories.

II Energy and Sustainability

Energy has been the foundation of every human civilization because in every civilization people have striven to improve their living conditions, and the “universal currency (Smil, 1994)” for the measurement of this improvement is the amount of energy used. In this way, “all levels of reality (White, 1943)” can be interpreted in terms of the universal currency energy, and civilizations can be regarded “as a form or organizations of energy (White, 1943).” No organism can exist without a food supply (metabolic energy) and no civilization can exist without energy. Energy is the foundation of every civilization and every culture. Hence “energy is ... the most vital product of societal activity, since without a continuous input of it, all activity would come to a halt (Nolan and Lenski, 2005).” And humans are the only beings who can develop culture (White, 1940). In the context of neo-evolutionary theory (Morgan, 1877 (1985), White, 1949, Lenski, 1966, Nolan and Lenski, 2005, McGee and Warms, 2007) the purpose of culture is to serve the needs of humans and so three factors describe the cultural situation of human civilization:

1. “the amount of energy per capita per unit of time harnessed and put to work within the culture,
2. the technological means with which this energy is expended, and
3. the human need-serving product that accrues from the expenditure of energy (White, 1943).”

Energy is the basis of cultural development if one understands culture as a "mechanism for serving human needs" so that “cultural development [can] be measured by the extent to which, and the efficiency with which, need-serving goods or services are provided (White, 1943).” In White’s theory, the technological systems which provide the goods and services determine the social system and the social system is thus a result of the amount of energy which can be used to produce human need-serving products. Hence culture evolves as the productivity of human labour increases and the productivity can be increased with the availability of energy. The spread of culture is thus for White a “manifestation of energy (White, 1943)” and, therefore, he formulated two laws for the description of cultural development:

1. “First law of cultural development: Other things being equal, the degree of cultural development varies directly as the amount of energy per capita per year harnessed and put to work (White, 1943).”
2. “Second law of cultural development: Other things being equal, the degree of cultural development varies directly as the efficiency of the technological means with which the harnessed energy is put to work (White, 1943).”

Building on these two laws of cultural development he formulated the general law of cultural development (the law of cultural evolution): “culture develops when the amount of energy harnessed by man per capita per year is increased; or as the efficiency of the technological means of putting this energy to work is increased; or, as both factors are simultaneously increased (White, 1943).”

White’s laws elucidate the meaning of energy for the cultural development of human civilizations. Sieferle supports White’s opinion that civilizations can be described with the help of their specific basic physical and energetic conditions (Sieferle, 2001). He divides the history of mankind into three main epochs within which every epoch has its own energy basis and therefore has a different social-metabolic regime (Sieferle, 1997, Sieferle, 2003a, Sieferle, 2001, Krausmann and Schandl, 2006, Sieferle, 2003b): the Neolithic epoch is based on the unmodified use of solar energy, the agrarian epoch on the self-controlled use of solar energy, and the industrial epoch is based on the use of fossil energy sources (Sieferle, 1982, Sieferle, 2003a, Krausmann and Schandl, 2006, Marquardt, 2005). With the success of industrialization and the expansion of the fossil energy system, Western-style societies believed that the industrial revolution and fossil energy sources would lead people out of the energy crises of the agrarian-solar world (Marquardt, 2005).

However, at the end of the 20th century it became clear that the fossil energy system was also coming up against new ecological, economic and social limits which White could not have foreseen in 1943. “This energy intensification came at a cost. Here I mention two aspects of that cost. First, fossil fuel combustion generates pollution. … . Secondly, fossil fuel use has sharply increased the inequalities in wealth and power among different parts of the world. The requisite technologies and corresponding social political structures developed first and most thoroughly in Europe and North America. Other parts of the world generally remained dependent on biomass for heat

and muscles for mechanical energy until 1950 or so. Indeed, the poorest countries remain so still (McNeill, 2001)."

Pollution and in part inequalities are the results of using different amounts of fossil fuels and initiated the two central issues for the Brundtland Commission for the definition of sustainable development, which is closely related to the use of fossil energy. In 1987, the Brundtland Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This definition contains two key concepts:

1. the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
2. the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Thus the goals of economic and social development must be defined in terms of sustainability in all countries (World Commission on Environment and Development (WCED), 1987)." That is valid especially for the energy system, for which the Brundtland Commission determined that "a safe and sustainable energy pathway is crucial to sustainable development (World Commission on Environment and Development (WCED), 1987)." However, in 2008 the IEA explained that the present energy system is not yet sustainable and must be transformed: "Current global trends in energy supply and consumption are patently unsustainable — environmentally, economically, socially. But that can — and must — be altered; there's still time to change the road we're on. It is not an exaggeration to claim that the future of human prosperity depends on how successfully we tackle the two central energy challenges facing us today: securing the supply of reliable and affordable energy; and effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply (International Energy Agency (IEA), 2008)."

The previous definitions show, on the one hand, how energy, especially fossil fuels, enables humans to shape the space of opportunity to create higher standards of living. On the other hand, the same energy sources cause environmental damage and inequalities. And the energy consumed by present and former generations cannot be used by future generations, so that future generations cannot use the clear-cut "subterranean forests (Sieferle, 2001)" of fossil fuels and will have to deal with the envi-

ronmental degradation caused by energy emissions. The use of energy plays an important part by generating the problems which have to be solved by sustainable development, so that energy is a central issue for a sustainable cultural development.

This short introduction has shown the importance of energy for the development of the socio-economic conditions of societies and in particular for industrialized societies. This is why the Brundtland Commission (Chapter 7) asserts that the energy supply plays an important role for the realization of sustainable development (World Commission on Environment and Development (WCED), 1987). But the use of energy fosters not only economic development and prosperity; it also has negative effects on the environment (e.g. climate change and air pollution). Therefore, any sustainability strategy has to find a balance between economic and social development and environmental integrity. Germany has taken up this challenge. In the following, we will use the example of Germany to carry out a sustainability analysis of its energy sector, based on the sustainability indicator system of the German Government and to examine whether Germany is on a sustainable development path.

III Theme-based Sustainability Approach

III.1 The theme-based framework of the Commission on Sustainable Development (CSD)

Chapter 40 of Agenda 21 encourage the nations of the international community to develop indicators of sustainable development to provide a solid basis “for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems (United Nations, 1992).” For this duty a special UN commission was founded for sustainable development (CSD = Commission on Sustainable Development) to guarantee an effective subsequent process of the 1992 Rio conference. “The United Nations Commission on Sustainable Development (CSD) was established by the UN General Assembly in December 1992 to ensure effective follow-up of United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. The Commission is responsible for reviewing progress in the implementation of Agenda 21 and the Rio Declaration on Environment and Development; as well as providing policy guidance to follow up the Johannesburg Plan of Implementation (JPOI) at the local, national, regional and international levels. The JPOI reaffirmed that the CSD is the high-level forum for sustainable development within the United Nations system.”[1]

The CSD is a functional commission of the UN Economic and Social Council and one of nine functional commissions of the Economic and Social Council of the United Nations (ECOSOC), which is subordinate to the UN general assembly and has no decision-making competence of its own. As a functional commission of the UN Economic and Social Council (ECOSOC), the CSD has 53 member States (about one third of the members are elected on a yearly basis). The CSD cannot make decisions that are internationally binding or dismiss conventions.

An important aspect of the work of the CSD is the development of indicator systems for measuring sustainable development. The Commission on Sustainable Development called upon countries, international governments and non-governmental organizations to take part in the process of developing indicator concepts according to the default of the Agenda 21 (United Nations, 1992).

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[1] http://www.un.org/esa/dsd/csd/csd_aboucsd.shtml

The first indicator system of CSD was published in 1996 and consisted of 134 indicators which were assigned to the three columns of sustainability. This indicator set was tested in 22 countries (Germany) (Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment Nature Conservation and Nuclear Safety), 2000), between 1996 and 1999 on practicalness and completeness (United Nations, 1996).

Between 1999 and 2000, the results of the national tests were evaluated by the CSD. Most of the test countries were of the opinion that the first indicator set with 138 indicators was too large, so that the second revised indicator system was reduced to 58 indicators and was published in 2001 as the 2nd revised indicator set of the UN (see annex) (United Nations, 2001).

In its second indicator set, the CSD explicitly dismissed the multi-pillar system approach of sustainability and transferred its indicators to the theme-based sustainability approach. The CSD is of the opinion that sustainability indicators can be politically better managed in this new system. The CSD has come to the conclusion that the multi-pillar model, which had its origin in Agenda 21 and was taken up by the CSD for its first indicator set, is no longer suitable to cover the complexity and multidimensionality of the world using sustainability indicators.

The CSD sees the advantage of the theme-based approach in comparison to the 3-pillar approach in the fact that it relates the single indicators directly to political processes and goals. This approach enables to communicate the idea of sustainability to the world of decision makers and thus to raise public awareness of sustainability. A thematic frame is more suitable in the view of the CSD to supervise the realization of sustainability in a monitoring process. In addition, the approach is more flexible for including new priorities and policy purposes in a sustainable strategy (United Nations, 2007).

The Commission explained its procedure: “The division of indicators along the lines of four ‘pillars’ (social, economic, environmental and institutional) is no longer explicit in the newly revised set. This change emphasizes the multi-dimensional nature of sustainable development and reflects the importance of integrating its pillars (United Nations, 2007).”

The current CSD indicator set of 2007, the result of the third audit process, also takes into consideration the experiences of UN with the millennium Development Goals (MDG[2]) and the MDG indicators (United Nations, 2007). The third revised indicator set consists of 50 core indicators, which are the central part of the whole indicators set of 96 indicators. The introduction of a core indicator set makes the indicator set easier to handle and the whole indicator set enables a differentiated analysis of the sustainable development to be made. Besides, the core indicators fulfil three criteria (United Nations, 2007):

1. These indicators take into consideration questions which are important for sustainable development in most countries.
2. They provide important information which cannot be delivered by other core indicators.
3. The core indicators can be determined in most countries with existing data.

The CSD also made clear that there are similarities between the indicators of the CSD and the MDG indicators, but, nevertheless, four main differences between the two indicator sets can be identified (United Nations, 2007):

- The CSD indicators serve as an instrument to build up a reference scenario for individual countries, so that they can measure progress on the way to sustainable development.
- However, the MDG indicators serve to measure global progress in a monitoring process with regard to the MDG.
- The CSD indicators cover a wide range of questions relating to all areas of sustainable development – economy, society, environment.
- However, the MDG indicators refer only to eight specific MDGs. The MDGs are a sub-group of the international sustainability agenda and refer, primarily, to poverty and health questions in developing countries (United Nations, 2007).

[2] The Millennium Development Goals were derived from the United Nations Millennium Declaration, adopted by 189 nations in 2000. Most of the goals and targets were set to be achieved by 2015 on the basis of the global situation during the 1990s. The baseline for the assessment of progress is therefore 1990 for most of the MDG targets.

In summary, we can say that the CSD sees the advantage of the theme-based framework compared to the 3-pillar approach in the fact that it relates the single indicators directly to political processes and goals.

The theme-based framework for sustainability indicators integrates a multi-dimensional field of political issues which are seen as central for the implementation of sustainable development. The theme-based concept also allows the consideration of general subjects like poverty, natural disasters and the important subject of the change of consumption and production patterns. Against this background, the CSD has divided its new revised indicator set into 14 themes: Poverty, Governance, Health, Education, Demographics, Natural hazards, Atmosphere, Land, Oceans, seas and coasts, Freshwater, Biodiversity, Economic development, Global economic partnership, Consumption and production patterns. These themes are the core indicators, and subthemes and other indicators have also been assigned, see Annex I.

We can conclude that with its third revised indicator set the CSD took a step towards better communicating the idea of sustainable development to policy makers and the general public. The Commission also makes clear that the monitoring process is an important aspect of the process towards sustainable development. “Using the CSD indicators as basis for national indicators of sustainable development can assist countries in monitoring national implementation of their international commitments too. In this regard, the CSD indicators are useful for measuring the outcome of policies towards achieving sustainable development goals (United Nations, 2007).”

The CSD has drawn attention to the fact that it not sufficient to define sustainability indicators, countries should also determine sustainability goals, as the UN did with the MDG. These goals can be reviewed in a monitoring process. The monitoring process and the sustainability goals are, in the view of the Commission, a central component of the countries’ sustainability strategy. “Monitoring is necessary for the effective implementation of a strategy, and it helps prevent the strategy from becoming a mere list of intentions. Monitoring facilitates the adjustment of policy interventions to changing conditions during implementation. It promotes a culture of learning, providing a basis for improved strategies in subsequent iterations, and it enhances the performance of key actors in implementation by allowing for better accountability. Moreover, together with appropriate reporting procedures, monitoring promotes public interest and information on sustainable development (United Nations, 2007).” The

theme-based sustainability approach combined with a monitoring process is the framework for an active social discussion process about the sustainability goals of the specific sustainability strategy of every country.

III.2 The German Sustainability Strategy

III.2.1 The theme-based German sustainability approach

As a result of the UN test phase, in which Germany worked intensively with its UN partners, Germany has also decided to develop a theme-based sustainability strategy. In 2002, the Federal Government presented its new sustainability strategy "Perspectives for Germany" (German Federal Government, 2002a). The government defines its key political priorities for sustainable development on the basis of the following four key themes (German Federal Government, 2002a):

1. intergenerational equity (IE)
2. quality of life (QL)
3. social cohesion (SC)
4. international responsibility (IR)

We have assigned the key themes of the German Sustainability Strategy to the corresponding CSD themes and this reveals a close connection between the German Strategy and and CSD system, as the following table shows.

Table 1 Key Issues of the German Sustainability Strategy and UN CSD Themes

Key issue of the German Sustainability Strategy	UN CSD Themes
Intergenerational Equity	Education, Atmosphere, Land, Biodiversity, Economic Development, Consumption and Production Patterns,
Quality of Life	Governance, Health, Atmosphere, Economic Development, Consumption and Production Patterns
Social Cohesion	Demographics, Economic Development
International Responsibility	Global Economic Partnership
Not included in the German System are the UN Themes of Poverty, Natural Hazards, Oceans, Freshwater.	
Source: (German Federal Government, 2002b, United Nations, 2007)	

The German Sustainability Strategy covers 10 of the 14 CSD themes. The Government has set up indicators and sustainability goals for these key issues and incorporated the UN's requirement to develop sustainability goals for the country-specific strategies. The Statistical Office of Germany performs the monitoring process. The German Government defines a reference scenario in the sense of the theme-based approach of the UN-CSD Indicator set, which enables the Government to measure progress on the way to sustainable development. The Government thus avoids the impression that its sustainability strategy is merely a list of good intentions.

III.2.2 Key themes of German SD strategy

The German Federal Government defines sustainable development as a leitmotif for the 21st century and as a method of preventing people from getting lost in the labyrinth of modern times (German Federal Government, 2002a, German Federal Government, 2002b). A new intergenerational contract was the Federal Government's starting point for the development of a sustainability strategy to reconcile the interests of the generations by taking into account the discussion about the national public finance deficit, the pension reform, the natural basis of life and the cost of the

health service. The Federal Government stated that the intergenerational contract presupposes fundamental agreement on the values and social aims of the development of society. The Government assumes that the achievement of intergenerational equity has to consider three aspects. First, the preservation of the natural basis of life, second, the increase of efficiency, and third, a sustainable management strategy has to consider the sustainability of the financial policy of the state by reducing the national public deficit, encouraging individual responsibility, shaping structural change, dismantling conflicting aims between economic and ecological interests, regulatory policy and the use of free-market instruments, and eco-labelling for companies using sustainability management strategies. Twenty-one topics and 34 indicators were chosen to measure the sustainability of the Government's policy (German Federal Government, 2002a). This sustainable strategy was the first attempt by the Germany Federal Government to define a normative quantitative sustainable pathway.

The first group of indicators on the theme of intergenerational equity covers 9 issues of sustainability - conservation of resources, climate protection, renewable energies, land use, biodiversity, national debt, provision for future economic stability, innovation, education and training. These indicators should enable us to analyse whether the Government is achieving its goal of intergenerational equity.

Table 2:

Sustainability Indicators of the German Government - Intergenerational Equity										
	1997	1998	1999	2000	2004	2006	2010	2015	2020	2050
I. Intergenerational equity										
1. Energy & raw materials productivity (1994=100)										
Energy			120				160		200	
Raw materials			117				158		200	
2. Emissions of the six greenhouse gases covered by Kyoto Protocol (1990=100)				81.3			79			
3. Proportions of energy consumption from renewable energy										
in % primary energy consumption				2.1			4.2			
in % electricity consumption				6.3			12.5			50
4. Land use for housing and transport - increase in ha per day				129					30	
5. Development of stocks of selected animal species (1995 = 100)			98.2	95.4						
6. Public finance deficit - in % of GDP			1.6	1.3	0.5	0				
7. Provision for future economic stability - gross capital formation in relation to GDP			22.6	22.5						
8. Innovation - private and public expenditure on research and development			2.45	2.46			3			
9. Education and training										
25-year-olds having completed education				6			9.5			
Leaving secondary school without certificate				9			4			
University entrance rate				30.2			40			

Source: German Federal Government, 2002.

The Federal Government has set itself the goal of almost doubling the energy and raw materials productivity of the German national economy by 2020 and, simultaneously, of reducing greenhouse gas emissions from 81.3% in 2000 to 79% in 2010. Moreover, the Government plans to increase the proportion of renewable energy consumed in Germany. In 2050, the proportion of renewable energy should represent 50% of the nation's energy consumption. The Government wants to reduce the rate at which land is built on from 129 hectares per day to 30 hectares per day in 2020 and to encourage the preservation of biodiversity in Germany. Additionally, the German Government intends to reduce the public finance deficit. However, the Government failed to present a balanced budget in 2006. The Government will significantly

increase the economic investment ratio (gross capital formation in relation to GDP). The present investment ratio is about 21.3%, which is about 2% lower than in 1992. The Government considers a higher rate of investment across the whole economy to be essential for sustainable development and therefore aims to increase private and public expenditure for research and development issues from 2.45% at present to about 3% in 2010. The Government has established the objective of increasing the proportion of young people taking up a university place by about 10% from 30.2% to around 40%, while simultaneously striving to reduce the student drop-out rate. In addition, the Federal Government intends to achieve a significant increase in the percentage of 25-year-olds with a university degree. The core of the sustainability concept of the German Government is quality of life, and maintenance of the economic prosperity of society.

The following indicators describe the quality of life: economic prosperity, mobility, nutrition, air quality, health, and crime.

Table 3:

Sustainability Indicators of the German Government - Quality of Life

II. Quality of Life	1997	1998	1999	2000	2004	2006	2010	2015	2020
10. Economic prosperity									
GDP per capita in 1995 prices			23281	23950					
11. Mobility									
Transport intensity 1999=100									
Passenger traffic			100				90		78
Goods traffic			100				98		95
Proportion of freight transported by rail			15%					25%	
Proportion of inland shipping	8%							14%	
12. Nutrition									
Proportion of organic farming in %				3.2			20		
Nitrogen surplus (kg/ha)				116.6			80		
13. Air quality									
Concentration of air pollution 1990=100			54	52			30		
14. Health									
Premature mortality (below 65)									
Women			150						
Men			300						
Satisfaction with health									
Men				6.6					
Women				6.4					
15. Crime									
Burglaries involving a break-in				140000			126000		

Source: German Federal Government 2002

The gross domestic product describes the economic prosperity of society per capita. The Government selected mobility as the second indicator for the quality of life. The

major goal of the Government is to decouple economic output and transport output by reducing transport intensity by about 5% for freight transport and about 20% for passenger transport by the year 2020. Additionally, freight transport by rail should be doubled in comparison to the 1997 volume. Inland shipping is set to increase its share of transport intensity by around 40% in the same period. Healthy nutrition is a further indicator for measuring the quality of life. The Government plans to increase the share of organic farming from 3.2% in 2000 to 20% in 2010. At the same time, the Federal Government has set itself the goal of reducing the nitrogen surplus of the agricultural sector from currently 116 kg/ha to 80 kg/ha. However, emissions should not only be reduced in agriculture. By 2010, concentration of the main air pollutants should be reduced on a scale of around 70% compared with 1990. Health is the central aspect of the quality of life for the general public. The Government has chosen two indicators for measuring the health of German society: “premature mortality (below the age of 65)” and “satisfaction with health”. The Government has not defined objectives for either indicator. It assumes that personal security is another important aspect for the quality of life. Therefore crime is included on the list of indicators. The Government assumes that against the background of the rapid structural change of the world economy the administration has to enhance the social security system. Social cohesion is seen as an important aspect of sustainable development.

Four indicators describe social cohesion: employment, prospects for families, equal opportunities, and integration of foreign citizens.

Table 4:

Sustainability Indicators of the German Government - Social Cohesion									
	1997	1998	1999	2000	2004	2006	2010	2015	2020
III. Social cohesion									
16. Employment									
Employment rate				65.4			70		
17. Prospects for families									
Full-time day-care facilities in the West German Länder									
0-3 years		2.2					30		
3-6.5 years		16.3					30		
6.5 - 12.5 years		3.4					30		
18. Equal opportunities									
Comparison of gross annual earnings from full-time employment (women and men aged between 35 and 39, West German Länder)	76						85		
19. Integration of foreign citizens									
Foreign school leavers without secondary school-leaving certificate	17.1	17	16.7	16.1					9

Source: German Federal Government 2002

The German Federal Government is striving to raise the employment rate to 70% in 2010 from around 65% in 2000 and plans to improve the living conditions of families by better full-time day-care facilities. Full-time day-care gives women and men equal opportunities in a sustainable society. Hence, the Government wants to improve the relationship of gross annual earnings from full-time employment for women and men between 35 and 39 from currently 76% to 85% in 2010.

The integration of immigrants into German society is an important aspect of social cohesion. The Government is especially trying to improve language skills. Inadequate language skills are the main reason for the higher rate of unemployment among foreigners. By 2020, the proportion of foreign school-leavers without secondary school-leaving qualifications of about 17.1% in 1997 should be brought closer to the rate of German school-leavers without qualifications of currently 9%. The Government sees Germany as an integral part of the world, especially in the context of globalization and climate protection. Hence, the national strategy for sustainable development must look beyond national borders and must face its international responsibility. The Government defines two indicators for measuring the international responsibility of its policy: development cooperation and open markets.

Development cooperation is measured by public development cooperation expenditure in % of gross domestic product.

Table 5:

Sustainability Indicators of the German Government - International Responsibility									
	1997	1998	1999	2000	2004	2006	2010	2015	2020
IV. International responsibility									
20. Public development cooperation (in % GDP)			0.27			0.33			
21. Open markets									
EU imports from developing countries (EUR billion)	263	268	304	420					
Source: German Federal Government, 2002									

This expenditure should increase to 0.33% in 2006, which still falls below the internationally defined goal of 0.7% of GDP. Furthermore, the Government is striving to achieve an opening of the European markets for goods from developing countries, in order to give them equal opportunities.

III.3 Monitoring the German energy sector

In the report by the Brundtland Commission (Chapter 7), the energy supply already plays an important role for the realization of sustainable development (World Commission on Environment and Development (WCED), 1987). The use of energy facilitates, on the one hand, economic development and prosperity, but, on the other hand, the use of energy has negative effects on the environment (climate change).

The development in the energy sector can be described with the help of the indicators chosen by the German Government. For the following analysis six indicator topics (energy productivity, emissions of greenhouse gases, proportion of energy consumption from renewable energy, mobility, air quality, employment) with ten indicators (CO2, NOx, SO2, CO, dust, energy productivity, passenger-kilometres (pkm), tonne-kilometres (tkm), renewables, employment in the energy sector) are selected from the above-mentioned sustainable strategy of the Federal Government (German Federal Government, 2002a, Deutscher Bundestag, 2002) considering ecological as well as social and economic issues. For these indicators the Federal Government has defined quantitative goals in their sustainability strategy.

Whether sustainable development has been achieved in the German energy sector can be determined by an analysis of all quantifiable indicators. The indicators measure the distance of a country from sustainable development. The indicator of sustainable development (ISD) developed by the authors measures this distance and thereby calculates the degree to which sustainable development has been achieved or not. The ISD shows whether society is "better off" in sustainable categories and is on a sustainable cultural pathway.

A picture of the status of sustainable development in the energy sector can be determined by the following formula:

$$I_{SD} = \frac{1}{N}\left(\sum_{x=1}^{N} AF_x \cdot I_x\right), \qquad (1)$$

Ix= activity indicator (i.e. CO2), N= number of indicators, AF=0,…,1

The meaning of the individual indicators for sustainable development can be adjusted by the weighting factor, AF, according to the values of society or the specific sustainability concept such as the weak or strong sustainable paradigm.

For the following formula, a weighting factor of AF=1 was chosen because the German Government did not mention in its strategy that the indicators should be treated differently. Hence all individual factors are treated the same. No difference, for example, will be made between CO2 emissions and fine dust emission load in an assessment of whether a development is sustainable or not.

Then the single indicators which define one aspect of sustainable development can be calculated by relating the real change rate of the single factors to the desired change rate of the sustainable order and thereby measuring the extent to which the sustainability goals have been achieved by calibrating the maximum value for the sustainable development goal as 1. This assumption is made on the basis of the fact that there is no such thing as "supersustainability" in the case of a normative sustainability concept such as the German one. "One" defines a complete congruence of real development with the normative sustainability goals and "zero" defines the total failure of any consistency between the normative goals and real development

We measure the sustainability of the German energy sector in a three-step procedure. First, we calculate the single indicators in the four key themes to measure

whether the single topic covered by the indicator is developing in a sustainable way. Secondly, we calculate whether the four themes are moving in a sustainable direction and, thirdly, we measure with ISD the sustainability of the whole Germany energy system.

The single factors I_x of the I_{SD} are defined as follows:

$$0 \le I_X \le 1; \forall\, I_X > 1 \Rightarrow I_X := 1; \quad I^{y=\text{Theme (IE, QL, SC, IR)}}_{x=\text{Indicators (CO2, NOx, etc.)}}$$

Key Theme: Intergenerational Equity (IE)

$$I^{IE}_{CO_2} = \frac{79_{SD-Goal^{2010}_{1990=100}}}{84.22_{Real^{2010}_{1990=100}}} = 0.94 \tag{2}$$

$$I^{IE}_{\text{Energy productivity}} = \frac{119.24_{Real^{2020}_{1990=100}}}{200_{SD-Goal^{2020}_{1990=100}}} = 0.60 \tag{3}$$

$$I^{\text{IE}}_{\text{Renewables}} = \frac{218_{Real^{2010}_{1990=100}}}{200_{SD-Goal^{2010}_{1990=100}}} = 1.09 := 1 \tag{4}$$

Key Theme: Quality of Life (QL)

$$I^{QL}_{NO_x} = \frac{30_{SD-Goal^{2010}_{1990=100}}}{54.38_{Real^{2010}_{1990=100}}} = 0.55 \tag{5}$$

$$I^{QL}_{SO_2} = \frac{30_{SD-Goal^{2010}_{1990=100}}}{11.07_{Real^{2010}_{1990=100}}} = 2.71 := 1 \tag{6}$$

$$I^{QL}_{CO} = \frac{30_{SD-Goal^{2010}_{1990=100}}}{38.68_{Real^{2010}_{1990=100}}} = 0.78 \tag{7}$$

$$I^{QL}_{Dust} = \frac{30_{SD-Goal^{2010}_{1990=100}}}{4.49_{Real^{2010}_{1990=100}}} = 6.6 := 1 \tag{8}$$

$$I^{QL}_{Pkm} = \frac{78_{SD-Goal^{2020}_{1990=100}}}{99.64_{Real^{2020}_{1990=100}}} = 0.78 \tag{9}$$

$$I^{QL}_{Tkm} = \frac{95_{SD-Goal^{2020}_{1990=100}}}{98.31_{Real^{2020}_{1990=100}}} = 0.97 \tag{10}$$

Social Cohesion (SC)

$$I^{SC}_{\text{Employment}} = \frac{93.84_{\text{Real}^{2010}_{1990=100}}}{107_{\text{SD-Goal}^{2010}_{1990=100}}} = 0.88 \tag{11}$$

International Responsibility (IR)

There is no energy-related indicator in the fourth theme. One possible energy indicator could be fairly traded energy sources according to the ILO Declaration on Social Justice for a Fair Globalization (International Labour Organsiation (ILO), 2008).

The results show that under present trend conditions the sustainable development goals will not be achieved. NOX emissions, CO2 emissions, CO emissions, energy productivity, transport intensity (passenger-kilometres (pkm), tonne-kilometres (tkm)) and the development of employment will not meet the sustainability goals of the government either. Whereas the SO2 emissions, fine dust emissions and the development of the renewable energy sector will meet the Government's specific goals.

The single indicators show a very heterogeneous picture of the development of the German energy sector.

We obtain the following equations for the four themes of the sustainability strategy:

$$I^{IE}_{SD} = \frac{1}{3}\sum_{i=1}^{3} AF_{i,j} \cdot I_{i,j} = \frac{1}{3}\left(0.94 + 0.6 + 1\right) = 0.85 \tag{12}$$

$$I^{QL}_{SD} = \frac{1}{6}\sum_{i=1}^{6} AF_{i,j} \cdot I_{i,j} = \frac{1}{6}\left(0.55 + 1 + 0.78 + 1 + 0.78 + 0.97\right) = 0.84 \tag{13}$$

$$I^{SC}_{SD} = \frac{1}{1}\sum_{i=1}^{1} AF_{i,j} \cdot I_{i,j} = \frac{1}{1}\left(0.88\right) = 0.88 \tag{14}$$

$$I^{IR}_{SD} = \frac{1}{0}\sum_{i=1}^{0} AF_{i,j} \cdot I_{i,j} = 0 \tag{15}$$

The results show that Germany's energy sector is not developing in a sustainable way. The equations also show that the first three themes are more or less developing in the same way. The International Equity Theme is not developing in a sustainable way. That is also valid for the Theme of Quality of Life and the Theme of Social Cohesion. For the fourth Theme of International Responsibility, the German Government has not developed any energy-related indicators.

In the third step, we calculated an overall-sustainable indicator, which summarizes the heterogeneity of the different effects described in the energy sector and measures the degree of sustainability the German energy system has achieved against the background of the normative sustainable goals defined by the Federal Government. And with the help of the following equation we get the overall indicator:

$$I_{SD} = \frac{1}{N}\left(\underbrace{AF \cdot I_{NO_X} + AF \cdot I_{SO_2} + AF \cdot I_{CO} + AF \cdot I_{Dust} + AF \cdot I_{Pkm} + AF \cdot I_{Tkm}}_{\text{Quality of Life}} + \underbrace{AF \cdot I_{Eprod} + AF \cdot I_{CO_2} + AF \cdot I_{\text{Renewables}}}_{\text{Intergenerational Equity}} + \underbrace{AF \cdot I_{Employment}}_{\text{Social Cohesion}} + \underbrace{AF \cdot I}_{\text{International Responsibility}} \right)$$

$$AF = \text{Assessment Factor}, \; I_{SD} = \text{Sustainability Indicator}$$

(16)

We calculated two overall indicators. One considering only the three themes covered by the German Government (equation 17) and one which also considers the fourth theme and interprets the absence of energy indicators for the theme of International Responsibility as not sustainable (equation 18).

$$ISD = \frac{1}{3}\left(0.846 + 0.846 + 0.88\right) = 0.857 \tag{17}$$

$$ISD = \frac{1}{4}\left(0.846 + 0.846 + 0.88 + 0\right) = 0.6425 \tag{18}$$

Equation 17 shows that by considering three themes the German energy system is nearly on a sustainable development pathway as outlined by the Federal Government if one extrapolates the present trend into the future. That is to say, the sustainable order derived from people's behaviour does not yet correspond to the sustainable development order of the Federal Government, but the sustainable order of the Government is 85% (ISD=0.857) equal to the order derived from people's behaviour.

If one chooses equation 18 and interprets the absent indicators in the fourth theme as not sustainable then we obtain a value of 0.6425 of the indicator of sustainable development. This value can be interpreted such that the German energy system is 35% away from sustainable development, because the missing indicators in theme four receive the value zero. The German Government failed to include energy-related indicators in theme 4.

In an annual monitoring process, the time series can be examined with respect to whether the energy sector is moving in the direction of a sustainable development goal defined by the Government or whether the distance to that goal is increasing. Each element of the sustainability indicator indicates where political actions are needed and where political measures are most effective in generating sustainable development. The individual indicators therefore reveal specific progress and deficits in certain areas and enable policy makers and scientists to communicate the results to society. The overall indicators, the theme indicators and the individual indicators measure a country's distance from sustainable development. This result is based on the normative assumptions of the German Federal Government set up in its sustainability strategy on the form sustainable development in Germany has to take. Against the background of other ethical and political assumptions, we may obtain a different picture of the status of sustainable development, because the definition of the sustainable pathway is always a normative social process.

IV Conclusion

The development of energy systems and sustainable development are closely interlinked. Therefore, one focus of the German Government's sustainable strategy is on energy. The development of the energy system is described by the indicator set chosen by the German Government. The Government thereby defined a sustainable order for Germany based on four key themes. The sustainable development indicator (ISD) developed here reflects implicitly the three-dimensional concept of sustainability (environment, society, economy) and explicitly the theme-based sustainability indicator approach. The sustainability indicators measure the distance between the current development and the normative sustainable development, which is substantiated by the defined sustainability order of the German Government expressed in its sustainability indicators and goals. When the value of the ISD is below one, then the order of the Government is not congruent with actual social trends.

Indeed, it has to be taken into consideration that the decision on what is socially and ecologically acceptable and economically efficient is a normative issue which can only be determined by social and political discussions and political decisions. However, the analysis has also shown that the energy system can be described by measurable sustainable indicators and that the ISD can be determined to indicate whether

the energy or any other system is “better off” and is working in a sustainable way, if normative reference values defining a sustainable pathway are fixed by the government or society. The sustainable indicators of the ISD make clear where political action is needed and show the starting points for political measures.

Peter Ulrich very pertinently points out that defining a sustainable order is about discussing models of the different ways of life and about the social order of society (Ulrich, 2001). So it has to be taken into consideration that sustainable development is always an open and dynamic process whose models of life will also continue to be discussed in the future.

V Annex I

Table 6: CSD Indicator Set

CSD Indicator Set			
CSD Theme *(German Key Issue)*	Sub-theme	Core Indicators	Other Indicators
Poverty	Income poverty	Proportion of population living below national poverty line	Proportion of population below US $ 1.
	Income inequality	Ratio of share in national income of highest to lowest quintile	
	Sanitation	Proportion of population using an improved sanitation facility	
	Drinking water	Proportion of population using an improved water source	
	Access to energy	Share of households without electricity or other modern energy services	Percentage of population using solid fuels for cooking
	Living conditions	Proportion of urban population living in slums	
Governance *(Quality of Life)*	Corruption	Percentage of population having paid bribes	
	Crime	Number of intentional homicides per 100,000 population	
Health *(Quality of Life)*	Mortality	• Under-five mortality rate • Life expectancy	Healthy life expectancy at birth

		at birth	
	Health care delivery	• Percent of population with access to primary health care facilities • Immunization against infectious childhood diseases	Contraceptive prevalence rate
(Quality of Life)	Nutritional status	Nutritional status of children	
(Quality of Life)	Health status and risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	• Prevalence of tobacco use • Suicide rate
Education *(Intergenerational Equity)*	Education level	• Gross intake ratio to last grade of primary education • Net enrolment rate in primary education • Adult secondary (tertiary) schooling attainment level	Lifelong learning
	Literacy	Adult literacy rate	
Demographics *(Social Cohesion)*	Population	• Population growth rate • Dependency ratio	Total fertility rate
	Tourism		Ratio of local residents to tourists in major tourist regions and destina-

			tions
Natural hazards	Vulnerability to natural hazards	Percentage of population living in hazard-prone areas	
	Disaster preparedness and response		Human and economic loss due to natural disasters
Atmosphere *(Intergenerational Equity)*	Climate change	Carbon dioxide emissions	Emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone-depleting substances	
(Quality of Life)	Air quality	Ambient concentration of air pollutants in urban areas	
Land *(Intergenerational Equity)*	Land use and status		• Land-use change • Land degradation
	Desertification		Land affected by desertification
	Agriculture	Arable and permanent cropland area	• Fertilizer use efficiency • Use of agricultural pesticides • Area under organic farming
	Forests	Proportion of land area covered by forests	• Percent of forest trees damaged by defoliation • Area of forest under sustainable forest management
Oceans, seas and coasts	Coastal zone	Percentage of total population living in coastal areas	Bathing water quality

	Fisheries	Proportion of fish stocks within safe biological limits	
	Marine environment	Proportion of marine area protected	• Marine trophic index • Area of coral reef ecosystems and percentage live cover
Freshwater	Water quantity	• Proportion of total water resources used • Water use intensity by economic activity	
	Water quality	Presence of faecal coliforms in freshwater	• Biochemical oxygen demand in water bodies • Wastewater treatment
Biodiversity *(Intergenerational Equity)*	Ecosystem	Proportion of terrestrial area protected, total and by ecological region	• Management effectiveness of protected areas • Area of selected key ecosystems • Fragmentation of habitats
	Species	Change in threat status of species	• Abundance of selected key species • Abundance of invasive alien species
Economic development *(Intergenerational Equity, Quality of Life)*	Macroeconomic performance	• Gross domestic product (GDP) per capita • Investment share in GDP	• Gross savings • Adjusted net savings as percentage of gross national income (GNI) • Inflation rate

(Intergenerational Equity)	Sustainable public finance	Debt to GNI ratio	
(Social Cohesion)	Employment	• Employment-population ratio • Labour productivity and unit labour costs • Share of women in wage employment in the non-agricultural sector	• Vulnerable employment
	Information and communication technologies	Internet users per 100 population	• Fixed telephone lines per 100 population • Mobile cellular telephone subscribers per 100 population
(Intergenerational Equity)	Research and development		Gross domestic expenditure on R&D as a percent of GDP
	Tourism	Tourism contribution to GDP	
Global economic partnership *(International Responsibility)*	Trade	Current account deficit as percentage of GDP	• Share of imports from developing countries and from LDCs • Average tariff barriers imposed on exports from developing countries and LDCs
(International Responsibility)	External financing	Net Official Development Assistance (ODA) given or received as a percentage of GNI	• Foreign direct investment (FDI) net inflows and net outflows as percentage of GDP

			• Remittances as percentage of GNI
Consumption and production patterns *(Intergenerational Equity)*	Material consumption	Material intensity of the economy	Domestic material consumption
(Intergenerational Equity	Energy use	• Annual energy consumption, total and by main user category • Intensity of energy use, total and by economic activity	Share of renewable energy sources in total energy use
	Waste generation and management	• Generation of hazardous waste • Waste treatment and disposal	• Generation of waste • Management of radioactive waste
(Quality of Life)	Transportation	Modal split of passenger transportation	• Modal split of freight transport • Energy intensity of transport
Source: (United Nations, 2007, German Federal Government, 2002b)			

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