



Methods of measuring sustainable development of the German energy sector

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HIGHLIGHTS

- ▶ Sustainability indicators are a precondition for converting the model of sustainable development.
- ▶ The measurability of sustainability is the key to the implementation of sustainable development.
- ▶ The two Indices (ISUD, SSEI) calculate the degree to which sustainability is achieved.
- ▶ The indices compare the normatively defined sustainability order with the behaviour of society.
- ▶ The indices show whether Germany is on a sustainable energy path.

ARTICLE INFO

Article history:

Received 29 November 2011
 Received in revised form 19 April 2012
 Accepted 5 May 2012
 Available online 23 June 2012

Keywords:

Sustainable development
 Sustainable indicators
 Energy

ABSTRACT

The availability of sustainability indicators is a precondition for the conversion of the model of sustainable development into policy. Sustainability indicators define characteristics that are important for sustainable development. A single sustainability indicator defines a key issue, which characterizes a certain aspect of sustainability in the observed system. Sustainability indicator systems capture the complexity and order of the systems, and they offer new knowledge about the system that can be communicated to the general public. That is why in 2002 the German Government developed a sustainability indicator set for its sustainability strategy, including indicators for a sustainability energy system within this comprehensive strategy. The Government thereby defined a sustainable order for Germany based on the theme-based sustainability approach.

The sustainability indicators thus have to measure the difference between the real and the normatively defined sustainability order: Do the individual preferences of society (households, enterprises) correspond to the sustainability order of the Government, is the implicit preference order of society congruent with the explicit order of the Government as expressed in the national sustainability strategy?

The question of the measurability of sustainability is the key to the implementation of sustainable development of the energy sector. The index of sustainable development (ISUD) and the standardized sustainability index (SSEI), developed by the authors, calculate the degree to which sustainability is achieved.

Both indices show whether Germany is on a sustainable energy path according to the goals set by the German Government in its strategy, but from a different perspective. The indices enable us to compare the normatively (politically) defined sustainability order of the German Government (goals) with the actual “behaviour” of German society. Both indices enable us to answer the question of whether the German energy sector is “better off” in sustainable categories. In a monitoring process, calculations of the sustainable indicators help us to understand where political action is needed.

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1. Introduction

The discussion about alternative welfare and sustainability measures started in the 1960s when Tobin and Nordhaus developed the Measure of Economic Welfare (MEW) [1,2]. With their pivotal paper “Is Growth Obsolete?” they also laid the foundation

for the later development of sustainability indicator measures [3,4], ecological footprint [5] and Green Accounting [6,7].

This discussion took a new direction in 1992, when the 1992 UN Rio de Janeiro Conference adopted Agenda 21 [8]. Chapter 40 of Agenda 21, one of the main documents of the '92 UN Rio de Janeiro Conference, encourages the nations 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

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systems [8].” For this purpose, a special UN Commission, the Commission on Sustainable Development (CSD), was founded to guarantee effective subsequent implementation of the 1992 Rio Conference.

An important aspect of the work of the CSD is the development of indicator systems for measuring sustainable development. The Commission 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 [8]. The CSD’s first indicator system was published in 1996 and consisted of 134 indicators which were assigned to the three columns of sustainability [9]. The CSD revised their approach in 2001 and 2007. The idea of the multidimensional UN sustainability concepts is a focus on the economic, social, and ecological problems which have to be addressed and solved simultaneously to ensure that development is sustainable. In these multidimensional concepts such as the UN CSD approach, a single sustainability indicator defines a key issue, which characterizes a certain aspect of sustainability in the observed system. Sustainability indicators, if developed well, capture the complexity and order of the systems and they offer knowledge about the system that can be communicated to decision makers and the general public [10]. Sustainability indicators measure the difference between the current conditions of a society and a reference situation defined as sustainable [11]. Sustainability indicator systems contain a certain number of indicators that serve to measure the functioning and the interdependence of the analysed system and they enable us to measure and evaluate the consequences of this interaction. They can be used to analyse ecological, economic and social goals in the overall system as well as in the subsystem.

Whereas a great deal of research is done about pros and cons of these concepts, about the shaping of the pillars, their indicators and the adequate goals of sustainable development, quite surprisingly there is a lack of research on standardized methods to aggregate the indicators to one index. Therefore, the basic idea of our indices is to contribute to closing this research gap and to defining an aggregated index concept for the multidimensional sustainability concepts in order to also have clear measurement results such as the GDP in sustainability science. We will also demonstrate that it is necessary to explicitly define the sustainability goals and the database and, in particular, to define the calculation method.

2. Methodological background for measuring sustainable development of the German energy sector

2.1. The normative versus the derived sustainability order

The sustainability order of a society can be derived from the observable market and societal actions of households, enterprises and institutions, and reveals their true preferences for sustainability, thereby allowing implicit conclusions to be drawn about the significance sustainability has for society. This approach is related to the theory of the individual welfare measurement, where a welfare measure is an instrument for drawing conclusions from the observable market actions of the consumers about their unobservable preference order [12,13]. This derived societal sustainability order has to be compared with the politically defined sustainability order of, in our case, the German Federal Government. The sustainability indicators therefore have the function of measuring the difference between the derived observable sustainable order and the politically defined order. The difference between these sustainable orders is the sustainability gap [14,15], determining the degree to which the development of society is (un)sustainable.

2.2. The sustainability strategy of the German Federal Government – a normative order for Germany

Based on the UN sustainability strategy [9,16] and the UN Millennium Goals [17], the German Federal Government defined a quantitative sustainable development strategy for Germany [2,18]. In preparation for the Rio+10 Conference in Johannesburg [19], the German Federal Government sought to develop a sustainability concept for Germany thereby fulfilling its obligations entered into at the United Nations Conference on environment and development.

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 society [18,20]. The sustainability strategy of the German Government is inspired by the multidimensional sustainable indicator concept and defines a normative sustainable order for Germany on the basis of the following four key considerations [2]:

1. Intergenerational equity.
2. Quality of life.
3. Social cohesion.
4. International responsibility.

The Government set up indicators and sustainability goals for these key issues to avoid the impression that its strategy is merely a list of good intentions. Twenty-one topics and 34 indicators were chosen to measure the sustainability of the Government’s policy [2]. This sustainable strategy was the first attempt by the German Federal Government to define a normative quantitative sustainable order for Germany [21]. We selected the following 15 energy indicators (Table 1) from the German sustainability strategy for our analysis of the German energy sector.

Table 1 shows the time frame defined by the German Federal Government for the single interim values and the target values of the sustainability indicators. Table 1 shows that the Government has not set a consistent time frame for all indicators. We adapted our sustainability measuring method to the different time frames and calculated the sustainability of the single indicators for the given periods set by the German Government. The following calculations are based on estimates of how the individual indicators will develop in the future under current conditions (*ceteris paribus* condition). The estimates are made on the basis of linear regression for the time frame of the single indicators and are based on data from the Federal Environment Agency [22], German Federal Ministry of Economics and Technology [7,8], Working Group on Energy Balances [3], Working Group on Environmental Economic Accounting of the Federal States [4].

The development in the energy sector can also be described with the help of these indicators. The indicators enable us to measure recent developments and compare them with the normative goals of the German Federal Government.

The environmental aspects are defined by eight indicators (air quality, emissions of CO₂ (carbon dioxide), SO₂ (sulphur dioxide), NO_x (nitrogen oxide), CO (carbon monoxide), dust, NMVOC (non-methane volatile organic compounds), NH₃ (ammonia)), the social aspects are described by one indicator, (employment in the energy sector) and six indicators (energy productiveness, energy raw material productiveness, renewable energy as a share of primary energy consumption, renewable energy as a share of electricity production, transport intensity of passenger transport and transport intensity of goods transport) describe the economic aspects of sustainability in the energy sector. For these indicators, the Federal Government defined quantitative goals in their sustainability strategy and these goals were used for the analysis of the energy system in Germany. The sustainability strategy of the German

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