# Getting back to Scenario Planning: Strategic action in the Future of Energy Europe

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**Abstract**: **Scenario planning is a commonly used method in order to analyse complex aspects of the energy system. Historically it has been an important tool to prepare for long-term action. Today however, due to the deregulated market, it could be assumed that scenario analysis is abandoned. Maybe more (the only) attention is on short-term action.**

**This paper presents a review over the time period of 1970 to 2010 on scenario-planning articles. The overall purpose is to evaluate how historical scenario studies stand in a situation of today's deregulated energy markets.**

**Articles surveyed are published in well-respected and internationally well-spread peer-reviewed journals. Focus is put on 1, when, and by whom, articles have been published 2, for what reasons projects have been taken and with what method 3, what aspect that have been in focus. The articles are also analysed in terms of possible use in today's deregulated situation.**

**Three conclusions are drawn. Firstly, the main use of scenario planning still tends to be a support to political processes. Secondly, three major issues and drivers for change dominate when different aspects of the energy system are analysed in scenario projects: climate change, security in terms of demand/supply and economic development. Thirdly, it is concluded that scenario planning still tend to be of value when analysing the future of the deregulated energy sector in Europe.**

**However, in order to be fully utilized for the future scenario methodology must take into account that energy industry actors are not being controlled by politics as they where during the regulated period.**

## I. Introduction

Scenario planning is a commonly used method in order to analyse the energy system [1] - [3]. Historically it has been an important tool for politicians, academia and industry to analyse complex issues and prepare for long-term action [4] - [7]. Over time the method have been debated, for misuse as well as for it's meaning [8], [9]. Still it is said to be of major interest and used in practice [10].

During the last decade however, due to an increase of deregulated energy markets, it can be assumed that market oriented short-term action have increased. Major structural changes appear on international level. This could mean that long-term strategic thinking, thereby scenario planning, is becoming obsolete, even left behind [11]. In this paper a literature review is presented in order to analyse if that is the case.

The paper presents an extensive review of energy scenario literature published between 1970 and 2010. The aim is to identify groups of studies as well as to categorize them and to evaluate their possible use in a deregulated environment. The review is based on a sampling of important articles, which mirror the major streams of academic interest over the years.

## II. Review Methodology

Energy scenario projects are published in the crossroad of engineering and social sciences and also to be found under different headlines. The term "scenario", as such, can also be utilized as a common buzzword for "future in general" but without a scenario methodology applied behind. Here we define scenarios as *focused description of different futures.* This is a definition in line with [12] even though we broaden our scope, also including non-narrative scenario projects.

With our broad definition there is a need for an identification process of articles clarified in three steps. First, a broad round of analysis was made in order to; A. Test possible search terms, B. Generate hypotheses for suitable search method, and C. Identify possible journals of interest. Second, a focused analysis was made in order to; 1. Define final search terms, 2. Establish Method, 3. Identify targeted journals. Third, the articles were collected, categorized and analysed.

### *A. Establishing method*

The sampling of articles was collected with the help of the electronic journal database "Scopus" (covering about 18,000 titles from more than 5,000 publishers). The initial scope was

broadly set for articles with "Energy" and "Scenario" included in "Title" as well as in "Abstract" and "Keywords". Journals included were categorized under the umbrella of "Physical Sciences" (>7200 titles) as well as "Social Sciences & Humanities" (>7300 titles). Journals like "Astrophysical Journal", "Physical Review" and "Physical Letters" was manually excluded in order to exclude the use of "scenario" as a term used for purely technology oriented topics.

The result revealed 1232 articles presented in Table 1.

TABLE I
JOURNALS WHERE SCENARIO TERMS ARE REVEALED

| **Journal Amount of articles** | **1970-1979** | **1980-1989** | **1990-1999** | **2000-2010** | **Sum** |
|---|---|---|---|---|---|
| Energy Policy | *7* | *8* | *68* | *458* | *541* |
| Energy – The International Journal | *13* | *27* | *44* | *132* | *216* |
| Renewable Energy | - | - | *16* | *62* | *78* |
| Applied Energy | *1* | *2* | *18* | *53* | *74* |
| Renewable and Sustainable Reviews | - | - | - | *73* | *73* |
| Energy Economics | *1* | *5* | *14* | *53* | *73* |
| International Journal of Global Energy Issues | - | - | *22* | *45* | *67* |
| Energy Conversion and Management | - | *2* | *20* | *41* | *63* |
| Climate Change | *2* | *4* | *1* | *40* | *47* |
| Sum | *24* | *48* | *203* | *957* | *1232* |

The survey revealed a clear overweight of articles in "Energy Policy" and "Energy" indicating these journals to be of biggest interest. The dominance of "Energy Policy" however, at least to some extent, is explained by its increase of size over last decade. In 1973 only 39 articles were published in "Energy Policy", by 1983 "Energy Policy" published 93 articles, and by 2010 more than 740 articles was published (1993, 113; 2003, 141).

The survey also revealed journals that normally are categorized within the field of "Economics", and by Scopus classified under the umbrella of "Social Sciences & Humanities" (like "Energy Economics"). At the same time a journal like "Energy Policy", by Scopus classified under the umbrella of "Physical Sciences", was revealed. This confirms that scenario projects are published in the crossroad of engineering and social sciences.

In order to get a clearer picture of the sampling of the 1232 articles and the journals respective importance, the top 19 articles with more than 15 citations was analysed, see Appendix A. 8 of these articles where published in "Energy policy". The result emphasised a need for a further focusing towards "Energy policy". At the same time Appendix A also revealed that several influential articles do not have a scenario project focus, according our definition. The result confirms that the term "scenario" occasionally is used synonymously with "future in general".

### *B. Identifying targets*

For the second round of identification process the scope was limited towards the terms "Scenario" AND "Energy" included in "Titles". The result is revealed in Table 2.

TABLE 2
JOURNALS WHERE SCENARIO PROJECTS ARE PUBLISHED

| **Journals where search terms "Scenario" AND "Energy appear in the titles - over the whole period of 1970 - 2010 (Amounts of articles)** |
|---|
| - Energy Policy (61) |
| - Energy (17) |
| - International Journal of Global Energy Issues (12) |
| - Revue De L Energie (10) |
| - Technological Forecasting and Social Change (9) |
| - Renewable and Sustainable Energy Reviews (7) |
| - Physical Review D Particles Fields Grav. and Cosmology (7) |
| - Futures (6) |
| - Renewable Energy (5) |
| - Applied Energy (4) |
| - Biomass and Bioenergy (4) |
| - Long Range Planning (4) |
| - Ecological Economics (4) |
| - Building and Environment (3) |
| - Environmental Science and Policy (3) |
| - Energy and Buildings (3) |
| - Physical Review D (3) |
| - European Journal of Operational Research (3) |
| - Physical Review B Condensed Matter and Mat. Physics (3) |
| - Fusion Engineering and Design (3) |
| - Energy Conversion and Management (3) |
| - Nuclear Engineering and Design (3) |
| - International Journal of Hydrogen Energy (3) |
| - VDI Berichte (3) |
| - International Journal of Energy Research (3) |
| - 2010 7th International Conference on the European Energy Market EEM 2010 (3) |

Journals like "Energy policy" and "Energy" also end up on top of this list, emphasizing the assumption of these journals to be of biggest interest.

Interesting result with this sampling is however that "Energy Economics", revealed within the first round of analysis, does not appear at all on the list. Journals like "Energy policy" and "Energy" dominated the result with "International Journal of Global Energy Issues" on third position. This reveals that within the field of "Economics" the term "scenarios" often is used without a scenario methodology project behind. It seems that it is not unusual within the field of Economics to do mathematical oriented scenarios on one hand as well as using the term synonymously for "future in general" on the other.

The "International Journal of Global Energy issues" is however not part of the pattern of journals with most cited articles analysed within the first round of analysis (Appendix A). It also came out on place 7 within Table 1 during the first round of analysis. This confirms the previously raised assumption of "Energy policy" and "Energy" to be of biggest interest for our purpose.

With this result shown it was decided to limit the final sampling of articles to be included within the analysis towards the 78 articles published within "Energy policy" and "Energy" (top two journals in Table 1 and Table 2). Since this review only is made with the purpose to mirror the major stream of energy scenarios the sampling made is considered as valid.

## III. Data Collection

The 78 articles included in the review are collected from "Energy Policy" and "Energy", see [13] – [90]. They are published according the pattern shown in Table 3.

TABLE 3
YEAR AND AMOUNT OF PUBLICATION

| **Articles** | **1970-1979** | **1980-1989** | **1990-1995** | **1995-2000** | **2000-2005** | **2005-2010** |
|---|---|---|---|---|---|---|
| Year (number of articles) published that year) | 1978 (1)<br>1977 (1) | 1983 (2)<br>1981 (1) | 1994 (2)<br>1993 (4)<br>1991 (5)<br>1990 (1) | 1998 (2)<br>1997 (1)<br>1996 (1) | 2005 (1)<br>2004 (1)<br>2003 (5)<br>2001 (3)<br>2000 (1) | 2010 (15)<br>2009 (9)<br>2008 (10)<br>2007 (9)<br>2006 (3)<br>2005 (1) |
| Total | 2 | 3 | 12 | 4 | 11 | 47 |

A decrease in the number of publications can be observed during end of 1990s with an increase around 2005 and further on. By that, it can be observed that the pattern for publication roughly follows the pattern of the deregulation process.

Truly, it is complicated to tell exactly when deregulation "started" [102], [109]. Normally deregulation is a long process ongoing over time including several changes of regulations in several subareas of an industry [110]. Sometimes it even includes the setting up of rules, which formally did not exist before deregulation. If comparing for instance the electricity and the natural gas markets these differences are shown where clear [111] - [113].

However, it could be claimed that deregulation in countries like UK and Norway started around 1993, in countries like Sweden 1996. At EU-level as whole it started around 2001 – 2003, and still is ongoing [114]. In countries like USA the process of deregulation started earlier [99], [101]. By that it could also be claimed the pattern of publications to follow the deregulation process.

Authors and affiliations with more than one article published are shown in Table 4. Neither any author nor any research group dominates the area. Biggest amount of articles are published by Wolfram Krewitt at the "Deutsches Zentrum for Luft- und Ruamfart" in Stuttgart, Germany, see [52] - [54].

TABLE 4
AUTHORS, AFFILIATION AND RESEARCH GROUP

| **Author (Amount of articles published)** | **Affiliation/Research Group (Amount of articles)** |
|---|---|
| Krewitt, W. (3)<br>Graus, W.(2)<br>Schafer, O. (2)<br>Phdungsilp, A. (2)<br>Simon, S. (2)<br>Strachan, N. (2)<br>Teske, S. (2)<br>Turton, H. (2)<br>Browne, D. (2)<br>Koomey, J.G. (2)<br>Berntsson, T. (2)<br>Barreto, L. (2)<br>Abreu, S.L. (2)<br>Zervos, A. (2)<br>Martins, F.R. (2)<br>Kypreos, S. (2)<br>Simon, S. (2)<br>Strachan, N. (2)<br>Teske, S. (2)<br>Turton, H. (2)<br>Browne, D. (2)<br>Koomey, J.G. (2)<br>Berntsson, T. (2)<br>Barreto, L. (2)<br>Abreu, S.L. (2)<br>Zervos, A. (2)<br>Martins, F.R. (2)<br>Kypreos, S. (2) | Chalmers Tekniska Högskola (3)<br>Lawrence Berkeley National Lab. (3)<br>Deutsches Zentrum fur Luft- Und Raumfahrt (3)<br>Paul Scherrer Institut (3)<br>UC Berkeley (3)<br>Ecofys (2)<br>Greenpeace International (2)<br>European Renewable Energy Council (2)<br>Dhurakij Pundit University (2)<br>Zhejiang University (2)<br>Universität Bochum (2)<br>University of Limerick (2)<br>Inst. Nacional de Pesquisas Espac. (2)<br>Univers. Federal de Santa Catarina (2)<br>UCL (2)<br>University of Oxford (2)<br>Instituto Federal de Educação, Ciĕncia e Tecnológia de Santa Catarina (2) |

## IV. A typology of the Literature

Our analysis is influenced by the typology used by [91] even though developed post hoc and used with different purpose. The typology reveals distinct categories even though overlapping types of scenario projects concerning geography, scope of interest, methodologies, and time perspective, exist.

### A. *Geographical interest: national, regional, global*

Most scenario projects analyzed covers a geographical area or analyze a certain problem from a geographical perspective point of view (66 out of 78). 42 of them cover 26 singular countries, 9 are regional and 15 supranational see Table 5.

During the 1970s and 1980s, the interest was related to singular countries, like Germany and New Zealand. The scope has been broadened over time, gradually for instance also covering Russia and China. However, it was not until 1990 when the first article covering the whole of Europe was published [33]. The first article covering the globe as a whole was published 1993 [85]. The first article covering China was published as late as 2003 [86].

TABLE 5
GEOGRAPHICAL SCOPES AND AMOUNT OF ARTICLES

| Geographical scope | Amount of articles | Geographical Scope | Amount of articles |
|---|---|---|---|
| National | 42 sum | Regional | 9 sum |
| China | 6 | California | 2 |
| Germany | 4 | Bangkok | 2 |
| India | 3 | West- | 1 |
| Brazil | 3 | Germany | 1 |
| USA Irland | 2 | Shanghai | 1 |
| Mexico | 1 | Irish city | 1 |
| UK | 2 | Himalaya | 1 |
| New Zealand | 2 | Aalborg | |
| Malasia | 1 | Eastern- | 1 |
| USSR | 1 | Russia | |
| Korea | 1 | | |
| Norway | 1 | Supranational | 15 sum |
| Sweden | 1 | Global | 8 |
| Portugal | 1 | Europe | 3 |
| Switzerland | 1 | East. Europe | 1 |
| Austria | 1 | Middle East | 1 |
| Jordan | 1 | Asia | 1 |
| Turkey | 1 | OECD | 1 |
| Libanon | 1 | | |
| Laos | 1 | | |
| Thailand | 1 | | |
| Australia | 1 | | |
| Eritrea | 1 | | |
| Taiwan | 1 | | |
| South Africa | 1 | | |

B. *Issues of interest: Transportation, housing, industry, security of supply – and climate change*

As mentioned; a certain amount of articles does have an interest to analyse a whole future situation - like a country, a region or the whole globe - or apply its issue of interest in a geographical setting (or as a case). To some extent topics of interest do overlap with a geographical focus.

One segment of interest is the three dominating sectors for energy use, meaning: housing, transportation and the industry sector (14 out of 78). Occasionally also specific sectors are in focus, like agriculture [34].

Another segment of interest are future supply and the future for different energy sources like for instance oil, water, wind, nuclear and bio energy (19 out of 78). Certain specific energy source technologies have also been identified like fuel cells [54], energy storage [80], pulp-mills [48], waste energy [69] or solar cells [58].

The main aspect of interest is however climate change issues in different forms, like energy efficiency need [88], renewable resources in a broad sense [39], [57], policy requirements [43] and policy implications [81]. Within that category 29 articles was identified. Surprisingly, not that many of them relate explicitly to the work made by IPCC [66].

This group of articles can be divided in two sub-categories: articles where climate change issues is the main topic and articles where it is one out of two important aspects (the other one most commonly used is economic constraints). It is also interesting to observe the limited interest in connecting climate change with security of supply. This has sometimes been claimed to be one main reason for China being interested in renewable energy resources [115], [116].

Articles where climate change is considered as one, out of several, important aspects of the energy system, are thereby categorized under other headlines. In nearly all articles published during the last decades the climate change issue is touched upon one way or another. For identified articles within each category see Table 6.

TABLE 6
ARTICLES CLASSIFIED CONCERNING ISSUE OF INTEREST

| Issue of interest | Examples of articles |
|---|---|
| Climate change, The main issue: | [17], [21], [23], [24], [25], [26], [28], [39], [42], [53], [56], [57], [60], [62], [67], [70], [78], [82], [84], [85], [86], [87], [88] |
| Climate change, One, out of two: | [37], [43], [66], [72], [77], [79] |
| Housing | [27], [35], [61], [74], [75], [76] |
| Transportation | [14], [20], [40], [65], [81], [89] |
| Industry | [19], [88] |
| Security of supply and energy sources | [15], [16], [31], [33], [38], [41], [44], [45], [46], [47], [50], [58], [59], [69], [71], [73], [80], [83], [90] |
| Certain energy technologies | [54] [31], [48], [54], [69] [58], [59] |

C. *Methodological differences: Forecasts, Exploratory studies and Visions, Back casting and Roadmaps*

From a methodological point of view the literature can be categorized in six streams of approaches, see Table 7. The dominating use is forecasting, back casting and roadmaps.

Forecasting studies are made with a given basic situation as a starting point and thereafter parameters, normally a limited amount of (most commonly only one), are added in order to predict a future situation.

TABLE 7
ARTICLES CLASSIFIED WITH DIFFERENT METHODOLOGICAL APRROACHES

| Methodology | Examples of articles |
|---|---|
| Forecasts | [13], [14], [22], [25], [26], [30], [31], [34], [38], [47], [49], [52], [55], [56], [61], [63], [65], [67], [68], [70], [81], [84], [89] |
| Back casting and roadmaps | [15], [17], [20], [21], [23], [24], [28], [37], [42], [50], [52], [60], [62], [70], [73], [78], [85], [86] |
| Exploratory studies and visions | [19], [24], [27], [35], [41], [44], [77], [86] |
| Assessments and evaluations of previously made scenarios | [16], [23], [32], [33], [44], [56], [66], [69], [86] |
| Developing methodology | [29], [57], [58], [82] |
| Utilising existing models | [40], [46], [75], [79], [82], [83], [87] |

The characteristics for back casting and road maps is having a clear target as starting point, like for instance a perceived need to adapt to climate change issues (the most common case). These projects are made in order to investigate how to avoid, or achieve, a certain future. Back casting studies work their way backwards with a target set as starting point in order to visualise for instance what kind of actions are needed to achieve the target. Roadmaps are investigating the way forward.

It is uncommon that several approaches are used simultaneously even though it exist, [37] and [70].

Exploratory and vision studies utilise a more open methodology, mainly with the purpose to explore possible - in stead of wished for or expected to be - futures. Common is to sketch several different futures with the help of a script and a narrative approach utilising several parameters simultaneously.

This exploratory method is also an approach commonly used in more business oriented settings in order to analyse complex matters [92], [93], [94].

Close to the articles with exploratory or vision approach other purposes for contribution, than affecting or understanding future, have also been identified. Several projects have partly been made in order to test and develop energy scenario methodology as such. In Table 7 they are categorized as "developing methodology".

There are also several articles where the purpose is to assess and evaluate scenario projects, or for instance utilizing baseline scenarios, previously made by others. Already existing cost-optimization models, like "Eclipse", the "Markal-model" or "TIMES PT-model", have been used. These articles have been categorized as "utilizing existing models" in Table 7.

### D. *Different time perspectives*

Future easily becomes a fluffy word. The applied time perspective is therefore of importance to bring forward. The timeframes utilized are normally either about 10 years long or far longer than so, about 30 – 60 years. The longest timeframe is 100 years [66], [86]. Occasionally articles do have unspoken time targets for their study. Table 8 reveal articles within different time frames.

TABLE 8
STUDIES CLASSIFIED IN DIFFERENT TIME FRAMES APPLIED

| Time frame | Examples of articles |
|---|---|
| 10 -20 year long perspective | [19], [24], [32], [34], [63], [64], [67], [73], [79] |
| 20 – 30 years | [14], [16], [36], [41], [48], [50], [56], [69], [70], [76], [81], [88], [89] |
| 30 – 50 years | [13], [17], [21], [24], [43], [44], [45], [47], [52], [72], [78], [87], [89] |
| 50 – 100 years | [20], [37], [42], [66], [75], [85], [86] |

## V. What does the literature say about strategic action?

Implicitly, or explicitly, every kind of future oriented analysis is based on a perception on how strategic action occurs [95], [96]. When doing scenario studies, future is always considered "as if to be driven" by different kind of forces - often considered as to be in the hands of different kind of actors [97], [98]. These forces can be elaborated within a scenario project, most explicitly made within explorative projects. They can also be taken for granted and thereby be used as a foundation for the study as such (most straightforward articulated in forecasts).

Most common within the articles reviewed is an embedded perception where the dominating actor influencing the future of the energy system is the policy actor. This is either raised very explicitly, see for instance [17], [25], [28], [60], [67], [82], [88] or utilized implicitly, see [39], [42], [86], [87].

When it comes to drivers for change in future an overall view can thereby be achieved by categorizing the articles in three streams: projects where climate change, economic development or security of supply is perceived as the main underlying drivers affecting future. The dominating aim, often explicit but sometimes implicit, is the request for policy action and to bring forward conclusions relevant from a policy point of view.

The issue of interest for doing the scenario projects can also be divided between push and pull oriented driven aspects concerning future. Examples of push are perceived increase of population [37], [73], the future of living standards [35], [74] or a need for economic development [30] – assumed to be putting pressure upon the energy system from the outside. Examples of pull oriented driven aspects are supply [42] and pricing [55] – issues changing the system from the inside. Historically the industrial actor, in this respect, has been considered as an "insider". Deregulation has made industry partly becoming an "outsider".

## VI. Discussion concerning the literature and a deregulated market

In the pure world of "Economics"; when markets are deregulated the former nationally controlled actor is becoming an independent actor. In several cases, like in the energy sector, there do however still exist, and have always existed, important strings attached towards industry from governments. This could be about ownership, new regulations being set up, control of capital needed etc [99], [100], [101]. This mean that policy action still has a huge impact on the energy system, but not the same way as during regulated times [102].

Compared to a previously regulated environment the industrial actor is given far bigger possibilities to act "of its own". In many cases the industrial actor, as such, is therefore to be considered as an actor affecting the energy system. It is not only being a marionette within the hands of governments and a "consequence of issues developed by others".

Due to the deregulation of the European energy market it is therefore of interest to observe that it, still, is rare with scenario projects concerning the industrial energy actors, even though such articles exist [19], [36], [48], [50], [54] and [64].

It is also of interest to notice that most scenario projects published still are based on the assumption of the energy

actors being in control in the hands of governments. No articles have been identified where the industrial actor, as such, have been taken into account as one of the main drivers for change or as an actor/parameter "interfering" towards other possible actors. Neither have articles where industrial oriented scenario work has been influential, been identified.

There do however on one hand for instance exist several references within our reviewed literature towards early scenario work made by Shell scenario unit during 1970s, 1980s and 1990s, [1], [96], or [98]. This is an industrial think-tank well known in industry as well as in the policy area. On the other hand: none of the reviewed articles seem to have been influenced by Shell when accomplishing their projects.

Within the European market of today we can observe former national actors having done tremendously big amounts of mergers and acquisitions during the last ten years. They have ended up becoming international actors acting across national boarders, [103], [104]. It is clear that the industrial actors today are forces "interfering with future" in many different ways since deregulation started. For example they have started to unbundle their own value chain [105] - [107].

Maybe the exploratory methodology could be widely used when developing new knowledge concerning the energy system in such direction. This is a rather open approach and opens up for bigger possibilities of elaborating with several different forces and actors simultaneously.

Still, the topics revealed in the review are of relevance, even within a deregulated energy market.

## VII. Conclusions

This article has presented a literature review concerning the major streams of publications of scenario projects during 1970 – 2010 published within "Energy policy" and "Energy". The review has shown a continuous interest in scenarios, even though the European, as well as many other energy markets, have been deregulated. There was a short decline of articles during the start of the deregulation process but then the amounts of publications grew again.

The interest within energy scenario projects over the years seem to be rather stable, even though geographical interest have been broadened as well as a growing interest in climate issues have been shown. Under that stream of interest, there is an ongoing interest utilizing traditional scenario methodology - not the least: forecasting, back casting and road maps. Issues like climate change, demand and supply, security of supply as well energy sources have been of interest. The three dominating sectors utilizing energy (transportation, housing and industry) are also common topics of interest.

The analysis being made has also shown that the interest of scenarios is more theoretically oriented compared towards its interest of scenario practice within, and for, industry. It is concluded that the use of scenario planning within the energy business is notably lacking of research. Conclusions recently made by [10] are thereby supported.

It is also concluded that the main interest within academia concerning energy scenarios still is directed towards policy action. Explicitly, or implicitly, the industrial actors are perceived as acting as if they where being marionettes within the hands of the political systems. A major drawback with recent research is that it still does not embed the industrial actor as one of the actors "interfering" with the energy system.

It is therefore suggested that future research concerning energy scenarios start considering, as well as embed, the industrial actor – as an industrial actor. This could for instance be made by an increasing use of exploratory approaches. As claimed before: Energy Scenarios should be considered as a learning process [108].

## Appendix A. Top ranked publications within the broad scope during initial survey

| **Articles within the sampling of 1232 articles where search terms "Energy" AND "Scenario" is included in titel, abstract or keywords - with more than 15 citations** | **Cita-tions** |
|---|---|
| 1. Stabilizing greenhouse gas concentrations at low levels: An assessment of reduction strategies and costs, Van Vuuren, D.P., Den Elzen, M.G.J., Lucas, P.L., Eickhout, B., Strengers, B.J., Van Ruijven, B., Wonink, S., Van Houdt, R. 2007 Climatic Change 81 (2), pp. 119 – 159 | 64 |
| 2. Renewable energy sources: Their global potential for the first-half of the 21st century at a global level: An integrated approach, de Vries, B.J.M., van Vuuren, D.P., Hoogwijk, M.M. 2007 Energy Policy 35 (4), pp. 2590 - 2610 | 48 |
| 3. Scenarios for a clean energy future, Brown, M.A., Levine, M.D., Short, W., Koomey, J.G. 2001 Energy Policy 29 (14), pp. 1179- 1196 | 37 |
| 4. Multi-gas scenarios to stabilize radiative forcing, van Vuuren, D.P., Weyant, J., de la Chesnaye, F. 2006 Energy Economics 28 (1), pp. 102-120 | 35 |
| 5. Abatement costs of post-Kyoto climate regimes, den Elzen, M., Lucas, P., van Vuuren, D. 2005 Energy Policy 33 (16), pp. 2138-2151 | 33 |
| 6. The consistency of IPCC's SRES scenarios to recent literature and recent projections, Van Vuuren, D.P., O'Neill, B.C. 2006 Climatic Change 75, pp 9 | 29 |
| 7. Models for mid-term electricity demand forecasting incorporating weather influences,, Mirasgedis, S., Sarafidis, Y., Georgopoulou, E., Lalas, D.P., Moschovits, M., Karagiannis, F., Papakonstantinou, D. 2006 Energy 31 (23), pp 208-227 | 29 |
| 8. Technological learning for carbon capture and sequestration technologies, Riahi, K., Rubin, E.S., Taylor, M.R., Schrattenholzer, L., Hounshell, D. 2004 Energy Economics 26 (4), pp. 539 – 564 | 29 |
| 9. Exploring the ancillary benefits of the Kyoto Protocol for air pollution in Europe, van Vuuren, D.P., Cofala, J., Eerens, H.E., Oostenrijk, R., Heyes, C., Klimont, Z., den Elzen, M.G.J., Amann, M. 2006 Energy Policy 34 (4), pp. 444 – 460 | 25 |
| 10. Energy and emission scenarios for China in the 21st century - exploration of baseline development | 25 |

| | |
|---|---|
| and mitigation options, van Vuuren, D., Fengqi, Z., de Vries, B., Kejun, J., Graveland, C., Yun, L. 2003 Energy Policy 31 (4), pp. 369 – 387 | |
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