AIEE ASSOCIAZIONE ITALIANA ECONOMISTI DELL'ENERGIA www AIEE.IT

IAEE INTERNATIONAL ASSOCIATION for ENERGY ECONOMICS WWW.IAEE.ORG

12th IAEE European Energy Conference

Energy challenge and environmental sustainability

September 9-12, 2012 in Venice, Italy
Ca' Foscari University of Venice

Welcome to Venice | Conference venue | Who should attend | Travel information

Home
Organisation
Programme
Registration
Accommodation
Students
Sponsors
Paper submission
Social events
Climate & weather
Contact

DOWNLOAD

Call for papers
Conference programme

The Conference Objectives

Recent events - such as the conflicts within several North African and Middle East oil and gas-exporting countries, and the nuclear disaster in Japan - have added elements of uncertainty in the already complex evolution of the energy situation in the world and in Europe in particular.
Security of supply, geopolitical aspects and environmental problems are once more at the forefront.
The Conference aims at providing a forum for an analysis of the new developments and a new vision of the future.
No better stage can be imagined for this discussion than the magic and fragile environment of one of the most beautiful cities in the world.

The first plenary sessions of the **12th IAEE European Energy Conference** will therefore be dedicated to the evolution of demand and to the new energy markets less dependent on major commodities.

A debate will follow on how to deal with climate change through better regulation of CO_2 emissions and what opportunities Europe can get from these new regulations.
The last sessions of the Conference will deal with energy security in a geopolitical context that is getting more and more complex and difficult in all the main areas of the world .

Besides these main topics the 12th IAEE Conference will also discuss all the issues related to the environmental change and its new perspectives, such as energy efficiency, developing renewable sources, biofuels and sustainable transportation. 8 plenary and 80 concurrent sessions will be organized by the AIEE - together with the International Association for Energy Economics - IAEE in cooperation with Fondazione Eni Enrico Mattei and Ca' Foscari University of Venice.

Fondazione Eni Enrico Mattei

Università Ca'Foscari Venezia

Raphael Bointner

ENERGY R&D EXPENDITURES AND PATENTS IN SELECTED IEA COUNTRIES

Raphael Bointner, Vienna University of Technology
Institute of Energy Systems and Electric Drives, Energy Economics Group – EEG
Gusshausstrasse 25-29/370-3, A-1040 Vienna, Austria
Phone +43(0)1-58801-370372, Fax +43(0)1-58801-370397, e-mail bointner@eeg.tuwien.ac.at

Overview

The long history of IEA and patent data offer a huge playground for scientific investigations of the energy innovation process. As part of my current research I present energy R&D expenditures and patents in four IEA countries in this paper. Calculations of the knowledge stock are followed by comparative innovation and patent shares.

Methods

The cumulative knowledge stock *(KS)* of energy technologies from 1974 to 2012 in selected IEA-countries *i* (Austria, Germany, Japan and United States) is broken-down among seven groups *k* defined by IEA (energy efficiency, fossil fuels, renewable energy, nuclear power, hydrogen and fuel cells, energy storage technologies, other cross-cutting technologies). This comprises the depreciated cumulative knowledge stock of the last period $(1 - \delta) \times KS_{(t-1)}$ and the R&D expenditures in period *t-x*. So, the cumulative knowledge stock *(KS)* is as follows

$$KS_{(t)\,i,k} = (1 - \delta) \times KS_{(t-1)\,i,k} + RD_{(t-x)\,i,k} \qquad (1).$$

Klaassen 2005 and Kobos 2006 give a comprehensive overview of this methodology. In a second step and more specifically, five dedicated items *j* of the renewables group, namely solar heating and cooling, photovoltaic, wind energy, biofuels as well as hydroelectricity are subject to further investigation following the above mentioned methodology. Finally, comparative shares for R&D expenditures *(CIS)* derived from the knowledge stock and comparative shares of patents *(CPS)* are calculated as shown in formula (2), where *p* is the number of patents in country *i* in sector *j*; see Bointner 2012 and Walz 2008 for details on the methodology. Comparative shares for R&D expenditures *(CIS)* with *I* for innovation are derived in the same manner. *CIS* are an input to the innovation process while *CPS* are an output parameter, respectively.

$$CPS_{(Comparative\ Patent\ Share)} = 100 \times \tanh \ln \frac{\frac{p_{ij}}{\sum_i p_{ij}}}{\frac{\sum_j p_{ij}}{\sum_{ij} p_{ij}}} \qquad (2)$$

Results

The knowledge stock shows a high sensitivity regarding the depreciation δ in all countries whereas the time lag *x,* after which the R&D expenditures count for the knowledge stock in time *t*, has a negligible influence. With $\delta = 0{,}1$ and $x = 3$ years, which seems to be appropriate in the given case of surrounding conditions, I derive quite suspenseful results for the four countries. Nuclear power counts for 44,4% of the total knowledge stock (see table 1) with a focus in Japan, while the German nuclear knowledge stock declined by more than 70% after its peak value in 1988. Although Japan's GDP (2010) is about 2/5 of US' GDP, Japan's total *KS* is slightly larger.

Table 1: Cum. knowledge stock (mil. €; 2010 prices and exc. rates) with δ =0,1 and x=3 by group and country

	Austria	Germany	Japan	United States	Total by group
energy efficiency	135,4	308,9	3.355,2	5.125,3	**8.924,9**
fossil fuels	10,4	357,3	2.764,6	5.961,5	**9.093,8**
renewable energy	136,5	984,9	1.480,2	3.983,4	**6.584,9**
nuclear power	35,4	2.261,9	22.125,3	6.135,4	**30.558,0**
hydrogen and fuel cells	12,2	123,5	848,1	1.138,7	**2.122,5**
energy storage technologies	48,2	142,7	890,8	1.675,6	**2.757,2**
cross-cutting technologies	43,2	534,1	615,0	7.530,1	**8.722,4**
Total by country	**421,3**	**4.713,3**	**32.079,2**	**31.550,0**	**68.763,8**

Table 2: Cum. knowledge stock of selected renewables (mil. €; 2010) with δ =0,1 and x=3 by country

	Austria	Germany	Japan	United States	Total by group
Solar heating and cooling	12,6	91,3	21,1	61,7	**186,7**
Photovoltaics	16,1	402,1	679,9	596,1	**1.694,3**
Wind energy	3,9	189,8	57,0	391,8	**642,5**
Biofuels (incl. liquids, solids and biogases)	91,1	103,1	265,6	1.670,9	**2.130,7**
Hydroelectricity	5,5	0,8	4,5	51,6	**62,3**
Total by country	**129,3**	**787,1**	**1.028,1**	**2.772,0**	**4.716,5**

The five selected technologies in table 2 count for 72% of the renewable energy knowledge stock whereat biofuels and photovoltaics take the lion's share. Surprisingly the Austrian biofuel knowledge stock is almost as large as the German one and its hydroelectricity knowledge is larger than German and Japanese together. By transforming the renewable *KS* of table 2 into *CIS* and computing *CPS* by using European Patent Office data we can learn about fields of strength and connections between R&D expenses and patents (see table 3).

Table 3: Comparative innovation and patent share (+100... strong field of strength, -100... no field of strength)

	Austria		Germany		Japan		USA	
	CIS	CPS	CIS	CPS	CIS	CPS	CIS	CPS
Solar heating and cooling	72	46	79	36	-58	-79	-52	1
Photovoltaics	-79	-85	34	-46	54	51	-47	-13
Wind energy	-91	-28	52	49	-72	-90	4	-6
Biofuels	42	22	-84	-8	-51	-37	28	21
Hydroelectricity	82	82	-99	-8	-80	-42	33	13

Conclusions

Though R&D expenditures and patents have several limitations (cf. Popp 2005 and Watanabe 2001), they seem to be a suitable proxy for determining the innovation process. Time series of the cumulative knowledge stock give insight in structural changes among time (e. g. a "solar peak" in the early 1980s due to the first oil crisis in all four countries and the tremendous decline of nuclear knowledge in Germany). Despite the nuclear debate after Fukushima, the nuclear knowledge stock is still the largest by far, whereas the renewable knowledge stock in those four countries is ranked 5th place, only. So, if policy makers go for a transition towards renewable energy lot more efforts have to be undertaken to create the needed know-how. However, even if doing so, R&D expenditures for decommissioning nuclear power and repositories are still needed over the next decades.

References

Bointner R. et al, 2012: „Wachstums- und Exportpotentiale Erneuerbarer Energiesysteme", Studie im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Wien, Jänner 2012.

Daim, T. et al, 2006: "Forecasting emerging technologies: Use of bibliometrics and patent analysis", Technological Forecasting & Social Change 73 (2006) 981–1012

Deutsches Patent- und Markenamt, 2010: „Geistiges Eigentum im Gespräch, Klimawandel und ‚Grüne Technologien' – Herausforderung für das Patentsystem", Deutsches Patent- und Markenamt, 2010

Indinger, A., Katzenschlager, M., 2011: „Energieforschungserhebung 2010 - Ausgaben der öffentlichen Hand in Österreich, Erhebung für die IEA" im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Berichte aus Energie- und Umweltforschung 47/2011, Wien 2011.

Kobos, P. H. et al, 2006: „Technological learning and renewable energy costs: implications for US renewable energy policy", Energy Policy Volume 34, Issue 13, S. 1645–1658, September 2006

Klaassen, G. et al, 2005: "The impact of R&D on innovation for wind energy in Denmark, Germany and the United Kingdom", Ecological Economics, Volume 54, Issues 2-3, Pages 227-240, 1 August 2005

Karachalios et al. 2010: "Patents and clean energy: bridging the gap between evidence and policy", United Nations Environment Programme (UNEP), European Patent Office (EPO), International Centre for Trade and Sustainable Development (ICTSD), München 2010

Kahouli-Brahmi, Sondes, 2009: "Testing for the presence of some features of increasing returns to adoption factors in energy system dynamics: An analysis via the learning curve approach", Ecological Economics, Volume 68, Issue 4, Pages 1195-1212, 15 February 2009

Lee, M. et al, 2010: "A study on the relationship between technology diffusion and new product diffusion", Technological Forecasting & Social Change 77 (2010) 796–802

Lund, P. D., 2009: "Effects of energy policies on industry expansion in renewable energy", Renewable Energy, Volume 34, Issue 1, Pages 53-64, January 2009

McCrone, A. et al, 2011: "GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2011 - Analysis of Trends and Issues in the Financing of Renewable Energy", United Nations Environment Programme and Bloomberg New Energy Finance, Nairobi/Frankfurt, 2011

Nelson A. J., 2009: "Measuring knowledge spillovers: What patents, licenses and publications reveal about innovation diffusion", Research Policy 38 (2009) 994–1005

Popp, D. et al, 2011: "Technology and the diffusion of renewable energy", Energy Economics 33 (2011) p. 648–662

Popp, D., 2006: "Innovation in climate policy models: Implementing lessons from the economics of R&D", Energy Economics 28 (2006) 596–609

Popp, D., 2005: "Lessons from patents: Using patents to measure technological change in environmental models", Ecological Economics 54 (2005) 209– 226

Van Sark, Wilfried, et al: "Photovoltaic solar energy" in Junginger, Martin, et al: "Technological Learning in the Energy Sector" p., 93ff, Cheltenham, UK, 2010

Walz, R. et al, 2008: „Innovationsdynamik und Wettbewerbsfähigkeit Deutschlands in grünen Zukunftsmärkten", Forschungsprojekt im Auftrag des Umweltbundesamtes, Dessau-Roßlau / Berlin, 2008

Watanabe, C. et al, 2001: "Patent statistics: deciphering a 'real' versus a 'pseudo' proxy of innovation", Technovation 21 (2001) 783–790

Watanabe, C. et al, 2000: "Industrial dynamism and the creation of a "virtuous cycle" between R&D, market growth and price reduction The case of photovoltaic power generation (PV) development in Japan", Technovation 20 (2000) p. 299–312