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Energy technology foresight in emerging economies

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ABSTRACT

This paper offers a novel comprehensive conceptualization of Energy Technology Foresight (ETF) in emerging economies, including development trajectories, key methodological tools and elements, major challenges and weaknesses. ETF allows the emerging economies to provide the basis for government's energy policy, to create a common vision among the various actors and to strengthen R&D and innovation basis in the energy sector.

The author presents five basic premises to conceptualize the ETF approach in emerging economies: the need to take into account higher risks and uncertainties; integration of foresight outcomes in national and corporate strategic planning; constant revision of ETF methodology; dominance of economic, technological and security considerations; and the inability to catch-up with the energy technology development of the world leaders. Three case-studies (Russia, Brazil and China) of ETF in emerging markets are presented to illustrate and substantiate the conceptual approach.

The paper is of interest for researchers that are involved in future studies, as well as decision-makers, who commission such studies and use their outcomes to advance the policy processes and documents.

1. Introduction

Emerging and transition markets offer unique commercial opportunities for companies and investors, while at the same time carry high risks of different nature (Khanna et al., 2005). Growing economies are energy-thirsty: they need it to support their industries and domestic energy resources are not always sufficient. For some emerging economies export of hydrocarbons has become the main source of growth. These countries are usually the first to take a grasp of future developments in this sector.

Energy technology future studies are often implemented on the basis of Foresight methodology with a combination of qualitative and quantitative tools, active involvement of key experts and decision-makers. The goal of such projects is the identification and agreement on strategic goals and action plans for their achievement. The demand for energy outlooks has increased due to substantial changes that already occurred in the sector and are expected in the foreseeable future, including volatile prices, smart grid, shale revolution, affordable solar and hydrogen energy, superconductivity and many more. Indeed, the energy sector in 30 or 40 years from now may look markedly different from the way it is organized today (Beynaghi et al., 2015; OECD/IEA, 2015; Greenpeace, 2015).

Today Energy Technology Foresight (ETF) is widespread in many countries, including the European Union, North America, and BRICS. ETF is part of a comprehensive national and international foresight and monitoring systems that are closely interlinked with strategic planning and science, technology and innovation policy. The outcomes of ETF are used for decision-making at international, national and corporate levels, including the identification of priority areas for science and technology development.

ETF studies differ not only by goals and tasks, but also by time horizon, thematic (sectoral) coverage and methodology. Future energy studies are prepared by consulting companies (McKinsey, Energy Saving Trust), energy companies (Statoil, ExxonMobil, BP, Shell) and international organizations (Association of Asia-Pacific Cooperation, Organization for Economic Cooperation and Development/International Energy Agency, World Energy Council, and Organization of Petroleum Exporting Countries).

Analysis of ETF in developed countries allows for identification of a number of common features: long time horizon (up to 40–90 years); governmental agencies as main customers; participation of a wide range of stakeholders (including interdepartmental cooperation of government agencies); shift of the thematic focus of research priorities following key technological developments; and the methodology is usually based on a Delphi survey as the key (and at times) only methodological tool. Quantitative and semi-quantitative tools are rarely employed and include mathematical modelling, statistical analysis

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(Clarke and Edmonds, 1993; Gielen and Taylor, 2007), bibliometric and patent analysis (Harell and Daim, 2009).

International energy organizations and national public authorities in many countries develop energy-related strategic documents and outlooks that also serve as instruments for reaching an agreement on key energy technologies that should be supported in the first place. Such exercises involve multiple stakeholders and take various forms.

The importance of technology foresight, ETF in particular, has been gradually increasing in developing countries due to new challenges appearing and a growing interest from the part of stakeholders (Pietrobelli and Puppato, 2016; Sokolov and Chulok, 2015; Alizadeh et al., 2015). International comparisons of ETF practice allows for identification of new instruments and their combinations, as well as major challenges and weaknesses of these projects. Most ETF initiatives could be classified by the thematic scope (renewables or oil), geographical coverage (national, regional, international), and by sector (public or corporate).

The paper consists of four sections. In the 'Materials and methods' key information sources, methodological approaches and study limitations are presented. Thereafter, three case-studies of Energy Technology Foresight from emerging economies are presented. In the third section, a conceptual approach to ETF initiatives in the emerging markets based on case-studies and other research methods is provided. Conclusions suggest how to overcome existing ETF limitations in emerging economies.

2. Materials and methods

National traditions, special features of national energy and innovation systems and other external factors have an impact on the foresight studies, including the Energy Technology Foresight (ETF) (Andersen and Rasmussen, 2014). The particular characteristic of emerging markets and transition countries is that they attempt to quickly close the economic and technology gaps with the developed economies, and use technology foresight to serve these purposes. This was the case in the 1990-ies for Korea, South Africa and Latin America countries (Shin et al., 1999). We now see that some of them have indeed advanced rather fast (Korea, Brazil), while others still lag behind (Venezuela).

Previous studies of science and technology foresight in emerging economies, covering a broad range of thematic areas, have either focused on a single country (i.e. Santos and Filho, 2007; Mu et al., 2008) or on organizational issues of the studies, such as structure, outcomes, thematic areas covered, sequence of steps (i.e. Chan and Daim, 2012; Sokolov, 2008). However the evolution of Energy Technology Foresight in emerging markets in a conceptual way or in the form of case-studies has not yet been considered.

The information sources for a comparative analysis of ETF are international and national publications and documents (regulatory and strategic documents; analytical reports; published foresights, scenarios and roadmaps; working and progress reports on the outcomes of foresight projects) and research publications that discuss foresight and monitoring energy studies. Most of the publications selected for analysis are dated 2012–2016, while older publications of key importance were also reviewed.

Experience of transition economies in ETF draws upon the experience of important hydrocarbon producers - Russia, Brazil and China and others that have pioneered ETF. In emerging markets the focus is more on energy supply and less on demand. In the case studies important ETF studies, commissioned both by governmental agencies and companies, are mentioned to offer a quick overview and comparison. For consistency only nation-wide ETF are reviewed in this paper. However, these lists of ETF projects are not exhaustive, as other initiatives (corporate and regional level foresights) also exist and their volume has been increasing.

3. Case studies

3.1. Brazil

Brazil has 40 years' experience of technology foresight and integration of outcomes into national planning. The national foresight project 'Brazil 2020' was carried out by the Secretariat of Strategic Subjects of the Presidency of the Republic (SAE/SAA/PR) in 1998. It was based on scenario analysis and focused on social and economic development. Thereafter technology foresight exercises, including ETF, have been implemented at regional, sectoral, and national levels with the use of a variety of methods. More specifically, ETF was part of several cross-sectoral programs (Table 1) and the central focus of the sectoral studies implemented by the Center for Strategic Management and Studies (2002–2005).

ETF was first applied in Brazil by energy companies in late 1980-ies and has evolved ever since. Energy technologies were the focus of future studies commissioned by the Government (Cagnin, 2014). There was a widening application of ETF with a wide variety of methods applied, where the classical qualitative and semi-qualitative methods prevail. On the one hand, in the years 2000s and after more evidence-based methods have been demanded and gradually introduced, such as bibliometrics, cross-impact analysis, modelling and statistical analysis. Methods of economic analysis (such as modelling and econometric tools) have also begun to spread. On the other hand, nearly no tools that belong to the creativity group (Popper, 2008) have been applied in ETF in Brazil. These two methodological trends may be explained by the nature of the studies commissioned by government agencies and companies, which require precision and are used to classic strategic planning methods (technological, economic and financial).

Along with Delphi studies, scenario analysis has been among the most popular tool applied not only in ETF, but more generally, in national future studies and national planning. This is due to economic and political instability typical for emerging economies (Porto et al., 2010). Generally, energy technology foresight plays an important role in defining the country's energy prospects vis-à-vis its competitors from the developed and developing world (d. Santo et al., 2006).

Brazil has long and rich experience of ETF that were implemented as part of national science and technology future studies, as well as for the sector and certain energy segments. However, there is a lack of a coherent step-by-step approach to ETF that would involve regular exercises performed at certain time intervals, sequencing of certain studies (national and sectoral, trends-oriented and scenario analysis). In Brazil companies are active customers to commission sectoral and national studies.

3.2. Case study: Russia

The first foresight-like studies on technological advancements were carried out in the Soviet Union in 1970s (Sokolov and Chulok, 2015), when a large-scale national project—the "multi-aspect program of technology progress" was carried out for policy planning purposes. In contemporary Russia the first list of 'critical technologies' in eight sectors, including energy, were commissioned by the Ministry of Education and Science in 2004–2005 (Sokolov, 2007). The Concept of the long-term S&T Foresight 2025 was developed in 2006, following the years of economic and political stability. The first foresight study followed two years later and identified priority markets, technologies and underlying global trends in ten thematic areas, including energy (Sokolov, 2008). ETF in Russia has then gradually evolved as part of the national exercises, as well as a sectoral initiative (Table 2).

The best international foresight practice from the developed countries are used in the Russian national foresight activities. Delphi survey was the core method used initially (following the experience of Germany, UK and Japan), while every study thereafter has used a more comprehensive array of tools. Evidence-based tools have