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Special Issue on New Challenges in Energy Materials

Research on materials and renewable energy

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Abstract

In this paper, an overview on the subject of materials and renewable energy, mainly from the research point of view, is carried out. Energy and materials are nowadays driving science and technology. There is a search for cleaner, cheaper and more efficient energy production, and this is obviously related to the development of new and innovative materials. As energy is a top European priority, materials research can enable Europe to meet its future energy and climate goals. The importance of raw materials for the energy sector and the future of advanced materials for low carbon energy are addressed. Materials-based solutions to the energy problem and guidance on research in this field are also the aim of this paper.

Keywords: Materials; energy research; energy technology; critical materials.

1. Introduction

Different environmental and supply concerns related to fossil fuels have driven scientists to explore new technological solutions, looking for alternative means for energy production and storage. New and innovative materials are at the core of the new findings in this field [1]. The time when only a few materials such as steel, copper and concrete were the main components for energy technologies are long gone [2].

Materials are fundamental to industrial, social and economic development, and can be the trigger for the development of many new products and technologies [3]. There is a need to improve physical and chemical properties of materials in order to lead to new and competitive energy production [1].

One way to measure the progress of mankind is to take a look at the evolution of man-made materials, their development and use over time, their variety, quality and performance [4]. Furthermore, without continuous innovation in advanced materials the performance improvement, cost reduction and extended life time of energy technologies would not be possible [2].

Solar modules, wind turbine blades, batteries and wave power components, amongst others, all rely upon advanced materials, e.g. the efficiency of solar modules needs to increase, the weight of turbine blades must be reduced, batteries need longer life cycles and, in general, corrosion resistance must be improved [2].

The European Strategic Energy Technology Plan (SET Plan) aims to transform the way energy is produced and the use of energy in the European Union (EU), with the goal of EU leadership and the development of technological solutions for forthcoming energy and climate targets [2]. This plan aims to accelerate the development and deployment of low carbon technologies. The integrated SET-Plan is part of a new European Energy Research & Innovation (R&I) approach designed to accelerate the transformation of the EU's energy system and to bring promising new zero-emissions energy technologies to market. The SET-Plan comprises the SET-Plan Steering Group, the

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European Technology and Innovation Platforms, the European Energy Research Alliance, and the SET-Plan Information System (SETIS). Among other actions the SET-Plan identifies 10 actions for research and innovation, based on an assessment of the energy system needs and on their importance for the energy system transformation and their potential to create growth and jobs in the EU.

The Materials Information System (MIS), established in 2014, provides information on materials used in the SET-Plan technologies i.e. low carbon technologies as bioenergy, solar, wind, fuel cell, and hydrogen technologies, nuclear fission, electricity grids and carbon capture and storage. This includes information on the technologies; the materials supply chain; which materials, and their quantity, are used in each technology; the materials description; relevant references; and other info [2].

Sixty metals were identified as vital for the different energy technologies covered by the SET-Plan. About 70% of all technical innovations can be directly or indirectly attributed to the materials they use. The impact of advanced materials (fraction of growth attributed to these) for the energy sector is expected to reach 70% in 2030 [2].

A technical roadmap was published by the European Commission to establish what materials are needed in order to drive the next generation power sources or to make buildings more efficient [2].

2. Economic aspects of materials and energy

The Energy Materials Industrial Research Initiative (EMIRI), a pan-European initiative and an association that works for the future of advanced materials for low carbon energy (LCE) in Europe, identifies four key numbers as follows [5]:

1) >4 billion € in sales of advanced materials for energy;
2) >400 million € of investment in Research & Innovation (R&I) on advanced materials for energy;
3) >20,000 direct jobs in the manufacturing of advanced materials for energy;
4) >4000 researchers for R&I on advanced materials for energy.

Energy systems are changing profoundly, and the share of renewable and decentralized energy production in the energy mix is foreseen to increase. A wide range of advanced materials in sufficient quantities will be needed to modernize energy installations. However, several years of Research and Innovation (R&I) can be taken before the development and market uptake of these materials as every-day components. Long, capital-intensive development times, in combination with strong technology and marketing risks, means that it is very difficult to progress new materials from the lab to the industrial scale and, after this, to the markets [2].

In a 2012 study [6], carried out by Oxford Research AS for the Directorate-General for Research and Innovation of the European Commission, nearly 40% of the interviewed venture capitalists and private investors were willing to invest in early stages, or seed capital in advanced materials, for the energy sector, more than that for materials for other applications, showing the interest in investment on materials for energy. The total worldwide market for advanced materials is expected to grow to about 1100 billion € by 2050, with a share of 16% for materials for energy applications (176 billion €) [6].

3. The EMIRI initiative

The industry-driven initiative (IDI) promoted by EMIRI [5] calls for prioritization and action in R&I on advanced materials. Through collaboration between Industry, Research Organizations and Associations with the European Directorate-General Research & Innovation, a focused R&I program on advanced materials for LCE was defined. The IDI, aiming at bridging the gap between lab and market, focuses on 19 topics (Technology Readiness Levels (TRL) 4-7) over four key components (KC). These topics and KCs address the challenges of the European Energy System and contribute to the SET Plan. The four KCs are [5]:

KC1 - Advanced materials to increase energy performance of buildings;
KC2 - Advanced materials to make renewable electricity technologies competitive;
KC3 - Advanced materials to enable energy system integration;
KC4 - Advanced materials to enable the decarbonisation of the power sector.

Among the 19 topics promoted by this IDI, five are of interest to support Action 4 of the SET Plan (Increase the resilience, security and smartness of the energy system). These are [5]:

1 - Advanced materials for thermal energy storage (TES) - Next generation of TES technologies;
2 - Advanced materials for lower cost, high safety, long cycle life and environmental friendly electrochemical batteries (Li-ion batteries);
3 - Advanced materials for lower cost, high safety,