

Critical and precious materials consumption and requirement in wind energy system in the EU 27



Junbeum Kim^{a,b}, Bertrand Guillaume^a, Jinwook Chung^{c,*}, Yongwoo Hwang^d

^a CREIDD Research Centre on Environmental Studies & Sustainability, Department of Humanity, Environment & Information Technology, University of Troyes, France

^b Department of Geocology and Geochemistry, Institute of Natural Resources, Tomsk Polytechnic University, Russia

^c R&D Center, Samsung Engineering Co., Ltd., Suwon, South Korea

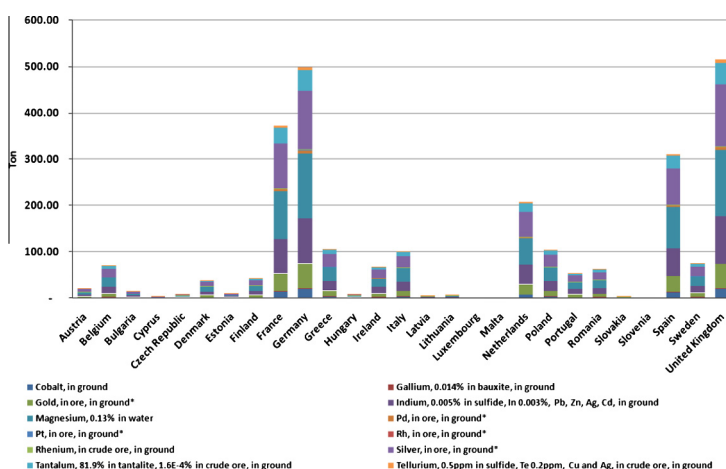
^d Department of Environmental Engineering, Inha University, Incheon, South Korea

HIGHLIGHTS

- The critical and precious materials consumption were calculated in wind energy system in the EU 27.
- The future requirement of critical and precious materials was estimated in the EU 27 by 2020.
- Fluorspar, silver, magnesium, indium, gold and tantalum are the mainly used and required materials.
- This research approach could be applied to other industrial sectors as well as other renewable technology.

GRAPHICAL ABSTRACT

Critical and precious materials requirement in the wind energy system in the EU 27 by 2020.



ARTICLE INFO

Article history:

Received 15 April 2014

Received in revised form 20 October 2014

Accepted 1 November 2014

Available online 22 November 2014

Keywords:

Sustainable resources management
Material flow
Critical and valuable raw material
Wind energy
Scenarios

ABSTRACT

Critical materials as well as rare earth elements and precious metals such as platinum, gold and silver are used significantly for computer hard disk drives, mobile phones, hybrid electric vehicles, batteries, renewable energy system and many other applications. It is therefore important to quantify and estimate both current stocks and flows of such materials, as well as future requirement for industries and economies. In this study, which is focused on wind energy system in the European Union (EU) 27, the current consumption and future requirement of critical and precious materials were calculated and estimated using the wind power production dataset from ecoinvent and data from National Renewable Energy Action Plan (NREAP). It is shown that fluorspar has been the most consumed material to date, and will probably be the most required material in the future. Among other critical and valuable materials, the main materials used for current wind energy system are silver, magnesium, indium, gold and tantalum. These materials will also be required significantly by 2020 for the wind energy system in the EU 27. It is argued that these results should be connected to the future energy and material policy and management.

© 2014 Elsevier Ltd. All rights reserved.

* Corresponding author at: R&D Center, Samsung Engineering Co., Ltd., 415-10 Woncheon-Dong, Youngtong-Gu, Suwon, Gyeonggi-Do 443-823, South Korea.

E-mail address: jin-wook.chung@samsung.com (J. Chung).

1. Introduction

There has been a dramatic rise in consumption of energy resources, mainly fossil fuels, since the advent of the industrial revolution [1–5]. The World Energy Outlook suggests that total energy consumption is expected to increase by 60 percent in the next 25 years [1]. As we know, therefore, the renewable energy system is playing an important role to meet the world's energy demands in the future. Renewable energy, either from photovoltaic, hydroelectric power, geothermal energy tidal power, or wind accounted for 13.2% of the U.S. produced electricity in 2012 [6]. For EU 27, the share of energy from renewable sources in gross final energy consumption reached 12.5% in 2010 and is showing steady progress towards the Europe 2020 target (20% in total final energy consumption) [7]. Renewable energy systems are contributing significantly toward creating new economic opportunities and the supplying of these energy forms. In addition, they are reducing greenhouse gas (GHG) emissions when fossil fuels are replaced by renewable energy system [8–10]. However, the renewable energy systems are consuming a number of critical, precious and energy raw materials, as well as using available land while providing benefits at national and local levels. Furthermore many studies and issues related with life cycle water supply and materials recycling in renewable energy systems were conducted and published [11–14].

According to the Environmental and Energy Study Institute (EESI), the term “critical rare materials” describes naturally-occurring earth elements that play a critical role in advanced technologies for batteries, lighting, motors, energy systems, electronics, and many other uses, especially emerging technologies involving magnets [15]. Some of these materials are rare earth elements (REEs), which are 17 elements on the periodic table that have similar physical and chemical properties. In addition, energy critical elements include chemical elements that have the capacity to transform the way we either capture, transmit, store or conserve energy [16,17]. In the critical materials strategy of the US Department of Energy (DOE) [18], the U.S. focused on materials used in four clean energy technologies, namely wind turbines (permanent magnets), electric vehicles (permanent magnets & advanced batteries), solar cells (thin film semiconductors), and energy-efficient lighting (phosphorus).

The demand for a number of essential metals and critical raw materials is forecasted to double over the next 50 years [19]. Recently, wind energy technology has more particularly acquired the potential to become a major source of renewable power generation for the world [20]. The data from World Wind Energy Association (WWEA) shows that the worldwide wind capacity reached 336,327 MW by the end of June 2014 and expected 360,000 MW by end of 2014. The annual growth rate of global wind energy grew by 13.5% on an annual basis (mid 2014 compared with mid 2013) [21]. In the global installed capacity, China accounted for 41% of the world market for new wind turbines. By June 2013, China had an overall installed capacity of 98.6 GW. The ten largest markets for wind energy system included next to China, U.S. (61.9 GW), Germany (36.5 GW), included Spain (22.9 GW), India (21.3 GW), the United Kingdom (11.2 GW), France (8.6 GW), Italy (8.6 GW), Canada (8.5 GW) and Denmark (4.8 GW) [21].

According to the European Wind Energy Association (EWEA) [20], in 2012, installed wind power capacity in the EU was total 105,000 megawatts (MW) (about 7% supplies in the EU's electricity). The EU wind industry has had an average annual growth of 15.6% over the past 17 years (1995–2011). The Global Wind Energy Outlook “advanced scenario” of the Global Wind Energy Council (GWEC)'s forecasts that by 2020, more than 40% of the total global

wind power capacity could be installed in this area, up from 31% at the end of 2010 [22]. Based on these future targets and predictions for wind energy system in the EU 27, quantifying and estimating current material flows and stocks as well as future requirement for industries and European economies appear as very important issues.

Recent studies show overviews of constraints and materials availability for many low-carbon and new technologies [23–27], and metal resource constraints for specific technologies such as electric vehicle batteries [27–29] and solar photovoltaic [27,30–36]. However, there have seldom been studies on critical and precious materials availability and requirement on wind energy system. The purpose of this study is therefore to quantify current critical and precious resources consumption and stocks in wind system in the EU27, as well as estimates the required amount based upon wind energy production scenarios and national roadmaps in the EU 27 by 2020.

2. Data and methods

2.1. Wind energy system in the EU 27

The dataset from National Renewable Energy Action Plan (NREAP) [37] was used to calculate and estimate current and future material resources in the EU 27' wind energy system. NREAP [37] is a document setting the consumption targets of renewable energy sources until 2020, as well as the manner to meeting the challenge. EU Member States have notified their national renewable energy action plans to the European Commission (EC) by June 30th, 2010. Member States set out the renewable energy targets, the technology combination they expected to use, the trajectory they would follow, and the actions they would undertake to overcome barriers of developing renewable energy [37]. Fig. 1 shows the current and future requirement of wind energy system by 2020 in the EU 27 (here, the blue column is current installed wind energy and the red column is 2020 target in each country, so the sum of this two columns is total installation capacity by 2020). As we can see here, there would be a significant increase of the wind energy system installation by 2020 in all member countries. Regarding the top 5 wind energy system installation countries in the EU 27, they should increase their wind energy capacity and installation as follows: Germany (about 3 times more, 38.63–104.43 TW h), Spain (about 2 times more, 37.77–78.30 GW h), United Kingdom (8 times more, 9.30–78.30 TW h), France (about 7 times more, 8.05–57.90 TW h), and Netherlands (7 times more, 4.38–32.30 TW h). In other countries, Romania and Slovakia need 722 times (0.01–8.40 TW h) and 52 times (0.01–0.60 TW h) more wind energy system than current capacity and installation, respectively. Also Finland and Latvia are required to increase their wind energy system by 22 times (0.28–6.10 TW h) and 20 times (0.05–0.91 TW h), respectively.

Onshore wind refers to turbines located on land, while offshore turbines are located out at sea or in freshwater. The onshore wind energy system plays a prominent role in the generation of renewable electricity in the EU. Offshore wind energy system can be installed both right off the coast, with wind turbines located on concrete platforms which extend to the bottom of the sea, and further out in the sea via the use of floating platforms, increasing environmental cost through additional materials [38,39]. Accurate estimates of resource consumptions from wind energy system should therefore distinguish between onshore and offshore systems. According to EWEA report on EU 27 NREAP [40], as shown in Table 1, onshore and offshore wind energy production targets in the EU by 2020 were also separated. In 2005, the installation

Download English Version:

<https://daneshyari.com/en/article/6688176>

Download Persian Version:

<https://daneshyari.com/article/6688176>

[Daneshyari.com](https://daneshyari.com)