Land Use Policy 66 (2017) 105–110

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Land reuse in support of renewable energy development

Jacqueline L. Waite

Oak Ridge Institute for Science and Education (ORISE) Research Participant, hosted by the US Environmental Protection Agency, Washington, DC, USA

A R T I C L E I N F O

Keywords:
Renewable energy
Contaminated lands
Land reuse

A B S T R A C T

Renewable Portfolio Standards are U.S. state-level policies that encourage renewable energy development to meet a proportion of electricity demand. These policies, along with state and federal incentives and private sector demand, have motivated interest in renewable energy capacity, which is a function of available land. As global climate change has been driven by the combination of fossil fuel combustion and land cover change, renewable energy development is best achieved through sustainable land use practices. One option is to site renewable energy installations on land that has been contaminated or degraded. This analysis looks at the degree to which renewable energy demand created by state renewable portfolio standards in the United States could be met by contaminated or formerly contaminated sites. Results suggest that land resources are more than sufficient to meet current and possibly future RPS-generated demand in three out of four regions.

1. Introduction

The nearly 200 signatories of the Paris Agreement (UNFCC, 2015) have made national policy commitments to limit the use of fossil fuels. The International Energy Agency (IEA, 2015) has predicted that by 2020 renewables will count for 26% of global electricity generation. At the time of the Agreement, the United States had been making the transition toward meeting its electricity demands through a higher proportion of clean energy sources. The national goal set by the Obama Administration called for the U.S. to produce 30 percent more of its electricity from clean energy sources (e.g. hydro, nuclear, geothermal, wind and solar), by 2030 (White House, 2016). Concurrent with national policy has been an effort at the state level to integrate more non-fossil fuel energy sources into utilities' energy portfolios. Twenty-nine states and the District of Columbia have mandatory renewable portfolio standards (RPS) and another six states have non-binding goals (Fig. 1). These state RPS policies, in many cases, were put in place with the expectation that the requirement would stimulate new resource development within a state or region (Wiser and Barbose, 2008). After over a decade of RPS, it is possible to quantify the amount of energy resources developed and the remaining demand generated by these policies (Barbose, 2016).

Previous studies have documented opportunities for, and barriers to, using contaminated or degraded lands (hereafter, DLs) for renewable energy in various contexts. This study supports those efforts by comparing a quantifiable land resource energy capacity with an established level of RPS- generated energy demand. The result is a definitive statement about land resources which is discussed relative to other land re-use and renewable energy development challenges.

2. Review of literature

As Gordon Walker (1995a, 3) explains in his introduction to a special issue of this journal, "energy and land use are closely entwined," and the expansion of renewables has lead to a new set of challenges. A driving question for renewable energy developers is where to site new installations. According to the analysis by Trainor et al. (2016), "per unit energy, renewable energy generally has a greater direct land use footprint than extractive energy" (p.9). Commonly, renewable energy developers target "greenfields," (e.g., open spaces, agricultural land or forested land.) Developers consider resource (i.e., sun, wind, biomass) availability; site conditions; energy markets, and grid access which may require investments in new transmission infrastructure. Increasingly, urban and regional planners are weighing the sustainability trade-offs associated with using greenfields for energy development, such as habitat protection, food production and preservation of ecosystem services (Hernandez et al., 2015; Hernandez, 2014; Northrup and Wittemyer, 2013; Sliz-Szkliniarz, 2013; Copeland et al., 2011; Lovich and Ennen, 2011). It is also not uncommon for communities to oppose solar, and often to a greater extent, wind installations which interfere with landscapes to which they feel connected (see Pasqualetti, 2011). For larger cost-effective projects, a sustainable option may be to reuse thousands of underutilized degraded land parcels.

The shift toward envisioning DLs as opportunities for productive reuse is well documented (see Spiess and De Sousa, 2016; Adams et al., 2010). This common sense approach tackles two land use quandaries at

E-mail addresses: Waite.Jacqueline@epa.gov, jlwaite894@gmail.com.

http://dx.doi.org/10.1016/j.landusepol.2017.04.030
Received 25 November 2016; Received in revised form 6 April 2017; Accepted 9 April 2017
Available online 05 May 2017
0264-8377/

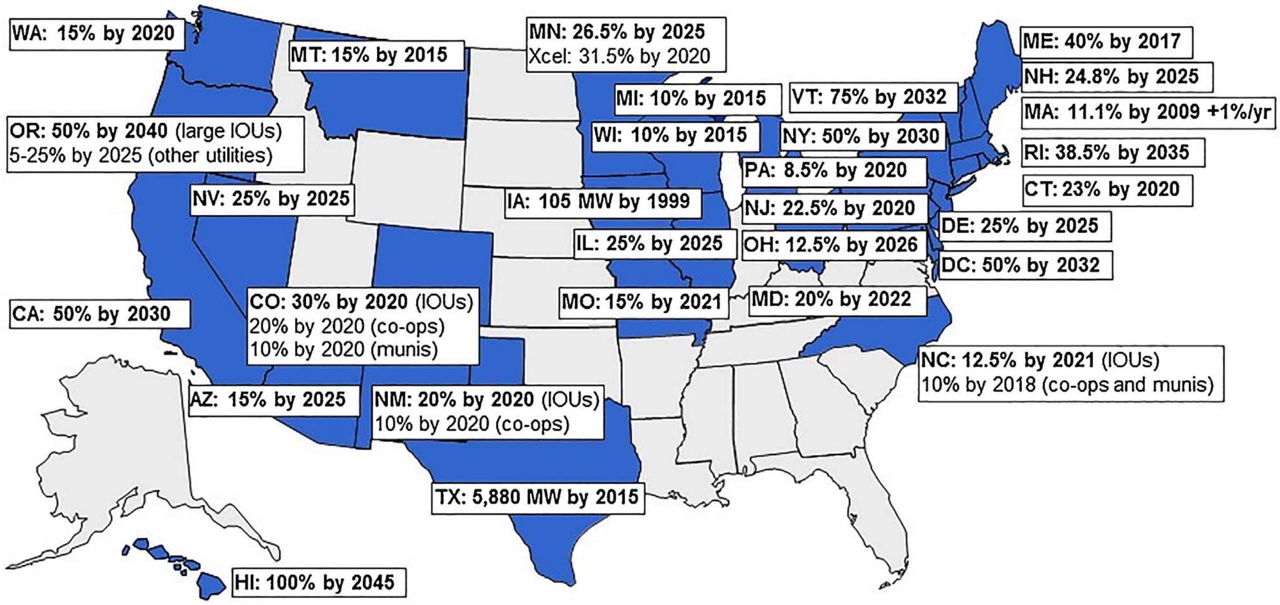

Fig. 1. States with RPS Policies in 2016.
Source: Reprinted with permission from G. Barbose, Berkeley Lab, Environmental Energy Technologies Division, Energy Analysis Department. Original note: Compliance years are designated by the calendar year in which they begin. Mandatory standards or non-binding goals also exist in US territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

once: motivating the clean-up, protection and re-use of thousands of acres of contaminated lands, landfills and mine sites; and developing sustainable sources of energy (Adelaja et al., 2010). Earlier studies suggested potential for solar energy production on abandoned buildings (Greenstein and Sungu-Eryilmaz, 2006), landfills (Ferrey, 2007) and brownfields (Adelaja et al., 2010). More recently, Spiess and De Sousa (2016) find that where renewable energy installations are unpopular, they are more palatable when placed on land that has already been sacrificed to contamination.

This envisioned potential has been realized to some degree. There has been modest yet steady growth of projects in the United States (EPA, no date). In addition to examples in the Czech Republic (Klusáček et al., 2014), recent international examples include a proposed solar array on a closed landfill in the city of Taipei (Taipei Times, 2016), and a 2.7 MW solar park on a former tar acid disposal site in Neukirchen, Germany (Chen, 2013).

Other research more fully documents barriers to renewable energy projects on DLs and provides some evidence for why there are not more of them. Financial risk and liability are barriers for energy developers on contaminated lands according to Spiess and De Sousa's (2016) inquiry involving 100 energy experts in North America and Europe. This aligns with Neuman and Hopkins' (2009) recommendation of an insurance product which would cover both energy projects and pollution control liability associated with contaminated sites. Relatedly, Spiess and De Sousa (2016) find that technical and environmental challenges, such as fully understanding the extent and implications of the environmental contamination, are prohibitive to getting projects off the ground. Klusáček et al. (2014), found that despite a lack of government incentives, and technical challenges, a small proportion of solar energy projects in their study area of the Czech Republic were sited on degraded agricultural and industrial land in situations where site ownership was straightforward and uncomplicated. Frantál and Osman (2013) highlight the range of policies and public attitudes toward developing renewable energy on DLs across the Czech Republic, Germany, Poland and Romania.

This report builds upon previous attempts to describe the benefits and quantify the potential wind and solar energy capacity of contaminated or degraded lands in the United States (see for example, Milbrandt et al., 2014). In this instance, let the calculation uniquely describe the energy capacity of an existing federal database of lands measured against actual current and future policy-driven (i.e., RPS-driven) demand for renewable energy. Specifically, (1) can siting wind and solar installations on DLs help states meet RPS- generated demand, and (2) where might siting on DLs be most useful?

3. Methods

The sample for this calculation was drawn from a set of nearly 81,000 sites initially screened by U.S. EPA's RE-Powering America's Land Initiative in partnership with the National Renewable Energy Laboratory (NREL). Criteria for this initial pre-screen included: site size (based on reported acreage); distance to transmission lines and roads, and resource-specific criteria such as wind speed and maximum direct normal irradiance, which is a measurement of sunlight (US EPA, 2015). Table 1 describes the pre-screening criteria in more detail. Sites listed as having only "off-grid" potential were not included in this study.

The database of pre-screened sites is comprised of lands associated with federal clean-up programs (e.g., Superfund sites, RCRA corrective action sites, Brownfield grantees, and sites that were identified through EPA's Landfill Methane Outreach Program). In addition, eleven states supplied some data on DLs registered with state abandoned mine inventories and/or clean-up programs (see Appendix).

The data were further cleaned by removing duplicate records. Sites listed on both state and federal inventories were systematically removed based on site ID number. The total number of sites included in the analysis for solar PV and wind are n = 20,065 and n = 5,382, respectively. Many sites (n = 2,843) screened positively for both wind and solar PV and have been captured in both calculations, although the expectation is that only one technology would be developed on each site.

The analysis involved calculating renewable energy (wind and solar PV) capacity of DLs based on land area. Wind and solar PV capacity per site was calculated based on NREL estimates of land-use impacts of renewable technologies. For solar PV, the author used the average total land use figure of 7.9 acres per MW (see Ong et al., 2013, v). This figure represents the estimated area required to generate 1 MW of electricity based on the average production of all solar technologies and efficiencies at the time of the study. This is called a "total" land use figure because it captures the amount of land needed for the solar technology (e.g. solar panels) plus buffer zones and access roads. Thus for