Renewable Energy

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I. Introduction

Renewable Energy: Renewable energy uses energy sources that are continually replenished by nature—the sun, the wind, water, the Earth's heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy—most often electricity, but also heat, chemicals, or mechanical power. Why Use Renewable Energy? Today we primarily use fossil fuels to heat and power our homes and fuel our cars. It's convenient to use coal, oil, and natural gas for meeting our energy needs, but we have a limited supply of these fuels on the Earth. We're using them much more rapidly than they are being created. Eventually, they will run out. And because of safety concerns and waste disposal problems, the United States will retire much of its nuclear capacity by 2020. In the meantime, the nation's energy needs are expected to grow by 33 percent during the next 20 years. Renewable energy can help fill the gap.

II. GIS for Renewable Energy

Faced with grim predictions of energy supply and consumption, humankind is responding with tremendous efforts to capture and cultivate renewable resources. We are looking to help sustain ourselves using wind, solar, geothermal, and biomass energy. We are also searching for cleaner, smarter, and more conscientious methods of energy production, transmission, and distribution. GIS technology is supporting and underlying the progress of this monumental change. GIS is not only improving the way we produce and deliver energy, it is changing the way we view our earth's resources.

III. How GIS is Used to Map Renewable Energy Resources

Imagine taking a road trip and as you're driving, you come across wind turbine after wind turbine. There's dozens of them on either side of you as you're driving past fields and farm land. Why are they there? And how was it decided that wind turbines should be placed there? Chances are GIS technology helped project planners make this decision.With a global focus on climate change, there is a significant need for renewable energy sources like solar, wind, water, and thermal energy. As great as renewable energy is, it can't be used everywhere.The question is, why not?Let's take the state of Colorado as an example. While the state was a prime candidate for solar and wind energy, the challenge was finding specific locations that have high enough wind speeds and sun penetration. On top of that, planners had to cut out locations that weren't close enough to large populations and distribution centers that would make the delivery of renewable energy cost effective. GIS technology helped narrow down where to build wind and solar farms.With GIS technology and mapping, policymakers and planning commissions can more easily determine the right location for renewable energy. This is because GIS allows for deep analysis of wind potential, solar potential, distance to cities, population size, and type of land cover. GIS can even tell project planners the social and environmental impact, like if habitats or migratory patterns would be harmed from the building of a renewable energy plant in that area. All this information offers a clear picture of which locations would be best to implement renewable energy resources versus those that would be a waste of resources and money.In Colorado's case, planners were able to analyze wind speeds and determine that the best locations for wind farms were in the northeast part of the state. After reviewing solar radiation levels and temperature trends, they were then able to determine that east of Denver was the best spot for solar power plants.GIS technology's impact can also be felt on a global scale, giving policymakers and planners the ability to examine renewable energy potential across entire continents. The International Renewable Energy Agency (IRENA) used a GIS approach to make initial estimates of Africa's renewable energy potential. In its 2014 report, IRENA reported that GIS analysis showed that eastern and northern Africa have the largest potential for solar and wind applications, while the equatorial region offers the most significant potential for biofuel resources.GIS is playing a large role in determining where to focus renewable energy efforts and how best to manage them. This technology highlights the potential for sustainable energy resources, shows data of the actual use of that particular energy source in question, land analyses, and where planners should design renewable energy power plants

- U.S. DOE's Renewable Energy Lab Maps Wind Resources with GIS U.S. DOE's Renewable Energy Lab Maps Wind Resources with GIS Highlights Using Ar-

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cGIS Desktop software, the NREL team can determine the most favorable locations for wind farms. GIS-based modeling enables analysis of terrain, which signifi cantly impacts the quality of wind at a particular site. The primary audience for these maps is government decision makers. During the 1970s, the United States experienced a signifi cant energy crisis as oil consumption grew and supply fell. Soon after President Jimmy Carter came into offi ce in 1977, he addressed the nation and said, "We must balance our demand for energy with our rapidly shrinking resources. By acting now, we can control our future instead of the future controlling us." His energy policy included maintaining healthy economic growth; protecting the environment; and developing the new, unconventional energy sources that the nation would rely on in the following century. Several months later, Carter established the U.S. Department of Energy (DOE), and the Solar Energy Research Institute (SERI) was opened in Golden, Colorado. In September 1991, SERI was designated a DOE national laboratory, and its name was changed to the National Renewable Energy Laboratory (NREL). NREL is the primary laboratory for renewable energy and energy effi ciency research and development in the United States. NREL works to advance many renewable resources, including solar, hydrogen and fuel cells, biomass, and geothermal, but wind is currently the most developed renewable energy market. Windmills appeared on the American landscape in the early 20th century and evolved into wind turbines that increasingly capture more energy and become more cost-effective. In 2006, President George W. Bush spoke about the nation's need for a more diversifi ed energy portfolio and how wind energy might provide 20 percent of the nation's energy by 2030.

In May 2008, DOE released a groundbreaking report, 20Wind Energy's Contribution to U.S. Electricity Supply. The report provides a road map to reaching this important goal, including identifying steps and challenges. As part of the research behind having 20 percent wind energy by 2030, NREL team members were tasked with updating wind resource maps. The updated maps were a critical component of the wind deployment model used to develop the 20 percent scenario. Using ArcGIS Desktop software (through a U.S. government license agreement), the NREL team can determine the most favorable locations for wind farms based on the cost of transmission, locations of load GIS BEST PRACTICES 7 WWW.ESRI.COM centers and wind resources, and the layout of the electrical grid. GIS-based modeling enables analysis of terrain, which signifi cantly impacts the quality of wind at a particular site. The NREL team also examines economic development potential based on strong manufacturing centers and fi lters the data to exclude sites such as national parks and wilderness areas. "We use GIS for policy analysis and implementation analysis," says Marguerite Kelly, senior project manager at NREL. "We use it to help decision makers at all levels understand what their resource is." For utility developers, NREL creates forecasting models. "A utility wants to know not only what the average wind speed is at a location," Kelly adds, "but also what's going to happen in 10 minutes, and then in an hour—that's how they buy and sell electricity." The collaborative that produced the road map report includes the American Wind Energy Association, engineering consultants from Black and Veatch Corporation, DOE, Lawrence Berkeley National Laboratory, NREL, Sandia National Laboratories, and more than 50 energy organizations and corporations. Maps include details such as voltage of transmission lines and classes of wind speed and wind power. Forecasts include projected wind capacity by state in 2030 and the expansion of transmission lines that would be required. "The wind maps consistently amaze people," Kelly notes. "Often, the wind resource is much bigger than people expect, since a wind farm requires a strong steady breeze, not gusts." The primary audience for these maps is government decision makers who are thinking about how renewable energy can be used in their counties and states. The secondary audience is developers looking for renewable energy installations. As of September 2008, 35 states were generating wind power. Texas, California, Iowa, Minnesota, and Washington (respectively) made the Top 5 list of total wind power capacities. According to the American Wind Energy Association, as of December 3, 2008, U.S. wind capacity was just over 21 gigawatts (GW) (awea.org/projects). The United States must reach 305 GW by 2030 to meet the 20 percent goal.

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