3GreenIndex: Making Informed Decisions by Visualizing, Exploring, and Evaluating Renewable Energy Data

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Motivation and Problem Definition

The Biden administration has set goals for a net-zero emissions future[17]; but, there are difficulties in state-level implementation due to geographical landscape[22], lack of workforce[12], transmission constrictions, lack of battery storage[7][10], and permit requirements[20]. Roughly half of the 50 states have set goals to overcome these hurdles and achieve 100% renewable/clean energy. Renewable energy sources (RES) such as solar, wind, water, biomass, and geothermal can be replenished faster than consumption[15]. For our project, we will provide a "one-stop-shop" within an interactive heat map of existing RES within the US. For each state, time series data will be used to predict the date of 100% renewable energy and compare it to current state energy goals. Each state will also have links to relevant policies and statewide renewable incentives. Our project data set will include the renewable energy data of wind and solar. Hydro-power, biomass, and geothermal will be added as time permits.(Q1)

Literature Survey

Despite the hurdles, the development of RES contributes to economic growth, energy resiliency, grid decentralization, job creation, climate and health benefits.[9][4] According to [8], an opportunity presents itself as most power plants in the US will need to be replaced by 2050.

Studies have assessed the resource potential [3] of solar [20], wind, biomass, marine, geothermal [24][19], and hydro-power[6][18][23]. Others expand upon what was learned and discuss the technical/economic/market potential[17][1][2][11][14] of RES. An even higher order of analysis is done by [16] and [21]. [16] forecasts solar power through clustering and neural networks while [21] simulates scenarios that will meet regional renewable goals (Q2). However, there is no "one-stop shop" that integrates RES potential, forecasting, and policy information at a per region (e.g., State/County/City) level (Q3). Through our web application, policy makers and energy industry analysts can make data-driven decisions on selecting the most technically feasible RES of a given region. Anyone who cares about our environment, our life quality, and the future generation will be interested in this information. Energy industry, government agencies, policy makers, advocacy groups will find this as a helpful benchmark (Q4). If we are successful, users will be able to identify which states are on track for their renewable energy goal. This can provide incentive for more policy shifts to lower the hurdles of renewable energy development. The renewable resource map will aid in identifying the best resources to develop. It can encourage construction of wind turbines on or next to buildings where local wind regimes are created [13] or solar farms in deserts and degraded areas[20][5]. (Q5)

Costs, Risks and Payoffs

Risk factors include: lack of data at fine-granularity (for a given local regional area), uncertainties of the global/macro-economic factors impacts to regional energy market and time and availability of team members. (Q6) The project will be implemented using free, publicly available data sources, and the primary cost of this project will be the time and effort of the team. The web application will be hosted on AWS, using free tier AWS credit. (Q7) Payoffs include allowing users to have a cohesive data resource that will help inform decisions, understand where a state may be in their renewable energy journey, and take further steps to invest in alternative energy sources that combat climate change.

Project Plan and Timeline of Activities

The project team had their first team meeting on Thursday, January 19, 2023 and holds weekly meeting at 8PM PST, Thursday. From January through April 2023. The teamwork will be divided into three phases with respect to each of three required deliverables in the course schedule (the proposal due on Friday, March 3, 2023, the progress report due on Friday, March 31, 2023, and the final report due on Friday, April 21, 2023). (Q8) The detailed project plan and timeline activities are developed in a Gantt chart (**Table 1**).

RENEWABLE ENERGY PROJECT | Team 7				2/2	2/9	2/16	2/23	3/2/	3/9	3/16	3/23	3/30	4/6	4/13	4/20
TASK	ASSIGNED	START	END	1	2	3	4	5	6	7	8	9	10	11	12
Phase I															
Select Topic	All	1/19/23	2/9/23												
Search Data Set	KS/IC	2/9/23	3/1/23												
Literature Survey	All	2/9/23	2/23/23												
Exploring UI Tool	DM/ED	2/16/23	2/23/23												
Submittal	AB/HP	2/23/23	3/1/23												
Phase II															
Get/Clean Data	All	3/2/23	3/31/23												
Model Calculations	All	3/9/23	3/31/23												
Data Visualization	KS/IC	3/9/23	3/31/23												
Implementing UI	DM/ED	3/2/23	3/31/23												
Submittal	AB/HP	3/23/23	3/31/23												
Phase III															
Data Visualization	KS/IC	4/1/23	4/21/23												
Implementing UI	DM/ED	4/1/23	4/21/23												
Exp Design/Eval	All	4/1/23	4/21/23												
Submittal	AB/HP	4/20/23	4/21/23												

Table 1: Gantt Chart Division of Labor

All team members have contributed a similar amount of effort.

References

[1] D. Heimiller C. Davidson P. Denholm J. Melius A. Lopez D. Hettinger D. Mulcahy A. Brown, P. Beiter and G. Porro. *Estimating renewable energy economic potential in the United States. methodology and initial results.* National Renewable Energy Laboratory (NREL), Golden, CO (United States), 2016.

[2] Donna Heimiller Nate Blair Anthony Lopez, Billy Roberts and Gian Porro. *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis.* 2012.

[3] Adria Brooks. *Renewable Energy Resource Assessment Information for the United States.* 2022.

[4] Jonathan J. Buonocore et al. Climate and health benefits of increasing renewable energy deployment in the united states*. *Environmental Research Letters*, 14:11, 2019.

[5] J. Byrne, L. Kurdgelashvili, D. Poponi, and A. Barnett. The potential of solar electric power for meeting future us energy needs: A comparison of projections of solar electric energy generation and arctic national wildlife refuge oil production. *Energy Policy*, 32(2):289–297, 2004.

[6] Eugene D. Coyle et al. Harnessing nature: Wind, hydro, wave, tidal, and geothermal energy. In *Understanding the Global Energy Crisis*, pages 91–124. EUGENE D. COYLE and RICHARD A. SIMMONS, Purdue University Press . JSTOR, 2014.

[7] Joe Daniel and Sam Gomberg. *Why Does Wind Energy Get Wasted?: The Myth of Wind Energy Oversupply and the True Causes of Wind Curtailment.* Union of Concerned Scientists JSTOR, 2021.

[8] C. R. DeRolph, R. A. McManamay, A. M. Morton, et al. City energysheds and renewable energy in the united states. *Nat Sustain*, 2:412–420, 2019.

[9] Daniella Echeverría et al. Renewable energy. *Circular Economy Proxy Measures: Indicators on Job Effects for a Closed-Loop Economy, International Institute for Sustainable Development (IISD) pp*, pages 15–19, 2020.

[10] Hannah Findling. A regional energy market to achieve california's renewable energy goals. *Consilience, no*, 24:1–16, 2021.

[11] Margolis R. Melius J. Phillips C. Elmore R. Gagnon, P. *Rooftop solar photovoltaic technical potential in the United States: A detailed assessment.* Golden CO: National Renewable Energy Laboratory, 2016.

[12] Morgan Higman et al. *Clean Resilient States: The Role of U.* S. States in Addressing Climate Action. Center for Strategic and International Studies (CSIS) JSTOR, 2020.

[13] K. C. S. Kwok and G. Hu. Wind energy system for buildings in an urban environment. *Journal of Wind Engineering and Industrial Aerodynamics*, 234(10534):9, 2023.

[14] Sigrin B. Gleason M. Preus R. Baring-Gould I. Lantz, E. *Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects.* Golden: National Renewable Energy Laboratory, 2016.

[15] Ashley J Lawson. Variable renewable energy. *CRS In Focus IF11257*, 2019.

[16] I. Koprinska M. Rana and V. G. Agelidis. Solar power forecasting using weather type clustering and ensembles of neural networks. *International Joint Conference on Neural Networks (IJCNN)*, page 4962–4969, 2016.

[17] Kevin McCabe et al. Distributed wind energy futures study. *Golden, CO: National Renewable Energy Laboratory NREL/TP-*, 7:A40–82519, 2022.

[18] Kao S. C. Stewart K. M.-Elrod B. Hadjerioua B. DeNeale S. T. ... Smith B. T. McManamay, R. A. *New Stream-Reach Development: A Comprehensive Assessment of Hydropower Energy Potential in the United States*. Washington D.C.: U.S. DOE Wind and Water Power Technologies Office, 2014.

[19] Kevin McCabe Meghan Mooney Timothy Reber Michelle Mullane, Michael Gleason and Katherine R. Young. *An Estimate of Shallow, Low-Temperature Geotherm Resources of the United States*. NREL, 2016.

[20] John Rogers and Laura Wisland. *Solar Power on the Rise: The Technologies and Policies behind a Booming Energy Sector*. Union of Concerned Scientists JSTOR, 2014.

[21] B. Sigrin and M. Mooney. *Rooftop Solar Technical Potential for Low-to-Moderate Income Households in the United States*. National Renewable Energy Laboratory, Golden CO, 2018.

[22] Erin Ann Thomas. The energy future of america. *Coal in Our Veins: A Personal Journey, University Press of Colorado pp*, pages 187–200, 2012.

[23] Johnson M. M. Shan R. Uria-Martinez, R. *U.S. Hydropower Market Report*. Washington, D.C.: U.S. DOE Water Power Technologies Office, 2021.

[24] Reed M. J. Mariner R. H. DeAngelo J. Galanis S. P. Williams, C. F. *Assessment of moderate- and high-temperature geothermal resources of the United States: U.S. Geological Survey Fact Sheet 2008-3082*. Washington DC: U.S. Geological Survey (USGS), 2008.