REACHING DRAWDOWN: EXPLORING ELECTRICITY GENERATION SOLUTIONS POTENTIAL AT EUROPEAN UNION

João Pedro Gouveia, CENSE—Center for Environmental and Sustainability Research, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal, Portugal, +351917428448, jplg@fct.unl.pt
Diogo Freitas, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal, Portugal, dc.freitas@campus.fct.unl.pt
Francisco Vieira, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal, Portugal, fmp.vieira@campus.fct.unl.pt
Luis Zilhão, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal, Portugal, l.zilhao@campus.fct.unl.pt

Overview

Climate change is an undeniable problem, and the solutions available to fight it need to be deeply understood. Along with other institutions, Project Drawdown is one of the leading fronts in research and resources about climate solutions. Its global analysis in 2017 and 2020, followed by regionalization efforts in the US and Europe (where we frame this work), are critical pieces of this understanding and contextualization of climate change solutions in multiple sectors. "Drawdown solutions" are defined as any technology or practice that directly affects the concentrations of GHGs in the atmosphere by (a) reducing GHG emissions through lowering demand, (b) avoiding GHG emissions through stopping fossil fuel emissions and replacing them with zero- or low-emitting alternatives and (c) sequestering atmospheric carbon through viable natural and engineered sinks (Frischmann *et al*., 2020).

According to EMBER (2021), the electricity demand worldwide has been growing since 2009, with the exception being the year 2020 (a year marked by the Covid-19 global pandemic where the global electricity demand fell around 0.1%). The electricity generation from wind and solar sources has doubled in the last five years, amounting, today, to almost 10% of the world's total electricity in 2020. A slight increase in hydropower generation has also been recorded. The exponential growth in these technologies has contributed to the further fall of coal-based electricity generation. The amount of generation growth from these renewable sources and the decline in coal use has been very similar. Unfortunately, electricity generation from renewable sources does not seem to be keeping up with the increasing demand mentioned.

The focus of this work is on electricity generation solutions that are categorized in project Drawdown across three areas of action that foster large-scale integration of renewable energy systems (RES): (1) utility-scale power plants, e.g., Concentrated Solar Power (CSP), or Onshore Wind Turbines; (2) decentralized systems, e.g., Distributed Solar Photovoltaics (PV) or Micro Wind Turbines; and (3) enabling technologies, *e.g*., Energy Storage, Microgrids, and Grid Flexibility.

Methods

This study aims to understand the contribution that key renewable energy technologies such as solar, wind, hydro and ocean power solutions can have in climate change mitigation in the European Union up to 2050. Precisely we assess the impact of their increased adoption for reducing greenhouse gas (GHG) emissions, associated implementation and O&M costs and their role in future developments of the electricity generation industry, one of the most significant GHG emitters. Within this set of RES technologies, we make an in-depth assessment of 9 solutions, being: concentrated solar power, utility-scale solar, decentralized solar, onshore wind, offshore wind, micro-wind, large hydro, small hydro and ocean power. Besides emissions reductions, the solutions assessed have significant co-benefits with most SDGs as detailed in, *e.g.* IRENA (2016); IEA (2016).

The analysis within this work was made resorting to Project Drawdown's Excel-based model, also known as the Reduction and Replacement (RRS) model, a bottom-up model developed to help define and describe existing individual social, ecological, and technological solutions that reduce and sequester greenhouse gas emissions in the atmosphere (Project Drawdown, 2019), allowing, therefore, the assessment of the potential emission reduction impact due to different future adoption pathways.

The methodology is supported by extensive data collection of electricity generation projections (TWh) on over 60 studies (*e.g.* EWG&LUT, 2018; Eurelectric, 2018; IRENA, 2018; JRC, 2020) and key characteristics of the different RES technologies modelled to replace coal, oil, and natural gas, hereby referred to broadly as conventional technologies. We make an analysis of the total electricity generation in the European Union (*i.e.* TAM – Total Addressable Market) followed by future pathways for these RES technologies presented in energy and emissions projection studies (i.e. Adoption). Additionally, research is conducted to obtain several financial, technical, and social indicators regarding these technologies, such as investment costs, capacity factors, or jobs created.

Results

The results show that the electricity generated in the EU (TAM) will grow in every studied scenario (Figure 1), with electricity generation for 2050 expected to range between 3 904 – 10 455 TWh/y. Wind power systems can make up between 24–46% of the European Union's electricity generation mix, solar-based solutions can account for 7% to 33%, hydro with 4.5-10%, reducing its current share, while ocean power could provide up to 10% of electricity needs by 2050 in the highest ambition scenarios. Over the next 30 years, wind technologies together can avoid between 5.6-27 Gt CO_{2e}; solar power technologies 1.32-26.31 Gt CO_{2e}, hydropower between 1.8-3 CO_{2e}, with ocean power encompassing lower impacts. However, the extent of these impacts is vast due to the different scenarios considered from the various publications, models used, main socio-economic and technological assumptions.

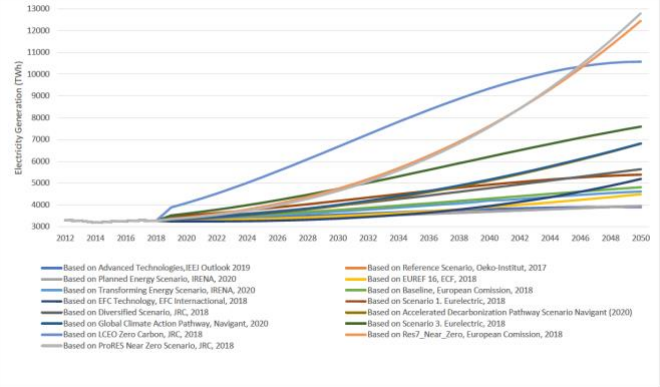

Figure 1- Electricity Generation projections up to 2050 for the European Union for selected scenarios

Conclusions

The results of this study can be utilized to assess the current state of different technologies, how they are expected to evolve in the decades to come under different energy system models and assumptions, and the possible and likely middle grounds that can be adopted. As shown by the existing plethora of solutions in Project Drawdown, the climate change problem does not have a "silver bullet"; it cannot be fixed through a single solution. Therefore, united with solar PV and onshore wind, other less-established renewable energy technologies such as wave and tidal, CSP, and offshore wind can see substantial growth and capture relevant market shares. Existing large hydro systems can be used as a reliable backup through transition periods and the establishment of all these technologies.

References

- EMBER (2021) *Global Electricity Review 2021*. EMBER. Available at: https://ember-climate.org/project/global-electricity-review-2021/.
- Energy Watch Group (EWG); LUT University, (2018). *Global Energy System Based on 100% Renewable Energy - Energy Transition in Europe Across Power, Heat, Transport and Desalination Sectors*. 2018. Available: 84 https://www.researchgate.net/publication/332865382_Global_Energy_System_based_on_100_Renewable_Energy__Power_Heat_Transport_and_Desalination_Sectors
- Eurelectric (2018). *Decarbonization pathways.* Eurelectric. Available: https://cdn.eurelectric.org/media/3457/decarbonisation-pathways-h-5A25D8D1.pdf
- Frischmann C.J., Mehra M., Allard R., Bayuk K., Gouveia J.P., Gorman M.R. (2020). *Drawdown's "System of Solutions" Helps to Achieve the SDGs.* In: Leal Filho W., Azul A., Brandli L., Lange Salvia A., Wall T. (eds) Partnerships for the Goals. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-71067-9_100-1
- IEEJ (2020). *IEEJ Outlook 2020*. Institute of Energy Economics Japan. Available: https://eneken.ieej.or.jp/data/8650.pdf
- IRENA (2016) *Renewable Energy Benefits: Measuring the Economics.* International Renewable Energy Agency, Abu Dhabi. ISBN: 978-92-95111-80-6. https://www.irena.org/publications/2016/Jan/Renewable-Energy-Benefits-Measuring-the-Economics
- IRENA (2018). *Renewable Energy Prospects for the European Union, 2018*. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Feb/IRENA_REmap_EU_2018.pdf
- IEA (2016). *Energy and Air Pollution*. World Energy Outlook special report. International Energy Agency, Paris. https://www.iea.org/reports/energy-and-air-pollution
- Joint Research Centre (JRC) (2020). *Towards net-zero emissions in the EU energy system by 2050*. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC118592
- Project Drawdown (2017). *Drawdown, the most comprehensive plan ever proposed to reverse global warming*. Penguin, New York
- Project Drawdown. (2019). *Drawdown Reduction and Replacement Solutions (RRS) Model Framework and Guide.* 2019.
- Project Drawdown (2020). *The Drawdown review – climate solutions for a new decade*. http://www.drawdown.org. Accessed 25 Feb 2022