

Technical University of Denmark



LCA of electricity systems with high wind power penetration

Turconi, Roberto; O' Dwyer, C. O.; Flynn, D.; Astrup, Thomas Fruergaard

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Turconi, R., O' Dwyer, C. O., Flynn, D., & Astrup, T. F. (2014). LCA of electricity systems with high wind power penetration. Abstract from 9th International Conference on Life Cycle Assessment in the Agri-food Sector, San Francisco, United States.

DTU Library
Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LCA of electricity systems with high wind power penetration

R. Turconi ^{a,*}, C. O'Dwyer ^b, D. Flynn ^b, T. Astrup ^a

^a Department of Environmental Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark

^b School of Electrical, Electronic & Communications Engineering, University College Dublin, Dublin, Ireland

Electricity systems are shifting from being based on fossil fuels towards renewable sources to enhance energy security and mitigate climate change. However, by introducing high shares of variable renewables - such as wind and solar - dispatchable power plants are required to vary their output to fulfill the remaining electrical demand, potentially increasing their environmental impacts [1,2]. In this study the environmental impacts of potential short-term future electricity systems in Ireland with high shares of wind power (35-50% of total installed capacity) were evaluated using life cycle assessment (LCA). Cycling emissions from dispatchable generators due to part-load operation and start-ups [3] were included for the first time in LCA.

Part-load operations significantly affected the average power plant efficiency, with all units seeing an average yearly efficiency 1-11% lower than optimal. Given that similar penalties were seen for power plant with the same role in the system (i.e. load following, mid merit, and base load), it is suggested that only power plants within the same category should be compared. Since power production technologies are typically modeled in LCA assuming steady-state operation at full load [4], the efficiency reduction would result in a large underestimation of emissions, especially for load following power plants.

With regards to the entire electricity system, cycling emissions accounted for less than 10% of lifecycle CO₂, NO_x and SO₂ emissions in the scenarios considered: while not outweighing the benefits from increasing wind energy, cycling emissions are not negligible and should thus be systematically included (i.e. by using emission factors per unit of fuel input rather than per unit of power generated). Cycling emissions increased with the installed wind capacity, and decreased with the addition of storage. However, a consequence of adding storage was the increased use of base load coal power plants, ultimately leading to an increase in total emissions from the Irish electricity system. Consequently, the present study indicates that while investing in new storage capacity reduces system operating costs at high wind penetrations and limits cycling, the emissions reductions may be negated when coupled with base load coal.

References

- [1] Katzenstein W, Apt J. Air emissions due to wind and solar power. *Environ Sci Technol* 2009.
- [2] Valentino L, Valenzuela V, Botterud A, Zhou Z, Conzelmann G. System-wide emissions implications of increased wind power penetration. *Environ Sci Technol* 2012.
- [3] Lew D, Brinkman G, Kumar N, Besuner P, Agan D, Lefton S. Impacts of wind and solar on emissions and wear and tear of fossil-fueled generators. *IEEE Power Energy Soc Gen Meet* 2012.
- [4] Masanet E, Chang Y, Gopal AR, Larsen P, Morrow III WR, Sathre R, et al. Life-Cycle Assessment of Electric Power Systems. *Annu Rev Environ Resour* 2012.