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EDITORIAL

# Decommissioned facilities for renewables harvesting—recycling and environmental issues

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The need to maximise the efficiency of energy supply and use, followed by maximising the share of renewables, has been widely discussed—including media (Engel 2023). It was also highlighted in a previous editorial (Varbanov et al. 2018). Some researchers and engineers advocate a 100% share of renewables (Hansen et al. 2019) for certain energy systems. The technologies for renewable energy capture span a wide spectrum. The most popular and well-developed are dams with hydraulic turbines, solar panels—photovoltaic, thermal and combined, wind turbines, and biofuel technologies.

At the level of operation, these technologies are nearly GHG-neutral, except for biomass use which features a low but tangible GHG footprint. That pattern explains the high popularity and ease of marketing PV and wind technologies as environmentally friendly. Currently, photovoltaic (PV) panels and wind turbines already have a history of several decades of production, exploitation and evolution. However, most installations have not yet been retrofitted or decommissioned, and there is little practical experience with recycling their constituent parts.

This issue is already pressing. Both PV panels and wind turbines contain components built of potentially toxic materials and are almost certainly impossible to dispose of safely. Since some wind turbines have already been decommissioned or replaced, there are reports available concluding that the safest option for disposal of old turbine blades is to landfill, which raises the question of the practical degree of safety—especially what is the risk of landfill leaching to nearby soil. PV panels will likely present installation owners and operators with similar problems.

The technology challenges are already being tackled—by researchers and companies. There is still some confusion between recycling and upcycling methods of minimising the related waste. Specifically for PV panel recycling, costs of up to 25 USD/panel were mentioned, where only 3 USD/panel can be salvaged from selling the materials. The cost and efficiency are seen as the main challenges of PV recycling also for deep recovery schemes. The energy spending or the footprints from recycling are not yet discussed.

The steady progress and success of Clean Technologies and Environmental Policy journal have resulted from the wide spectrum and the multidisciplinarity of the scope, managed thoroughly since the journal's foundation. Within that context, the discussed issues of minimising the Life-Cycle impacts of renewable energy technologies are very important and are quite timely, with the expected retirement of many of the PV panel and wind turbine facilities deployed a couple of decades ago. The relevance and the knowledge gaps in this area are apparent and pressing, bringing the need for Research and Development, minimising the overall Eco-Cost of these technologies. The impact and cost reductions can come from the combined efforts in using smarter design of the materials, the facilities and their Life Cycles. Key roles can be played by applying the principles of resource base sharing, increased durability, process intensification and integration. The cascading and reuse of value, mapping to the concepts of recycling, upcycling and downcycling, need a further systematic consideration, starting with the unification of the conceptual base.

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## Declarations

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