

# **Optimal Timing for the Repowering of Wind Turbines: The Case of Denmark**

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For more than 20 years now, wind power has been one of the main renewable energy sources, especially in countries like Denmark, one of the pioneer countries in developing onshore wind turbines. Whereas offshore wind power utilization is still awaiting its commercial exploitation, the repowering of wind converters offers an interesting alternative to further increase the use of renewable energy. This paper first provides an overview about the historical development of wind utilization in Denmark, with a special focus on incentive systems. Second, we study the economics and optimal timing of repowering for the case of Danish wind farms. We use a two-factor real options modeling framework following the Mc Donald & Siegel (1986) approach, which allows consideration of the investment costs as well as revenues, both following a continuous, time - stochastic process. In a next step, a Monte Carlo Simulation is applied to determine the probability of success of repowering for each year. Finally, we discuss the results and highlight the effects for further repowering. We find that until now, the high uncertainty in terms of revenues hinders the further development of repowering in Denmark and lowers the probability of success significantly, while the selling price of the used turbine has only a minor effect on the optimal timing of repowering. Therefore, wind developers could be tempted to argue for a larger guaranteed revenue share, achievable, e.g., via more attractive feed-in tariffs.