# Design of Renewable Support Schemes and Windfall Profits: A Monte Carlo Analysis for the Netherlands

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Subsidies have become highly popular as a tool to increase the production of renewable energy and to realize climate-policy objectives. These schemes contribute successfully to the latter but at the same time involve sizable government expenditures. For instance, in the electricity sector alone, which represents less than 25% of total energy use and is one of the least costly sectors to decarbonize, the governments of the EU countries in 2017 jointly spent 78.4 billion or 0.5% of GDP on subsidies for renewables. This contributed to a renewable-electricity share of 30%, illustrating that achieving, for instance, the long-term EU climate goals (net-zero emissions in 2050) will require vast additional efforts. In turn, this illustrates that it is of critical importance to design subsidy schemes in a cost-efficient manner. From the perspective of the government budget, cost-efficient subsidies imply not only stimulating low-cost technologies but also not paying more than necessary for a specific project.

This paper analyzes the degree to which subsidized renewable energy projects yield private benefits in excess of what is required for investors to be willing to undertake them. We refer to these "excessive" private benefits as windfall profits. Limiting windfall profits implies that the compensation for a project should not exceed the project's levelized-cost-of-electricity (LCOE). A key challenge for achieving this is that, due to information asymmetry between governments and investors, it is prohibitively costly to observe both the true LCOE and revenues of individual renewable electricity projects. This hinders tailoring the subsidy at the minimally required level for each project. As a consequence, most governments provide a uniform subsidy for renewable electricity or a specific technique (e.g. on-shore wind). This means that projects with favorable characteristics will be remunerated in excess of their LCOE and, as a consequence, earn windfall profits.

Our empirical analysis investigates the extent to which the Dutch feed-in premium scheme has resulted in windfall profits to on-shore wind projects. We analyze the period 2003–2018, in which a number of design adaptations were implemented that specifically aim at limiting windfall profits. Specifically, for 2003, 2009 and 2018, using Monte Carlo simulations, the analysis estimates the distributions of the required subsidy across virtually all *potential* on-shore wind projects (i.e. all projects that were available), and compares them to the granted subsidies. In addition, for 2018, the paper estimates the distribution of the required subsidy of the 187 *actual* projects that were granted subsidies. We compare these estimates with the results for *potential* projects to evaluate how successful investors are in seeking out the most profitable projects.

We find that the degree of windfall profits has decreased considerably over time. Specifically, the share of *potential* investments with an actual subsidy above what would have been required decreased from 81% in 2003 to 68% in 2018. At the same time, the average windfall profits decreased from 2.42 ct/kWh to 0.85 ct/kWh. These decreases followed from two adaptations in the scheme: differentiating in subsidy levels between on-shore wind projects on the basis of the turbine location as well as tighter estimates by the government of the required subsidy for a reference project. In relative terms, however, average windfall profits were at 32% of the actual subsidy in 2018 not lower than the 31% in 2003. Hence, despite that windfall profits have decreased in absolute

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terms, they have not disappeared, and remained constant in relative terms. Furthermore, analyzing *actual* investments in 2018, it appears that investors successfully seek out the most profitable investments. 85% of the actually subsidized investments generates windfall profits, and, at 1.28 ct/kWh, which equals 50% of the actual subsidy, the average windfall profits of *actual* investments are 50% higher than that of the *potential* investments. This is likely due to investors having better information about individual characteristics of on-shore wind projects than the government, enabling them to seek out the most profitable investments.

Several policy lessons can be drawn. For the Dutch government, the results imply that, at least theoretically, the Dutch government may realize the same amount of projects with 50% of the current subsidy expenditures, or considerably more projects given the current expenditures. Generally, for all governments, differentiating in the subsidy level between projects contributes to mitigating windfall profits and to reducing expenditures without reducing the number of realized projects. Such design improvements help to make renewable-energy policy more cost efficient.