

# Optimal timing and scale of green technology

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## Abstract

This paper considers the decisions of a firm concerning the timing of installing green technology in production. We find that regulatory goals for a high green use in production help accelerate investment in green technologies. However, firms facing more volatile demand may delay investment in green technologies. When green technology is inefficient, small technological leaps postpone their adoption; however, when they become competitive in terms of efficiency, small additional improvements in efficiency accelerate their deployment.

*Keywords:* capacity investment; real options; green assets, corporate social responsibility, environmental social governance.

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Declarations of interest: none

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## Introduction

Firms face continual pressure from multiple stakeholder groups to devote resources to corporate social responsibility (CSR). These pressures emerge from customers and community groups, governments, and oftentimes from shareholders, especially institutional shareholders with environmental mandates in their investment policies.

From a regulatory standpoint, countries around the world are shifting towards more environmentally friendly policies, which affect firms' decisions. For example, the revised Renewable Energy Directive, adopted by the European Union in 2023, sets a binding renewable energy target for the EU of at least 42.5% by 2030.<sup>1</sup> To achieve this target, several policies have been implemented to increase investments in renewables in power generation, industry, buildings, and transport. Additionally, specific goals have been set to improve energy efficiency by 11.7% compared to projections of expected energy use for 2030.<sup>2</sup>

Green technologies may be less proven and costlier to install (despite subsidies) compared to existing technologies. Therefore, the adoption of green technologies presents a complex timing problem, considering uncertain demand, regulatory pressures, and the costs associated with implementing such technologies.

In this paper, utilizing a real options framework, we aim to internalize the benefits and costs involved in such decisions. Our approach is aligned with the work of McWilliams and Siegel (2001) in which decisions ultimately rest in the hands of firms' shareholders, who balance costs (e.g., costlier production) against benefits (e.g., increasing demand). A framework for quantifying the trade-offs is currently lacking in the literature.

We address the gap by providing a real options framework that captures several realistic features, including uncertain consumer demand and high costs for implementation of green technologies. The real options literature (e.g., Dixit and Pindyck, 1994, and Trigeorgis, 1994) provides an ideal setting for providing insights into the timing of investments. The real options approach has been previously employed to offer useful insights into capacity investments (see for example, Huberts et al., 2015 for a review). Regarding green investments, such as the framework have been used by Nagy et al. (2021) for green capacity investment under the risk of subsidy withdrawal.

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<sup>1</sup> See [https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets\\_en](https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en)

<sup>2</sup> See [https://commission.europa.eu/energy-climate-change-environment/overall-targets-and-reporting/2030-targets\\_en](https://commission.europa.eu/energy-climate-change-environment/overall-targets-and-reporting/2030-targets_en)

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