# Financing green technologies: lessons from generous subsidy programs in Belgium

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Economic instruments are essential to fight climate change and the introduction of generalized carbon pricing is definitely an important element of the transition to a low-carbon economy. But, on top of that, dedicated subsidies for selected green technologies (electromobility, heating, isolation, etc.) and/or targeted to certain categories of the population might still be necessary (Blanchard, Gollier and Tirole, 2023). Furthermore, subsidies, unlike carbon pricing, remain popular among citizens and decision-makers. If a well-designed subsidy scheme could reduce the cost of fighting climate change, often subsidies suffer from some flaws. There are many examples of subsidy schemes with a high implicit carbon price, that are regressive or that lead to opportunistic behavior.[22] These inconsistencies reduced the effectiveness of the policy and imposed a high cost to the society. In this paper, we draw lessons from the support mechanisms provided to residential solar PV in Belgium to improve the design of future subsidy programs and their effectiveness.

Starting in 2006 in Flanders, all the regional governments of Belgium have provided generous subsidies to small-scale, residential solar photovoltaic installations. To start, we describe the main component of the subsidy programs for PV installations made by households on their rooftop.[23] Even if there were some differences between the three regions, the support mechanisms combined the same elements: green certificates, net metering and, at the early stages, investment subsidies and tax deductions.

*Green certificates* were the main component of the subsidy scheme. Each time the solar installation produces 1 MWh of energy, the owner receives green certificates that can be converted in euros. The solar installations were eligible for green certificates for a long period of time, up to 20 years in Flanders. In addition, the installations benefited from the *net metering* system. Accordingly, if at some moment, the installation produces more than the consumption of the house, the

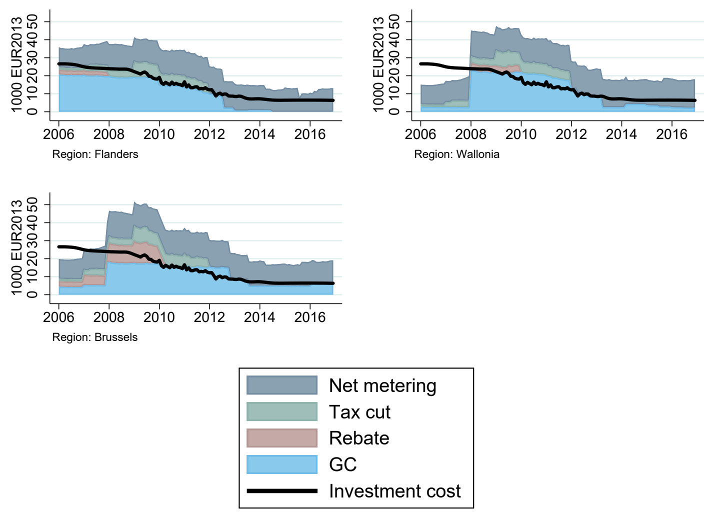
[22] Solar subsidies in Belgium suffered from these three weaknesses. Boccard and Gautier (2018) and De Groote, Gautier and Verboven (2023) document a high implicit cost of carbon; De Groote, Pepermans and Verboven (2016) show that subsidies mainly benefited to richer households and Boccard and Gautier (2021) report a substantial rebound effect encouraged by the subsidy scheme.

[23] See De Groote, Gautier and Verboven (2023) for a more complete description of the support mechanisms in the three regions of Belgium.

surplus is injected to the grid, and can be consumed later. With net metering, the grid acts as a storage facility for the households and the solar energy produced is valued at the electricity retail price, including tax and grid fees. Finally, the regions provided investment subsidies (rebates) and the federal government tax deductions for solar installations, but the importance of these upfront investment subsidies was comparatively small and they were rapidly suppressed. Hence, the support mechanisms were mainly commitments to subsidies for future solar energy production. After 2012, the programs were progressively dismantled, and the subsidies became far less generous.

The following figure shows the relative importance of each component of the subsidy mechanisms for each region and compare them to the price of the PV modules. Since 2008, in all three regions, the benefits exceed the cost and the installation has a positive NPV.

**Figure 1: Total subsidies of a 4kWp installation in each region, 2006-2016**

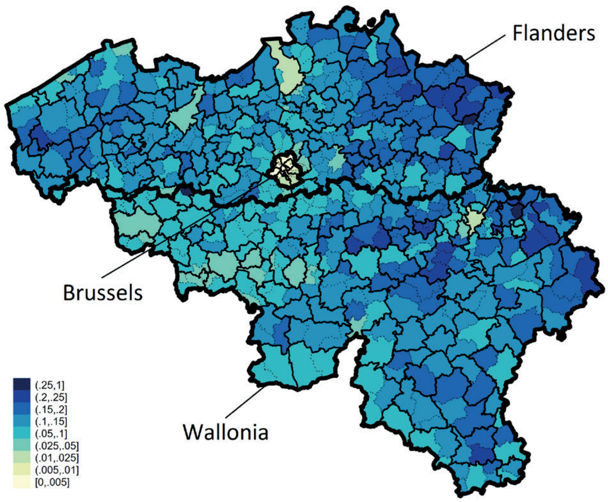



Source: De Groote, Gautier and Verboven (2023).

The subsidies were initially very generous and the benefit increased even further with the decline in the module prices. As a consequence, adoption was massive and substantially higher than expected. The following map illustrates the level of adoption at the end of 2017, i.e. the percentage of households that have invested in a solar installation per municipality.[24]

[24] See De Groote, Pepermans and Verboven (2016) for a detailed analysis of the determinants of PV adoptions.

**Figure 2: Adoption of solar PV at the end of 2017 in percentage of households**




The combination of high subsidies and high adoption generated substantial costs for society. To illustrate the cost of the mechanism, we compute the subsidy provided by the green certificates and the net metering in the three regions. We estimate an average subsidy of 302€ per MWh in Belgium (in 2013€). If we consider that 1 MWh of solar electricity displaces 1 MWh of electricity produced by a gas turbine (emitting 450kg of $CO_2$ per MWh), the implicit carbon price amounts to 671€ per ton of $CO_2$, well-above both the recommended and the actual carbon price. Based on that, we can conclude that Belgium over-subsidized solar energy. The costs of these high subsidies were ultimately passed on to two concerned parties: consumers, who end up paying a higher price for their electricity, and prosumers (adopters) to whom the regulators imposed a prosumer fee to compensate for the grid costs.

The subsidy mechanisms suffered from three main weaknesses: a lack of flexibility, a lack of predictability and the use of inappropriate instruments.

In the initial subsidy schemes, the governments committed to a given subsidy per MWh produced under the form of green certificates, i.e. a fixed nominal production subsidy. But, during the period between 2008 and 2013, the module prices was halved. With fixed subsidies, this dramatically increased the return on investment and boosted adoption. The subsidy schemes were not designed to be adapted quickly to changing market conditions and the adaptations were too slow and too late.

The mechanisms were profoundly reformed in 2012 in Flanders and in 2014 in Wallonia. In those reformed mechanisms, the governments committed to a given rate of return on investment and the subsidies were mechanically adapted to the market conditions.

The mechanisms also lacked predictability both for the government and for the adopters. In their forecast, governments and regulators systematically underestimated adoption by households. Consequently, costs were underestimated and the consequences on the electricity bill were not expected. Financing these solar subsidies turned out to be a serious and contentious political problem, both in Flanders and Wallonia. Governments in the two regions were forced to adopt corrective measures, like surcharges on the electricity bill and taxes on prosumers, which were unpopular and, eventually, some of these measures have been challenged in courts. Ultimately, both adopters and non-adopters may lose confidence in governments.[25] The mechanisms were unpredictable by design as they did not specify binding targets either, in terms of cost or in terms of solar capacity.

Finally, households had to pay an upfront investment cost for their solar installations but their benefits, both from net metering and the green certificates, were linked to the solar production i.e. benefits were spread over time. Despite the generous subsidies, households considerably underestimate these future benefits linked to electricity production.[26] This behavior is also known as the energy efficiency paradox, i.e. households often do not make energy-saving investments despite their profitability. A consequence is that, in terms of budgetary costs, production subsidies are much more costly than upfront investment subsidies. In other words, direct support to investment should be preferred to subsidies linked to production, or in other contexts, to energy savings.

Fighting climate change requires a broad range of regulatory measures. Apart from generalized carbon pricing, specific measures to promote new technologies can be important. We can draw three main lessons for the design of subsidies from the experience of the generous subsidy programs to solar energy production in Belgium. First, because the development of new technologies involves a lot of uncertainty, it is desirable to have flexible subsidy mechanisms that can adapt to evolving market circumstances. Second, to maintain future public support, it is recommended to have predictable policies, for example by specifying targets at which point subsidies can be reduced. Third, because

[25] De Groote, Gautier and Verboven (2023) study the consequences of these programs in ballots.

[26] De Groote and Verboven (2019) evaluate an implicit real interest rate of 15%, far above the market interest rate.

households tend to undervalue the benefits of future energy cost savings, upfront investment subsidies are more effective than subsidies on future green energy production.

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