



# Subsidizing renewable energy under capital mobility<sup>☆</sup>

Thomas Eichner<sup>a,\*</sup>, Marco Runkel<sup>b,c,1</sup>

<sup>a</sup> Department of Economics, University of Hagen, Universitätsstr. 41, 58097 Hagen, Germany

<sup>b</sup> School of Economics and Management, University of Technology Berlin, Straße des 17. Juni 135, H51, 10623 Berlin, Germany

<sup>c</sup> CESifo, Germany



## ARTICLE INFO

### Article history:

Received 26 June 2012

Received in revised form 24 February 2014

Accepted 16 May 2014

Available online 24 May 2014

### JEL classification:

H71

Q42

Q58

### Keywords:

Renewable energy

Capital mobility

Green subsidy

Emissions regulation

## ABSTRACT

This paper provides a rationale for subsidizing green (renewable) energy production. Within a multi-country model where energy is produced with mobile capital in green and dirty production, we investigate the countries' decentralized choice of emissions taxes and green energy subsidies. Without green subsidies, the emissions tax is set inefficiently low, since each country ignores the environmental externality inflicted on other countries and since the emissions tax leads to a capital outflow to other countries. When the green subsidy is available, countries choose a positive subsidy rate since this reduces the overall distortion of the tax–subsidy system. In doing so, each country internalizes a larger part of the environmental externality. As a consequence capital is relocated from the dirty into the clean sectors and reduces global pollution. Hence, the subsidy is not only beneficial for the country which imposes it but also for all countries.

© 2014 Elsevier B.V. All rights reserved.

## 1. Introduction

Classical energy production relies on fossil fuels like oil, natural gas and coal. At this production there emerges as by-product carbon dioxide which is the most important greenhouse gas since a too high concentration of it in the atmosphere accelerates climate change and causes environmental damage. Renewable energies like solar and wind do not generate greenhouse gases and hence do not harm the environment. In order to fulfill the emissions reduction commitment of the Kyoto protocol and to contribute to the mitigation of climate change, a large number of countries have implemented policy measures for promoting renewable energies. For example, as of 2009 more than 60 countries worldwide use Feed-In-Tariffs which guarantee suppliers of renewable energy a price that lies above the market price, implying an implicit subsidy on renewable energy. Other widely used policy measures are Renewable Energy Portfolio Standards (used in many U.S. states), tax incentives or direct R&D subsidies (used mainly in

European countries).<sup>2</sup> Giving this evidence, the present paper addresses the question whether there is an economic rationale for subsidizing renewable energy production.

Standard arguments from environmental economics suggest the following answer. Energy producers that use fossil fuels emit greenhouse gases without taking into account the environmental damage caused by climate change. The resulting environmental externality can be internalized, in a cost-effective way, either by a Pigouvian emissions tax on the polluting energy sector or by a cap-and-trade system where polluting energy producers have to buy permits for each unit of their emissions. Green subsidies paid to the renewable energy sector are then not only unnecessary, they even reduce efficiency by distorting the decisions of energy producers without contributing to the internalization of environmental externalities.<sup>3</sup> At first glance, one should expect that this distortion is aggravated in an international context with mobile capital and decentralized environmental policy of countries. The reason is that the uncoordinated choice of environmental policy instruments would result in a detrimental subsidy competition among

<sup>☆</sup> We would like to thank Kathy Baylis, Don Fullerton, Michael Hoel and Rüdiger Pethig for their helpful comments and discussions. The usual disclaimer applies.

\* Corresponding author Tel.: +49 2331 987 4141.

E-mail addresses: [thomas.eichner@fernuni-hagen.de](mailto:thomas.eichner@fernuni-hagen.de) (T. Eichner),

[marco.runkel@tu-berlin.de](mailto:marco.runkel@tu-berlin.de) (M. Runkel).

<sup>1</sup> Tel.: +49 30 314 22940.

<sup>2</sup> A comprehensive survey of policy instrument promoting renewable energy is given in the CESifo database DICE under <http://www.cesifo-group.de/portal/page/portal/ifoHome/a-wininfo/d3iiv>.

<sup>3</sup> Such an argument has currently been brought forward by, e.g., Johnstone (2003) who argues that the mix of policy instruments '... will be at best redundant and at worst counterproductive.'

countries, since each country tries to attract firms and investments and to raise employment by overbidding the green subsidies paid by other countries.

In stark contrast to this view, our analysis identifies an argument in favor of subsidizing renewable energy. We show that under capital mobility and decentralized policy choice, a green subsidy is not only in the interest of the country imposing the subsidy, but it also lowers global emissions of greenhouse gases and therefore benefits all countries. This argument is made within a stylized multi-country model. Each country hosts two energy sectors. The first sector produces energy with the help of a dirty technology (fossil fuels) which generates emissions. These emissions cause environmental damage not only in the country where the emissions originate, but also in the other countries. The second sector uses a green technology to produce energy without emissions (renewable energy). Both sectors employ internationally mobile capital as production input. We first determine the centralized (first-best) capital allocation which is characterized by the condition that the marginal return to capital in the dirty sector is equal to the opportunity costs of capital (in form of the forgone marginal return to investments in the green sector) and the marginal environmental damage.

Against this benchmark result, we investigate the efficiency properties of decentralized environmental policy making. Under decentralization, each country chooses its policy instruments such as to maximize welfare of its residents, taking as given the policy choice of the other countries. If green energy subsidies are not available, emissions taxes are inefficient for two reasons. First, in setting the emissions tax rate each government takes into account the environmental damage in its own country, but not the environmental damage in the other countries. Second, from the point of view of the individual country the emissions tax distorts the investment decision of the dirty sector since it increases the user costs of capital in this sector and thereby leads to a capital outflow to other sectors and, in particular, to other countries. Both reasons induce the individual country to set its emissions tax rate inefficiently low, i.e. lower than the world-wide marginal environmental damage. The distorted policy choice, in turn, causes overinvestment in the dirty sector and underinvestment in the green sector.

If green energy subsidies are at the governments' disposal, the subsidy distorts investment decisions in the green sector since it lowers the user costs of capital in this sector and *ceteris paribus* leads to overinvestment in green energy production. But both the distortion caused by the emissions tax and distortion caused by the green subsidy increase over proportionally with the tax/subsidy rate. Then, mixing the emissions tax with the green subsidy reduces the overall distortion of the tax–subsidy system, and hence each country has an incentive to choose a positive green subsidy rate. In so doing, each country internalizes the environmental externality of its dirty sector at lower costs and thus increases the degree of internalization. As a consequence, capital is relocated from the dirty sectors to the green sectors, the capital allocation becomes more efficient and global emissions fall. The use of the green subsidy is therefore beneficial not only for the country which imposes it, but also for all other countries, even though the first-best capital allocation is still not attained.

This argument in favor of green subsidies turns out to be quite robust against modifications of the model. We explicitly consider two modifications. While in the basic model capital is in fixed supply, the first extension considers endogenous savings and capital supply. With fixed capital supply, the reduction in global emissions is achieved by a relocation of capital from dirty to clean sectors. In contrast, with endogenous savings the use of the green subsidy raises world-wide capital supply and, thus, has an additional positive effect on investment in both the clean and dirty sectors. However, we show that the additional effect on investments in the dirty sectors is more than compensated by the reduction of dirty investment due to the larger internalization of the environmental externality. Moreover, the additional effect on green investments does not lead to overinvestment in the clean sectors. Put

differently, even with endogenous savings, capital supply in the equilibrium of the policy game is always sufficiently inelastic in order to preserve our argument in favor of green subsidies.

The second modification turns to a different kind of environmental policy. Many countries tackle pollution problems with a cap-and-trade (emissions trading) system instead of emissions taxes. If all countries establish such a system, our argument in favor of green subsidies breaks down since the caps fix overall emissions and the green subsidy cannot further reduce them. But in practice not all countries use emissions trading or taxation. We therefore show that our argument in favor of green subsidies may even be strengthened in an asymmetric policy setting. This point is illustrated for the two-country case with one green country that chooses a cap-and-trade system and a green subsidy, and a dirty country, which totally abstains from environmental policy. In such a setting the incentive for the green country to use the green subsidy is even stronger than in the basic model since this country is capital exporter (due to the more stringent environmental regulation) and the subsidy raises the rate of return to capital. The green subsidy relocates capital from the dirty sector in the dirty country to the green sector in the green country and thus reduces global emissions. This is again beneficial for all countries, even though we now cannot exclude that overall the dirty country is harmed, since capital also flows out from its green sector.

As the use of green subsidies still fails to implement the first-best capital allocation, our argument in favor of promoting renewable energy is of the second-best type. It relies on several assumptions, most importantly on the assumptions that capital is mobile, that emissions cause global environmental damage and that there is no (world-wide) coordination of climate policy. While the first two assumptions are undisputable in the context of climate change, the assumption of missing policy coordination deserves more motivation. In the last decades there have been great efforts of the world community to implement common measures against climate change. The Kyoto protocol is the most important example for this kind of policy coordination. In 2012 the Kyoto protocol run out and several climate change summits in Copenhagen, 2009, Cancun, 2010, Durban, 2011, Doha, 2012, Warsaw, 2013, recently have tried to find a comprehensive climate agreement with targets, actions and binding legislation for the time after 2012. However, the results of these summits were disappointing since the countries only agreed to rather weak and non-binding political statements. In light of this experience, it seems unlikely that in the near future full coordination of climate policy will take place. Instead, to a large degree countries will choose their environmental policy decentrally, and we are left with the question of optimal climate policy in a decentralized, second-best world.

Our paper is part of a very small, but growing literature discussing economic rationales for subsidizing renewable energy. One argument is that green subsidies spur learning effects in renewable energy production and, due to learning spillovers between energy producers, are beneficial not only for the recipient of the subsidy, but also for the society at large. See, for example, Bläsi and Requate (2007), Fischer and Newell (2008) and Lehmann (2009) for a detailed analysis. Related is the argument developed by Acemoglu et al. (2012) who use a growth model in order to show that a green research subsidy may induce an efficiency-enhancing change of private R&D policy from dirty to clean technologies. A further rationale for green subsidies is identified by Eichner and Pethig (2014-a). They show that small open economies may have an incentive to subsidize renewable energy in order to compensate for the uncertainty of fossil fuel prices and to increase energy security. Finally, Eichner and Pethig (2014-b) investigate a union of countries with a common cap-and-trade system and show that permit-importing countries may have incentives to subsidize renewable energy in order to influence the permit price in their favor. In contrast to our analysis, however, all these studies ignore capital as a mobile input factor in energy production and, thus, do not make our point in favor of green subsidies. A further important difference is that

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات