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An EU-wide Nuclear Power Tax: Rationale and Possible Effects

Fanny Dellinger[1], Margit Schratzenstaller[2]*

[1]University of Vienna, Austria, [2]Austrian Institute of Economic Research, Austria. *Email: Margit.Schratzenstaller@wifo.ac.at

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ABSTRACT

Nuclear power plays an important role in Europe's energy mix today. Considering the manifold environmental and health hazards related to all phases of nuclear power production, which may cause considerable negative externalities, it is remarkable that the whole issue of using taxes as instruments to internalise the externalities associated with nuclear power is completely neglected in the literature. The paper provides a rationale for taxing nuclear power which is based on an analysis of its social costs and of potential windfall profits for the nuclear industry generated by EU policies. After giving an overview over existing nuclear taxes in the nuclear power generating EU Member States, we elaborate the case for channeling revenues from a nuclear power tax into the EU budget as sustainability-oriented tax-based own resource. We also estimate the potential revenues from an EU-wide nuclear power tax.

Keywords: Nuclear Power Tax, Sustainability-oriented Taxation, EU System of Own Resources
JEL Classifications: H23, H87, Q58

1. INTRODUCTION

Nuclear power plays an important role in Europe's energy mix today. In the EU it is the largest low-carbon source for electricity generation, contributing 27% of the electricity produced in the EU (European Commission, 2016a). In mid-2016, there were 127 nuclear reactors with a mean age of 31.4 years in 14 EU Member States[1] in operation (Schneider and Froggatt, 2016). The Paris Agreement as well as the 2030 Agenda for Sustainable Development (European Commission, 2016b) give fresh impetus also in the EU to the debate about a sustainable energy mix and about adequate instruments to promote it. In this respect, particularly two issues are disputed. First, whether nuclear power should gain in significance (further) as one relevant low-carbon energy source besides low-carbon renewable energy sources. Second, while there is broad agreement about the necessity and effectiveness of carbon pricing schemes to dampen carbon-intensive production and consumption activities involving fossil fuels (World Bank Group/ECOFYS, 2016), the implications for the tax treatment of non-fossil energy sources in general and especially of nuclear power seem to be less clear (OECD, 2011).

Against this background, the paper first provides a rationale for taxing nuclear power (section 2) and gives an overview of existing nuclear taxes and nuclear power subsidies in the EU (section 3). Section 4 elaborates the case for channeling revenues from an EU-wide nuclear power tax into the EU budget and estimates potential revenues. Section 5 concludes the paper.

2. RATIONALE FOR TAXING NUCLEAR POWER

Taxing nuclear power can mainly be justified by its external costs as well as windfall profits.

1 Bulgaria, Czech Republic, Finland, France, Hungary, Netherlands, Romania, Slovakia, Spain, Sweden, United Kingdom, Belgium, Germany, Slovenia (with the latter three Member States currently phasing out nuclear power).

2.1. The External Costs of Nuclear Power

D'haeseleer (2013) provides a range between 0.1 cents and 0.4 cents per kWh for the total external costs of nuclear power. In the following the existing estimations for the various components of the external costs of nuclear power are reviewed briefly.

2.1.1. The external costs of nuclear accidents

One first indication for the risk of future nuclear accidents is the incidence of past ones. Since the beginning of the commercial use of nuclear power, there have been 17,022 reactor operating years (IAEA, 2017), with 4 catastrophic accidents receiving the highest rating of level 7 on the international nuclear event scale. This yields a ratio of one disastrous reactor accident for every 4,256 reactor operating years. This actual rate of accidents casts doubt on conventional estimates of nuclear accident risks specified as the probability of a catastrophic nuclear event for one reactor in 1 year, which often are in the order of magnitude of 1:1,000,000 (Lelieveld et al., 2012).

A generic estimate of the accident risk of one nuclear reactor in 1 year representing a pessimistic view of the existing reactor fleet is 1:10,000 (D'haeseleer, 2013; Meyer, 2012). A more optimistic estimate focusing on new third generation reactors is 1:1,000,000; but so far, there are no third generation reactors operating in the EU (D'haeseleer, 2013). Wheatley et al. (2017) perform a statistical analysis of the nuclear accidents frequency based on cost data of documented nuclear accidents and conclude that an accident of the size of the Chernobyl accident or larger has a 50% probability of happening in the next 27 years. Overall, their work comes quite close to assuming a frequency for large accidents of 1:20,000.

The few existing estimates for the costs of nuclear accidents differ widely. It is obvious that these do not only comprise the immediate economic and social costs in terms of fatalities and property damage, as recorded, for example, by Sovacool (2008b) for the period 1907–2007. However, it is neither clear where to draw the border regarding the additional cost categories to be included, nor how to value them adequately.

Meyer (2012) presents a cost range of € 69 billion to € 343 billion for any nuclear accident in Western Europe,[2] thereby updating previous studies from the 1990s (CEPN, 1995; Ewers and Rennings, 1992). The major part of these costs is caused by the health impact of radioactivity.[3] For any nuclear accident happening in France, Momal and Pascucci-Cahen (2012), who include image costs, present a cost range of € 120 billion to € 430 billion.

Based on the above cost and risk estimates, Meyer (2012) calculates the expected external costs of nuclear energy by weighting cost estimates by risk estimates for accident frequency and relating the result to the amount of nuclear energy produced in an average German reactor. Combining the maximum accident cost estimate of € 343 billion and the pessimistic accident risk estimate of 1:10,000 yields expected external costs of 0.34 cents per kWh of nuclear energy produced. D'haeseleer (2013) arrives at external costs of nuclear accidents between 0.03 cents and 0.3 cents per kWh.

Under the realistic assumption of strong risk aversion when faced with the prospect of a nuclear disaster, expected costs must be adjusted accordingly. Using the risk aversion factor of 100 for nuclear accidents suggested by the German Ministry of the Environment (Federal Environmental Agency, 2012), Meyer (2012) arrives at an upper limit for external costs of 34 cents per kWh.

2.1.1.1. The costs of decommissioning and radioactive waste

The backend cycle of a nuclear power plant is cost intensive, while not generating revenues any longer. It is the legislator's task to prevent the danger of private producers filing bankruptcy and leaving the costs of the clean-up to the public. The EU already plays an active role in providing directives for the decommissioning of nuclear power plants and the managing of radioactive waste and storage. According to the polluter pays principle, the financing of these activities has to be provided by the nuclear plant operators. Member States therefore are obliged to put in place systems, e.g. special funds, by means of which nuclear power plant operators will cover all decommissioning costs (European Commission, 2013).

By 2025 about one third of the nuclear reactors operated in the EU will have to be decommissioned, causing estimated future decommissioning costs including radioactive waste management and final disposal of € 253 billion (European Commission, 2016a). Given the lack of experience with decommissioning and considering that there is still no final repository for high level radioactive waste anywhere in the world, these cost estimates are subject to considerable uncertainties (OECD, 2016). In 2016 the funds collected so far in EU Member States operating nuclear reactors amount to € 133 billion (European Commission, 2016a). Whether accrued funds will suffice to cover future decommissioning and waste management costs does not only depend on future costs but also on the interest rates nuclear power plant operators can achieve, which are uncertain as well. Thus, there is a non-negligible risk of the private costs of decommissioning and radioactive waste management eventually turning into external costs burdening tax payers.

2.1.1.2. Carbon emissions of nuclear energy generation

There is some disagreement in the literature regarding carbon emissions during the nuclear power lifecycle, which are mainly caused by uranium mining and enrichment (Sovacool, 2008a). Also, the energy mix used for mining and enrichment plays an important role in the lifecycle assessment of nuclear energy (Dones, 2007; Warner and Heath. 2012).

Based on a meta analysis of lifecycle studies, Sovacool (2008a) concludes that with 66 g of CO_2 emitted per kWh, nuclear power fares worse than renewable energy technologies. Warner and Heath (2012) in another meta analysis comparing different energy technologies derive an estimate of 13 g of CO_2 emitted per kWh. In comparison, the carbon footprint of a modern combined-cycle gas turbine is estimated at 480 g of CO_2 emissions per kWh (Sijm et al., 2006).

2 For the assessment of the costs of a nuclear accident, population density close to the plant and in the area where most nuclear fallout occurs is an important factor.

3 It is interesting to note that compared to other energy technologies, nuclear power does not fare so badly in terms of safety or casualties (OECD, 2010 for details).

2.1.1.3. Other external costs of nuclear energy

Potential health risk causes estimated external costs of 0.17 cents per kWh according to the CASES project (CASES, 2011). The external costs of resource depletion caused by nuclear energy generation are estimated at 1.8 cents to 2.2 cents per kWh (ECOFYS, 2014). Further potential external costs, as the danger of nuclear weapons proliferation, terrorist attacks and war (Davis, 2012; Kovynev, 2015) obviously are impossible to estimate.

2.2. Windfall Profits for Nuclear Energy

2.2.1. Windfall profits generated by emission trading in the EU

Carbon pricing through the EU ETS raises the price of electricity by increasing the marginal costs of fossil fuel electricity producers. Nuclear power plant operators, which are exempted from the ETS, become more competitive and benefit from windfall profits. Diekmann and Horn (2007) estimate the price increase of electricity due to carbon pricing as determined by the price of carbon times the factor 0.0005. Thus, for each € per tonne carbon emissions, the price of electricity increases by 0.05 cents per kWh. Other estimates are of similar magnitudes: Schwarz and Lang (2006) estimate a price increase of 0.076 cents per kWh for each € per tonne carbon emissions. Based on the more conservative estimate of Diekmann and Horn (2007), potential windfall profits of the nuclear industry in the EU can be easily calculated. If the carbon price increased to 25 € per tonne of CO_2, the electricity price would increase by approximately 1.25 cents per kWh. Under the assumption that nuclear energy production remains approximately at the 2014 level of 830,000 GWh, this price increase would lead to about € 10 billion a year in extra profits for the nuclear industry.

2.2.2. Windfall profits caused by long-term operation of nuclear power plants

Windfall profits may also result from lifetime extensions for existing nuclear power plants, which are currently regarded as a viable policy by the European Commission (2016a) considering their future energy scenarios for the EU according to the EU Energy Roadmap 2050 (European Commission, 2011). The levelised costs of electricity (LCOE[4]) after a lifetime extension, including the projected investments required for safety upgrades, are estimated at 2.3 cents to 2.6 cents per kWh (D'haeseleer, 2013): Thus considerably undercutting those of gas power plants, which are often seen as setting the wholesale price of electricity. The ensuing increase of competitiveness of nuclear power compared to other energy sources creates windfall profits for nuclear power plant operators.

3. TAXATION OF NUCLEAR POWER IN EU MEMBER STATES

3.1. Nuclear Taxes in EU Member States – An Overview

Currently 8 of the 14 nuclear energy countries in the EU levy some nuclear tax, which generally do not generate substantial revenues (Table 1).

The main tax bases in practice in EU Member States are electricity produced, thermal capacity, nuclear fuel, and nuclear waste. Of course, also other charges can be in place: Sometimes lump-sum taxes per plant or plant operator, in some cases (increased) taxes on completely unrelated bases. The tax burden per MWh ranges from 0.31 cents (Slovakia) to 7.80 € (Spain).

In some Member States nuclear taxes – especially earmarked fees for nuclear waste management – were introduced rather early (Sweden and Finland in the 1980s; France, Slovakia, and Hungary in the second half of the 1990s). In several other countries such taxes – mostly non-earmarked ones – were implemented during the last decade only; sometimes as fiscal consolidation measures (Belgium, Spain, France, Germany). In Belgium and Germany skimming off windfall profits due to lifetime extensions was put forward as one central justification of implementing the nuclear tax.

Currently the level of taxation of nuclear power in Europe is the lowest in years. In several Member States nuclear energy taxes have been or will be reduced or phased out because of the heavy competition from other (renewable) sources for electricity generation. Those nuclear taxes still in place mainly aim at collecting earmarked revenues to finance the management of radioactive waste and decommissioning.

3.2. Subsidies for Nuclear Power

The flipside of the minor importance of nuclear taxation in the EU are substantial public subsidies from national budgets and the EU. These are granted to decrease the substantial private costs to make the construction and operation of nuclear power plants profitable at all for private investors, as one specific characteristic of nuclear power generation are extraordinarily high up-front capital costs, ranging between 60% and 75% of total costs according to Rogner (2012), between 60% and 85% according to D'haeseleer (2013). A comprehensive stock-taking of subsidies for electricity-generating technologies is a complex task (Badcock and Lenzen, 2010), not least due to data limitations. However, the available data suggest that nuclear power is a rather heavily subsidised electricity source. Subsidies for electric power generation can take various forms. Kitson et al. (2011) distinguish between the direct and indirect transfer of funds and liabilities, government revenue foregone (i.e. tax breaks), provision of goods and services, and income or price support. These can be directed specifically at research and development (R and D), investment, generation, consumption or decommissioning, or they can be provided throughout the whole production cycle.

The EU is a major player in the field of R and D expenditures for energy technologies. A closer look at subsidies granted from the EU budget to support research on individual energy technologies reveals an apparent imbalance between research funding dedicated to nuclear power on the one hand and to all other energy technologies on the other hand. 5 R and D on energy technologies (including renewable energy technologies, but also carbon capture and storage and smart grids) except nuclear power received € 2.35 billion from 2007 to 2013 under the Seventh Framework Programme, while € 4.1 billion were granted to nuclear power comprising fission and fusion (European Commission, 2017).

4 Usually comparisons of the costs of different energy sources are based on levelised costs of electricity (LCOE) (D'haeseleer 2013 for details).

Table 1: Nuclear power Taxes and charges in selected EU Countries

Country	Tax design	Tax burden in € per MWh	Tax revenues in Mio. € (in % of GDP)	Introduced in	Modifications
Abolished nuclear power taxes					
Germany	Nuclear fuel tax; €145 per gram of fissile uranium or plutonium lump-sum payments into decommissioning fund	7.30–15.8 (2015) n.a.	1.018 (0.03%) (2015) n.a.	2011 (2017[c])	Abolished in 2017
Netherlands	Nuclear fuel tax; Dfl. 31.95 per gram uranium-235	n.a.	6.8 (0.002%) (1997)[b]	1997	Abolished in 2000
Existing nuclear power taxes					
Belgium	Lump-sum nuclear plant charge	5 (2014)[a]	200 (0.05%) (2015)	2010	Initially temporary for the period 2010–2014 Increased in 2012 Decreased in 2015, 2016 Increased in 2017
Finland	Higher property tax rate for buildings used for nuclear waste management, based on property value Lump-sum fee for nuclear waste management fund	0.4 (2012) 1.6 (2012)	n.a.	n.a. 1987	Increased in 2016 contribution determined yearly
France	Lump-sum nuclear plant tax, multiplied by coefficient depending on type and power of plant 3 additional taxes (research, support and technological transfer tax); lump sum multiplied by coefficients	0.8 (2012) 0.3 (2012)	350 (0.02%)) (2012) n.a.	2000 2006	Increased in 2006, 2010, 2017
Hungary	Fee for nuclear waste fund	n.a.	64 (0.06%) (2012)	1998	
Romania	Fee for nuclear waste disposal Fee for decommissioning of nuclear power plants	1.40 0.60	n.a. n.a.	2007 n.a.	
Slovakia	Nuclear facility tax and immovable property tax Levy of 10% on the wholesale price of electricity for state fund for radioactive waste and decommissioning	0.31 n.a.	n.a.	2004 1995	
Spain	Four charges related to nuclear waste management Nuclear waste taxes on nuclear waste generation and storage	n.a. 6.60–7.80	n.a. n.a.	1997 2012	
Sweden	Capacity tax based on thermal output Fee for final storage of spent fuel and decommissioning of nuclear power plants	7.50 4.40	403 (0.09%) (2015) n.a.	2000 1982	Increased in 2006, 2008, 2015 Phased out between 2017 and 2019 Increased in 2015

Sources: Espensen et al. (2015); Finnish Energy Industries (2014), Eurelectric (2014), World Nuclear Association; OECD (2016); Cour des Comptes (2012), Fiedler (2016), Zorn (1999), Rozas (2014), own research and compilation. [a]More than halved after the modifications starting with 2015. [b]Projected revenues. [c]The state aid approval by the European Commission is still pending

Acoording to an ECOFYS study (2014), energy subsidies in the EU28 amount to € 113 billion in 2012, with subsidies for nuclear power reaching € 6.96 billion. Of these, € 3.7 billion stemmed from Member States (mainly the UK) and € 3.26 billion from the EU budget. While current subsidies granted to nuclear power production are minor compared to other energy technologies (e.g., coal), historic subsidies directed towards nuclear energy are substantial. From 1970 to 2007 they accumulated to € 220 billion. Additionally, EU Member States spent € 84 billion on R&D on nuclear energy (mainly fission, but also fusion) between 1974 and 2007, which make up for 78% of overall R&D expenditures on energy technologies. Finally, € 87 billion were spent on R and D for energy supply technologies, which, however, not solely benefitted nuclear power.

4. POTENTIAL REVENUES OF AN EU-WIDE NUCLEAR POWER TAX

4.1. The Case for an EU-wide Nuclear Power Tax

In the EU there is a strong case for introducing nuclear power taxes on a harmonised basis. Very generally, assigning a role to the EU in the taxation of nuclear power may be justified by the fact that the EU already is a major player in the field of nuclear policy:[5] As an important provider of subsidies as well as a regulator establishing the regulatory framework regarding safety provisions for nuclear power plants and radioactive waste repositories in Europe. In addition, a nuclear power tax aiming at siphoning off windfall profits linked to carbon pricing is closely linked to an existing EU policy, namely the ETS.

Unilateral introduction of nuclear power taxes at Member State level may distort competition in the internal market for energy (which the EU Energy Taxation Directive aims to avoid). Moreover, the externalities associated with nuclear power generation are cross-border in nature so that unilateral tax rate setting may lead to under-taxation from a European perspective. In a liberalised energy market with cross-border electricity trade also the benefits of nuclear power generation in terms of contributing to the security of electricity supply are not confined to national borders. Thus, the potential revenues of national nuclear power taxes are hardly attributable to individual Member States, which speaks in favour of assigning revenues to the EU level, partially replacing national contributions by Member States.[6]

4.2. Design of an EU-wide Nuclear Power Tax

4.2.1. Tax base of an EU-wide nuclear power tax

A tax on nuclear fuel is most likely to have steering effects by incentivising the efficient use of nuclear fuel; also, it is clearly an environmental tax and as such its introduction would be compatible with European law (Küchler and Meyer, 2009). Another possible tax base is thermal capacity, which – compared to nuclear fuel – has the clear advantage of administrative simplicity (Küchler and Meyer, 2009). Charges on nuclear waste may be levied to reimburse funds for the management of radioactive waste. On the one hand, the development of new fuel cycle technologies may be encouraged (Rogner, 2012). On the other hand, a tax on nuclear waste may be used as an argument by the nuclear industry later to circumvent the polluter pays principle and have society pay for the disposal of nuclear waste. Given the heterogeneous strategies for generating funds for the back-end fuel cycle currently pursued in EU Member States, the implementation of an EU-wide radioactive waste tax may be difficult.

4.2.2. Tax Rate of an EU-wide Nuclear Power Tax

In principle, corrective Pigovian taxes aim at creating a socially efficient outcome by gradually adjusting the tax rate and thus the taxed externality up to an optimal level. In the case of nuclear power, however, there is no easy way to gradually adjust the risk to eventually achieve a socially efficient outcome, as the nuclear industry lacks flexibility. The construction of a nuclear power plant creates a substantial risk, with the actual accident probability being highly uncertain. It is therefore impossible to calculate the gradual impact of safety measures on risk, which would then justify graduated tax rates. Naturally, safety regulations are of an "all-or-nothing" nature: We do not want firms to choose an "efficient" trade-off between investing in nuclear safety and risk reduction. Rather a nuclear plant which does not follow safety regulations simply has to be shut down.

Nonetheless, there may be some scope for imposing differentiated tax rates on individual nuclear power plants in theory. For example, the potential costs of an accident depend a lot on the population density in the area where a nuclear power plant is located, as this determines how many people will have to be evacuated in the case of a major accident. In practice, however, such a tax design does not appear to be practicable, not least due to the difficulties to determine the external costs of nuclear power.

For ease of exposition, we will therefore consider only a uniform tax rate per kWh of electricity produced. We suggest a flexible tax rate with up to three components. The first tax component is a Pigovian tax aiming at the internalisation of the risk of nuclear accidents. Nuclear power does not have to carry the full costs of insurance against nuclear accidents, which may be considered as distortion of competition.[7] Therefore one major objective of the tax is to level the playing field between nuclear energy and other industries.

As a Pigovian tax rate, we propose a symbolic tax rate of 1 cent per kWh: More than double the maximum expected external costs of a nuclear accident as presented in the studies reviewed in section 1.2.1.2, but staggeringly little when compared to the risk aversion adjusted external costs. Still, a tax rate of 1 cent per kWh means a significant increase of LCOE of nuclear energy (which range between 3 cents to 5 cents per kWh for the existing fleet and 4 cents to 9 cents per kWh for newly built nuclear reactors (CASES, 2011; D'haeseleer, 2013; Cour des Comptes, 2012)), while not rendering nuclear power uncompetitive.

The second component relates to windfall profits due to carbon pricing. We suggest a flexible tax rate depending on the price of carbon: It would be applied only above a certain threshold for the price of carbon, as below this threshold it can be expected that carbon pricing won't influence electricity prices significantly. The price of carbon is multiplied by 0.0005 to derive the tax rate per kWh of electricity produced. A carbon price of 25 € per tonne of CO_2 would thus lead to a windfall profits tax on nuclear power of 1.25 cents per kWh. This tax would only be charged if the carbon price exceeded 15 € per tonne carbon emissions. A carbon price of 25 € per tonne of CO_2 would result in tax revenues of approximately € 10 billion per year in the EU.[8] The actual effect of the carbon price on the wholesale price of electricity will require close monitoring and possibly adaptations of the tax rate.

The third component consists in a tax on windfall profits due to long term operation of nuclear power plants in the range between 90% and 100%. This tax should be linked to the license granting process. Based on a very cautious first rule of thumb calculation these profits can be estimated at € 200 million per year for a nuclear reactor with 1,000 MWh of installed capacity.

5 For a brief overview of the engagement of the EU in European nuclear energy policy see Kiyar and Wittneben (2010).

6 See for a detailed criticism of the current EU system of own resources and the concept of sustainability-oriented tax-based own resources for the EU budget Schratzenstaller et al. (2016 and 2017) and HLGOR (2016).

7 Heyes (2002), see also as D'haeseleer (2013) and Meyer (2012) and the literature cited herein.

8 This calculation assumes no changes in production of nuclear power with respect to the year 2014. As nuclear capacity is projected to decrease until 2025, the revenues of any nuclear tax will decrease accordingly.

Estimating potential revenues of the proposed nuclear power tax requires some assumption on the elasticity of the tax base. In principle, the more capital intensive an industry is, the smaller is its short-term price elasticity of supply (Dahl, 2002). As nuclear power is extremely capital intensive, we can expect the short term supply elasticity to be close to zero. On the other hand, a plant could be shut down quite quickly. The question is whether a newly introduced tax on nuclear power would lead to plants being shut down.

A closer look at the cost structure of nuclear plants helps to clarify matters. The operating costs of nuclear power plants are low and stable, leading to marginal costs of electricity production far below the market price of electricity in most countries. An EU-wide tax on nuclear power will increase operating costs. However, 60–85% of the total generating costs of nuclear energy are due to the construction of the reactor (D'haeseleer, 2013). As soon as the construction of a reactor is completed, it is in the interest of its operator to keep the reactor running in order to pay off investment costs. Moderate tax increases should not affect the decision of whether to keep an existing plant open, but it is possible that the math on future plants might change.[9]

The introduction of a tax rate of 1 cent per kWh will raise generating costs of nuclear power by 20–33%. This will decrease the profitability of nuclear power plants accordingly and will as well reduce corporate tax revenues. However, for plants currently in operation and requiring little additional inputs now, profitability per se is not in danger. Fluctuations in the producer price of electricity have the potential to be more harmful for nuclear power plant operators (D'haeseleer, 2013).

However, a tax on nuclear power will affect the profitability assessment of new nuclear power plants. Currently, five EU Member States (Bulgaria, the Czech Republic, Lithuania, Poland, and Romania) plan to build new reactors; however, the projects are still in a preparatory state (European Commission, 2016a). In three EU Member States new reactor projects are in a licensing process (United Kingdom, Finland, and Hungary). These projects might be affected by the introduction of a nuclear power tax. Four reactors are currently under construction in the EU (one each in Finland and France, and two in Slovakia).

4.2.3. Potential revenues of an EU-wide nuclear power tax

As stated above, our tax proposal comprises three elements. The windfall profits component relating to carbon pricing will only be introduced if the ETS starts working properly and carbon prices rise above a threshold value of 15 € per ton of carbon emissions. Given the current state of affairs, only the Pigovian tax component would be introduced. The expected revenues amount to approximately € 8.3 billion per year, under the assumption that the introduction of the tax leaves the current level of nuclear power production unchanged. As the nuclear power tax will reduce plant operators' profits corporate tax revenues of the Member States affected by it will be reduced accordingly. Thus, the estimated potential revenues presented in Table 2 do not represent the net increase of fiscal revenues in the EU but will be lower if tax payments are made deductible from the corporate tax base.

Compared to Member States' current national contributions to the EU budget, the potential revenues of a tax on nuclear power are rather moderate. Total national contributions to the EU in 2015 amount to € 118.6 billion, while the Pigovian tax would generate no more than € 8.3 billion. If the carbon price rose to 25 € per tonne of CO_2 and the windfall profits tax on nuclear power was levied, tax revenues would increase to € 18.7 billion. Hereby it must be kept in mind that tax revenues would diminish as nuclear power is being phased in the medium-term, for example in Sweden.

9 In Spain the Garoña Nuclear Power Plant was closed down in 2012, with the operator arguing that newly introduced taxes were part of the problem. In fact, the operating license of the plant was about to expire in 2013, and a license renewal until 2019 would only have been granted if considerable upgrades had been carried out. The plant was shut down, but a year later the operator asked for a new license until 2031. So far, no final decision has been taken (Stibbs, 2016). This particular episode shows that at the end of a licensing period, nuclear power plants might be more sensitive to taxation, and old plants might be shut down earlier because of a tax on nuclear power.

Table 2: Potential revenues of an EU-wide nuclear power tax

Tax rate	Nuclear electricity production in 2014, GWh	Pigovian Tax revenues in € million	Windfall profits tax (25€/t CO_2) revenues in € million	Total revenues in € million
		1 cent/kWh	1.25 cent/kWh	
Belgium	31,969	319.69	399.61	719.30
Bulgaria	15,014	150.14	187.68	337.82
Czech republic	28,636	286.36	357.95	644.31
Germany	91,800	918	1147.50	2,065.50
Spain	54,961	549.61	687.01	1,236.62
France	415,857	4,158.57	5,198.21	9,356.78
Hungary	14,778	147.78	184.73	332.51
Netherlands	3,873	38.73	48.41	87.14
Rumania	10,739	107.39	134.24	241.63
Slovenia	6,061	60.61	75.76	136.37
Slovakia	14,420	144.2	180.25	324.45
Finland	22,646	226.46	283.08	509.54
Sweden	62,185	621.85	777.31	1,399.16
UK	57,903	579.03	723.79	1,302.82
Total	830,842	8,308.42	10,385.53	18,693.95

Source: Eurostat, European Commission, own calculations.

5. CONCLUSIONS

Overall, the above considerations suggest that there is indeed some justification for taxing nuclear power. A tax on nuclear power might act as a deterrent to a short term license renewal of a nuclear power plant. At the end of a nuclear power plant's operating period, there might be a real trade-off between implementing required investments and shutting down a plant early. A tax on nuclear power might tilt the balance in favour of early shut down. Particularly, it might make lifetime extensions, which are worsening the unfavourable age structure of EU nuclear reactors further, less attractive.

Taxing nuclear power, as well as removing the subsidies granted by EU Member States and at the EU level to nuclear power production, will remove the existing cost advantage nuclear power is enjoying vis-à-vis genuine renewable energy and conventional fossil fuels, which is exacerbated by carbon pricing schemes discriminating in favour of nuclear energy. In addition to the external costs of nuclear power production, windfall profits reaped by nuclear power plant operators due to carbon pricing driving up energy prices as well as lifetime extensions may justify nuclear power taxes.

In a liberalised energy market, a tax on nuclear power slightly increasing its marginal costs will not be passed on to the consumers, as the market price of electricity is determined by the merit order of power plants (D'haeseleer, 2013; Küchler and Meyer, 2010). Therefore, undesirable distributional effects usually associated with taxing electricity are not to be expected. Of course, tax incidence issues at the level of the EU Member States can be expected to be the subject of intense debates among Member States, considering that only one half of them is generating nuclear power at all and that only 20% of nuclear power reactors are located in "newer" Member States. Furthermore, depending on how tax revenues will be spent, it may be hard to convince EU Member States with large shares of nuclear power to give up completely or partially the revenues from a nuclear power tax; and obviously particularly those Member States already taxing nuclear power: Also against the backdrop of rather diverging perspectives on and prospects of nuclear power across Member States. Finally, it should be kept in mind that in the medium-term nuclear power is being phased out and thus the tax base will disappear accordingly in several Member States, as Germany and Sweden, with possibly additional Member States to follow.

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