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Social Discount Rate and the Energy Transition Policy

Abstract

Energy transition is driven by policies that require investment in long-term undertakings such as energy infrastructures and/or the pricing of environmental externalities such as carbon emissions. The efficiency of such policies, in terms of resource allocation, is usually evaluated through cost–benefit analysis (CBA). As benefits and costs extend over long time horizons, they are converted to present value using a measure of the social discount rate. The higher the value of the social discount rate, the greater the importance given to the present at the expense of the future. Furthermore, the discount rate plays a central role in establishing the speed at which energy transition policy should achieve its objectives. A key problem is that certain aspects of the individual's economic behaviour – such as those concerning the long term as well as other intertemporal preferences – cannot be easily reflected in the cost–benefit approach and discounting mechanism. Moreover, the long-term financial implications of energy transition policy are not generationally neutral, and this is hardly ever taken into account when using a social discount rate in the evaluation of energy policies. The economic net present value – a mere aggregation of discounted benefits and costs – alongside the well-known limits of the theoretical framework, from which the discount rate stems, are unmanageable obstacles for the appraisal of the importance of wealth transfers that may occur among multiple generations during long-term initiatives such as energy transition. This all means that the criteria under which energy transition policies achieve efficiency need to better reflect the preferences of society, with respect to the compensation that is required to renounce immediate consumption for future benefit. Furthermore, the efficiency of transition policies is necessary but not sufficient, the distributional impact of these policies needs to be examined with the aim of minimizing intergenerational equity issues that may arise.

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Rahmatallah Poudineh Senior Research Fellow, OIES &
Domingo Penyalver, Researcher, Centre for Innovation in Transport, Polytechnic University of Catalonia

1. Introduction

Energy policy affects how energy is produced, distributed, and consumed. It is also a key instrument for governments to reach political, economic, and social goals, encourage sustainable resource development, provide environmental protection, and reduce greenhouse gas (GHG) emissions (Oxilia & Blanco, 2016). This is specifically relevant during the energy transition, as the current transformation of the energy sector is mainly driven by government policies.

Policies aimed at driving energy transition often result in costs and benefits that spread over many decades. The public sector usually evaluates the convenience of policy strategies and investment projects[1] using cost–benefit analysis (CBA), as the choice among policy alternatives or investment strategies depends on their consequences for citizens now and in the future (Stern, et al., 2006). Decision-makers typically use CBA methodology to assess the economic efficiency of policy in terms of the efficient use of resources for the whole of society, as it allows future benefits and costs to be presented in their current value (Dietz & Hepburn, 2013). Socio-economic costs and benefits, usually measured in monetary terms according to individuals' willingness to pay,[2] are compared to each other in order to discover if a policy is efficient in a CBA sense (Lind, 1995). The results are finally presented by means of synthetic indicators, such as the economic net present value (ENPV), which is a measure of the investment's marginal utility for 'present' society (Gollier, 2011; Boardman, et al., 2017). It does so through the use of an 'appropriate' discount rate (Lind, et al., 2011; Penyalver, et al., 2018), which is used to diminish future benefits and costs in importance as time passes (Kelleher, 2012; Davidson, 2014).

A major issue related to the use of a discounting mechanism in general and a social discount rate in particular, however, is that it assumes that a single theoretical welfare function can adequately represent the people's values and preferences over the years (Laibson, 2003) and also that future generations will be richer than the 'present' one (Rendall, 2011; Kelleher, 2012). These assumptions involve potential intergenerational welfare effects that decision makers should consider in addition to the efficiency criterion (Lind, 1995; Dasgupta, 2008; Stern, et al., 2006; Penyalver, 2019). This is mainly because the dynamics of society imply an evolution of the social interest of individuals living at different times (ISR, 2017) and because future generations are not represented in current decisions about energy transition policy that may have impacts over decades or centuries (Stern, et al., 2006). In other words, it can be challenging to shape collective preferences through a single welfare function, considering that a particular energy transition policy will extend its effects over very long timespans. On the other hand, energy transition policy and its benefits rarely pay due attention to the long-term financial implications and incentives that decision makers have to provide in order to get the policy implemented, despite the fact that evidence exists that the financial implications are not generationally neutral (Penyalver, 2019). Indeed, the financial strategy accompanying energy transition policy may lead to wealth transfers among the members of different generations as the costs of these policies are eventually passed to final consumers.

This paper offers an insight into the issues of relying on CBA and discounting mechanism in evaluating energy transition policy efficiency. It also provides a fair number of arguments that lead to the conclusion that it would be advisable to complement the traditional economic view used in evaluating energy transition policy with the results that can be obtained from an analysis of redistribution across the successive generations concerned. The paper is organized as follows: Section 2 draws attention to the role of the discounting mechanism and the value of the discount rate in shaping energy policy. Section 3 highlights the implications of the social discount rate (SDR) used in economic analysis to drive energy transition through infrastructure investment and/or determining the social cost of carbon. Section 4 describes the limits of applying social discount rates in evaluating a national energy transition policy

[1] For the purpose of this article, investment projects can be considered as small variations around a particular strategy or path such as energy transition policy.

[2] A benefit is calculated as the maximum amount the beneficiary would be willing to pay for that benefit whereas a cost is computed to be the minimum amount that the person incurring the cost would be willing to accept as full compensation (Lind, 1995).

and investments aimed at decarbonization. Finally, Section 5 offers concluding remarks and highlights issues for further discussions.

2. Discounting Mechanism and Discount Rate

Both the discounting mechanism and the discount rate are core elements of welfare economics. In CBA, they both make up the discounting function that is used to compare investments' costs and benefits that are expected to occur over the years (Meunier, et al., 2013; Penyalver, et al., 2018). While discounting is an algorithm that allows for a decline in the importance of future socio-economic effects over the years by using an SDR (Laibson, 2003), a single interest rate *(i)*, representing the investment' marginal utility for society (SDR), is usually applied as a discount rate. The SDR encompasses society's pure-consumption preferences – social value – and other factors related to the productivity of collective investments for society – opportunity cost or social cost (Ramsey, 1928; HM Treasury, 2018). In the absence of externalities[3] and other distortions (such as investment tax and transaction cost), the social rate of return to investment *(r)* – determined as a commercial discount rate – matches the social rate of time preference *(δ)*, and both can be expressed as a sum of the pure time preferences rate *(ρ)* and the rate of growth of the economy *(g)*, which is in turn nuanced according to the marginal utility of consumption *(θ)* (see Equation 1). However, the SDR values in terms of social cost and social value can be quite different due to different appreciations of individuals' socio-economic context, meaning that r and δ rarely match in practice (Moore, et al., 2004; Groom, et al., 2005), so decision makers tend to adopt an *appropriate*[4] discount rate value as SDR (Penyalver, et al., 2018).

Equation 1. Ramsey Rule

$$i \equiv r = \rho + \theta g = \delta$$

The discount rate and discounting mechanism are needed to analyse welfare. In formal discounting models (exponential discounting), it is assumed that people's welfare (W) can be represented as a discounted ($D(\tau)$) sum of current and future utility, and that such utility (U_t) can be presented in terms of income or consumption (see Equation 2). This assumption implies that preferences among economic agents do not vary substantially (Gollier & Zeckhauser, 2003) and, in addition, that people's preferences do not change over time (the property of time consistency). From a broader perspective, discounting functions implicitly assume that 'present' individuals may benefit from an investment indefinitely, or that the utility of consumption is the same regardless of when their consumption takes place (Lind, 1995).

Equation 2. Generalized discounting model

$$W \equiv U_t = \sum_{\tau=0}^{T-t} D(\tau) \cdot u_{t+\tau}$$

The welfare function transforming future socio-economic costs and benefits into present values does not necessarily have to adopt a constant discount rate. In fact, one of the major challenges in welfare economics practice is how to justify a single declining model for the analysis of the socio-economic convenience of national energy policy, whose costs and benefits could be perceived over many decades and even beyond. It is in this sense that experts point out that choice behaviour is largely inconsistent, as time preferences vary due to uncertainty, risk, and other contextual factors (Little, 2002); for example, price fluctuation of goods and services and/or the relative importance that the future holds (Kelleher, 2012; Arrow, et al., 2014; Freeman, et al., 2015). Some individuals could even take into account their own probability of death at the moment of making decisions about

[3] Externalities (such as pollution) may be perceived as a social cost depending on the size/threshold reached and, hence, they may cause a distortion in the theoretical value of the SDR (Harford, 1997), which ideally would reflect both the investment's social value and the opportunity cost for society.

[4] There are multiple contenders for use as the SDR. Thus, it is not possible to talk of a single 'appropriate' discount rate. The choice of such an 'appropriate' SDR for a project or sub-sector investment (in railway infrastructure, for example) often ends up being defined by the public administration in order to achieve certain policy objectives (Meunier, et al., 2013; Penyalver & Turró, 2018).

consumption/saving (Angelsen, 1991). In short, collective preferences may change significatively as time moves on (ISR, 2017; Penyalver, et al., 2018), so the property of time consistency assumed in declining models does not hold for multi-decade projects (Lee & Ellingwood, 2015).

These arguments lead to the conclusion that the basis on which long-term public decisions are made deserves special scrutiny from society (Frederick, et al., 2002). In CBA, the higher the value of the discount rate, the greater the importance given to the present at the expense of the future. Heavy SDR values have thus the potential to severely diminish in importance any potentially strong effects that may occur in the long term (Nesticò & Maselli, 2018), while extremely low SDR values are often used when pursuing 'green objectives' in the long run[5] (Turró & Penyalver, 2019). SDR values below market interest rates in general, and very low SDRs in particular, have indeed the potential to help multi-decade projects to pass the CBA test; however, this approach does not mean that investments with a positive ENPV are necessarily fair for future generations (Weitzman, 2007; Lee & Ellingwood, 2015).

A recently proposed solution that avoids the distortion introduced by the use of exponential discounting in decisions concerning very long-term periods, namely those subject to great uncertainty[6] about the future, is to use a discount rate that declines according to some predetermined trajectory[7] (HM Treasury, 2018). Compared to the use of a constant discount rate, a declining discount rate (DDR) may be used to put relatively more effort into improving social welfare in the far distant future than in the shorter term (Gollier, et al., 2008). There is no consensus, however, on how to apply this solution because the time schedule of DDRs involves making tricky assumptions concerning the points in time at which the discount rate scales down (Weitzman, 1998; Newell & Pizer, 2003); in addition, social welfare measured in terms of utility cannot be maximized in a process where the discount rate changes as time moves on (Groom, et al., 2005; Freeman, et al., 2015). What is more widely agreed is an arbitrage between exponential and declining discounting. This means using an equivalent SDR if there is a possibility that the effects under examination could involve very substantial and, for practical purposes, irreversible wealth transfers between different genealogical generations (Lowe, 2008) which basically do not overlap.

A major inconvenience is, however, that this utilitarian approach to cost–benefit analysis based on discounting appears to be more useful as a way of determining the maximum ENPV of an investment rather than of comparing different alternatives to solving the same problem (Rendall, 2011; Freeman & Groom, 2014), which is the main purpose of a CBA. To see this, consider the example where decision makers must choose between two alternatives for managing the electrification of transport: construction of more electricity grid versus investment in digital technologies to manage network congestion more actively. In this case, the adoption of an equivalent SDR would let them compare both investment alternatives in terms of economic efficiency and identify the one with higher economic net present value (ENPV). In practice, however, it is reasonable to apply a higher SDR in CBA for digital technology projects than for grid infrastructure projects, as networks typically require the evaluation of larger timespans for benefits, to counteract the huge investment costs they require. However, if the SDRs are different, it will not be possible to compare their ENPVs and thus argue which investment strategy is more convenient for society (exclusively in the CBA sense).

[5] At the time of the decision to build, for example, a low-carbon energy infrastructure, it is notoriously difficult to measure the economic benefits fully and accurately. Moreover, these benefits will materialize several decades after construction in the case of mega projects, such as nuclear plants.

[6] This term refers to unknown–unknown events – events that cannot be rationally forecasted but that may produce a fundamental change in social preferences and values as, for example, the recent pandemic of Coronavirus-19 or the emergence of a new major technological breakthrough (such as the advent of the internet). Known–unknown events (such as extreme weather episodes) are, however, considered as risks as it is possible to assign them a probability of occurrence and, in that way, they can be included in project appraisal.

[7] As opposed to exponential discounting functions, this solution implies adopting hyperbolas and quasi-hyperbolas discounting functions, which show much higher discount rates in the short term than in the long term, when they remain relatively constant (Herrnstein, 1961; Mazur, 1987; Ainslie, 1992; Loewenstein & Prelec, 1992).

3. The Discount Rate and Energy Transition Policy

Energy transitions are driven by a set of policies that:

- incentivize the deployment of low-carbon technologies and energy efficiency measures,
- encourage fuel switching or the phasing of out of existing high-carbon infrastructure,
- provide low-carbon financing models,
- price the negative externalities of fossil fuel consumption,
- promote RD&D for low-carbon and negative-emission technologies, and
- invest in the necessary supporting infrastructure.

These policies, however, have significant financial aspects, the impact of which are often not marginal for final consumers. The financial sustainability of major infrastructure investments, such as those carried out by electricity generation companies and/or transmission networks, relies primarily on guaranteed tariffs that are recovered from end users. There are also other financial obligations that governments make, the cost of which are transferred to final consumers. For example, the construction of a nuclear plant may last more than a decade and, as a consequence, it is subject to a fair number of risks.[8] Its operation, maintenance, and final dismantling may embrace more than a century and, thus, it is subject to high uncertainty.[9] Government often provides various guarantees – such as a fixed price long-term contract, not to mention other public collaterals (back stop) – that are demanded by institutional investors. Therefore, consumers are exposed to both the direct and indirect costs of energy transition policies.

In recent years, the main discussion has been about the efficiency of existing energy transition policies. In Germany, for example, critics have been arguing that plans to phase out existing fossil fuels and nuclear plants are extremely costly and can hurt Germany's position as an industrial powerhouse, but opponents argue that such costs are modest compared with the benefit that will be provided. Similar discussions have also been happening in France, Great Britain, and the Netherlands, among other countries.[10] While discussion about the efficiency of energy transition policies is important, such analysis is very much dependent on how the costs and benefits that are distributed over long-term horizons are translated to their present value (Stern, et al., 2006). There is always a level of discount rate that make such initiatives inefficient.[11] Conversely, there are levels of discount rate that make them efficient. Therefore, the discussion about efficiency of energy transition policy cannot be decoupled from the social discount rate and the compensation that society requires to forego current consumption for future benefits.

It is not just infrastructure projects for which the discount rate plays a crucial role. Discounting and the discount rate are also central elements for the determination of the social cost of carbon (SCC). The application of the SCC to reflect the long-term economic damages of climate change, in a given year, is particularly useful in coordinating actions towards an efficient fight against climate change (Stern, et al., 2006; Gollier, 2018). It incentivizes individuals and organizations to limit their marginal damages to society – a task that may be especially worthy where there are large divergences between private and social costs (Coase, 1960), which is the case with environmental problems (Hahn & Ritz, 2015). In this sense, the SCC is deemed an important piece of global energy policy and, in a more local setting, it is called on to be used in energy policy if the weight of the benefits of reducing GHG emissions represents a fair part of the total net benefits of an energy policy[12] (Pingou, 1920; Hahn & Ulph, 2012; Taylor,

[8] For example, technological obsolescence, unforeseen costs, environmental impacts, and public rejection, etc.

[9] Such as unforeseen extreme events: drought, flooding … even extraordinary tsunamis.

[10] 'How much does Germany's energy transition cost?', Sören Amelang, 1 Jun 2018, Clean Energy Wire, https://www.cleanenergywire.org/factsheets/how-much-does-germanys-energy-transition-cost.

[11] Actually, the discounting function and the SDR value used therein are even more critical when very long-term and large impacts among (not-overlapped) generations are involved.

[12] This is the case, for example, in the transport sector, which is approximately responsible for 1/6 of global GHG emissions and thus causes clear negative effects at local and regional levels (for example in air pollution, lung diseases, and acid rain). In this

2018). Policy makers employ the SCC to generate awareness of the external socio-economic costs stemming from incremental additions of carbon dioxide (CO_2) and other GHG emissions to the atmosphere (Hepburn, et al., 2020). In a more practical setting, the SCC can be implemented by means of carbon taxation or shadow price[13] in the economic evaluation of major (public) investments in infrastructure (microeconomic CBA).

An important point, however, is that the SCC is highly sensitive to assumptions about the social discount rate. This is because most impacts and costs of climate change happen in the future; translating them to the present time thus requires application of the discounting mechanism and discount rate. To understand the effect of the discount rate, consider the following example: if you were promised a gift of $10 million in 30 years' time, the present value of such money is $2,910,000 at a 2.5 per cent discount rate. At a 5 per cent discount rate it is around $772,000, and at a 7 per cent discount rate it is around $339,000. Thus, a higher discount rate will lead to a lower value for the SCC and vice versa. Different countries have also used different discount rates to estimate the SCC. In 2013, the USA's Interagency Working Group on Social Cost of Greenhouse Gases, for example, estimated the SCC based on three different discount rates: 2 per cent, 3 per cent, and 5 per cent. At 3 per cent they estimated an SCC of $32 for 2010, which rises to $52 in 2030, and $71 in 2050 (Gollier, 2018). Similarly, in 2009, the Commission Quinet in France used a 4 per cent discount rate and estimated the SCC at €32 in 2010, which will rise to €100 in 2030 and to between €150 and €350 in 2050 (ibid).

Having such a significant impact on the SCC, it is not surprising that the discounting mechanism and social discount rate used to determine SCC are subject to scrutiny in academia. However, this does not mean that the SCC is only affected by the discount rate. There is also a range of other complex factors. For example, determination of the SCC involves dealing with a huge level of (structural) uncertainty (Tol, 2011): estimating climate change damages at a national or global level requires an accurate (macroeconomic) vision, a very long-term perspective, as well as complex assessment models – without entering into the discussion on whether climate change concerns ought to be appraised from an anthropocentric perspective or from a broader (non-human animal and natural world) one. Moreover, its implementation in the market is made at a microeconomic level, by means of a carbon tax on fossil fuel consumption, and individual states establish the SCC price on the basis of domestic and global considerations (Taylor, 2018). Finally, the nature of the integrated assessment models used to calculate the SCC prices can be labelled as 'unstable', as alterations in key assumptions and/or particular elements of the methodology used in its determination imply significant differences in the final value of the SCC (Tol, 2011; Weitzman, 2013; Weitzman, 2014; Gollier, 2018).

The aforementioned arguments lead to the conclusion that the choice of the discount rate is crucial for the SCC (Arrow, et al., 1996; Frankhauser & Tol, 1996; Dietz & Hepburn, 2013; Davidson, 2014) and, by extension, for energy transition policy. The cost per ton of emissions associated with climate change damages may be dramatically[14] raised or lowered by changing the discount rate, especially in combination with exponential discounting (Weitzman, 2013; Taylor, 2018). A low social discount rate thus can accelerate energy transition by making a wider range of low carbon investment projects and initiatives efficient.

4. The Limits of Applying Social Discount Rates

The application of the discount rate is not free of controversy in environmental and climate change economics, despite the fact that it is widely used for both policy evaluation and investment ranking in the public sector (Meunier, et al., 2013). In evaluating energy transition policy, it is hard to accept that a single value for the discount rate may combine, fairly, concerns from individuals that are alive now, with the judgements of generations far away from the moment of discussion. Certainly, in dealing with

context, SCC is increasingly used by local authorities to generate awareness of the environmental costs of fuel-powered vehicles and the necessity of boosting sustainable mobility solutions (such as e-mobility, electric private vehicles, mobility as a service).

[13] In the EU, avoided CO_2 emission costs should be calculated according to the European Emissions Trading System.

[14] Interestingly enough, the Trump-era SCC estimates employed discount rates of 3% and 7% and considered only domestic SCC, resulting in a dramatic reduction in the SCC estimates as opposed to those seen in the Obama era (Taylor, 2018).

investment decisions that may come to fruition only after many years and whose positive and negative effects may embrace decades or centuries (for instance, a new nuclear plant), the use of a pure-consumption preference rate[15] has little relevance at the moment of establishing a value for the SDR, as it bears little correlation with society's willingness to delay consumption. Furthermore, the intertemporal valuation of individuals over their lifetime, reflected in the pure-consumption preference, is not the same as a decision issue for the long run, which concerns allocation across generations (Stern, et al., 2006). However, the use of a pure-time preference rate does appear relevant, in principle, to introduce into discussion about the social productivity of an investment (such as a nuclear plant) (Stern, et al., 2006), as it fairly represents how the investment's social productivity decreases for the 'present' generation as time passes.

The discount rate may be also controversial because it can be used with the aim of seizing upon the sustainable development vision to favour the 'present' generation at the expense of future ones (Evans & Sezer, 2004; Leleur, et al., 2007; Meunier, et al., 2013). Present investment in infrastructure (such as transport, energy, and water supply) provides essential services that influence, directly or indirectly, the attainment of the UN Sustainable Development Goals (SDGs), as infrastructure projects are usually motivated by the desire to enable employment and economic activity and/or to mitigate[16] the negative consequences of climate change (Rendall, 2011; Thacker, et al., 2019). In this framework, fairness towards 'our children', a mantra of ecologists, is often used to justify, politically, certain projects that provide ethereal benefits in the long run, even though they might be inefficient with general SDR values (Penyalver & Turró, 2018). The fact that infrastructure projects are normally financed through debt issue (for example, project bonds), long-term loans, and other types of credit facilities, exacerbates the issue because it implies that today's consumers will benefit from access to infrastructure and competitive services at the expense of tomorrow's who pay for these debts (Lerner, 1961; Penyalver, 2019).

At the global level, equity issues may arise with the choice of discount rate. Despite the fact that experts argue that the costs of abating GHG emissions and reducing global warming are immediate, and that most benefits are global and will occur to distant generations (Tol, 2011; Gollier, 2018), powerful countries/regions may still reap the benefits[17] from ambitious abatement measures that are justified by a low social discount rate (Isla, 2009), even though such projects bring about (unintended) intergenerational equity[18] issues and other types of redistributive effects on distant regions (Rendall, 2011; Penyalver & Turró, 2018).

The point is that a simple aggregate of benefits and costs – discounted at a point in time – does not offer information about the redistribution of wealth and/or the long-term implications resulting from present decisions (Lind, 1995; Penyalver, 2019), which is the case for energy policy in general and for the effects of regulatory measures to fight against global warming in particular (Tol, 2011). Indeed, the use of a discount rate might even be introducing a bias in favour of a transition plan to clean energy sources that is somehow unfair for current or future generations. For example, if global decision makers

[15] The pure-consumption preference rate is generally drafted up from the rate of return for private capital in the market, which focuses on maximizing private gains, keeps a clear general risk aversion, and shows opportunistic behaviour (von Hagen, et al., 2011).

[16] Decisions adopted for resilience enhancing are normally based on the necessity to protect later generations from catastrophic losses, despite the fact that such catastrophic scenarios are often subject to structural uncertainty (unknown–unknowns – such as a nuclear war) which science is unable to evaluate meaningfully (Rendall, 2011). However, the procedures presently used in the appraisal of projects that unfold over long timespans are not including any adequate measure of their intergenerational implications (Turró & Penyalver, 2019).

[17] For example, in the European Union, the 'Sustainable European Investment Plan' that accompanies the 'European Green Deal' will unlock billions of euros with the aim of boosting the global green transition. However, it can be also seen as a strategy to sustain the EU's status quo globally (DiEM25, 2019).

[18] Intergenerational equity typically means achieving a fair, ethical balance of costs and benefits between present and future generations (Rawls, 1971; Daniels, 1988; Barnes & Lord, 2017). In the environmental context, topics on intergenerational issues include global warming, climate change, exhaustible resources, and diversity of species (United Nations, 1987). In a socio-economic context, intergenerational issues refer to age-related expenses (Thompson, 2003; Williamson & Rhodes, 2011), infrastructure provision, and/or fiscal equity (McCrae & Aiken, 2000). In the context of major investment plans and projects, it essentially refers to country debt or the taxes that will need to be paid by future generations to meet the costs of present investment (Jim & Love, 2011).

are able to reach more and more agreements to reduce GHG emissions, which would result in governments accelerating energy transition globally, the marginal utility of CO_2 emission rights should rise and, as a consequence, CO_2 trading prices should increase too. In other words, in a perfect market, the more carbon dioxide is emitted in the present time, the higher should be its price in the future. This, in turn, implies that the socio-economic benefits stemming from emission savings should rise as time passes. Since the value of the net benefits arising from any particular energy transition policy will be higher in the long term than in the short term, it appears clear that some redistribution of wealth will be in place (from the present to future generations).

The reverse is also true when current energy transition decisions involve costs that are fully realized only many decades after the deployment of the infrastructure or technology. A case in point is a nuclear power plant, for which the costs related to decommissioning or handling wastes are likely to be borne by future generations. The economic pareto efficiency criterion assumes that net losers will be compensated by net gainers. This means that, in order to ensure pareto efficiency, future generations should be able to require former ones to pay compensation. However, it is obvious that society in general, and future rate payers and/or taxpayers in particular, cannot react to former decisions. In practice, rather than a reduction of their electricity bill, future consumers will bear additional financial charges due to existing energy policy trends (Gross, et al., 2010; Moreno, et al., 2012; Blazquez, et al., 2018). This is not just in the power sector. The implementation of ‘green solutions’ in other sectors can also lead to a higher burden for future tax payers whilst the ‘present’ generation benefits from more competitive services. For instance, e-mobility deployment can lead to a reduction of revenues from the taxation of fossil fuel consumption and thus to an increase in the urban public transport system’s deficit, which has to be covered with funds from the annual public budget, which is fed from taxpayers. It is thus fair to argue that energy policy has the ability to produce redistributive effects among the successive generations involved, if no compensation measures are adopted.

Other limitations to dealing with intergenerational equity issues in the economic evaluation of energy policy stem from the inability of discounting and the discount rate to take the financing impacts into consideration (Penyalver, 2019). Any public policy is funded by access to financing sources, and when countries are in deficit, they are compelled to cover a part of the annual public expenditure through debt instruments.[19] In the case of energy policy, where substantial amounts of public subsidies are normally in place,[20] it is clear that an increase in public debt – or at least part of it – will produce a certain redistribution of wealth among generations (Lerner, 1961). Although the actual impact of such borrowings on future generations could be somehow nuanced over the years if, for example, the interest rate of the financing is below inflation, the possibility of wealth transfer among generations, in this context, cannot be disregarded.

This all leads to the fact that energy transition policies can give rise to severe equity issues if energy policy is not designed to give the required consideration to intergenerational redistributive effects (Wiser & Pickle, 1998). The economic appraisals of energy policy and/or major investments in low-carbon infrastructures that are carried out with CBA methodology, in combination with the discount rate, do not provide any account of their intergenerational implications. The financial strategy of energy policy often generates intergenerational impacts that need to be analysed if the policy/project’s benefits and costs are to be distributed across a substantive number of years. This is to adapt the financial strategy with the aim of avoiding, as much as possible, unintended intergenerational transfers.

In short, it appears clear that the discounting mechanism and the use of an appropriate social discount rate are unsuitable for performing a proper analysis of the impact that energy policy decisions may have on successive generations. Intergenerational redistribution does not appear to captivate the attention of society as a whole, despite the emphasis that many social and economic agents place on the well-being of future generations, and given the fact that ‘present’ decisions related to energy policy will

[19] Governments may finance their current expenditures by collecting taxes or by borrowing. However, when accumulated (permanent or structural) deficit is in place, debt management can only be addressed through short-term or long-term debt emissions (Greenwood, et al., 2016), which may have different maturity (5, 10 … 100 years, also known as perpetual bonds).
[20] With the aim of, for example, incentivizing renewable energy investment or relieving the energy bill of a particular group of consumers such as households or energy-intensive industries.

undoubtedly imply an opportunity cost for end users in the future. How to incorporate redistributive effects in the decision-making process is actually an open question (Khraibani, et al., 2016). In any case, the biases they introduce should be measured and put into perspective, so the individuals involved do not end up being adversely affected or, if they are, they can be adequately compensated by the policy's champions (Penyalver & Turró, 2018). In this sense, policy decisions that are not delivering, to the (overlapping) generations concerned, a balanced relation between costs and benefits should be understood as being unfair from an intergenerational perspective (Penyalver, 2019), especially if a specific generation is bound to foot most of the bill stemming from energy transition policies.

5. Conclusions

Energy transition policy aims at giving a response to a number of economic, social, and environmental challenges with which society is confronted. Some of these stem from such pressing needs as, for example, ensuring that there is sufficient energy supply capacity available to satisfy demand forecasts. Others may come from strategic views on national development and social evolution, which imply larger timespans and, thus, are more subject to risks and uncertainties in terms of costs and benefits. In this framework, discounting and the use of a discount rate are central to comparing different policy strategies and investment programmes, as well as to establishing the speed at which an energy transition policy should be implemented to achieve, in due time, decarbonization goals.

In energy transition policy, the main target of economic evaluation is ensuring that its implementation will result in a positive balance between socio-economic benefits and costs – in other words, it seeks to ensure its economic rationale from the perspective of 'present' society. The discount rate used in combination with the discounting mechanism establishes the efficiency of the policy or investment project. However, a major point of controversy is that there is always a level of discount rate that makes investment initiatives efficient/inefficient when taking a very long-term perspective.

An ambitious energy transition policy may well produce a fundamental change in social preferences and values if fully developed. In this sense, a major barrier to the reliance on efficiency analyses (CBA) framed in the very long term, with costs and benefits subject to multiple risks and great uncertainty, is that it is hard to accept that a simple discount function can adequately represent the vision of distant generations in current discussion. A recent solution has been the use of a declining discount rate using a pre-defined declining trajectory, which may be adapted to different levels of risk and uncertainty throughout the period under scrutiny. However, the longer the period, the less reliance should be placed on this approach. Beyond this, economic analysis made using discounting in combination with an 'appropriate' discount rate is unable to provide insights on the redistribution issues that energy transition strategy may cause among the successive generations concerned.

In principle, distributional considerations are not a major concern of decision makers when dealing with energy transition and fighting against the negative effects of climate change, as they focus more on the efficiency of these policies. This is despite the fact that the implications of energy transition policies are increasingly under social scrutiny due to possible intergenerational equity issues. The economic net present value obtained from the CBA – a mere aggregation of discounted benefits and costs – alongside the well-known limits of the theoretical framework of welfare economics, from which the discount rate stems, are unmanageable obstacles to the appraisal of the importance of wealth transfers that may occur among multiple generations during long-term initiatives such as energy transition.

In developed countries, society is particularly sensitive to intergenerational equity issues, as there is a perception that future generations will have to bear the consequences of policies and investment decisions implemented without due consideration for both individuals who are young now and others who are yet to be born. How to assess the intergenerational impact that may arise from national energy policy/multi-decades projects that aim to boost energy transition, resilience, and environmental sustainability, while reducing the impact of global warming on generations to come, remains an open question. The efficiency criterion should always be a main concern of decision makers, but the arguments presented herein justify the convenience of performing a proper assessment on the intergenerational impacts separately.

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