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The role of the discount rates in energy systems optimisation models

Diego García-Gusano [a,b,*], Kari Espegren [a], Arne Lind [a], Martin Kirkengen [a]

[a] Institute for Energy Technology (IFE), PO Box 40, NO-2027, Kjeller, Norway
[b] Systems Analysis Unit, Instituto IMDEA Energía, E-28935 Móstoles, Spain

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ABSTRACT

The selection of the social discount rate and the consideration of hurdle rates in energy systems optimisation models affect the creation of sound and comprehensive scenarios useful for energy modellers. Due to the lack of studies about the use of different discounting options in energy optimisation models, the goal of this paper is to fill that gap by establishing the foundations for a debate among energy modellers, policy-makers and stakeholders in this regard. So firstly, we introduced the concept of discount rates both social and technology-specific including a thorough literature review concerning figures, scopes and approaches. Secondly, two models, ETSAP-TIAM and TIMES-Norway, were used to assess the behaviour of the energy systems at different regionalisation levels, Europe and Norway respectively. Thirdly, we analysed the evolution of the electricity production mixes and system costs for both models and considering several values for the discount rates. Finally, results showed that the energy system is strongly affected by changes in the social discount rate. The lower the social discount rate is, the higher the renewable contribution. The social discounting exerts influence on capital intensive investments so it is quite important to look at the energy carriers pathways (fossil-renewable transition). This is what happens in the case of ETSAP-TIAM for Europe. Reversely, in the case of TIMES-Norway, as the electricity system is almost 100% renewable, it is important to take into account the hurdle rates of the technologies to enrich the competition by including their particular risks and barriers. In summary, we recommend using a value not higher than 4–5% for the social discount rate for the European countries as well as to include an exhaustive portfolio of hurdle rates for all the technologies included in the energy optimisation model.

Contents

Abbreviations: BFG, Blast Furnace Gas; CAPM, Capital Assets Pricing Model; CCS, Carbon Capture and Storage; CHP, Concentrated Heat and Power; COG, Coke Oven Gas; DR, Discount Rate; GDP, Gross Domestic Product; HFO, Heavy Fuel Oil; HR, Hurdle Rate; IGCC, Integrated Gasification Combined Cycle; IRR, Internal Rate of Return; LNG, Liquified Natural Gas; LPG, Liquified Petroleum Gas; LWR, Light Water Reactor; MARKAL, MARKet Allocation model; MARR, Minimum Acceptable Rate of Return; MSW, Municipal Solid Waste; NGCC, Natural Gas Combined Cycle; NOK, Norwegian Kroner; NPV, Net Present Value; PBMR, Pebble Bed Modular Reactor; PV, Photovoltaic; RoR, Run-of-river; TIAM, TIMES Integrated Assessment Model; TIMES, The Integrated MARKAL-EFOM System

* Corresponding author at: Instituto IMDEA Energía, Systems Analysis Unit, Avenida Ramón de la Sagra 3, E-28935 Móstoles, Spain. Tel.: +34 91 7371120x207.
E-mail address: diego.garcia@imdea.org (D. García-Gusano).

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1. Introduction

The use of MARKAL/TIMES [1], a bottom-up energy optimisation modelling framework has been living an intense upsurge during last decade. This fact is founded on the countries' need to develop sustainable and long term policy goals, via roadmaps and strategic plans, which make possible ensuring the economic growth, combined with emission reductions and maximising social welfare. In particular, TIMES models (the evolution of MARKAL) are used worldwide to develop energy plans and scenarios both at global level and country level. In Europe, most of the countries have developed their own national TIMES model [2]. Besides, International Energy Agency (IEA) is an important user/developer of this type of energy system models and collaborates in projects and consortiums spreading its use.

TIMES is a model generator for local, national or multi-regional energy systems, which provides a technology rich basis for estimating energy dynamics over a long-term, multiple period time horizon [1]. It is usually applied to the analysis of the entire energy sector, but may apply to study in detail single sectors. Nowadays, over 70 countries globally make use of the TIMES family of models [3,4]. The modelling tools have been used for numerous studies, on a regional, national and global level, with various focus areas [5].

Even though TIMES modelling is a promising and interesting framework to manage prospective studies concerning energy systems, there are some weaknesses that should be analysed in depth. Prasad et al. [6] discussed the potential weaknesses of the energy models and they concluded that if the structure of a model is oversimplified results deviate from reality. One of the main issues detected in the community of the energy optimisation modellers, both in peer-reviewed papers and technical reports from projects, is the lack of sensitivity analyses and discussions concerning the discount rates.

The choice of the discount rates and the evaluation of its consequences in terms of technological preferences, sustainability and policy goals, involves a controversial issue. Some studies have brought into question this point: *why they chose that discount rate? It seems too low/high*. For instance, the Integrated Energy Policy Report (IEPR) [7] stated that "*apply inappropriately high discount rates to future fuel costs, thereby understating the impact upon consumers. The net result is a systematic undervaluing of non-fuel-intensive procurement alternatives, such as efficiency and renewables, and an increasing dependence on gas-fired generation*." As Ringer [8] remarks, the IEPR should recommend to discount future fuel costs at the 3% social discount rate used in ordinary activities, unless the investor-owned utilities can prove that these costs should be allocated to shareholders. So, we can observe that the choice of the discount rate entails problems. In particular, the selection of this value in the TIMES models is crucial, as demonstrated in this paper.

This work aims to review the literature on social discount rates, and also hurdle rates, from a TIMES modelling point of view. It has the purpose of enlighten the absence of references and the need of discussion in data selection as well as to point out the weakness of this type of models with respect to the uncontrollable parameters, such as the discount rates. To do so, the recognised worldwide ETSAP-TIAM model is used to analyse the European energy system and likewise the TIMES-Norway model is used to observe the consequences of using several discounting options at national level. Differences and similarities due to the regional approach are also discussed. Finally, some main conclusions and recommendations are pointed out.

2. Discount rates and hurdle rates

According to EC [9], the discount rate is the degree at which future values are discounted to the present. There are two approaches: financial discount rate and/or economic discount rate. They may differ, likewise that market prices may vary from accounting prices. Furthermore, the concept of social discount rate, in contrast to the financial discount rate, attempts to reflect the social view on how the future should be valued against the present.

The discount rate is used to adapt all costs and reimbursements to 'present values', so that they can be compared. Calculating the present value of the differences between the streams of costs and reimbursements provides the net present value (*NPV*) of an option. The *NPV* is the primary criterion for deciding whether government action can be justified [10]. The discounting factor (D_t) to calculate the *NPV* is given by:

$$D_t = \frac{1}{(1+r)^t} \quad (1)$$

where r is the discount rate and t is the time in years. In consequence, it is required to distinguish between the social discount rate and the financial discount rate in relation with the use of the discounting expressed in Eq. (1). The choice of social discount rates is usually a concern to the governments since they are entities which represent the entire society and its awareness (environment, moral principles, sustainability, economic growth, security, etc.). On the contrary, the financial discount rate is a concept to characterise the private investments which do not have the duty to consider the social concerns such as welfare or sustainability.

From a private point of view, the appropriate discount rate should represent the opportunity cost of what else the firm could accomplish with those same funds. If that means that the money