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8 Summary

In this dissertation a qualitative framework and a quantitative methodology are developed and implemented to assess interactions, in particular antagonisms, between energy and environment policy instruments.

Section 1 General introduction

This section introduces the research problem. The section includes an overview on the need for environment and energy policy integration, the approaches that have been used to do so, the several available methods used for policy evaluation and assessment, and a short description of the Portuguese case-study. The following main research questions are introduced:

- A) What divergences exist between the objectives of energy and environment policies and how relevant are these?
- B) How well can we assess the interactions between energy and environment policies and instruments? In particular, how can they be quantified?
- C) How do the different energy and environment policies instruments & measures along the power energy system interact with each other and how does that interaction affect their effectiveness and cost-effectiveness?
- D) How can energy and environment policy instruments be better integrated in order to improve their overall effectiveness and cost-effectiveness?

Section 2 A tangled web: assessing overlaps between energy and environmental policy instruments along the electricity supply chain

This section presents the background for non-coordination in environment and energy policies, characterizes most of the energy and environment policy instruments along the electricity supply chain, and presents a qualitative framework to assess interactions between policy instruments in place along the electricity supply chain.

The electricity supply chain was considered not only in this section but also throughout this dissertation because the use of electricity for provision of energy services is pervasive throughout the economy. Therefore, policies affecting the electricity system might significantly condition wellbeing.

Presently there is a large number of energy and environmental policy instruments in place which overlap with each other in as much as they share the same targets for policy. A total of 27 different generic types of instruments are or will be in place along electricity systems, creating quite a complex picture which in this dissertation is named "a tangled web".

Some of these policy instruments' overlaps are synergistic, but quite a few steer the behaviour of stakeholders in opposite directions, compromising the overall policy effectiveness. Each of these policy instruments aims to steer stakeholder behaviour in a particular direction. In most cases the steering effects of the policy instruments are also affected by the other instruments in place, i.e. the policy instruments have co-effects. These co-effects occur not only within the same policy field, but also between instruments of different policy fields.

Although several studies have looked into such interactions of policy instruments they are limited to specific pairs or groups of instruments from the field of energy policy and/or climate policy. In this section is presented a framework in which to consider both the energy policy instruments as well as those from the broad field of environmental policy (climate policy is seen as a segment of the wider field of environmental policy).

The framework looks into the extent to what the policy instruments overlap and how their steering effects affect each other. To understand this, the objectives of the instruments, its mechanisms and the targeted stakeholders have to be looked upon, as follows:

1. A **screening** of the objectives of the different policy instruments is made to assess as to what point they are **overlapping** (i.e. to what extent they either target the same stakeholder and/or they steer related behaviour of stakeholders or not.

2. Their respective **mechanisms** are analysed to understand how well the instruments are coordinated. At this stage this can be done at two levels: a) no-coordination - the instruments do not acknowledge the existence of other or b) some coordination in the instruments (expressed as derogations or alterations in scope, among other).

3. The **steering effects** of the different instruments are analysed to identify if they are complementary (the objectives of the instruments steer the behaviour of the target stakeholders supplying mutual needs or offsetting mutual lacks), or counteracting (the objectives of at least one of the instruments steers the behaviour of the same stakeholders in a way that hampers the steering effect aimed by the other instruments).

The seemingly most relevant conflicts found in the tangled web are between hidden subsidies provided to energy supply infrastructures and environmental command-and-control regulation. Although there are policy instruments acting both on the supply and the demand side, these do not necessarily lead to integration of supply and demand-side policy instruments.

The section concludes with a discussion on how trade-offs can be structured, as well as some notes on issues to be considered towards policy integration.

Section 3 Cost of energy and environmental policy in Portuguese CO2 abatement – scenario analysis to 2020

In this section is presented how the interactions between energy and environment policies can be quantified by using an Economy-energy-environment model, in particular the TIMES model implemented for the Portuguese case-study. In the section the emphasis was placed on modelling different combinations of the existing energy and environment policy options in order to assess how these different combinations affect, in 2020, the CO2 marginal abatement costs, the total energy system costs, the primary and final energy demand, and the allocation of abatement effort throughout the different economic sectors.

The main emphasis was placed in CO2 abatement since climate change is currently one of the hot topics in energy and environment policy making. Multiple policy instruments are being developed to address the problem, aiming to coordinate the objectives of climate change mitigation with the ones of the European energy policy: security of supply, competitiveness and sustainability. Although it is clear that the way forward in European energy policy making includes climate change mitigation, it is not clear how policy options made in the past in a different context contribute to this objective.

The set of policy scenarios analysed including one or more of the following policies: ban on nuclear power; ban on new coal power plants without carbon sequestration and storage; incentives to natural gas power plants, and a cap on biomass use. It was found that the introduction of assumed policies significantly increases MAC: the policy scenario has 91 to 42% higher CO_2 MAC than the no policy scenario. The removal of the assumed policies leads to a significant decrease in total system costs of 10-13% (76-101 B€), roughly the equivalent to 2.01 to 2.65% of the 2005 Portuguese GDP.

The most general conclusion of this section is that even the limited set of policies in the energy domain assumed in this model exercise has a significant effect on the cost of CO_2 reduction. This interaction of policies therefore seems to be a prime subject for further analysis on cost-effective policy development in the energy and environmental policy domain, not only in Portugal.

Section 4 The Savings of Energy Saving: Interactions between energy supply and demand side options combined - quantification for Portugal

After looking on how the interactions in policies could be quantified using the TIMES_PT model in section 3, this section uses the same approach to quantify antagonism between policies implemented in the supply-side and on the demand-side of the energy system.

Although climate change policy brings together end-use energy efficiency, Renewable energy sources (RES) and other mitigation options, it is argued in the dissertation that policy makers often prefer supporting investments in the supply-side like in bio-energy and large scale hydro, wind and wave power or even centralised fossil power plants. Government subsidies to fossil fuels are typically maintained along with incentives to RES albeit in a more discrete manner. Thus, despite the fact that more recent energy strategies and programmes combine many policies and measures for tackling climate change, energy security, energy efficiency and promoting RES, there is still a need for quantified assessments of the contribution of the policies within each major policy objective, and of the synergies and antagonisms caused by different combinations of policy measures. This type of information is highly valuable for identifying the most cost-effective combination of policy measures and for reducing the overall cost of policies.

Taking Portugal as a case study, in this section is assessed the effect of specific uncoordinated supply-side and selected demand-side policies, namely of end-use energy-efficiency & small renewable applications. These effects are quantified in terms of reduced investments in large scale energy supply and contribution for compliance with energy and environmental policy targets. The bottom-up model TIMES_PT was used generate four scenarios till 2020 corresponding to different levels of efficiency of equipment in buildings, transport and industry. In the current policy scenario, the deployment of end-use equipments follows the 2000-2005 trends and the National Energy Efficiency Action Plan targets. In the efficient scenarios, all equipments can be replaced with more efficient ones.

Results show that aggressive industry and buildings demand-side options can make superfluous the increase in renewable electricity capacity of 4.7 GW currently discussed by policy makers. These measures reduce only 0-2% of total final energy, but this represents reductions of 11-14% in the commercial sector, with savings in total energy system costs of approximately 3000 M€$_{2000}$ - roughly the equivalent to 2% of the 2010 GDP.

The section concludes that there is substantial room for improvement in coordination of supply-side and demand-side policies for the case-study. It seems to be the lack of coordination in policy objectives (namely end-use energy efficiency targets, RES targets and energy security targets via liberalisation of electricity markets) that leads to an apparent intriguing sky-high issuing of permits for new power plants by authorities. The cost-effectiveness of policy measures should guide choices between supply shifts and demand reduction. Such balanced policy development can lead to substantial cost reductions in climate and energy policy.

Section 5 Effects of exogenous assumptions in GHG emissions models - A 2020 scenario study for Portugal using the Times model

In this dissertation it is argued that the Energy-economic-environment TIMES model should be used to quantify interactions between policy instruments. However, these models have a number of limitations, discussed in detail throughout the thesis. In this section the emphasis is on assessing one of these limitations: to what extent model outputs are dependant on the exogenous assumptions they have to integrate. In the section it is looked in particular to the assumptions that typically are used for climate policy making, reflecting the perception of policy makers on what is relevant.

Models such as TIMES (and PRIMES, POLES, etc.) are frequently used to support policy makers in climate change policy decisions, particularly to develop greenhouse gas (GHG) emission scenarios, as conditional forecasts. Examples of the required exogenous model assumptions are the rate of demographic and economic development, rate of energy-efficient technology evolution and deployment, the availability and price level of energy resources, and the pace of implementation and effectiveness of policy decisions.

Naturally, each of these assumptions has an associated uncertainty which affects the uncertainty of the resulting GHG forecast. It is common practice to model sets of alternative scenarios representing different sets of assumptions combined, as interesting pathways. Each pathway combines two or more sets of exogenous assumptions, resulting in a range of emission scenarios. There is good reason to combine different pathways into feasible scenarios. In that process, however, information on the role of the different assumptions is lost. It also is difficult and time-consuming to estimate the contribution of each individual assumption on overall uncertainty of scenario outcomes. This section is set out to fill this gap in knowledge, highly relevant in interpreting modelling outcomes for policy purposes.

The TIMES_PT model is used to develop seven alternative GHG scenarios for 2020. The Baseline scenario includes a combination of assumptions on all exogenous parameters. The other six technical scenarios each vary in only one assumption. The comparison between them shows how the assumption influences outcomes quantitatively.

The results show that the most relevant assumptions in a TIMES model for overall GHG variations are the ones related to the socio-economic development (macro-economic and population growth). The assumptions on end-use efficient technology deployment are the next most important. On the contrary to what is perceived by policy makers, fossil fuel prices and the availability of renewable energy resources present only minor variations on GHG emission (less than 2% of the Baseline).

Therefore it seems that key issues in energy supply in Portugal, the availability of water for hydropower and the price of – to be imported – oil hardly have any influence on the outcomes in terms of greenhouse gas emissions in 2020. The GHG emission estimates of the scenarios where exogenous parameters were varied lead to variations in 2020 total national GHG emissions less than 9% different from the Baseline. This has consequences in two directions. Improvement in model quality should not focus on these issues; and policies should not build on these elements. A policy-relevant consequence that should be further explored is the possibility that increasing oil prices, as a policy measure, as through carbon taxes, has a limited effect on overall climate performance.

Section 6 Top-down and bottom-up modelling to support low carbon scenarios: climate policy implications

Most of the research work in this dissertation relies on the use of the TIMES_PT model. Whereas the previous section assessed how different assumptions affect TIMES_PT outputs, in this section is assessed what are the differences in model results when using a different modelling tool (GEM-E3_PT).

Bottom-up (BU) and top-down (TD) models have been supporting climate policies, identifying the options required to meet greenhouse gases (GHG) abatement targets and evaluating its economic impact. Some studies have shown that GHG mitigation options from economic TD and technology BU models tend to vary, based on different baseline scenarios regarding divergence factors.

This section explores the relevance of the modelling approach used to support climate policy mitigation, by: (1) identifying to what extend the BU TIMES and the TD GEM-E3 models, applied for the case study of Portugal and considering a common baseline, lead to different abatement strategies and (2) how possible dissimilar outcomes could result in different domestic climate policy recommendations. To achieve these objectives we compare the models strategies to reduce sector emissions using a modified Kaya identity.

Three low carbon scenarios were generated until 2050, with different GHG reduction targets for the case study of Portugal. Results show that TIMES_PT and GEM-E3_PT models present close outputs when harmonized to a common Baseline scenario, assigning in general the larger mitigation potential to energy supply. However, the effort level required for each sector, especially for more stringent caps, and the strategy to reduce GHG emissions present dissimilarities which could lead to different policy design. GEM-E3_PT privileges energy efficiency, as it tends to focus more on the demand side, while TIMES_PT relies on the reduction of carbon intensity by shifting energy consumption in end use sectors to electricity and promoting renewable electricity, thus pointing towards incentives to promote low carbon technologies.

The approach suggested to deal with the different outcomes of the models would be for decision-makers to consider ranges of abatement potentials and costs rather than focus in just one model outcome. The two outcomes can actually be combined as it might be reasonable for the policy makers to create incentives for promoting the technological shifts suggested by the BU while taking into account the macroeconomic impacts defined by the TD model(s). In any case, both TD and BU models are simply tools to explore which technologies and policies could make a specific scenario attainable, and at what possible cost, and only one of the inputs informing the policy decision process. Thus, model outcomes adequacy should be discussed with industry stakeholders, consumer associations, among other.

Section 7 Overarching conclusions

In this section the results are presented in the form of a set of replies to each of the four main research questions. The main conclusion is that energy and environment policy integration at the level of its respective policy instruments is a good starting point towards the integration of the policy processes in all its components. Policy evaluation and integration should be supported in more practical and concrete terms with a bottom-up evaluation of concrete policy instruments in place. The approach developed in this dissertation allows obtaining a simple quantified measure of antagonisms and synergies between policy instruments which can more easily be communicated to policy makers. This dissertation concludes with a general discussion on the insights gained.