A Methodology to Address Social Concerns on Electricity Planning

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ABSTRACT

The topic Sustainable Development has brought a wide discussion across a number of sectors in our society, namely in Power Systems. Given the need to address other concerns than the economic ones, decision makers must take into account the rationale that lies beneath strategic choices, such as investing in generation technologies using renewable energy or rather doing business as usual and installing fossil fuel power plants. In this paper logic models were used as a decision-aid supporting tool, with the aim of contributing to explain the connection between building a given power plant and assessing its possible impacts in terms of sustainable development. All the electricity generation technologies were grouped in thermal, renewable energy sources (RES) and nuclear. The literature review fed the construction of three technology generation groups inference and relational diagrams to allow the visualization of environmental, social and economic causes and effects. The results of the literature review and of a set of interviews with experts, based on the diagrams, allowed to conclude that the use of RES have wider positive social impacts on the long run, despite their short-term higher costs compared to the traditional groups (nuclear and thermal).

INTRODUCTION

Among the strategies envisioned by the European Union, two of them concern especially power systems: the 20-20-20 and the European Union Sustainable Development Strategy (EUSDS).

- The EUSDS aims the building of a European Union respecting the inter-generational principle, while achieving full employment through a competitive social market economy and balanced economic growth, among other objectives. [1]

- The 20-20-20, with a horizon of 2020, points to a reduction of 20% of primary energy consumption with the improvement of energy efficiency, a minimum share of renewables energy of 20% and the reduction of greenhouse gases to 20% below the 1990 values. [2]

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The authors addressed in past works social issues in power systems planning [3][4]. They concluded that from the literature reviewed related to electricity generation, the methodologies that express explicitly economic, social and environmental criteria, fall mostly on Multi-Criteria Decision Aid (MCDA). It is clear in the literature that ultimately the economic and environmental criteria still prevail, given the "soft" aspects of social issues. Additionally, given the inter-relation between different groups of criteria (and the expression "socio-economic" proves it) situations exist where some short term "uneconomic" choices can be defended under the perspective that they induce virtuous cycles of social welfare and long-run economic return, as it is advocated, generally, by many who defend investment on renewables.

In these terms it becomes necessary to organize the rationale behind the defence of strategic importance that different groups of electricity generation technologies assume, and this is what this paper aimed by exploring the construction of diagrams that allow the visualization of impact chains associated with different technologies. The results of this work are three logic models (one for each group of electricity generation technology: thermal, nuclear and renewables), constructed from interviews with experts in power systems and also from document review (consultant reports and government strategy documents).

Impact Assessment and Logic Models

Impact Assessment aims at structuring and supporting the development of policies [5]. According to [6], "impact" is often associated at the level of welfare of households and individuals. Impact evaluation presupposes there is both an institutional intervention ("*impact of what?")* that produces results ("*impact on what?*"). The authors recognize that currently there is a shift from micro-earmarking (such as small programs of irrigation in a given district) to more complex intervention, induced by international treaties such as the Kyoto Protocol. [6]

Electricity production in the EU has become liberalized in the last decades. The role of the government as a central planning tends to be reduced authority and mostly previously state-owned companies and facilities tend to be privatized. Although this gives the idea that the expansion of the capacity is now only subject to private enterprises initiative, governments are committed mainly to limit GHG emissions. Central authorities still use mechanisms to regulate the market, such as the EU Emissions Trading System and the attribution of quotas to the construction of wind farms, for example. As a result, the market is not absolutely free and tends to be guided. So, to the questions *impact of what?* and *impact in what?*, we may answer *impact of energy policy upon the standards of living of the population, having in the background the contribution of power systems to sustainable development*. This work was applied specifically to the Portuguese situation, but with minor changes may also be representative of other countries.

Impact Assessment has been used widely within the EU and, in 2002, the single-sector assessment was replaced by a new integrated approach, capable of assessing economic, environmental and social effects [7]. This new approach allows Logic Models to be used when providing stakeholders with a visual map or narrative description of how specific program components are related to the program's desired results [8]. The literature related to logic models shows they have been applied both in a vast array of purposes, such as the monitoring of national R&D programs [9] [10], or education programs [11] [12] among others. For an overview of applications see the already mentioned [6].

METHODOLOGY

The objective of this paper is to organize the perceived short, medium and long-term impacts of electricity generation technologies, with the ultimate goal of assessing the sustainability of the Portuguese power system and supporting future strategic decisions in the electricity sector. For that purpose, logic models are built with the aid of literature review and interviews with a group of experts, as explained in the remainder of this section.

MacLaughin et al. [13] dedicated an article to the use of Logic Models for program performance evaluation, and described a five stages process to achieve the Logic Model. The present work was conducted upon their instructions:

1 – Collecting the relevant information: emphasizing the team work needed for building a Logic Model, along with the evidence that multiple perceptions about power planning exist, we invited experts in power systems, with varied positions on key questions such as markets in general and the renewable energy sources' role, to enter the process. Documents used to build preliminary inference diagrams, were consulted, namely [14] and [15].

2 – Clearly defining the problem and its context: Here the assumption is that a problem, the power generation planning, is to be solved under resource constraints and framed on the European energy policies, as well as a globalized competitive market. Therefore, the power planning has to allow the electricity demand to be met using three groups of solutions (thermal, renewable and nuclear), while addressing economic, environmental and social issues.

3 – Defining the elements of the logic model: Starting with three tables (one for each Logic Model) with Resources, Activities, Outputs and Outcomes, the interviewees were induced to speak about implications brought by the building of each type of power plants, and fill the table, while seeking to describe short, medium and long term outcomes.

4 – Drawing the Logic Models: The results are presented further in the next section.

5 – Verifying the Logic Models with stakeholders: The implementation of this phase, including the selection of stakeholders and their involvement, will be defined according to the results obtained during the interviews to occur in future work.

Conducting the interviews

The interviews lasted an average 45 minutes. The interviewees were first presented an example of a logic model to become familiarized with the goals of the interview (since the theme of the example was an European strategy to help reduce poverty in Tanzania, biases about sustainable development and energy were avoided) and were then invited to talk about economic, environmental and social impacts associated to each group of technologies, starting from the long-term perspective (example: how do you think that environment will get better if these technologies are used?) and progressing from there to more immediate impacts (which impacts does the construction of this type of power plants immediately cause?)
While the interviewee was talking, the interviewer was filling the table with short, medium and long-term impacts and would then present it to the interviewee.
The interviewer prepared, before the final results, a simple logic diagram and tables, aiming to discuss them further with the interviewee and possibly fill more impacts and connections that have arisen in the process.

RESULTS

Based on the literature review and the interviews conducted with experts, three logic models were drawn, presenting the impacts of electricity generation technologies.

Figure 1. The RES logic diagram

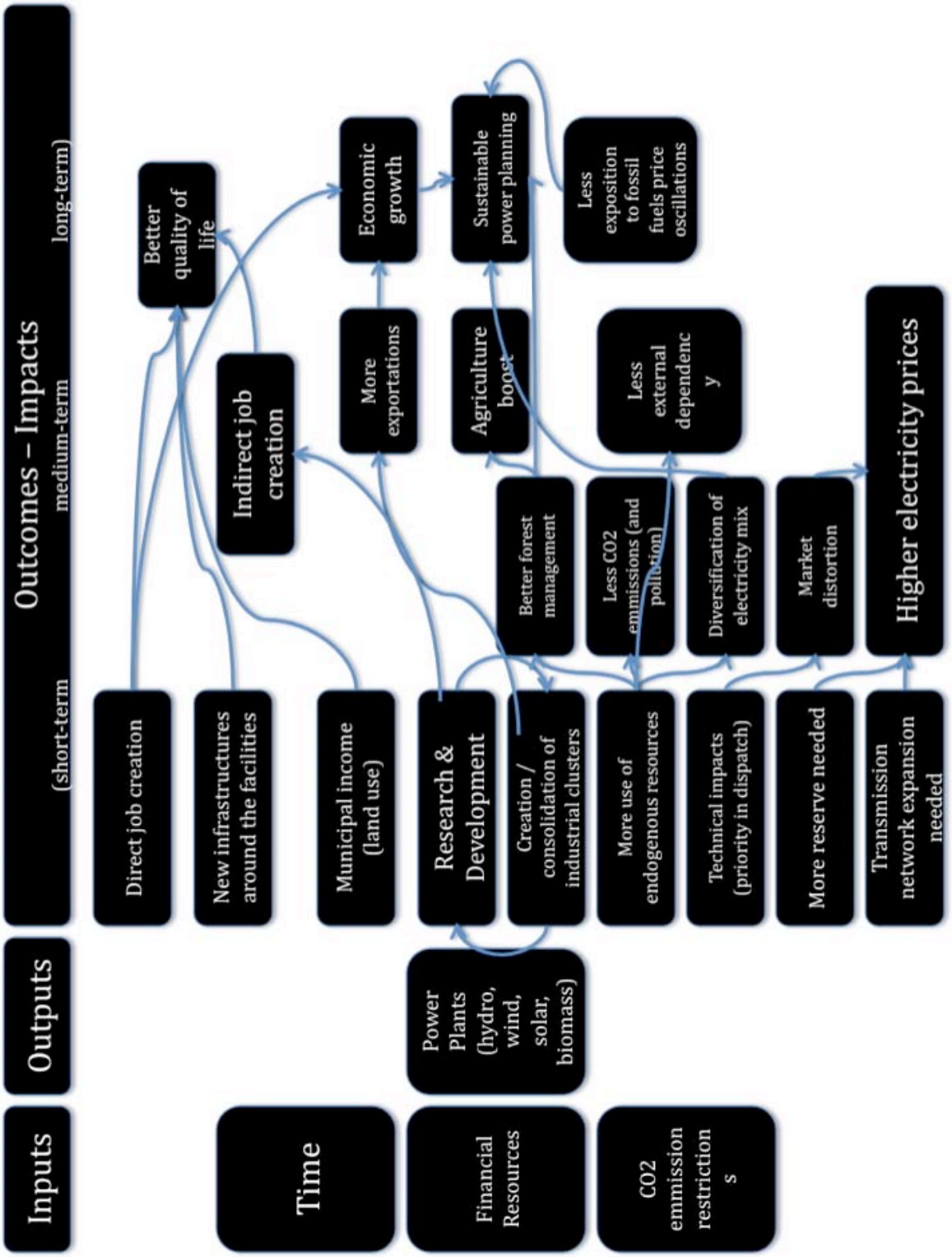


Figure 2. The thermal power plants logic diagram

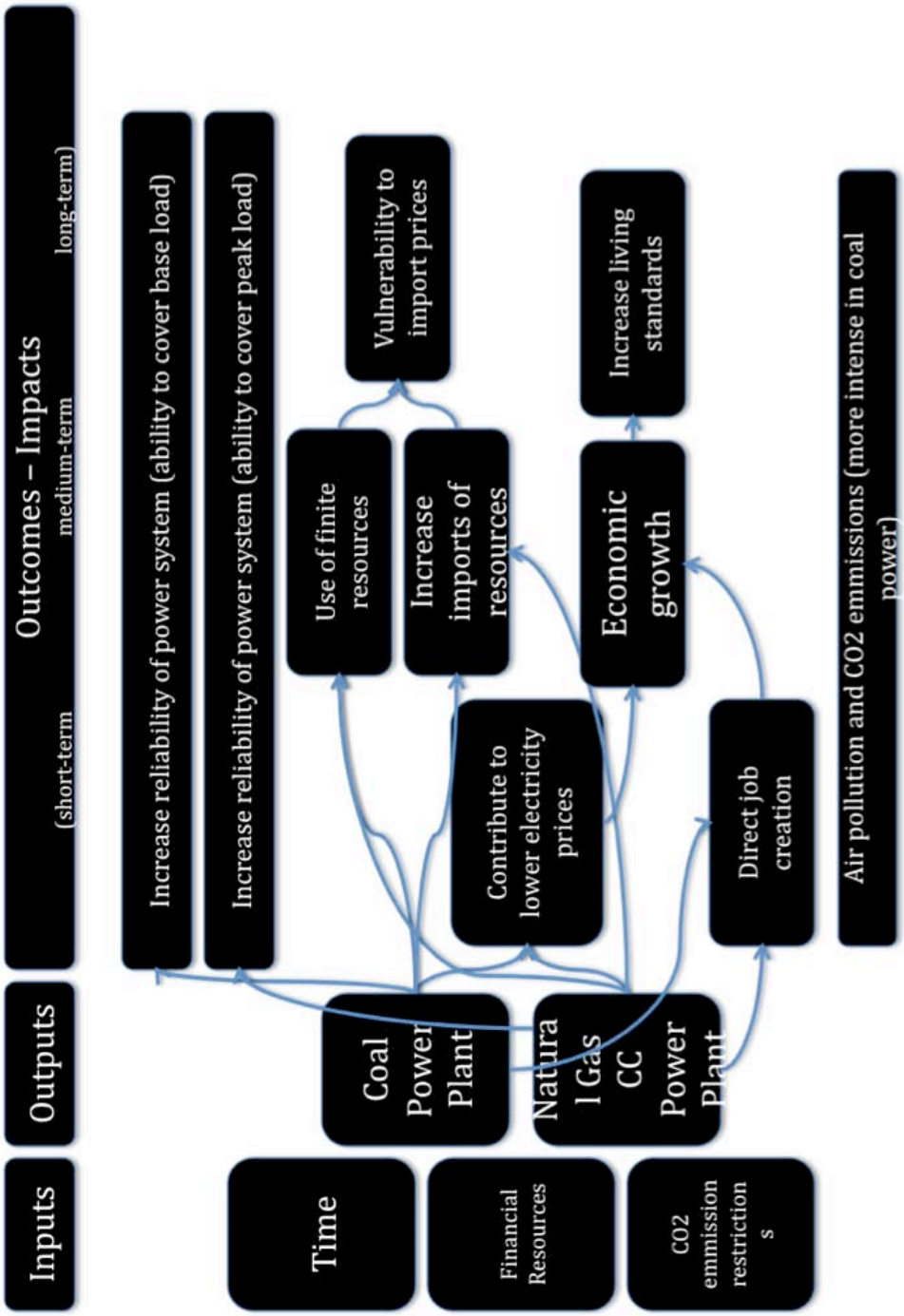
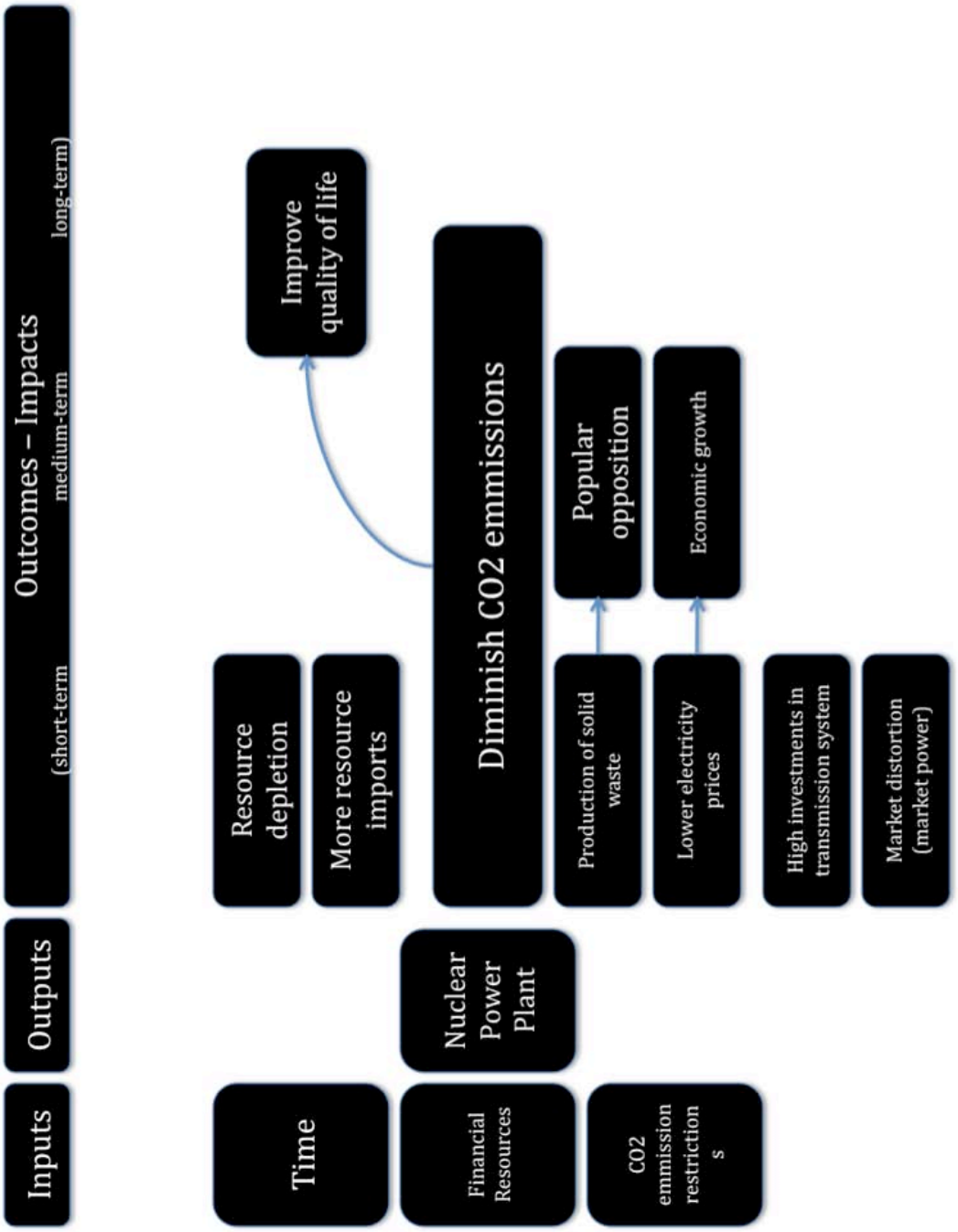


Figure 3. The nuclear power plants logic diagram



DISCUSSION

Decision-makers with different political points of view will tend to favour different political aspects of strategies about energy. The most visible example is the position towards market prices in short-term. As electricity costs affect a wide number of commodities, it can be argued that it is essential for a country to provide cheap electricity. Otherwise the country will lose competitiveness, and eventually impoverish by losing industry and other economic sectors. This argument transforms the perspective on sustainability concerns (for example, poorer countries have traditionally been committed to fewer goals of emissions than developed ones). On the

other hand there is the external energy independence factor, which can be achieved in the long run, and would be difficult to achieve yet in a free-market environment, given the high initial costs of exploiting the renewables. This duality is of extreme importance, and reflects what was said above: economic issues tend to prevail over social or environmental ones. The remainder of the discussion will reflect topics that have arisen in the interviews.

Renewables

One thing that became obvious during the process was that the renewables' logic model would definitely be more complex than thermal or nuclear power ones. Put simply, coal, natural gas and nuclear would be rational choices from an economic short and medium term perspective, while the renewables, being perceived as more expensive for now, have means to induce welfare in the long run.

The new infrastructures built around power plants were not seen as very important, given the fact that when they refer to roads, are normally away from large populated areas, therefore not resulting very useful. This conclusion led us to consider interviewing local inhabitants affected by wind farms, to have also their point of view, and we will address this issue in future work. When the infrastructures refer to housing, it is generally because of compensation after displacement, causing mostly displease. One of the interviewees referred that this ends up causing more employment. Additionally, new infrastructures associated with renewables have the impact of disturbing areas that were before isolated, often spoiling visually those areas.

General agreement was achieved on the connection between knowledge (R&D), industrial clusters and energetic / economic independence. Interviewees agree over the misuse of the term "cluster" as it exists on the wind power today. According to the general view, all the patents and most engineering aspects are imported. Instead a wider "national" value-chain should be favoured which would definitely induce a more durable economic development.

Although general agreement is that employment creation favours renewables, some interviewees emphasised that job quality and duration have to be addressed, and that renewables' projects are often creating low duration and low qualification jobs. Even the creation of jobs was seen by one interviewee as a critical point, since he argued that job creation in renewables is still artificial and destroys jobs in more productive sectors of industry, given the still high costs these technologies represent.

Biomass is not believed to occupy a central place in the near future energy landscape (and only assuming the form of cogeneration), although it can help to manage the forest in a better way.

It is widely agreed that renewables, due to their intermittency, oblige the existence of traditional units (reserve/back-up). This contributes to turning RES electricity even more expensive as a whole. One interviewee mentioned the fact that the existence of wind power capacity installed in Portugal already produces excessive energy in off-peak hours, resulting frequently in energy exported for free in those hours.

Although there is an agreement that the increment of renewables' use induces less exposition to fuel fossil prices, this strategy can be discussed in the terms given above: is it worth to invest now or later? If later, when? How long will the natural gas and coal remain cheap?

Construction of transmission lines is a very important requisite to the construction of renewable energy facilities. RES development implies the decentralization of the grid, resulting therefore in a greater number of associated infrastructures, namely substations and transmission lines.

About the topic "quality of life improvement", it can be two-folded: general population improvement or more local improvement. It is agreed that renewables offer more local positive impacts; given the low density of installed power, many wind farms are equivalent to one gas power plant, for example; therefore, many rents will come from land use probably in different regions in the case of wind farms, benefiting more people. On the other hand, the rising prices of numerous commodities, given their relation to electricity prices, can be seen as negative.

Thermal power

These technologies represent the *status quo* of power production, therefore contribute to keep low electricity prices at the cost of foreign dependency and vulnerability to finite resources price volatility. On the other hand, they represent tested and reliable forms of producing power. Coal is seen as a natural polluter in the long run, whereas natural gas is seen as cleaner from this point of view (a noble fossil fuel, in the opinion of two interviewees, which should not be burnt to produce electricity). The prices of natural gas depend very much on the regulatory framework and how will evolve the Portuguese and Spanish markets in the future and decisive strategic investments in this area. Also, the ability of natural gas combined cycle power plants to contribute to lower electricity prices was stated to depend on the ability to integrate those with wind power. If natural gas power plants play a minor role, their power will cover only the few peak (expensive) hours. This can lead to the misuse of these power plants, turning hard to justify such large investments. Therefore, no linear or clear relation exists between the power plant and low output price, but it rather depends on how the power plant is used.

Nuclear power

To what concerns nuclear power plants, it is agreed that only a large (in relation to the scale of Portugal) power plant is feasible, what would not only imply a redesign of the transmission grid, but also induce market power problems that would have to be carefully studied by regulators. The vulnerability to resource prices is not seen as dangerous as in the cases of coal or natural gas, given the historical stability of prices and its low value. This contrasts with the main problem: the high initial costs. Additionally, no know-how about nuclear power exists in Portugal, therefore knowledge and capital requirements have to account in the importations balance. Solid waste and opposition to power plants are very important matters yet, only expected to disappear if mankind manages to develop nuclear fusion technology and replace the traditional nuclear power plants.

CONCLUSION AND FUTURE WORK

A wide array of impacts was constructed from literature review and interviews with experts in power systems, and assumed the form of comprehensive impact chains or logic diagrams. These can aid decision-making in sustainability issues and evaluation applied to power systems.
A contradiction still exists: between needed short term economic competitiveness *and* long term sustainability. This means that trade-offs must be considered for the definition of electricity strategies for the future. Although this is an assumption accepted in general, political factors tend to influence significantly the decisions, even surpassing the power systems expertise.

Given that the traditional sources are not limitless, RES will eventually have to play an important role in the future, when fossil fuels become more expensive. This will turn RES automatically attractive under an economic perspective. Before that time comes, RES are still expensive, but can foster knowledge, new industries and eventually economic growth, especially for countries like Portugal, which relies mainly on foreign resources.

Since the expert interviews show some scepticism about the RES job creation potential and even about the RES ability to improve locals quality of living, it turns essential to proceed to the second phase of the research, to talk with local stakeholders, in order to recognize their perceived negative and positive impacts. As for thermal power plants, the importance of local impacts does not seem to be as significant. The general view of experts clearly favours that national level impacts are the most important ones, turning the local impact assessment studies a less important requirement for the verification of the logic models. In fact, most of the impacts related to CO2 emissions, cost or volatility of fossil fuel prices may be evaluated resourcing to mathematical models such as Pereira et al [16].

Future work will also use the logic diagrams in multi criteria techniques, aiming to weight the importance of the components of the logic models, to evaluate the sustainability of technologies and specific scenarios of production in Portugal.

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