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Facilitating solid biomass production planning: Insights from a comparative analysis of Italian and German marginalized areas

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ABSTRACT

Solid biomass planning is a complex and multifaceted process, as it aims to achieve a large number of objectives while involving various stakeholders. This complexity heightens particularly in marginal areas, where socioeconomic weaknesses are critical obstacles to the sustainable development of these territories. This paper proposes an integrated method for dealing with such problem by using a combined optimization approach. This is done in order to implement the 'best' investment solution to be realized in marginal areas, and a benefit cost analysis to assess the feasibility of investment for each involved operator. The methodology of the study maximizes the utility of the stakeholders in the respect of the territory. The effectiveness of the proposed approach has been demonstrated through a twofold and comparative application, both in Italy and in Germany, in order to verify the results.

1. Introduction

Over the time, the interest in energy has become a hot topic, so that its impact on the economy provides crucial elements in the development of policies for the progress of countries (IEA, 2016). Recently, the energy issues are a priority for many international organizations—such as the World Bank and the European Commission - in the economic and political agenda (Blazejczak et al., 2014). The Renewable Energy Directive (European Parliament, 2009) establishes an overall policy for the production and promotion of energy from renewable sources in the EU. It requires the EU to fulfil at least 20% of its total energy needs with renewables by 2020 – to be achieved through the attainment of individual national targets (European Parliament, 2015). Recently, in order to reach this objective, the debate is focused on—environmental, economic and social—sustainability of the current energy model that makes necessary interventions, in term of both policies to be implemented and infrastructure projects to be realized, such as to allow substantial improvements in terms of safety, costs, environmental and economic sustainability (Yigitcanlar et al., 2015).

This requirement should sway toward a reconversion of the energy model, which aims at 'alternative' energy production by maximizing the use of the renewable energy sources (RES), and that, in turn, could contribute to the economic growth (Kahia et al., 2017). Currently, this argument is supported by some of the economic literature that have corroborated both the energy-led growth hypothesis (Aslan, 2016). This is achieved by confirming the one-way causality direction relationship between the renewable energy consumption and the economic growth (Bhattacharya et al., 2016), and the feedback hypothesis on interdependent and complementary between the renewable energy use and economic growth as result of a two-way causality direction (Ahmed and Azam, 2016).

Among the renewable energy, the biomass is among those that have a largest positive impact on GDP (Armeanu et al., 2017). Currently, this renewable energy appears to be the most attractive among the available sources (Ben-Iwo et al., 2016): the relevance of the biomass is linked to both the possibility to storage allowing to meet seasonal heat demand and the investments to be realized, which, being part of the aggregate demand, play an essential role as driver for the local development (European Commission, 2014). According to Landolina and Maltsoglou (2017) the production of biomass, besides feedstock and downstream processes, determines further positive multiplier or spillover effects for the whole economy (i.e. by transporting biomass or biofuels to consumers or export markets or by creating new sources of income, which, if

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spent on consumer goods and services, creates a virtuous circle with additional demand for non-biofuel products). These motivations have moved the public authorities to implement a strong incentive policies for the production of biomass Energy by defining a coordinated program of action for implementing the feedstock and biomass (European Commission, 2005).

In fact, the biomass—being better realized in rural areas, where feedstock derives from energy crops and rural wastes—play an essential role on economic development of these areas for the generated impacts (Ahmed and Azam, 2016). The biomass plans support rural economies—affected by lower income levels, an unfavorable demographic situation, higher unemployment rates, a slower development of the tertiary sector, weaknesses in skills and human capital, a lack of opportunities for young people and a lack of necessary skills in parts of the agricultural sector and food processing industry—by creating jobs and providing an additional source of income (Demirbas, 2008).

However, planning of local biomass system can be very complex, because of multiple objectives and stakeholders. The growing complexity of socio economic system and the substantially increase of information have made more articulated the decision process, which can rely less and less on subjective judgment (Arbolino et al., 2018; Szopik-Depczyńska et al., 2017). In order to address this challenge and with the intention of decide, which plans are the most eligible, considered both exogenous constraints (availability of public funds-that are generally limited-emission retention, social acceptance, the side of usable lands, etc.) and constraints between variables, a decision support system (DSS) could be helpful (Marinakis et al., 2017). In so doing, decision-makers could consider priorities and factors that imply to choose between a wide range of proposals, evaluating impacts associated to the different variables. This procedure allows to find a best compromise solution among socially relevant objectives besides to quantify operative incomes and costs (Rostirolla, 1998). The economic evaluation has to be made before taking definitive decisions about the plan.

This paper describes the complexity of the planning problem by taking into account both economic, environmental and social impacts arising from the strategic choices. The purpose of this research is to provide a tool in order to evaluate both the goodness and the feasibility of an action plan by choosing, among alternative investments for the production of solid biomass energy, those that maximize the utility of the stakeholders in the respect of the territory. Thus, a methodology based on combined decision support tools is proposed.

At the first level, the approach incorporates a multi-objective optimization model, which allows to generate all the information the policymaker needs to support each decision step concerning the selection of the projects (Arbolino et al., 2017a); at the second level a direct and transparent cost benefit analysis allows to evaluate the feasibility of each involved actor—power company and farms—in order to lead a whole evaluation of biomass planning and to provide some reflections on the currently incentive system. In this context, the paper places Italy and Germany under the microscope to investigate their state to generate insights on the capability of the proposed approach. Literature highlights the suitability of these country contexts for this investigation (Arbolino et al., 2017b).

Our analysis participates to the debate on the methodologies to be apply for energy planning (Zhao, 2016). The importance of this issue, overall for the economic, social and environmental aftermath requires a deepen analysis of the tools to be used, which should focus not only on the choice of the projects that maximizing the social utility but also on the feasibility of the interventions (Santoyo-Castelazo and Azapagic, 2014). Given these weaknesses, our contribution consists of proposing an integrated approach to evaluate both sides, for considering the existent legislative framework and the incentive arrangements for better support policymakers. Moreover, a further innovative element is provided by the use of a disaggregated approach for operator in the application of the Cost Benefit Analysis, overcoming the classical approach that assesses the feasibility of the whole project without considering any redistributive effects (De Simone and Rostirolla, 2012).

The paper is structured as follows. Following this introduction section, the second section presents the main approaches for renewable energy planning. The third section describes the methodology applied and the data. The fourth section provides the results of the simulation implemented both in Italy and in Germany. The final section discusses the findings, provides policy suggestion, and concludes the paper.

2. Multicriteria decision-making methods for renewable energy planning

The political, social, economic and environmental relevance of energy sector, the features of the renewable (decentralized production, located costs, distributed benefits, involvement of stakeholders) and the complexity of the system to be analyzed require a decision support system in order to better solve the challenges of the energy planning (Banos et al., 2011). The purpose of DSS is to offer to the policy maker an ongoing support that allows to expand his capabilities from the formulation of the problems to the evaluation of the solutions, without imposes choices and default solutions (Gudes et al., 2010; Scott et al., 2012). Several methodologies exist in order to solve decisional problems. These methods can be distinguished in two categories: (a) techniques for alternatives elimination; (b) techniques for alternatives ranking. Among the most well-known procedures, in the first cluster belong conjunctive and disjunctive methods, (Yoon and Hwang, 1995); ELECTRE (Roy and Vincke, 1981); multiple attribute utility theory (MAUT) (Keeney and Raiffa, 1979); (c) in the second, analytic hierarchy process (AHP) (Saaty, 1990, 1980); preference ranking organization method for enrichment evaluation (PROMETHEE) (Brans and Vincke, 1985) and TOPSIS method (Yoon and Hwang, 1995).

A separate mention should be made for the optimization methodologies that involve many deterministic models with different objectives in the final choosing phase. These objectives are connected to the different applied algorithms and that can lead to choose among different alternatives, in order to achieve an ‘optimal solution’ or seek the best compromise solution (Zeng et al., 2011).

Decision Support systems and multi-criteria decision-making methods have been used to great effect in energy planning for assisting the decision makers due to the complex and interlinked data in this sector. Over the last two decades, there has been a notable increase of researches concerning energy planning by using DSS: until 1995 the survey on decision analysis (DA) in energy and environment counted 95 academic papers (Huang et al., 2015). Zhou (2015) has updating the counting discovering that about 160 more were carried out between 1995 and 2004.

Concerning the biomass sector, Marinakis et al. (2017) recently used MAUT in order to select sustainable renewable energy sources (RES), and rational use of energy (RUE) technologies. Sánchez-Lozano and Bernal-Conesa (2017) have suggested the implementation of the ELECTRE method, for the selection of renewable energy installations in order to promote the diffusion of such technologies to a regional level.

Delivand et al. (2015) applied the Analytical Hierarchy Process (AHP), integrated into a geographic information system (GIS), to determine the locations of a centralized and some decentralized power plants using biomass sources. Scott et al. (2015) integrated three aspects in a common framework: a stochastic approach,