



Research paper

Sustainability impact assessment for local energy supplies' development – The case of the alpine area of Lake Como, Italy

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ABSTRACT

The development of distributed energy systems has important environmental, social and economic implications. Local decision-making processes must be guided by a careful evaluation of the sustainability of production chains and alternative choices. The aim of this study is to explore if and how an integrated assessment can quantify the extent to which bioenergy supply chain development contributes to rural development and energy policy objectives. We applied a Sustainability Impact Assessment (SIA) for local bioenergy development in the alpine area of Lake Como (Italy). We modeled the local bioenergy chain in 2008 and eleven scenarios considering different biomass utilizations, mechanization levels, combustion technologies, and subsidies schemes at 2020. We calculated economic, social and environmental indicators. We interpret and discuss the scenario analysis in order to support the bioenergy planning under the light of its implications for the different policy aims and concerns.

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1. Introduction

The role of forests and the forest-based sector as a source of fuel is well known in the energy policy context [1–4]. The demand for wood is increasing due to the renewable energy targets of the European Union by 2020 and augmented competitiveness of renewable sources over fossil fuels [5–8]. “Overall wood energy accounts for 3.3% of the total primary energy supply and 38.4% of the renewable energy supply in 28 UNECE member countries” [9].

The European Commission's policy document of 1988 “The Future of Rural Society” [10] emphasized the “multiple links” between energy and rural development. For European policy, the role of forests is increasing in importance for rural development [11], as they are a source of raw materials, food, and recreational value [12]. Rural development is oriented towards the use of local resources to provide benefit to the local population, and to prevent the depopulation of rural areas thorough increasing local employment opportunities [13–16]. Several studies [17,18] confirm the linkage

between rural development and sustainable planning and the need to explore the trade-offs between different development options [19,20].

The development of distributed energy systems has important implications for sustainable development [21]. The aspects related to increased employment opportunities due to the development of local energy generation have been examined in several studies [22–25]. The main challenges are related to the economic feasibility and the need for investment in infrastructure [26,27].

In addition to this, the development of local energy chains causes environmental impacts along the whole supply chain. In the case of forest-energy chains, direct impacts from harvesting activities, transportation, transformation of raw materials, and energy generation must be evaluated [28]. Several studies in Europe show a growing contribution of wood fuel towards domestic heating in urban areas and the impacts of this on the environment, especially on air quality [29–31].

In this context, local decision-making processes must be guided by a careful evaluation of the sustainability of production chains and alternative choices [32,33]. Analysis of environmental, social and economic aspects of sustainability [34,35] are needed to provide comprehensive information to local decision makers [36–38]. Moreover, paying attention to the different stages of the bioenergy

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production chain strengthens the bioenergy sector [28]. For that reason, there is a need for assessment tools, that are able to take various aspects related to sustainability of processes into account [39,40]. However, bridging the gap between science and decision-making effectively is still an open challenge [41–43].

The aim of this study is to explore if and how an integrated assessment can quantify the extent to which bioenergy supply chain development contributes to rural development and energy policy objectives. We applied a Sustainability Impact Assessment (SIA) of energy development options for an alpine region in order to measure how different bioenergy scenarios impact on rural development and energy policy aims. Regional and local authorities believe that the improvement of short bioenergy chains can stimulate development in rural areas, aid in meeting regional goals by 2020 and improve the security of energy supply [44–47]. The 2020 target for the share of renewable sources in total energy consumption for the Lombardy Region is 11.3%. Local authorities' interest in a wider assessment is confirmed by the Interreg project "Saperi Alpini" [48], which aims at the sustainable development of the area, and high priority is given to the sustainable use of local wood for energy.

Environmental concerns, and particularly air pollution, also play a significant role for the study region [49,50]. Lombardy region is one of the most polluted European areas for particulate matters, due mainly to the topographic mountainous features that hinder air exchange. Biomass combustion is now more tightly regulated [51], since the combustion of wood produces an important share of particulate matters (about 30% of PM10 emissions in the Region in 2003) [52].

Generally, studies in the same context have focused only on a single aspect of sustainability, such as availability of natural resources [53], economic profitability and forest harvesting activities [54] or environmental impacts [49,55,56]. However, there is a lack of knowledge of the local forest and energy systems in local plans and frequently data are inconsistent or outdated. We expect that SIA can bring benefit to local decision-makers by quantifying impacts on environment, economy and society of a supply chain, and aiding in evaluation of the effects of planned actions over time. SIA can also help in handling heterogeneous datasets for obtaining a big picture of the local forest-energy sector. Specifically, we consider:

- Biomass utilization and energy generation technologies – The quantity of energy (heat and power) depends on the quantity (and quality) of used biomass and on the efficiency of the combustion processes, therefore, different inputs in terms of biomass and combustion technologies must be compared to estimate the (actual and potential) contribution to energy production from forest sources;
- Mechanization levels – Harvesting machinery owned by and available to local enterprises have been considered in the different scenarios in order to define different mechanization levels;
- Economic aspects – Economic impacts of baseline and several future scenarios have been analyzed. The focus here is on subsidies for energy from renewable sources, because they determine the economic feasibility of local energy production and also bring additional profit to local enterprises. However, a good investment cannot rely on long-term subsidies. Therefore, the role of subsidies in the various development options must be evaluated;
- Social aspects – Developing local energy production systems can prevent depopulation of rural areas; therefore it is important to estimate the direct impact on employment of the different options;

- Environmental aspects – Assessing the environmental impacts of biomass use for energy for various scenarios is one of the aims of the study, which focuses in particular on direct emissions.

The scenario analysis will be interpreted and discussed in order to support the planning of a local forest-energy supply chain in the rural area of Como Province in Italy under the light of its implications for the different policy aims and concerns.

2. Materials and methods

2.1. Study region

The Province of Como is in the north of the Lombardy Region of Italy and borders the Swiss Cantons of Ticino and Grisons to the North. Lombardy's forest area is estimated at 620,122 ha (at 2010) [57]. Its timber and furniture industry is important, with 9% of all workers in the national manufacturing industry [58].

The area of Como Province is about 129,000 ha and forests cover around 45%. The central and northern parts of the Province are montane, characterized by alpine and subalpine forests. Total population is about 600,000 habitants, and is concentrated in the plains and along the shores of Lake Como. The local economy is based on engineering, textile industry and tourism. The rural and montane areas have a low population density. At present, depopulation is not as much of a threat as in other rural and montane areas of the Alps [59], because many people work in Switzerland as daily commuters. Nevertheless, the political acceptance of Italian commuters among Swiss communities has been recently questioned and policies aimed at limiting the access of foreign workers have been proposed [60]. As a result, depopulation due to more limited employment opportunities could become a threat for the region in the coming years.

In spite of the plentiful availability of wood as a raw material, forestry operations are limited [61]. The overall management of the forests is hampered by the extreme fragmentation of property ownership (between public and private owners) and the limited economic power of public owners (mainly municipalities). In addition, the topography of the area (steep terrain with limited accessibility) and the characteristics of local forestry firms (small businesses, family managed, with limited equipment) limits the use of highly mechanized systems and reduces the productivity and the value added by harvesting activities.

As a result, the biomass stock in the forest is increasing because many forests are not being managed. In addition, forest area is expanding on agricultural land due to the abandonment of farmlands. Unmanaged forests are a threat for landslides [62] and fires and cannot be used for recreational purposes, as the costs of trail maintenance are not covered by the value added by forest operations.

The development of wood-based chains can be a way to pursue better management of the local forests, in addition to the creation of employment and the improvement of social conditions (e.g. no more need for commuting or emigration due to work needs).

2.2. Sustainability impact assessment of forest-energy chains

The Sustainability Impact Assessment (SIA) method has been chosen for a comprehensive assessment of certain environmental, social and economic impacts of several scenarios related to the development of local forest-energy chains. The Tool for Sustainability Impact Assessment (ToSIA) [63–65] has been applied to this case study. ToSIA has been chosen due to its user-driven ability to tailor system boundaries and assessment focus, its flexibility in merging various data, and its capacity to model local supply chains.

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