SEA and biomass energy industries planning

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Abstract

This work examines the case study of a biomass power plant in Sardinia (Italy), as a part of a greater industrial conversion plan. This plan combines: biodegradable plastic monomer plant, a biodegradable vegetable oils plant and a thistle biomass plant for steam and energy production.
So far, no Strategic Environmental Assessment (SEA) for the whole industrial plan has been performed. Environmental Impact Assessments (EIA) at the single plant level identified some issues, however, cumulative impacts and environmental sustainability assessments have not been yet implemented. Indeed, the integration between biomass production for energy purposes, oil production for monomer and biodegradable oils plants needs, has not been sufficiently addressed.
The combustion of thistle biomass used in this plant has environmental consequences, including loss of land due to intensive cultivation, potentially dangerous emissions and ash production, and uncertainties regarding a sustainable availability of the biomass. Further, the choice to produce energy from biomass combustion seems to be mainly determined by incentives granted for renewable energy.
The opportunities for a comprehensive strategic planning are substantial. For example, wastewater reuse planning could be directed toward the development of alternative and/or complementary crops that are better suited for biodegradable plastic production.
There are still several issues to be addressed in this field: food *vs* non-food crops; incomplete assessments of the environmental sustainability at single plant level; effectiveness and interpretation of National and European laws. Answers and solutions to these questions could come from suitable planning and from an effective SEA, as well as from the revision of laws concerning both renewable energy planning and policy for the incentives for bioenergy production.

Introduction

The production of electricity from renewable and sustainable energy sources has been encouraged by the European Parliament through Directive 2009/28/CE, and subsequent recommendations following the COM (2010) 11 report on the sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling.
The goal of Italian legislators has been to increase the production of renewable energy through economic incentives. As a result, the creation of renewable energy production plants has greatly increased, particularly plants dedicated to bioenergy. However, the development of biomass power plants has generated serious concerns among local communities.
The present research assesses the environmental impact at a single plant and highlights how energy production considered “Green” may cause cumulative negative environmental consequences.
We conclude that the simple criteria of assessing the reduction of CO_2 emissions to receive government incentives may not be adequate to ensure an effective and environmentally sustainable project.

Case study description

The present work focuses on the EIA for a biomass energy plant located in Sardinia — a Mediterranean island of about 24,000 km^2 whose economy relies mostly on tourism and agriculture. The plant would be able to burn 250,000 t/y of biomass and to produce, in 7,500 working hours, 135 MW_{th} in a year. It is part of an industrial conversion plan that includes the creation of plants for the production of monomer for bioplastic as well as for vegetable oils.

At this plant, biomass is obtained from the thistle crop, *Cynara cardunculus* var. *altilis*. Its seeds are processed for extracting oil that is used to meet partial needs of the chemical plants. The thistle straw feeds the thermal power plant in cogeneration, producing both electric energy used in the electric distribution network, and low-pressure steam for the monomer and biodegradable oil plants (Figure 1).

The whole project is divided into phases with each phase having its own independent EIA. Each phase is limited in space and time.

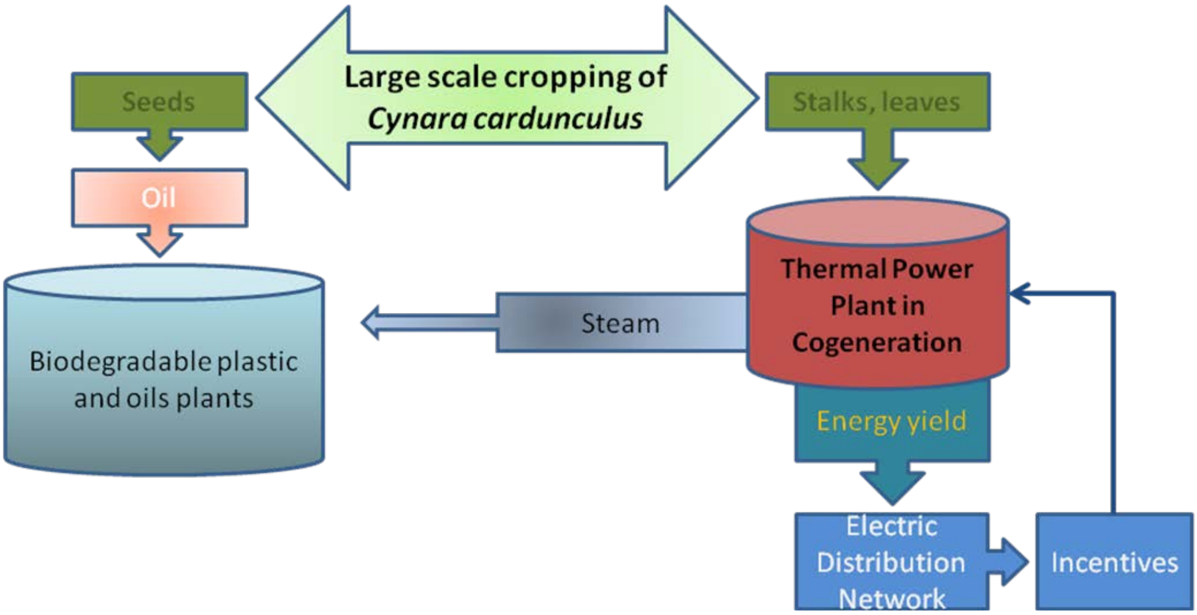

Figure 1 - Whole Project Diagram

Analysis and results

The analysis of the Environmental Impact Statement (EIS) of the biomass power plant highlights several environmental issues. Figure 2 depicts the critical environmental issues identified and related to each of the individual phases in the energy production.

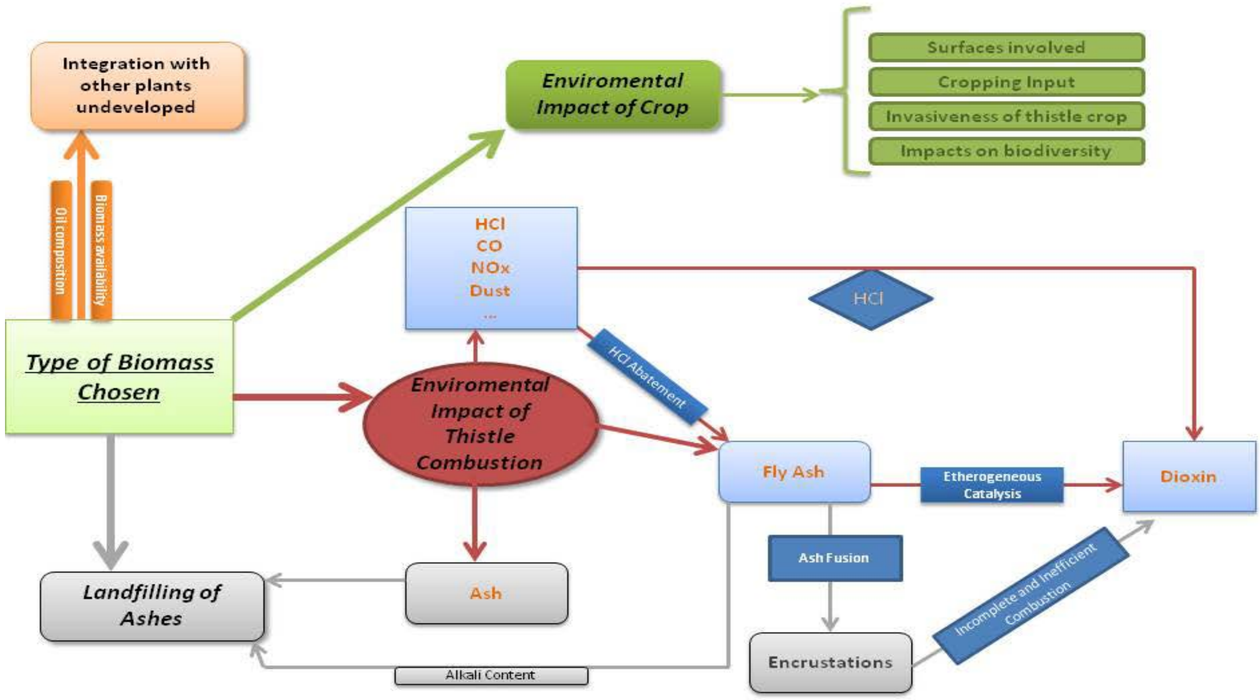

Figure 2 - Environmental Issues: Summary Diagram

Here below a more detailed description of the potential impacts related to the choice of *Cynara cardunculus* var. *altilis* as biomass.

<u>Combustion</u>

1. Thistle straw is characterized by a high chlorine concentration — from 1 - 2% of the total mass. High chlorine and alkali concentration may result in damage to the plant's infrastructure such as corrosion of metal parts and the creation of obstructions.
2. Combustion in the presence of organic carbon, oxygen and chlorine can generate dioxins. The high chlorine concentration in thistle can produce PCDD/PCDF in particular conditions such as: heterogeneous catalysis in the presence of fly ash in smoke, and/or lower combustion and smoke temperatures, and/or the presence of pesticide precursors or metals content.
3. Thistle straw is characterized by high ash content (about 10 % of mass) a part of which is classified as hazardous waste. Ash management options, identified by the proponent, involve their reuse in building materials, for environmental recovery and for compost production and landfill. However, the limitations of ash reprocessing are well known. Ash is characterized by a high alkali and chlorine content and is not suitable for building materials, and currently, technical and regulatory guidelines for the use of ash as fertilizer and/or soil amendments are not available. Indeed, research carried out in Northern Europe has demonstrated potential hazards related to ash composition including contaminants such as metals, Polycyclic Aromatic Hydrocarbons (PAH) and Dioxins.
4. Since the recycling of ash from thistle combustion is not practical, ash-waste between 500,000 and 750,000 tons would be placed in landfills in the next 25 years. Such landfill capabilities are not available in the geographical area surrounding the plant.
5. Thistle straw has both a good calorific value and biomass yield that could justify its use. On the other hand, oil yield is poor (0.4 – 0.6 t/ha) and inadequate to meet the actual need of chemical plants. Furthermore, oleic acid content of thistle oil is about 25%, whereas a higher content of 80% is required for the monomer production by the Environmental Permit.

<u>Large-scale cultivation of *Cynara cardunculus* var. *altilis*</u>

There are no legal requirements for an EIA for biomass crop and oil production from thistle. Further, the environmental impact of thistle crops grown in different environmental conditions has not been analysed.
The main issues related to monoculture of thistle are discussed below.
Cynara cardunculus var. *altilis* is a non-native species in Sardinia and its cultivation on 40,000 hectares raises concerns about its invasiveness and its impact on the natural and agricultural ecosystems. The potential invasiveness should be investigated using the *Pest Risk Analysis,* performed according to the International Standard for Phytosanitary Measures.
Additional issues regarding *Cynara cardunculus* cultivation involve: land avilability; its impact on surrounding crops; its integration with local production systems; the feasibility of crop rotation and, finally, the substantial and potentially irreversible change of the natural crop habitat, particularly in areas subject to environmental protection by National and/or European laws.
Cynara cardunculus var. *altilis* productivity varies from 5 to 15 t/ha, depending on meteorological factors, pest attacks and pedoclimatic characteristics of the site. Absence of irrigation, combined with lack of precipitation and the absence of phytosanitary protection against the curculionidae *Larinus cynarae* F., can make thistle biomass production economically unsustainable with reduction or failure of seed production. Figure 3 shows a large infestation of the sperimental crop by the curculionidae. Cultivation techniques for this crop are still experimental and have to be optimized for stable annual yields. Mechanized harvesting is also experimental, as well as the use of the prototype machinery (Figure 4). Further, high input cultivation to ensure high crop productivity, raises concerns about environmental sustainability of the project in the long term.

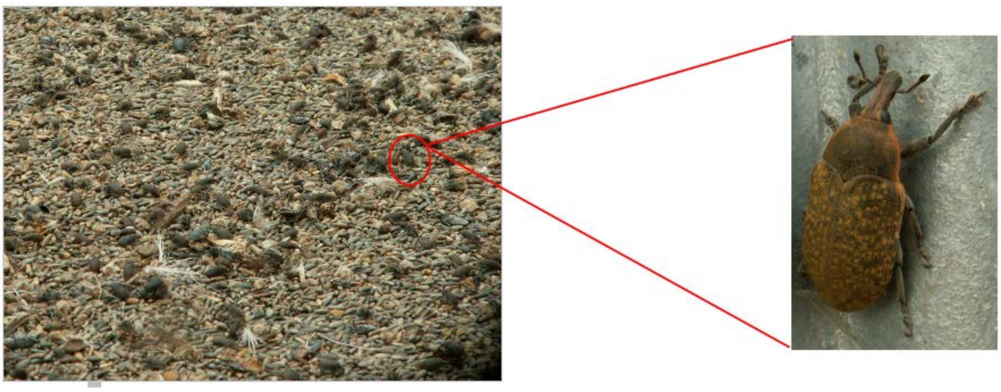

Figure 3 - Curculionidae *Larinus cynarae* F . on recently harvested seeds of *Cynara cardunculus* var. *altilis*. The insert shows an adult

Figure 4 - Experimental test for the separation of vegetable fractions, using a patented machinery

As far as biomass procurement planning is concerned, *Cynara cardunculus* var. *altilis* can be considered a dry farming crop. It should be emphasized that a number of agricultural areas intended for thistle cultivation, already have an effective irrigation infrastructure that would be largely unused in case of dry farming — unnecessary waste of public investments.
Further, these same areas host two wastewater treatment plants for the treatment of 25 million m^3/y of wastewater. These plants were financed with European funds specifically aimed at using treated wastewater for agricultural purposes. In the absence of agricultural use, the treated wastewater would be discharged in a catchment basin draining into a lagoon that is regulated by European Environmental Directives. Indeed, the lagoon, close to the sea, currently exhibits a number of anthropogenic environmental impacts related to the water quality. As a consequence, the coastal bathing water quality is also affected, with great economic consequences for the tourist sector. On the other hand, water availability (also considering wastewater reuse) could allow alternative crops, suitable for oil needs requested by monomer plants.
Taking into account all the reservations related to thistle cultivation combustion and the scarce thistle crop integration within the whole production cycle, it is necessary to assess the suitability of alternative crops for bioplastic and biodegradable oil production with fewer hazards associated with ash-waste, chlorine, alkali and nitrogen content.

Both EIA and SEA require a comparative analysis of different scenarios for crop cultivation and processing. As such, the consideration of alternative crops should represent a fundamental requirement to be assessed in the SEA. The lack of this methodological approach impairs both the identification and assessment of the global impacts of projects on the territory.

Conclusions

We have indicated the procedural deficiencies of the EIA for a specific biomass power plant. The choice of the type of biomass appears to have been determined by the demand for energy production, rather than optimizing oil production, possibly because of the incentive system. The choice of a specific biomass generates a number of environmental issues, indicating that the criteria used for the CO_2 emissions reduction are not comprehensive or adequately precautionary.
The integration for the requirements for the productions of energy, monomers and biodegradable oil appears to have been scarcely developed. This specific project had only considered the use of residual biomass-derived oil production, and therefore an estimated zero CO_2 emissions. However, even though the whole project does not concern energy crops, thistle cultivation has to be considered a non-food crop.
Therefore, appropriate assessments of the loss of land for food-crops and the cumulative impacts on biodiversity should be performed when considering intensive cultivation throughout the entire territory (making a distinction between food and non-food crops). Though the combined environmental effects of monomer production, biodegradable oil, thistle-crop and energy production have not been properly assessed.
Moreover, incentive policies should require greater guarantees on environmental sustainability — including constraints on waste production and its management; on air emissions, as well as on thresholds for use of non-food crops, as a form of protection for food crops in agricultural areas used.

Finally, the approach adopted by the proponent does not allow cumulative and synergistic impact assessments. Specifically, EIA at a single plant does not include the environmental impact of the production of crop and oil and it does not consider that monomer and biodegradable oil plants will expand over time.
We therefore believe that the EIA at a single plant might not be the right tool to meaningfully assess the real environmental/economic costs and benefits of a sustainable energy program, and only a SEA related to the whole industrial plan could provide a comprehensive assessment of the issues.
We emphasize the importance of planning a SEA in order to reveal the environmental impact issues in both the renewable energy incentive system and the sustainability assessment for bioenergy production in large combustion plants.

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