CHEMICAL ENGINEERING TRANSACTIONS
VOL. 67, 2018

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Valerio Cozzani, Bruno Fabiano, Davide Manca

ISBN 978-88-95608-64-8; **ISSN** 2283-9216

A Novel Methodology and Technology to Promote the Social Acceptance of Biomass Power Plants Avoiding Nimby Syndrome

Aristide Giuliano, Filomena Gioiella*, Daniele Sofia, Nicoletta Lotrecchiano

Sense Square srl, Corso Garibaldi 33,84123, Salerno (SA), Italy
filomenagioiella@sensesquare.eu

Nowadays the greatest contribution to atmospheric pollution is due to carbonic dioxide (CO_2) emissions resulting from industrial activities. Among the various technologies for the production of energies from renewable sources, the biomass combustion is the technology that better replaces the fossil fuels. Unfortunately, one of the limits to the spread of this technology in Europe and not only is the lack of social acceptability of the plants, in particular solid fuel biomass combustion. The “Nimby Syndrome” (Not In My Back Yard) is the strong opposition of the neighboring populations to their realization.
The most significant reason of non-acceptance by populations consists in atmospheric pollution. People are worried about the effects on human health of possible atmospheric pollution caused by the gaseous emissions of combustion plants. Consequently, the formation of citizen committees against plant installation is promoted.
The objective of this work is to identify a methodology able to contrast the “Nimby Syndrome” in the case of biomass power plants. The main actions to promote the social acceptance of biomass power plants are:

- Verify upstream of the realization (design phase) the effective use of BAT (Best Available Technologies);
- Involve the citizen at all stages of plant design;
- Install stationary cameras (internet connected) that make images of raw material in the plant available on-line 24 h/24.
- Realization of spatial and temporal high-resolution monitoring networks in order to verify the real impact of emissions on air quality in neighboring areas and to give the monitoring data available 24/24h to all citizens.

About the last point, an innovative technology was used to carry out the air quality monitoring at high spatial and temporal resolution. These monitoring networks have to be installed before and after biomass plant realization. In this way, it is possible to have a comparison of atmospheric pollution before and after plant operation. The optimal arrangement of low cost monitoring station and data processing modes (also by using forecasting models) are described in this work. In this way, is possible to demonstrate the transparency about emission levels to citizens.

1. Introduction

The growth of the world economy and the increase in the population of the planet (9 billion people are estimated within 2050) are clear warnings of fast consumption of earth resources. Energy is the most employed resources by human activities; it is used in various forms, thermal or electric. Today the custom of fossil sources predominates on renewable ones. It is expected that in the following years this scenery will be reversed thanks to the growing common knowledge of the environment consideration (Cicia et al., 2012). A source of renewable energy is represented by the use of biomass. The biomass combustion is the better technology that replaces the fossil fuels (Ng and Lam, 2013). The amount of biomass "actually available" is 5.4 million tonnes of dry matter per year which could contribute 10-12% to the world energy balance. These quantities could satisfy the needs of approximately 440 thermoelectric power plants with a capacity of 1 MW, setting an annual consumption of around 12’000 tonnes of woody biomass per year and an operation of 8’000 hours per year. On the other hand, in order to favor thermal production with the same amount of biomass it is possible to realize 5’500 district heating/cooling plants with a heat output of 1 MW with an average consumption of about 1’000 t/year for each of them for 3’000 operation hours. As an alternative to the each other, these plants could produce about 3.5 TWh of electricity (without considering the possible use of cogenerated heat) or about 16.5 TWh of heat in addition to an amount of electricity produced with cogeneration. In Italy the plants fed by solid biomass in operation are 192 (including 4 large co-firing plants with coal in Sardinia for a total capacity of 2’476 MWe and an annual electricity production equal to 2’463 GWh. In the next years, a total power of additional 1’500 MWe will be installed, equivalent to approximately 6’000 MWt of primary energy that will be located in rural areas, where the raw material needed to operate them is more available (State of the art of bioenergy in Italy, 2014). According to CNEL, within 2020 the contribution of biomass can produce 10 to 16 terawatt/hour. Biogas plants deriving from solid urban wastes and integrated incinerators with cogeneration will mainly benefit from the increase. About 3 billion euros of investments and an occupation between 8’300 and 23 thousand units are expected. Above all, the future prospects for solid biomass are significant: in fact according to the NAP (National Action Plan for Renewable Energy) about 45% of renewable energy will have to come from biomass within 2020. Further, from biomass is possible producing also fuels (ethanol, biodiesel, etc) and added-value chemicals, together electricity (Giuliano et al., 2015).

1.1 Biomass energy advantages and controversies

The most important contribution of biomass is the reduction of atmospheric pollution that concerns into the emissions of carbon dioxide (CO_2) (Sofia et al., 2013). As known, the CO_2 produced during the biomass combustion is counterbalanced by that absorbed by plants during their growth. Therefore it is "renewable" CO_2 compared to the "fossil" one emitted with the combustion of traditional energy sources. In addition to the CO_2 balance, the biomass can have a number of additional advantages compared to fossil fuels, which vary depending on the systems and technologies used. In previous works (Sofia et al. 2014), it was demonstrated that incentive for the gasification of biomass comes from the much higher power generation efficiency that can be obtained in Integrated Gasification Combined Cycle (IGCC) plants with respect to power plants based on direct combustion and steam cycles.

Nevertheless, this scenario does not lack some social issues and controversies. One of the main limitations hindering the development of biorefineries is the uncertainty of a continuous supply of the biomass feedstock during the year and the whole plant lifetime. As a result, the effect of the change of the biomass type and composition on the plant performance should be accounted for the initial conceptual design of the multiproduct biorefinery. Giuliano et al. (2016) applied a methodology that take into account the effect of the change of the biomass type and composition in the conceptual design of a multi-product biorefinery transforming lignocellulosic biomass into levulinic acid, succinic acid and ethanol.

Furthermore the development of electricity by biomass is limited due to the lack of social acceptability of the plants, in particular the plants that burns solid biomasses (Van der Horst et al., 2002). The public opposition to unwanted local energy projects for example plants from biomasses is called “Nimby” (Burningham, 2000; Devine-Wright, 2009.).

The "Nimby Syndrome" is the protectionist attitudes adopted by community groups that believe in the “noxious” utilities installation but not near their homes, hence the term “not in my back yard” (de Meo et al., 2014). The “Nimby Syndrome” has spread particularly in Europe, where there is always growing the mistrust of institutions due to past irregularities, an obstacle to the development of the supply chain, exacerbated by a perceived lack of fairness towards institutions, as well as lack of information (How and Lam, 2017).

The causes of the lack of social acceptability are a series of elements that could cause a loss of wellness for local residents. Among these causes the most relevant are (Upreti and van der Horst, 2004):

• The atmospheric pollution;
• The increase of vehicular traffic in residential areas;
• The fear of risks to public health;
• The negative impact on the landscape.

The most significant reason of non-acceptance by populations consists into atmospheric pollution derived from biomass plant installation (Upreti and Van Der Horst, 2004). People are worried about the effects on human health of possible atmospheric pollution caused by the gaseous emissions of combustion plants. In addition to gaseous pollutants, small particulates are substances responsible of direct damages to human health with particular reference to particulates with size less than 10 μm, PM 10, and less than 2.5 μm, PM 2.5. As a consequence, the installation of new plants can increase the vehicular traffic in residential areas (raw materials transport by trucks) and contribute into negative impact on the landscape. Accurate measurements of the concentrations of these pollutants are important not only from an environmental point of view, but also for economic reasons, since a part of taxation may be dependent on the emission values (Salehi et al., 2015).

Consequently, the formation of citizen committees against plant installation is promoted (Sacchelli, 2014).
As shown in Table 1, in Italy a lot of citizens' committees that promote opposition to the construction of plants for the generation of energy using biomass are realized.
Furthermore the lack of social acceptability translates into a substantial increase into installation costs. According to De Meo et al. (2014), the increase into initial investment costs can reach 30% of the value. This increase can be generated by changing the plant's location, the obligation to observe further requirements in order to obtain the license admission, the reduction of sales of heat or electricity, the lack of revenues deriving from the extension of the approval and/or modification times of the plant design. Therefore tackling the “Nimby Syndrome” is a priority to ensure that bioenergy is rooted in our lives and this must be done above all in already industrialized countries where the environmental knowledge is more consolidated.

*Table 1: List of some important Italian citizens’ committees against biomass plant construction (the thermal MW value of the plants takes into account the electricity yield according to : Thermal MW= Electric MW * 4).*

Objection year	Plant place	Thermal MW	Society name
2012	Argenta (FE)	84	San Marco Bioenergie Spa
2012	Cavernago (BG)	4	Malpaga
2012	Villanova Mondovì (CN)	4	General Electric
2012	Persiceto (BO)	4	L’Azienda Agricola Orsi Mangelli
2012	Crespellano (BO)	4	Azienda Agricola Gherardi Bruna
2013	Pontremoli (MS)	4	Renovo
2013	Caprese Michelangelo (AR)	4	GMP Bioenergy
2014	Putignano (BA)	32	Futura Bio Energy Development Srl
2014	Monticiano (SI)	4	Renovo Energia SPA
2014	Castagnaro (VR)	12	Ponte Servizi
2014	Monselice (PD)	4	Futuregreen
2014	Pian d'Assino (PG)	4	Gmp Bioenergy
2014	Avezzano (AQ)	93	Powercrop
2014	Furnari (ME)	4	Comet bio
2014	LENDINARA (RO)	4	Biopower
2014	Prato Cesarino (LT)	8	various companies
2014	Terni	18	Tozzi Holding
2015	Chivasso (TO)	72	Biogen
2015	Ospitaletto (BS)	8	Fraternità Società Cooperativa Sociale ONLUS
2015	Alife (CE)	4	general construction
2015	Pontecorvo (FR)	0.8	
2015	San Martino di Venezze (RO)	12	i frutti del sole

2. Possible solutions

In order to reduce the “Nymby Syndrome” and consequently to promote the social acceptance of biomass power plants, it is possible to make some important actions (Upham et al., 2015). First of all, it is necessary to verify upstream of the realization (design phase) of biomass plant the effective use of BAT. The Best Available Techniques (BAT) is defined as the “most effective and advanced stage in the development of an activity and its methods of operation, which indicates the practical suitability of particular techniques for providing, in principle, the basis for emission values designed to prevent or eliminate or where that is not practicable, generally to reduce an emission and its impacts on the environment. The BAT was introduced as a key principle in the IPPC Directive, 96/61/EC. This Directive has been incorporated into Irish law by the Protection of the Environment Act 2003. The basic principle behind power plant is the use of heat energy in a thermodynamic cycle to produce kinetic energy and finally electricity. These thermodynamic cycles necessarily entail a loss of energy as low-grade heat, and all power plants can be rated according to their efficiency or the ratio of useful energy produced to heat input. Particulate matter can arise either as emissions from fuel storage and handling or through emissions from the combustion of solid or liquid fuels (Epa

Environmental Protection Agency, 2008). The effective use of BAT can reduce the costs and therefore promote the social acceptance of biomass plant.
The second possible action against “Nimby Syndrome” concerns in involving the citizen to all stages of plant design. The aim is to attract potential participant’s interests (investors, credit institutes, local public policy makers, suppliers of raw materials, final users) who are not yet aware of the opportunities deriving from the new plant installation. Free publics sections or workshops can be organized in order to give information based on different stakeholder requirements (eg technical details of crop practices for farmers, risk assessment for private entrepreneurs, impact on quality of life for local citizens) (Lopolito et al., 2011). Furthermore, in order to ensure greater transparency stationary cameras (internet connected) can be installed that make images of raw material in the plant available on-line 24 h/24. In this way, citizens are aware that no waste is feed into the plant but only biomass. Even if the above possible solutions can act against the “Nimbysm” and consequently reduce it, there is a necessity to find other solutions that better struggle this public opposition.

3. The new methodology to avoid “Nimby Syndrome”

The objective of this work is to provide a valid alternative to defeat the “Nimby Syndrome” and consequently promote the installation of biomass powered plants (combustion, biogas, cogeneration, biofuels, green chemistry). The only effective way to overcome this syndrome is to carry out a "downstream" monitoring of the air quality in the area adjacent to the plants. In this way the companies that build and manage the plants would demonstrate transparency regarding the quality of the technologies for the abatement of pollutants and the type of raw material fed. On the other hand citizens would feel more secure. The air quality monitoring can be realized by using a capillary distribution of monitoring stations with spatial and temporal high resolution in the areas of interest in order to allow to any user information about the air that he breathes (Figure 1). The monitored parameters are the concentrations of fine dusts like PM10 and PM2.5, ozone, CO, NO_x, temperature, humidity, atmospheric pressure, wind direction and intensity (Sofia et al., 2018). From the stations it will be possible to obtain a large quantity of data 24/24h that will be transferred to an online application that collects data in an open-source database. It will be possible to read the recorded data from the stations in real time and to consider a daily or time history both from the web dashboard and the mobile application. The smartphone app will be available for all the latest smartphones with an Android or iOS operating system. Therefore it will be possible to verify data in real time and to access to the historical information.
In addition to the monitoring data of the individual stations, the online application will provide the following innovative tools:
• Registration of the users most interested in the visible data for example, the technical department of the company that installs the plants, the heads of the public administrations (technical office of the municipalities), simple citizens;
• A system of historical analysis of the data obtained from monitoring stations, such as the trend of pollutant concentrations. Thanks to a graphical interface designed to allow users a quick reading of data from mobile devices, the mobile app is an indispensable tool to consult data wherever you are.
• An automated system of alerts that, on the basis of the surveys, will forward a warning message to the responsible of the municipality affected by the pollution increase. If the parameter reaches the threshold indicated by the user, an email and a notification will be sent directly to the user's mobile device.
In this way, the rural world will be more sustainable and innovative, through the regard of the wood and agro-industry by producing biomass to be used for the production of renewable energy and globally by decreasing the intake of CO_2 into the atmosphere, as required by the last Paris Protocol. In this context the biomass should be an opportunity for the rural world, rather than a problem, both from an economic (for disposal) and environmental (with a bad management of residues, risk of fires, plants without better systems for the abatement of pollutants) point of view. This solution has economic consequences on the territory because it allows the recovery of deserted woods, avoiding free combustion. Furthermore, in order to have an appropriate monitoring network it is necessary to install in the adjacent areas two monitoring stations for each MWt of power generated. As a consequence, for a 1 MWe plant (corresponding to gross generated 4 MWt) about 9 monitoring stations are needed. The investment cost for the construction of this network is approximately € 40.000. Considering the average investment cost for a 1 MWe plant equal to about € 4 million, the impact of this solution is equal to about 1% of the total investment. From economic point of view, the benefits would amount to more than € 500.000 according to the analysis of De Meo et al. (2014).
On the other hand, from environmental point of view farms and wood owners (Municipalities and other entities) will have the opportunity to enhance their resources, through a productive recovery of the aged woods and residues of agro-industrial activities, feeding cogeneration plants located in the same areas where it is produced the raw material.

Figure 1: Example of an air quality monitoring network with spatial and temporal high resolution. The sensors are numbered from 1 to 9 and the plant is called P.

4. Conclusions

In this work a new methodology is proposed in order to support and promote a real cultural change. The installation of air quality monitoring systems can reduce the “Nimby Syndrome” and consequently promote the diffusion of biomass powered plants. With the dissemination of air quality data in real time, every citizen can be informed and sensitibilized about sustainable development and circular economy and also demand transparency from the companies or bodies that realize production facilities in their territory. The economic margins that could generate this methodology described in the work are around 20-30% of the investment cost for the construction of the plant, considering that the proposed solution has an economic impact of about 1%.

Future work will focus on monitoring the quality of the air within a rural municipality where there is a biomass plant of more than 1 MWe.

References

Burningham K., 2000, Using the language of Nimby: A topic for research, not an activity for researchers, Local Environment, 5, 55-67.

Cicia G., Cembalo L., Del Giudice T., Palladino A., 2012, Fossil energy versus nuclear, wind, solar and agricultural biomass: insights from an Italian national survey, Energy Policy, 42, 59-66.

De Meo E., Lopolito A., Giannoccaro G., Prosperi M., Ciccone R.A., 2014, How to promote community social acceptance of solid biomass in Europe? Identifying firms’ best practices, Econ. Bullettin, 34, 2080–2092.

Devine-Wright P., 2009, Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action, J. Community Appl. Soc. Psychol, 19, 426-441.

Epa Environmental Protection Agency, 2008, BAT Guidance Note on Best Available Techniques for the Energy Sector- large combustion sector.

Giuliano A., Poletto M., Barletta D., 2015, Process Design of a Multi-Product Lignocellulosic Biorefinery. Comput. Aided Chem. Eng., 1313–1318. https://doi.org/10.1016/B978-0-444-63577-8.50064-4

Giuliano A., Poletto M., Barletta D., 2016, Process optimization of a multi-product biorefinery: The effect of biomass seasonality, Chem. Eng. Res. Des., 107, 236–252. https://doi.org/10.1016/j.cherd.2015.12.011

How B.S., Lam H.L., 2017, Integrated Biomass Supply Chain in Malaysia : A Sustainable Strategy. Chem. Eng. Trans., 61, 1573–1578. https://doi.org/10.3303/CET1761260.

Lopolito A., Nardone G., Prosperi M., Sisto R., Stasi A., 2011, Modeling the bio-refinery industry in rural areas : A participatory approach for policy options comparison, Ecol. Econ. 72, 18–27. doi.org/10.1016/j.ecolecon.2011.09.010.

Ng W.P.Q., Lam H.L., 2013, Sustainable Supply Network Design through Optimisation with Clustering Technique Integration, Chem. Eng. Trans., 35, 661–666.

Sacchelli S., 2014, Social Acceptance Optimization of Biomass Plants : a Fuzzy Cognitive Map and Evolutionary Algorithm Application, Chem. Eng. Trans., 37, 181–186.
Salehi H. K., Sofia D., Barletta D., Poletto M., 2015, Dust Generation in Vibrated Cohesive Powders, Chem. Eng. Trans. 43, 69-774, doi.10.3303/CET1543129.
Sofia D., Giuliano A., Barletta D., 2013. Techno-Economic Assessnment of Co-gasification of Coal-Petcoke and Biomass in IGCC Power Plants. Chem. Eng. Trans. 32, 1231-1236. doi.10.3303/CET1332206.
Sofia D., Coca Llano P., Giuliano A., Hernandez M., Garcia Pena F., Barletta D., 2014, Co-gasification of coal-petcoke and biomass in the Puertollano IGCC power plant. Chem. Eng. Res. And Design. 92, 1428-1440. Doi.org/10.1016/j.cherd.2013.11.019.
Sofia D., Giuliano A., Gioiella F., 2018, Air Quality monitoring network for tracking pollutants. The case study of Salerno city center., Chem. Eng. Trans. 68.
State of the art of bioenergy in Italy, Table of Supply Chain for Bioenergy, Ministerial Decree No. 9800 of 27 April 2012, updated to June 2014.
Upham P., 2015. Towards a cross-paradigmatic framework of the social acceptance of energy systems. Energy Res & Social Science, 8, 100-112.
Upreti B.R., Van Der Horst D., 2004, National renewable energy policy and local opposition in the UK : the failed development of a biomass electricity plant, Biomass and Bioenergy, 26, 61–69.
Van Der Horst D., Sinclair P., Lofstedt R., 2002, Public partecipation in decision support for regional biomass energy planning, Options Méditerranéennes, 48, 123-130.