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On the role of efficient cogeneration for meeting Mexico's clean energy goals

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ABSTRACT

Cogeneration, or Combined Heat and Power, is generally recognized as a set of technologies contributing to the more efficient use of fossil fuels. After the energy reform in Mexico, *efficient cogeneration* plants can generate and trade Clean Energy Certificates, to the extent a certain efficiency threshold is exceeded. According to official planning documents, a significant fraction of Mexico's targeted clean power production is expected to come from efficient cogeneration; this assumption is critically examined. The official methodology for determining clean power contributions from cogeneration is studied in detail, and the expected clean electricity fractions for several case studies are calculated. The efficiency figures determined in this step are then combined with an assessment of the potential for cogeneration in Mexico, the current installed cogeneration capacity, and the official growth figures, in order to estimate the expected clean power contribution from efficient cogeneration through 2030. Since the clean power fraction from cogeneration is determined through an accounting procedure it is potentially prone to data mishandling or even manipulation. It is concluded that significant possibilities for accounting failures exist and that efficient cogeneration plants generating Clean Energy Certificates should be equipped with a continuous monitoring system to ensure correct accounting.

1. Introduction

One of the objectives of the recent electricity reform in Mexico is to increase the use of *clean energies*, referred to as technologies not emitting greenhouse gases (GHG). The Law of the Electricity Industry (*Ley de la Industria Eléctrica*) (LIE, 2014) explicitly recognizes a host of technologies considered as clean, including renewables such as wind, solar, small hydro ($\leq$ 30 MW), and ocean energy technologies as well as nuclear energy. Combustion-based technologies such as cogeneration, biomass-based co-fired steam cycles, and fossil fuel-based technologies with carbon sequestration can also qualify as sources of clean electricity according to a recently issued methodology (CRE, 2016a). Fossil fuel-generated electricity is recognized as fully clean energy if the specific GHG emissions are limited to 100 kg/MWh_e or lower, which is not deemed achievable with current technologies (Popa et al., 2011), although future technologies with carbon sequestration might be able to reach that limit. Large hydro facilities, defined as those with an installed capacity of 30 MW or more, are required to achieve a minimal installed power density of 10 W/m^2 in order to qualify as clean energy facilities, in which case all their generated electricity is accounted for as clean (LTE, 2015; CRE, 2016a). In the case of Combined Heat and Power (CHP), plants have to comply with a minimal equivalent electrical efficiency, in which case the electricity generated in excess of the efficiency threshold is considered *clean* in terms of the law.

Recognition as clean energy implies the benefit of being able to generate Clean Energy Certificates (*Certificados de Energía Limpia*, CELs) which have been implemented in Mexico in close analogy with Renewable Energy Certificates in the US (dCHPP, 2017) and the UK (DBIS, 2016). CELs are the only mechanism fostering both renewables and efficient cogeneration after the energy reform. Unlike in most states in the US and the UK where CHP receives recognition under Renewable Portfolio Standards (RPS) generally only if either renewable fuels or waste heat are used (dCHPP, 2017) (with fossil-fueled cogeneration plants often being able to be included in Energy Efficiency Portfolio Standards (EEPS)), the Mexican approach allows CHP generation to count towards clean electricity goals even if the primary energy is fully fossil, albeit subject to an efficiency requirement for the case of topping cycles; bottoming cycles where electricity is generated from waste heat are automatically considered clean. A similar approach has been implemented in a few US states such as Connecticut, Maine, and Washington where fossil-fueled CHP plants are eligible under the state RPS (dCHPP, 2017). In the United Kingdom a set of nine incentive schemes exist for cogeneration plants which are accessible to fossil- and renewable energy-fueled plants alike if previously certified as being of “Good Quality” under the CHP Assurance (CHPQA) program, with fossil-fuel CHP plants excluded from participating in the Renewable Obligation Certificates program only.

Combined Heat and Power, the simultaneous generation of

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electricity and useful heat in a heat engine or power station, has long been recognized as an efficient way of generating electricity (Lemar Jr, 2001; Hinnells, 2008), and the important role of efficient cogeneration as part of an integral energy efficiency and greenhouse gas abatement strategies has been recognized (Valenzuela and Qi, 2012; Howard et al., 2014). CHP systems are generally categorized according to their heat engines (also called prime movers), which fuel a generator to produce electricity. The thermal energy also produced can be captured and used for on-site processes such as generating steam or hot water, heating air for drying, or chilling water for cooling. The five main primary, commercially available, prime movers are currently gas turbines, steam turbines, reciprocating engines, microturbines, and fuel cells.

While a large potential of cogeneration for meeting energy efficiency and greenhouse gas emission has been identified by many authors, it is also often concluded that a host of barriers precludes its full realization. Howard et al. (2014) identified a number of barriers for the case of New York City, including difficulties with the grid interconnection process, backup rates, perceived financing risks, difficulties in obtaining local permits, and meeting code compliance, among others. A common root cause of many of these difficulties is the fact that a CHP plant, generally a relatively small facility compared to large centralized power stations, is often treated with the same rigor as its much larger counterparts, even though its impact is much smaller and the development costs incurred by these requirements account for a much larger share of the total project cost than in the case of large generation facilities.

A 2009 study commissioned by the Secretary of Energy in Mexico (SENER-CONUEE-GTZ, 2009) also reported a host of barriers for cogeneration, with the lack of a political strategy being at the root of many of the specific problems faced by cogeneration projects, in spite of the existence of a well-defined specific regime ("cogeneration") under the Public Service Electricity Law (*Ley del Servicio Público de la Energía Eléctrica*, LSPEE) valid until 2014, designed to foster cogeneration at industrial facilities including PEMEX, Mexico's state gas and oil company. It should be noted that PEMEX did not have a special status under the LSPEE and continues to be one of many actors in the power sector after the enactment of the LIE in 2014. Johnson et al. (2009) in their assessment of low-carbon development strategies for Mexico identified an important set of barriers impeding the full realization of Mexico's significant cogeneration potential. These barriers include the lack of appropriate contracting procedures for small power producers to reduce the risks and transaction costs, and a lack of financing for cogeneration projects in PEMEX, exacerbated by the restrictions to private capital investments at the time of the study. These findings were especially worrisome if the very favorable location of PEMEX cogeneration projects on the marginal greenhouse gas abatement cost curve was considered (Johnson et al., 2009), indicating low-hanging fruit waiting to be collected.

Since the time of the study by Johnson et al. (2009) a significant set of changes have been implemented in Mexico through the constitutional energy reform and the publication of the Law of the Electric Industry (LIE, 2014) and its associated set of regulations, where the latter is still being developed. A comprehensive description of the energy reform in the English language has been prepared by the International Energy Agency (2017). In order to promote *clean energy* production in Mexico, a market for CELs is currently being implemented. Load Serving Entities (LSE) will be required to purchase CELs corresponding to a percentage of the consumption of the loads they represent. For the initial year of 2018 this requirement has been set to 5%, whereas the goal for 2019 is 5.8%, 7.4% for 2020, 10.9% for 2021, and 13.9% for 2022 (SENER, 2017). Conversely, for *clean energy* generators the sales of CELs is an important source of income. In the two first recent Clean Energy Auctions in 2015 and 2016, organized by the national Independent System Operator CENACE (*Centro Nacional de Control de Energía*), the average values of the CELs of all awarded bids were 16 US$/MWh and 14.3 US$/MWh, respectively, representing a large fraction of the total specific average income to generators of 43 and 37 US$/MWh, respectively. The duration of the CEL contracts awarded during the auctions is 15 years. Whereas all CELs awarded during the first auctions were from solar, wind, and a small portion of mini-hydro, future market transaction might see contributions from other technologies.

In the present study several of the issues mentioned above will be addressed, including the actual vs the rated performance of CHP plants. The work focuses on the following research questions: (1) How stringent is the Mexican methodology in terms of its efficiency requirements, compared to standards in other countries and regions? (2) What are the expected contributions from efficient cogeneration to Mexico's clean energy goals through 2024 (year for which a 35% clean electricity goal has been established) and beyond? (3) How well is the methodology protected against incorrect accounting practices? It should be stressed that all three research questions have direct policy implications as (1) only a methodology enforcing state-of-the-art efficiency standards can be expected to lead to decreased emissions, (2) an accurate and realistic assessment of the expected clean energy contribution is vital to power sector planning and the compliance of the goals set by Mexico as part of its energy transition, and (3) a robust plant performance monitoring approach accounting for the inevitable variations in the electric and specially the thermal loads of CHP plants is necessary to provide reliable clean energy data.

To answer research question (1) we start up by conducting, in Section 2, a critical examination of the new methodology for efficient cogeneration in Mexico, as well as a comparison with standards from other parts of the world. Section 3 is intended to provide a feel for the expected clean electricity contributions from cogeneration at a plant level by analyzing data from an operating CHP plant in Mexico; as a comparison, the Mexican methodology is applied to the published performance of a set of international cogeneration plants. Section 4 addresses the projected contributions of efficient cogeneration to Mexico's clean electricity goals by tapping into a comprehensive study of cogeneration potentials in Mexico and conducting some indicative analyses of the potential of PEMEX. The projected contributions of efficient CHP plants to the countrywide clean energy production are then compared to official predictions. In order to address research question (3), the issue of the correct reporting of the heat streams in a CHP plant and the associated process is critically examined in Section 5, and some sources for reporting fictitious clean electricity numbers, unless appropriate measures are taken, are identified. Section 6 provides a critical discussion including policy recommendations, as well concluding remarks.

2. Methodology for efficient cogeneration evaluation

The concept of *efficient cogeneration* was first established in Mexico in 2011 (CRE, 2011). The initial purpose was for qualifying plants to be able to benefit from the incentives granted to renewable energy generators under the Public Service Electricity Law (*Ley del Servicio Público de la Energía Eléctrica*, LSPEE), if a certain threshold was met. While operating plants (also termed *legacy* projects) can continue to take advantage of these incentives, new projects (both renewables and other clean technologies) will have to rely on the sole incentive of being able to generate CELs. Legacy plants are allowed and encouraged to migrate to the new scheme, thereby acquiring the right to generate CELs, while losing all benefits associated with the former regulations such as energy banking and a preferential flat wheeling tariff, among others. Cogeneration plants under the new law (LIE) will generate CELs for each unit of electrical energy generated above a certain (revised) threshold, and none below. A revised methodology for calculating the amount of CELs generated by an efficient cogeneration plants was published in December of 2016 (CRE, 2016a) and will be discussed below.

As in all cogeneration plants, the system is expected to simultaneously produce an amount E of net electrical energy which may be