A systemic approach to assess the impact of distributed solar energy on utilities and customers: implications for energy policy

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1. Overview

In power systems, the largest emitter of all sectors worldwide, decarbonisation can be attained via technology transformation from fossil- towards renewables-based generation; this will in turn have an effect on a number of variables, including reductions in spot prices, as renewables displace more expensive technologies from the merit-order dispatch of energy (Cludius et al., 2013; O'Mahoney & Denny, 2011), prompting reductions of revenues for incumbent utilities. Additionally, distributed generation (DG) technology, particularly when based on solar photovoltaic PV, may be inconvenient to traditional business models of utilities, as costs have been showing swift reductions in recent years (Costello & Hemphill, 2014; Bronski et al., 2014); and these have also pressed further losses to utilities in terms of customers, sales and profits (EPRI, 2014; Satchwell et al., 2015a).

Death spiral of utilities may occur as an increase in the ratio between the electricity tariff and the cost of solar PV sparks the adoption of solar PV panels by households, since solar energy becomes cheap due to learning-curve effects and grid energy becomes increasingly expensive (Castaneda et al., 2016). Note that the cost of electricity from the grid – transmission and distribution – is largely fixed and is recovered through charges allocated to customers; these charges are volumetric, i.e., they are roughly calculated as the fixed cost divided by the electricity demand (Hledik, 2014).

The main objective of this research is to identify some of the determinants of a utility death spiral, and some of the possible paths for utilities to deal the transition process under a systemic and sustainable perspective. This paper therefore addresses some important questions about the death spiral issue, including: What are the market conditions that will lead to a death spiral for utilities? Can the regulator and utilities avert a death spiral achieving social welfare? May the regulator or policy maker adopt corrective actions with beneficial tariffs to customers? How can financial sustainability for utilities and affordability to all utility customers be guaranteed by means of tariff design?

2. Methodology

A literature review indicates that se The case study is the Colombian electricity market, due partly to its great potential in solar PV energy resources, but mostly because of its commitments to reduce 20% of greenhouse gases emissions by 2030 (Ministerio de Medio Ambiente, 2015)veral authors have studied the utility death spiral issue by considering the feedback loops associated with PV adoption, such as Cai et al. (2013), Darghouth et al. (2016) and Costello & Hemphill (2014), and only a few authors such as Ford (1997) and Grace (2015) have explicitly used System Dynamics (SD) methodology. This paper exploits a different SD insight to tackle death spiral issue, by examining how different systemic interventions may avert the negative effects of utility death spiral. Moreover, the utility death spiral is here integrated into a wider system – the dynamics of the power market (Cardenas et al., 2016; Dyner & Franco, 2004; Franco et al., 2015;

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3. Expected results

Net Metering policy enables PV adopters to sell surplus energy into the grid at an electricity retail rate, this along with grid parity could motivate households to install big PV systems to generate more power than the households needs. Death spiral is comparable with the tragedy of the commons where households make used of a limited resource (the network) to their benefit. Indeed, to offset 100% of the average energy consumption for a household, a 1kW system is enough. The simulation model employed allows to test different PV panel sizes installed per household, it is tested following sizes of solar panel 1kW, 2kW and 3kW. If households are over installed with 3kW panels the system collapses, the large-scale diffusion of solar PV provokes the highest residential tariff because network costs are spread over a shrinking energy consumption that falls to zero by 2035. By the end of this year, energy consumption of residential sector for a panel size of 2kW and 3kW is respectively 63% and 101% lower than for panel size of 1kW.

Following systemic interventions can be implemented to address death spiral problem, but some of them may discouraged PV investments: (i) implementing a back-up fee; (ii) modifying Net Metering; (iii) changing tariff designs and (iv) rethinking business models. The first four measures where simulated in this research, findings suggest that a volumetric plus fixed charge offers the greater level of PV investment along with affordability for customers and full cost recovery for utilities. Additional simulation runs, have shown that the system may collapse again in the future under all the measures analysed here. This demonstrates that the power transformation is unavoidable, and that during the transition period the regulator should find innovative ways − maybe rethinking traditional business models−, to integrate distributed energy resources into the grid, ensuring environmental quality, affordability and reliability

4. Conclusions

This paper explores the conditions, effects and some interventions to solve the utility death spiral in order to contribute to a friendly transition process for utilities and consumers, and keep up a sustainable energy system for society. Results indicate that death spiral for utilities is possible when some vicious cycles take place, where the electricity PV cost, the electricity tariff and the PV adoption rate for customers are critical variables.

Long-term consequences of the death spiral include sales depression as the result of greater PV adoption, and greater revenue losses for utilities; also, grid users with solar PV systems will experience benefits while the non-PV adopters will face very high tariffs. Mentioned effects not only harm the utilities traditional business model but also put at risk the system sustainability and the society welfare. Specifically, public goods affected by death spiral include grid reliability: if everyone becomes a prosumer, the network reliability is destroyed, and everyone loses since all residential customers are still grid connected. This situation resembles the "Tragedy of the Commons", suggesting that efforts to facilitate the transition toward a more decentralised power system are necessary.

Finally, for the Colombia case is possible to avert the death spiral issue through system thinking interventions, safeguarding not only the utilities profitability, but also the system reliability, social and environmental welfare. Nevertheless, the widest decision for Colombian utilities is to be prepared for technological change, rethinking traditional business models.

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