WHETHER AND HOW TO ENCOURAGE WIND AND SOLAR POWER IN COLOMBIA

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Overview

Following the worldwide trend to encourage the development of non-conventional renewable energy sources (NC-RES), Colombia has recently issued a law to promote these (Law 1715 of 2014). The exact mechanism is not yet defined and there are questions regarding the best way to encourage these technologies without adversely affecting the electricity market. Experiences in other countries offer a variety of approaches: Feed in Premiums (FiP), the classic Feed in Tariffs (FiT), Feed in Tariffs with contracts for differences, Market Premiums (MP), etc. However, all these options involve a risk of distorting the electricity market.

The case of Germany is so far the most successful experience of NC-RES development, encouraged by FiT. As a result, both technologies achieved a share of 25% of the country's consumption in 2013. However, the costs of such incentives have increased households tariffs, despite the wholesale price reduction. Given the incentive to produce electricity from renewables even during periods of oversupply, FiT have also resulted in important market distortions, leading to negative prices. This has led to a reconsideration of the encouragement mechanisms in Germany and in other countries.

While there is an extensive literature on wind and solar power development, only a few studies focus on the Colombian case [1–6]. Given the characteristics of the Colombian power market, such as its large share of hydro-storage electricity, it is difficult to extrapolate the results obtained elsewhere to Colombia. Thus, it is important to evaluate the likely performance of different types of incentives to gain insights into the mid and long-term evolution of the Colombian electricity market.

We use a system dynamics model to represent capacity adequacy in electricity markets. This model enables us to simulate the impact of NC-RES development on other technologies and, thus, on market prices, system costs and reliability. The model is calibrated for the Colombian market, which has a large hydropower share. We test different combinations of incentives of wind and solar power to understand their effects on the long-term evolution of the market.

Methods

We use a system dynamics model to simulate a representative day for each month. This allows us to capture both the hourly and seasonal aspects of supply and demand, which are extremely important given the low short-term elasticity of demand and the non-storability of electricity. These become even more important when the share of PV and wind energy increases.

Results

We define the following scenarios regarding NC-RES development policies. The current situation, without incentives, is considered as the base case.

- Planned expansion with FiT: we assume that investments are managed in a centralized manner, as with capacity auctions for example, to achieve NC-RES 20% share of consumption by 2035. The following alternatives are considered: 20% of wind power, 20% of solar power, or 10% of each. The amount of FiT that should be offered to attain the respective investments is calculated ex-post, taking into account the levelized costs for each technology in each period.
- Market driven expansion with incentives: no specific target for wind and solar penetration is assumed. Different incentives, such as Feed-in Premiums and Market Premiums are implemented and investment decisions are taken according to the expected profitability.

We compare the effectiveness of these incentives in terms of cost and penetration level by 2035, as well as their potential impact on the market. We also analyse these incentives in case of ENSO (El Niño Southern Oscilation) episodes.

Results show that under normal hydrological conditions, wind and solar are not profitable without incentives. Including the ENSO phenomenon yields prices that are on average 6% higher; consequently, investments in wind energy become profitable.

The implementation of FiT only for PV increases the system costs. Both wind and solar power lead to lower prices, given the increased availability of NC-RES and the higher reservoir levels resulting from a lower load factor of hydro-storage plants. However, the price-lowering effect of wind energy is higher than that of PV. As wind availability is more stable (including production at night), the need of HS to meet evening peak demand is lower than with a large PV share, which leads to lower peak prices. Therefore, NC-RES producers' surplus is lower when only wind energy is supported by FiT.

Regarding FiP, a very low premium is sufficient to trigger investments in wind energy due to its relatively low capital costs and high load factor during peak hours. Achieving a given level of penetration costs less when implementing FiP than FiT. We also observe that FiP for PV have an impact on wind energy investments: if PV is encouraged by a much higher FiP than wind energy, the price-lowering effect of PV makes investments in wind energy non-profitable in the long term.

When MP are implemented, achieving a certain level of NC-RES penetration is done at even lower costs than with FiP, since MP decrease in periods of high market prices. It is important to note that for comparable incentive levels the results obtained with high FiP and MP are similar as NC-RES profitability relies almost entirely on incentives and is not significantly affected by market prices.

Developing PV is significantly more expensive than wind energy in Colombia. However, lower reservoir variations occur when PV share is high compared to scenarios where wind energy share is high. This is due to the larger variability of monthly availability of wind and to its higher availability when HS inflows peak.

Conclusions

The key findings of our model suggest that NC-RES would not be expanded under the current conditions (without any incentive). Thus, if Colombia is keen to develop these technologies, incentives are needed. Three alternatives were analysed, with MP being the most efficient in terms of costs for the system. In the three cases, achieving a certain level of PV penetration has higher costs than achieving the same level of wind energy.

However, we cannot conclude that giving priority to wind energy development is the best solution. Although a large development of wind reduces system costs and improves reliability when inflows are at their lowest, the lower prices reduce the income of other generators and may threaten security of supply. Thus, the reliability remuneration mechanism might need to be reviewed in order to take into account the new market dynamics. Nevertheless, guaranteeing an adequate level of reliability in a liberalized market with high penetration of intermittent sources is quite complex.

In addition to evaluating the effects of expanding wind or solar power, our results also show the importance of choosing an adequate level of incentives. When incentives are significant, MP and FiP yield similar results. Besides, the incentive level determines the amount of investments, which in turn affects other technologies, as mentioned before. In the particular case of Colombia, high penetration of RES (>20%) leads to a quite significant price reduction due to the large share of hydro-power. Thermal generators are expected to have very low load factors, and thus prices are expected to remain at a very low level in the long-term. With such prices, HS cannot recover its capital costs. Furthermore, the country would have to keep incentives in the long-term since grid parity for NC-RES would not be achievable. The situation would be different in a system with a lower hydropower share, where thermal units should be kept for balancing purposes and prices can rise to levels allowing unsubsidized investments. This shows that an assessment of NC-RES encouragement policies cannot be generalised, as the results can change dramatically from one region to another depending on energy mix, as well as on demand patterns and the country's economy (affordability of NC-RES incentives).

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