

Foreword to the Special Issue on “High Shares of Renewable Energy Sources and Electricity Market Reform”

Carlo Andrea Bollino and Reinhard Madlener***

<http://dx.doi.org/10.5547/01956574.37.SI2.cbol>

This special issue is dedicated to the widespread belief that the supply of electricity from high shares of renewable energy sources (RES) is incompatible with the current design of electricity markets. The dispatch of power supply is typically based on a merit order of supply capacity that is based on increasing marginal cost of the generation units available. However, the very low or even zero short-term marginal cost of RES does not provide a sufficient signal to the market for timely investment, and may lead to a missing money problem of generation units already in use.

Various authors in different parts of Europe and North America have contributed both applied theoretical and empirical papers to this special issue, covering a range of subject matters relevant to the issue of “high shares of renewable energy sources and electricity market reform”. These are expected to provide timely and relevant guidance to policy-makers in developing new functional designs for the electricity markets in transition worldwide. The empirical studies from original research provide important lessons learned and new insights from studying recent market data. In doing so, they corroborate or challenge some of the political positions and recommendations currently under discussion especially in those countries with particularly ambitious targets to swiftly raise the share of RES. The topic of this special issue is crucial for energy companies as well, because there is a strong need to maintain, or restore, efficient and profitable market conditions. These are paramount for profitable investment and successful business operations of fuel suppliers and generators alike. The general conclusion of this Special Issue is that the relation between current market design and the growing share of RES is complex and challenging, thus deserving careful analysis.

Due to the limited number of contributions, it is quite obvious that a special issue like the present one cannot cover all relevant topics. Some studies focus on the market design and the growing need for (low-cost) flexibility options to tackle intermittency and supply-demand balancing, while others focus on the policy issues and on the investment decision making in the context of policy changes and the missing money problem caused by increasing amounts of electricity from renewables in the wholesale market. Nevertheless, they do cover a wide spectrum of issues, which are briefly summarized in the following.

Richard Green, Danny Pudjianto, Iain Staffell and Goran Strbac investigate the market design for long-distance trade in renewable electricity and cross-border compensation using an engineering-economic model of the European power system. The authors argue that while financial transmission rights (FTRs) may raise the confidence of companies investing abroad that the power can actually be delivered to their customers, their use to generate revenues for transmission capacity expansion could produce perverse incentives to under-invest and put an upward pressure on prices.

* University of Perugia

** RWTH Aachen University

The results from the model-based analysis are quite intriguing: the authors find that in the case of coordinated policy the expanded trade of renewable electricity would lead to a marked reduction in system costs of 5% in 2030 (or some €15 bn per annum), despite of the need for and costs of extra transmission capacity, peak-power generation, and balancing operations.

Karsten Neuhoﬀ, Sophia Wolter and Sebastian Schwenen analyze new perspectives for the European Target Model in the context of the evolving power market designs needed due to rising shares of intermittent renewables. Particularly, they investigate how system operation and short-term markets will have to be adapted to the different requirements of renewable and conventional power generation and flexibility options. They analyze the trade-oﬀs between a differentiated treatment of groups of technologies and synergies and efficiency in short-term system operation. The authors conclude that in terms of (re-)investment, diﬀerent technology groups may warrant differentiated treatment, reflecting diﬀerent levels of publicly available information, grid infrastructure requirements, diﬀerent types of strategic choices, and capital cost shares in overall generation costs.

Christiane Rosen and Reinhard Madlener study the available regulatory options for local reserve energy markets, which can facilitate the operation and allow trading within a microgrid, and the implications on prosumers, utilities and other stakeholders. Emphasis is mainly put on the European and German perspectives, which are also used as the basis for implementing the local reserve energy market with simple trading rules (dubbed “energy-eBay”). At the core are the balance groups and balancing group responsible parties, respectively, the latter of which can use these local markets to procure their own control energy balancing purposes. This may reduce grid losses and help to better integrate renewables-based, decentralized energy generation, thus helping to achieve the EU energy policy goals 2030.

Simona Bigerna and Carlo Andrea Bollino set forth an optimal price design in the day-ahead wholesale electricity market, thus trying to solve the conflict between conventional and renewable power generation. They find that the actual hourly market design is inappropriate for achieving an efficient market outcome in the presence of high shares of RES, given that it neither gives the right price signal for future investments nor does it take into account welfare considerations. Their new market design rests on three pillars: market-based incentives for conventional power generation, opportunity cost of RES for society, and adequate price signals to the demand side (Ramsey pricing). In an empirical application for the Italian electricity market, where heterogeneous buyers’ behavior is empirically estimated, the authors show improvements in both efficiency and welfare regarding zonal market prices for the suppliers and a uniform price for the buyers, quantifying the potential consumers’ savings at around 10%.

Michael Pollitt and Karim Anaya make an attempt to define what “high shares of renewables” actually means and what the real challenges are in terms of market design. Based on three case studies for three jurisdictions (Germany, the UK, and the State of New York), the authors investigate the ability of today’s electricity markets to cope with high shares of renewables. They find that diﬀerent countries follow diﬀerent pathways (‘just do it’—Germany, decarbonization—UK, distributed resources use—New York State) and thus face diﬀerent trade-oﬀs between security of supply, environment, and affordability. Most importantly, in all three case studies markets are seen as the main vehicle for absorbing high shares of intermittent renewables, rather than some central planners and monopolistic, vertically integrated electric utilities.

Aaron Praktiknjo and Georg Erdmann analyze the issue of a rapidly increasing level of intermittent renewable electricity versus the need for backup capacities. The authors first present a meta study on the merit order eﬀect in Germany that is supplemented by an econometric approach adopted from previous literature used to construct ordered day-ahead price curves for 2014. They find empirical support for a significant and growing merit order eﬀect of renewable electricity generation. The authors then go on and discuss two alternative concepts that may solve the dilemma,

one that is supply-sided and based on auctions for controlling RES investments, as proposed in the guidelines of the European Commission, and a support scheme for RES that is based on market premia paid on the demand (retail) side of the market and that accounts for the overcapacities in power generation.

Federico Boffa, Stefano Clò and Alessio D'Amato, taking a European perspective, focus on feed-in tariffs and climate policy under endogenous uncertainty, analyzing the choices made by two firms between a clean and a dark technology. The dark technology is confronted with carbon tax and cap-and-trade regime, whereas the clean technology is remunerated by a feed-in tariff. The authors show that symmetric firms make symmetric adoption choices (carbon tax regime), whereas under a cap-and-trade mechanism asymmetric adoption may occur. Feed-in tariffs have a different impact on adoption choices depending on the prevailing regime: under a carbon tax adoption it is reduced, whereas for a cap-and-trade regime the eventual outcome depends on the emission intensities of the clean and dark technologies, respectively. The findings shed new light on the need to adapt RES support schemes to changes in carbon mitigation regimes (such as the Market Stability Reserve added to the EU ETS).

Simona Bigerna, Carlo Andrea Bollino and Paolo Polinori investigate the issue of whether the increased supply of RES generation has affected the exercising of market power in the Italian Power Exchange (IPEX), taking explicitly into account grid congestion. Based on a residual load curve analysis, congestion rents are disentangled by a measure for unilateral market power. For the major power generators active in the Italian day-ahead market a zonal Lerner index is computed, and correlations between market power, grid congestion, and RES supply are analyzed. The authors find that market power abuse has been considerably weakened during peak hours, but on the contrary surprisingly been strengthened during specific off-peak hours (in the absence of solar RES and in specific zones where congestion leads to market splitting). Overall, the authors argue that the findings shed some new light on the role of RES and congestion on market outcomes, and that they can support policy-makers aiming at designing pro-competitive market regulation and reform strategies.

Ernesto Garnier and Reinhard Madlener study, from a micro perspective, the impact of policy regime risks on investments in innovative energy technology. They apply a compound real options approach for analyzing the investment strategy of a rational, risk-neutral actor planning to enter the virtual power plant (VPP) market. The investment is considered as a 2-step procedure: first, to acquire and run distributed energy resources (DER) assets and, secondly, to invest and operate an ICT platform. The model is applied to the case of a VPP operating in the German wholesale power market. The results suggest that policymakers ought to be more careful about the stimulation of investment by better predictability of policy processes, especially regarding (changes in) the support of already subsidized renewable energy technologies.

Angelica Gianfreda, Lucia Parisio and Matteo Pelagatti study the impact of RES in the Italian day-ahead and balancing markets by modeling the relationships between spot, adjustment and regulation prices. The model is applied to the Italian intra-day markets. The authors also find high and significant “premia of readiness” paid to conventional generators bidding on the real time market. The relationship is studied among price differences that exist in the regulation and spot markets on the one hand, and the amount of wind, solar, hydro and geothermal power production in all the Italian zones on the other hand. For some zones the premia are found to be significant.

Frank Wolak investigates the issue of how the aggregate output risk of intermittent wind and solar resources actually scales with the location and magnitude of these capacity investments, which is important for the security of electricity supply. To this end, he analyzes the trade-offs in wind and solar energy investments for the case of California in terms of mean value and standard variation. He uses hourly generation unit-level output data and real-time price data from the Cali-

fornian ISO control area (over a 1-year period) for computing the means and variances of all the state's wind and solar locations in order to compute mean-variance efficient frontiers based on annual hourly output and annual hourly revenues. He finds economically meaningful differences between portfolios on the efficient frontier and actual wind/solar capacity mixes, which are particularly large for the expected hourly output of wind/solar output frontier. Most of the hourly output and hourly revenues' risk-reducing benefits are captured by a relatively small number of wind resource locations, whereas the addition of solar resource locations can only slightly increase the set of feasible portfolio mean-variance combinations. Overall, the results show significant heterogeneity across wind and solar locations in the non-diversifiable solar/wind output and revenue risk.

Brian Rivard and Adonis Yatchew investigate three aspects concerning the integration of RES into the Ontario electricity system: prices and merit order effect, operational and market integration, and the procurement process. They find that government intervention can severely restrain private investment, that it can be self-perpetuating (since ad hoc government action, often as a reaction to short-term political pressure, creates the need for further government action), that a single government buyer (e.g. for power generation from RES) can severely undermine a competitive marketplace and investment incentives, and that investment decisions may be guided more by shifting policy objectives than market forces (or traditional utility planning) if policy intervention is too dominant. The authors call for a stricter separation between regulators and government policy-makers to enhance policy efficiency and efficacy.

Gert Brunekreeft, Marius Buchmann and Roland Meyer discuss the implications of the German *Energiewende* in terms of the rise of third parties and the fall of incumbents driven by large-scale integration of renewables for Germany. The authors find empirical evidence for the growing importance of intra-sector trading, and the shift towards a more distributed power generation, in order to underline changes in the industry. The authors argue that, supported by information and communication technology players and systems, the electricity sector has become increasingly fragmented. They argue further that, in the transition towards a more bottom-up multi-player system, the incumbents face "disruptive challenges", creating a need for adaptation of business strategies in order to survive.

Spiros Papaefthimiou, Manolis Souliotis and Kostas Andriosopoulos look into learning curve effects related to renewables, and in this context especially into the issue of "grid parity" (in the sense of cost-competitiveness against conventional power generation systems including grid use fees) of solar photovoltaics (solar PV) and concentrated solar power (CSP) as sustainable and—in light of grid parity—also cost-competitive electricity generation systems. The authors find that the deployment of the two technologies, and especially of solar PV, was largely driven by dedicated support policies, which begs the question as to whether governments are willing and able to sustain such trends by financial incentives, policy mandates, and the removal of regulatory and market barriers. The authors conclude that there are practical limits for (intermittent) renewables to compete on cost alone, and that in the long run, and despite of massive cost reductions, payment for renewables above market value may be insufficient to maintain a self-sustained market share growth process.

The papers contained in this Special Issue cover a wide range of topics relevant for a variety of actors dealing with higher and in some countries rapidly rising shares of electricity generated from intermittent renewable energy sources. Still, there is room left for more research and further insights needed on what has become a particularly dynamic and partly even disruptive field of business as well as research in energy economics and related fields. We are very confident that this Special Issue—which has turned into a really fine collection of topical articles—will find a wide and highly interested readership amongst academics, practitioners in industry, administration and politics all around the world.