An Optimization Procedure for Distribution Management Systems in Presence of Automatic volt var Controllers

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Extended abstract [1]

Power systems are facing a significant revolution in terms of energy generation and consumption. In particular, the generation centre of mass is

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gradually moving from transmission to distribution system, while new load typologies are supplied (such as electric vehicles) and demand response is attracting investors. For this reason, the network management/planning is becoming more complex and control strategies based on optimization are adopted also by distribution system operators. Unfortunately, flexible resources (normally owned by third parties) cannot always be monitored and controlled, especially when located in remote and/or low voltage areas of the distribution system. On these resources, automatic and stand alone volt-var controllers are often implemented in order to solve local issues. Of course, their operation has an impact on network power flows and voltages which, if not considered, can significantly interfere with the control actions decided by the distribution management system. The paper proposes an efficient algorithm for the centralized control of distribution system resources, which optimizes their activation in order to solve network loading/voltage issues and reduce losses. Its novelty is represented by the integration of automatic volt var controllers within the network optimization tool, allowing the consideration of their effects when determining dispatching orders [1], [2], [3], [4], [5].

Keywords
Power distribution networks; Flexible resources; Centralized control; Optimal Power flow; Local volt-var control.

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The abstract is devoted to the session *Modeling Decisions for Smart Grids, Energy Communities, and Electric Vehicles* organized by Paolo Falbo and Cristian Pelizzari.

Wind energy: social perception in Twitter communities

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Extended abstract [1]

The reduction of greenhouse gas emissions to address global environmental problems is an urgent matter. The adoption of policy instruments designed to move towards sustainable, low-carbon, and affordable energy systems is part of the international efforts needed to combat climate change. Those may include a new portfolio of electricity generation technologies and renewable energies. The development and implementation of a wind energy infrastructure is an important contributor to that energy transition [1, 3].

To date, however, the deployment of wind energy has been hampered by acceptance-related issues [2]. For that reason, the energy policy debates cannot disregard the analysis of the social perception of wind power. Having a knowledge of what the citizens, scientists, media (i.e., the stakeholders) think about wind power and how their opinions form may help governments

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change policies to make them more socially acceptable or increase acceptance of new power plants.

In this paper, we analyze the discussion concerning wind power coming up on Twitter. In particular, we measure the influence of individual twitterers on the community, in breadth and intensity, by building a retweet network.

Keywords
Wind power; Renewable energies; Twitter; Opinion formation; Social media.

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Optimal Incentive in Electric Vehicle Adoption

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Extended abstract[1]

In this work we investigate the interactions between a policy-maker and a population of vehicle owners, by means of a bi-level model. Under different perspectives, both the policy-maker and the fossil-fueled vehicle owners care about PM10 concentration and its link with the decision to switch from a traditional fossil fueled car in favor of an electric one. In particular, the policy-maker aims at minimizing a cost function deciding the optimal incentive to encourage such switching decision. The cost of the incentives is balanced by social benefits ([3]). More precisely, increasing shares of electric cars owners reduce the social health costs in the long run. Additionally, the policy-maker places a traffic ban, if the PM10 concentration exceeds the safety threshold for a fixed number of consecutive days. Fossil-fueled vehicle owners are cost minimizers and decide about purchasing or not an electric vehicle. Their switch decision depends on individual wealth, average distance traveled, the cost difference of using electricity instead of fossil fuel (see [1]) and, of course, on the level of the incentive provided by the

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policy-maker. Moreover, fossil fueled cars are subject to the additional costs of traffic ban stops ([2]).

We reduce the initial bi-level formulation to a single level problem and then we solve it analytically. Finally, we provide a model calibration through real data (among others [4], [5]) and a detailed comparative statics.

Keywords
Environmental Policy, Bi-level Problems, Electric Vehicles.

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Session: Modeling Decisions for Smart Grids, Energy Communities, and Electric Vehicles

Bidding strategy of an electricity retailer with flexible consumers

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Extended abstract [1]

In this work, we consider a retailer that participates in the daily electricity markets to purchase/sell the electricity consumed/generated by its clients, which are mainly flexible consumers. A flexible consumer may be a consumer with solar photovoltaic panels, batteries, electric vehicles, or the willingness to react to market prices. Moreover, the retailer has a PPA contract with a renewable producer so that the retailer sells the generated power to the electricity markets. Thus, the objective of this work is to propose a methodology to determine the bidding strategy of the retailer considering different uncertainty sources, such as the electricity prices, the net consumption of its clients, and the generation from the intermittent renewable producer. Stochastic optimization is used to formulate the decision-making problem.

In addition, to define the best bidding strategy, second-order stochastic dominance (SSD) constraints are incorporated in the optimization model.

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In the literature, most of the applications of SSD regard economics and finance problems, see e.g. [1], [2]. The use of SSD constraints in modelling approaches in the field of electricity markets is not very extended. [3] represents one of the first papers applying stochastic dominance tests to examine the planning alternatives of an electricity utility. [4] apply SSD constraints to the problem of an electricity retailer that seeks to determine the forward contracting purchases and the selling prices offered to its potential clients considering as uncertain parameters the future pool prices and the client demands. Recently, [5] applied SSD constraints to a multi-stage capacity expansion problem in generating and storage capacity to achieve renewable-dominated power systems. In this work, we continue the study developed by [4], but considering the new context of the green energy transition.

Keywords
Bidding strategy; Electricity markets; Electric vehicles; Flexible consumers; Stochastic optimization.

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Optimal installation of renewable electricity sources: the case of Italy

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Extended abstract [1]

In this work we validate empirically the theoretical results developed in [2], testing the real impact of current renewable installed power in the electricity price in Italy, and assess how much the renewable installation strategy deviated from the optimal one obtained from the model in the period 2012–2018. To do so, we consider the Ornstein-Uhlenbeck (O-U) process, including an exogenous increasing process influencing the mean reverting term, which is interpreted as the current renewable installed power. Using real data of electricity price, photovoltaic and wind energy production from the six main Italian price zones, we estimate the parameters of the model and obtain quantitative results, such as: the production of photovoltaic energy impacts the North zone, while wind is significant only Sardinia; the Central North zone does not present electricity price impact. Then, we implement the solution of the singular optimal control problem of installing renewable power production devices to maximize the profit of selling the produced energy in the market net of installation costs. We also generalized the singular control problem presented in [2] to the case when there are several energy producers in the market. We study the cooperative situation in which the players aim to maximize the sum of whole players' utilities net their total installation costs; and the competitive situation, where each player aims to maximize its own utility and to minimize its own cost. Subsequently, we compare both solutions for two electricity producers when there is not price impact. We found that the

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players, in a competitive situation, perform an installation at lower electricity prices than in a cooperative situation.

Keywords: Singular control; Irreversible investment; Pareto optimality; Nash equilibria; Market impact.

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Optimal Switch from a Fossil-Fueled to an Electric Vehicle

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Extended abstract [1]

In this paper we propose and solve a real options model for the optimal adoption of an electric vehicle. A policymaker promotes the abeyance of fossil-fueled vehicles through an incentive, and the representative fossil-fueled vehicle's owner decides the time at which buying an electric vehicle, while minimizing a certain expected cost. This involves a combination of various types of costs: the stochastic opportunity cost of driving one unit distance with a traditional fossil-fueled vehicle instead of an electric one, the cost associated to traffic bans, and the net purchase cost. After determining the optimal switching time and the minimal cost function for a general diffusive

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opportunity cost, we specialize to the case of a mean-reverting process. In such a setting, we provide a model calibration on real data from Italy, and we study the dependency of the optimal switching time with respect to the model's parameters. Moreover, we study the effect of traffic bans and incentive on the expected optimal switching time. We observe that incentive and traffic bans on fossil-fueled transport can be used as effective tools in the hand of the policymaker to encourage the adoption of electric vehicles, and hence to reduce air pollution.

Keywords
Electric Vehicle Adoption; Real Options; Stochastic Opportunity Cost; Pollution; Incentives.

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Energy exchange among heterogeneous prosumers under prices uncertainty

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Extended abstract [1]

Our paper provides a theoretical real options framework for modeling prosumers' investment decisions in photovoltaic plants in a Smart Grid context, when exchange of energy among prosumers (exchange P2P) is possible. We focus on the optimal size of their photovoltaic plants and on the self-consumption profiles the prosumers must comply with to assure the demand and supply matching in P2P exchange. The model was calibrated to the Northern Italy energy market. We investigate the investment decision under

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different prosumers' behaviors, taking into account all the possible combinations of their energy demand and supply. Our findings show that the existence of the exchange of energy among prosumers is not assured in all the cases we have focused on but depends on the shape and relationship between the supply and demand curves of the two prosumers. The best situation is when the two prosumers have an excess of supply and asymmetric and perfectly complementary demand curves. Sub-optimal cases occur when the exchange P2P and the sell to the national grid are exploited advantageously. This scenario is profitable if there is efficient cooperation between the two agents. Furthermore, prosumers invest in the highest capacity when they are characterized by different exchange P2P and self-consumption profiles, and they reach the maximum gain from the investment in a context characterized by excess supply in exchange P2P.

Keywords
Smart Grids, Renewable Energy Sources, Real Options, Prosumer, Peer to Peer Energy Trading.

Parallel sessions

- Parallel session title: Modeling Decisions for Smart Grids, Energy Communities, and Electric Vehicles
- Organized by: Paolo Falbo, Cristian Pelizzari

Dealing with the stochastic prosumanager problem with controllable loads

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Extended abstract[1]

In recent years, Home Energy Management (HEM) has attracted considerable attention as the residential sector accounts for a significant portion of total energy consumption. Solar power generation represents a promising and sustainable alternative to reduce the household consumption and the carbon footprint. Supported by continuously decreasing system costs and government incentives, Photovoltaic (PV) systems are nowadays widely applied, especially at the residential level.

The possibility of consuming the self-produced energy has changed the role of the end-users in the energy supply chain. PV systems are typically integrated with storage devices to mitigate the effects of the intermittent and unpredictable nature of solar production. Decoupling production from consumption storage systems help to maximize the self-consumption, reducing the user's electricity bill. In addition to new energy solutions, the wide diffusion of "smart" devices, which can be easily scheduled and controlled,

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allows the definition of more efficient load profiles and the implementation of demand response programs. For this reason, prosumers' role can go a step further, becoming now "prosumanagers", thanks to the possibility to effectively plan and manage the local energy resources exploiting the flexibility of the controllable loads (see [1], [2]). This paper focuses on the home energy management for a residential prosumanager with flexible loads. In particular, three different types controllable appliances (shiftable, interruptible, thermostatically controllable) have been considered, each one with a specific representation of energy consumption profile and a potential discomfort rate for the user. The inherent uncertainty affecting the main model parameters (i.e. loads, solar production, external temperature) is explicitly accounted for by adopting the two-stage stochastic programming modeling paradigm. The model solution provides the prosumanager with the optimal scheduling of the controllable loads and the operation of the storage system that guarantee the minimum expected energy procurement cost, taking into account the overall discomfort. A preliminary computational experience has shown the effectiveness of the proposed approach in terms of cost savings and the advantage related to the use of a stochastic programming approach over a deterministic formulation.

Keywords
Home energy management; Stochastic programming; Controllable appliances; User discomfort modeling.

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Linear transformation of multivariate AR processes in infinite dimension

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Extended abstract [1]

Our paper aims to consider supply and demand curves of electricity day-ahead markets, as already done in [4] as stochastic processes with values in a functional space. We study linear transformations of multivariate stochastic processes. It is a known fact that a linear transformation of a vector ARMA process is again an ARMA process [3]. However, in general, there are transformations of a finite order AR process that do not admit a finite order AR representation, but just a mixed ARMA representation.

We obtain a characterization result regarding the conditions that guarantees that a linear transformation of a vector AR process is again an AR process both in finite and in infinite dimension. More in detail, we characterize AR processes in Hilbert spaces (as defined in [1]) which are invariant under a linear transformation. We apply this result to variable selection models, which are particular models in infinite dimension which admit a finite dimensional representation (see e.g. [2]). In the finite dimensional case, we characterize the linear transformations of VAR processes which give processes of the same kind. Finally, we apply these results to the X-model in [5].

Keywords

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electricity day-ahead market; supply and demand curves; ARH process; variable selection models; X-model.

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