Natascia Andrenacci

ESPERIENZA LAVORATIVA

Ricercatore

ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development [21/12/2014 – Attuale]

Città: Roma | **Paese:** Italia

Ricercatrice presso il laboratorio “Mobilità Sostenibile e trasporti” dell'ENEA dove attualmente sta portando avanti studi sul fenomeno dell'invecchiamento e modellazione delle batterie, sia per applicazioni stazionarie che veicolari. È responsabile dello studio sull'invecchiamento delle batterie e delle celle nel Programma Nazionale di Ricerca sul Sistema Elettrico, occupandosi sia degli aspetti sperimentali che teorici. Si occupa dei problemi dei trasporti, in particolare all'ottimizzazione della distribuzione delle stazioni di ricarica elettrica nelle aree urbane, smart charge management, charging behaviour. Coinvolgimento in vari progetti sulla mobilità sostenibile, sia a livello nazionale che europeo.

responsabile dei sistemi informativi

Agenzia Nazionale per i Giovani, National Youth Agency [31/05/2010 – 20/12/2014] **Città:** Roma |

Paese: Italia

Responsabile delle Informazioni presso l'Agenzia Nazionale per la Gioventù (National Youth Agency, NYA), con il compito di raccogliere, analizzare, studiare ed elaborare le informazioni relative alle materie di competenza della NYA per fornire un adeguato supporto alla decisione, alla pianificazione strategica e attuativa e alla valutazione dell'impatto. Sviluppo di applicazioni software volte ad aumentare l'efficienza dei flussi di lavoro e delle procedure interne. Supporto tecnico al funzionamento ordinario dell'infrastruttura informatica. Supporto per l’attuazione delle direttive contenute nel Codice dell’Amministrazione Digitale.

Assegnista di ricerca

ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
[31/08/2006 – 29/05/2010] **Città:**

Rome | **Paese:** Italia

Assegno di ricerca presso ENEA, Centro Casaccia, riguardante lo studio dell'interazione elettromagnetica con materiali complessi. La ricerca ha previsto la simulazione e la misura sperimentale dell'interazione tra microonde e metamateriali, finalizzata alla scoperta di nuove proprietà dei materiali, e microonde e sistemi biologici, finalizzata alla rilevazione di tumori, in collaborazione con il prof. Tubaro dell'Ospedale Sant'Andrea di Roma.

Assegnista di ricerca

Università di Salerno, Dipartimento di Fisica [30/08/2004 – 30/08/2006] **Città:** Salerno |

Paese: Italia

Assegnista di ricerca presso l'Università degli Studi di Salerno in Fisica Teorica e Matematica, presso il gruppo di Meccanica Statistica del Non Equilibrio del Professor M. Zannetti. La ricerca si concentra principalmente sulle transizioni dell'ordine di fase. Utilizzo di tecniche di risoluzione analitiche e numeriche, con particolare attenzione alla simulaizone Monte Carlo.

Assegnista di ricerca

Università di Patras [31/01/2004 – 14/08/2004]

Città: Patras | **Paese:** Grecia

Post-doc in Scienza dei Materiali presso l'Università di Patrasso (Grecia), nel gruppo del Professor D.J. Fotini. Le attività facevano parte del Progetto Europeo ''Super Molecular Liquid Crystal Dendrimers'', HPRN CT 2000-00016. Sinossi: "Ho studiato il comportamento delle catene alcaline e di alcuni nuovi anfifili sintetizzati in una fase nematica biassiale. L'importanza di questo argomento deriva dalla recente rilevazione sperimentale della fase nematica biassiale a lungo ricercata in sistemi termotropici."

Assegnista di ricerca

Università di Neuchatel, Dipartimento di Fisica [31/12/2001 – 30/01/2004]

Città: Neuchatel | **Paese:** Svizzera

Assegno di ricerca post-doc presso l'Università di Neuchatel (Svizzera) in Fisica della Materia Condensata, nel gruppo del Professor Hans Beck.
La ricerca ha riguardato studi teorici sui superconduttori ad alta temperatura, sia nello schema della teoria del "crossover BCS to Bose-Einstein" che in quello degli "ordini concorrenti".

ISTRUZIONE E FORMAZIONE

Dottorato (Ph.D.) in Fisica

Università di Camerino [11/1988 – 01/2002]

Indirizzo: Dept. of Physics, Camerino (Italia) | **Sito web:** www.unicam.it | **Campi di studio:** Condensed matter Physics | **Livello EQF:** Livello 8 EQF | **Livello NQF:** Dottorato di ricerca | **Tesi:** Electrical response of superconductors at high critical temperatures in a transition approach between Bose-Einstein condensation and BCS theory.

Use of the Feymann diagram approach to formalize the problem and find the theoretical solution to the electricl response of a high temperature superconductors (SC).
The superconductor was described in a crossover approach between Bose-Einstein condensation and the BCS theory for low temperature SC.
Resolution of the theoretical model has been implemented using several numerical approaches.

Laurea Magistrale in fisica della materia condensata

Università di Camerino [10/1992 – 10/1998]

Paese: Italia | **Campi di studio:** Physics | **Voto finale:** 110/110 with honor | **Livello EQF:** Livello 7 EQF | **Livello NQF:** Laurea Magistrale (Vecchio ordinamento) | **Tesi:** Zero temperature properties of high critical temperature superconductors.

Perito tecnico informatico

ITIS Montani

Paese: Italia

COMPETENZE LINGUISTICHE

Lingua madre: Italiano

Altre lingue:

inglese

ASCOLTO B1 **LETTURA** C1 **SCRITTURA** B2

PRODUZIONE ORALE B2 **INTERAZIONE ORALE** B2

francese

ASCOLTO B1 **LETTURA** B2 **SCRITTURA** B1

PRODUZIONE ORALE B1 **INTERAZIONE ORALE** B1 *Livelli: A1 e A2: Livello elementare B1 e B2: Livello intermedio C1 e C2: Livello avanzato*

COMPETENZE DIGITALI

Programming language: fortran, C, C++ / Modelling and Simulation Tools / Organizational and planning skills / Microsoft Powerpoint / Microsoft Word / Microsoft Excel / Microsoft Office / Social Media / Google Docs / Google Drive / Data Bases / Team-work oriented / Statistical and predictive modelling / Skype **PUBBLICAZIONI**

[2021]

Battery Life Estimation of a Battery Under Different Stress Conditions The prediction of capacity degradation, and more generally of the behaviors related to battery aging, is useful in the design and use phases of a battery to help improve the efficiency and reliability of energy systems. In this paper, a stochastic model for the prediction of battery cell degradation is presented. The proposed model takes its cue from an approach based on Markov chains, although it is not comparable to a Markov process, as the transition probabilities vary as the number of cycles that the cell has performed varies. The proposed model can reproduce the abrupt decrease in the capacity that occurs near the end of life condition (80% of the nominal value of the capacity) for the cells analyzed. Furthermore, we illustrate the ability of this model to predict the capacity trend for a lithium-ion cell with nickel-manganese-cobalt (NMC) at the cathode and graphite at the anode subjected to a life cycle in which there are different aging factors, using the results obtained for cells subjected to single aging factors.

DOI: 10.20944/preprints202110.0004.v1 (to be published in Energies)

[2020]

Impedance spectroscopy characterization of lithium batteries with different ages in second life application The aging behavior of lithium cell has a profound impact on its performance in terms of energy, power efficiency and capacity fade, especially when it is considered in End of Life (EOL) in automotive field. Lithium battery is considered in EOL if at 85-80% of nominal capacity. Today, the reusing of Electric and Hybrid Vehicles EOL batteries on less-demanding grid connected energy storage applications, giving them a second use/ life, is an interesting solution to reduce high potential cost of lithium batteries. Currently, there is a lack of investigation of the performances of these second life batteries. In this paper, authors show the results of the impedance spectroscopy of 20 Ah lithium NMC batteries after EOL, exactly at 100, 85, 80, 60 and 50% of rated capacity, in a wide range of frequency: 450 mHz to 3.5 kHz. By results, there are many way to correlate battery state of health and battery impedance spectroscopy, especially when the battery is in second life.

[2020]

On the Hybridization of Microcars with Hybrid UltraCapacitors and Li-Ion Batteries Storage Systems The objective proposed by the EU to drastically reduce vehicular CO emission for the years up to 2030 requires an$_2$ increase of propulsion systems' efficiency, and accordingly, the improvement their technology. Hybrid electric vehicles could have a chance of achieving this, by recovering energy during braking phases, running in pure electric mode and allowing the internal combustion engine to operate under better efficiency conditions, while maintaining traditionally expected vehicle performances (mileage, weight, available on-board volume, etc.). The energy storage systems for hybrid electric vehicles (HEVs) have different requirements than those designed for Battery Electric Vehicles (BEVs); high specific power is normally the most critical issue. Using Li-ion Batteries (LiBs) in the designing of on-board Energy Storage Systems (ESS) based only on power specifications gives an ESS with an energy capacity which is sufficient for vehicle requirements. The highest specific power LiBs are therefore chosen among those technologically available. All this leads to an ESS design that is strongly stressed over time, because current output is very high and very rapidly varies, during both traction and regeneration phases. The resulting efficiency of the ESS is correspondingly lowered, and LiBs lifetime can be relevantly affected. Such a problem can be overcome by adopting hybrid storage systems, coupling LiBs and UltraCapacitors (UCs); by properly dimensioning and controlling the ESS' components, in fact, the current output of the batteries can be reduced and smoothed, using UCs during transients. In this paper, a simulation model, calibrated and validated on an engine testbed, has been used to evaluate the performances of a hybrid storage HEV microcar under different operative conditions (driving cycles, environment temperature and ESS State of Charge). Results show that the hybridization of the powertrain may reduce fuel consumption by up to 27%, while LiBs lifetime may be more than doubled.

[2019]

Battery Conditional Reliability Function under an Inverse Gaussian model and its Bayes Estimation This paper proposes a new methodological approach in the field of studies devoted to proper and accurate selection of a reliability model for battery systems. The study is performed with particular emphasis on the modeling and estimation of the Conditional Reliability Function, conceived as a key analytical tool in predicting the "Remaining useful life" of the battery, which is in turn an important information in order to identify the best maintenance strategy selection, or for inspection optimization, and also spare parts provision. Estimation of the Conditional Reliability Function is developed by means of a method based on the Inverse Gaussian Distribution and its Bayes Estimation. The performances of this estimation are developed and validated by means of extensive simulations and available experimental data. A brief account is reported of robustness analyses of the method with respect to the assumed prior Distribution.

Comparison of different scenarios of users distribution among charging infrastructure in an urban area F ast charging stations are becoming more common in cities. However, the most suitable positioning and size remain problems to be solved. The work focuses on the analysis of demand and the supply of fast recharging points in an urban area, using fuzzy models to simulate users behavior. The proposed model simulates real-world traffic situation, to obtain a "what-if" analysis of different scenarios, in which the parameters of the model were changed in turn to observe the implications on the results. Different decision models are proposed to simulate the charge policy for users distribution among the available charging point. Various charging behaviors are also compared. The results reported show that the variables involved in the charging infrastructure design strongly influence the output scenarios. The model can be a valuable tool to support decision making in an urban area.

On line Bayes Estimation of Capacity Fading for Battery Lifetime Assessment This study is devoted to a proper modeling and estimation method of battery capacity fading under the widely adopted exponential decay model, in view of an efficient lifetime assessment of battery. The method is based upon recursive online Bayes estimation of capacity fading. It is also shown how a degradation-based modeling of battery reliability can be adopted, leading to a Bernstein lifetime distribution. The performances of the proposed method are successfully evaluated by means of extensive Monte Carlo simulations based upon available literature and experimental data. A brief account is also given of a robustness analysis of the proposed methodology with respect to departures from the assumption of Gaussian noise.

https://ieeexplore.ieee.org/document/8890119

[2019]

Technical and economical evaluation of fast charging infrastructures for electric buses The Electrical Energy Storage (EES) is recognized, among all the possible options, as one of the most promising solutions to support the challenges posed by the decarbonization of the economy and integration into the distribution network of the electricity produced from intermittent and non-programmable renewable sources. The highpower request to the electricity network during charging process of electric busses, especially for fast, ultra-fast or flash charges, requires EES systems in order to level such impulsive requests. The research activity illustrated in this work investigates the most promising technologies for a stationary application for electric buses charging. We investigate different types of storage systems, whose peculiarities satisfy specific types of applications rather than others. The solutions under study for fast and flash charge are mechanical storage systems such as flywheels (FES), electrical and electrochemical systems such as supercapacitors (SC) and batteries, in particular, the high specific power Lithium Titanate (LTO). The results show the potential economic advantage of flywheels and supercapacitors as stationary storage systems over electrochemical storage

[2018]

Experimental Analysis of NMC Lithium Cells Aging for Second Life Applications Nowadays the electric power system is facing new challenges related to the integration of renewable sources, more and more frequently combined with energy storage systems. The use of these technologies is very promising, although it requires sophisticated control architectures in order to successfully balance the intermittence and unpredictability of renewables, and provide the power grid with new services. The presence of a storage state estimator is absolutely required to correctly identify the storage performance and present conditions, in terms of stored energy, aging or possible failures; this is crucial to assess the real exploitability of the battery, both during its first or second life application. This paper focuses in particular on aging mechanisms, describing and comparing three possible models and their deployment procedures. Flexibility of implementation, accuracy in aging determination, and ease of use of each technique have been deeply analysed and compared.

[2018]

Life cycle estimation of battery energy storage systems for primary frequency regulation An increasing share of renewable energy sources in power systems requires ad-hoc tools to guarantee the closeness of the system's frequency to its rated value. At present, the use of new technologies, such as battery energy storage systems, is widely debated for its participation in the service of frequency containment. Since battery installation costs are still high, the estimation of their lifetime appears crucial in both the planning and operations of power systems' regulation service. As the frequency response of batteries is strongly dependent on the stochastic nature of the various contingencies which can occur on power systems, the estimation of the battery lifetime is a very complex issue. In the present paper, the stochastic process which better represents the power system frequency is analyzed first; then the battery lifetime is properly estimated on the basis of realistic dynamic modeling including the state of the charge control strategy. The dynamic evolution of the state of charge is then used in combination with the celebrated rain-flow procedure with the aim of evaluating the number of charging/ discharging cycles whose knowledge allows estimating the battery damage. Numerical simulations are carried out in the last part of the paper, highlighting the resulting lifetime probabilistic expectation and the impact of the state of the charge control strategy on the battery lifetime. The main findings of the present work are the proposed autoregressive model, which allows creating accurate pseudo-samples of frequency patterns and the analysis of the incidence of the control law on the battery lifetime. The numerical applications clearly show the prominent importance of this last aspect since it has an opposing impact on the economic issue by influencing the battery lifetime and technical effects by modifying the availability of the frequency regulation service

[2018]

Tools for Life Cycle Estimation of Energy Storage System for Primary Frequency Reserve Battery energy storage systems are widely recognized as viable means for providing frequency regulation in electrical systems characterized by the massive deployment of renewable resources. In this case, the estimation of the battery lifetime is very complex since its response depends strongly on the stochastic nature of various contingencies. By starting from the characterization of the power system frequency in terms of the stochastic process, in this paper, tools needed for the battery lifetime estimation are detailed. On the basis of a realistic dynamic model, the state of charge profile requested to a battery providing primary frequency regulation is derived, with the aim of characterizing statistically its degradation. In this way, it is expected to obtain an efficient battery

lifetime estimation compared to the heuristic methods. Numerical simulations are carried out in the last part of the paper, illustrating a simulation tool for the estimation of the battery working cycle.

[2017]

Ageing effects on batteries of high discharge current rate Among the various stress factors determining the ageing of the battery when cycled at high discharge currents, the temperature increase was identified as the main operating mechanism. In order to quantify the improvement of the battery pack cycle life with load levelling, a model was developed to calculate the temperature inside the battery. A curve correlating the battery cycle number with the internal temperature of the battery was designed. As a result, it was calculated that the differential temperature decreased from 11°C in the high stressed battery down to 1.5 °C in the load-levelled system.

EVS 2017 - 30th International Electric Vehicle Symposium and Exhibition

Determination of the level of service and customer crowding for electric charging stations through fuzzy models and simulation techniques Electric mobility is regarded as an important option for reducing environmental impacts of transport. State incentives and planning efforts for the mass deployment of a public charging infrastructure (CI) are in hand in many countries; in particular, public CIs based on the Level 3 DC fast charge are most likely to become commercially viable in the short to medium term, as the drivers are more likely to view the operation as traditional refuelling.

The aim of this work is to develop a procedure for the evaluation of the level of service of a configuration of electric fast charging stations (CI scenario), located in a selected urban area of the city of Rome. By varying the configuration of the stations in the area, and taking into account a charge demand inferred from real-world traffic data, we are able to make comparative analyses among different CI scenarios, and to determine the best one in terms of average and maximum waiting time to recharge (demand-side analysis). The steps considered included:

creation of realistic CI scenarios based on lists of existing car parks and petrol stations; estimation of the potential battery electrical vehicle (BEV) users in the selected urban area using a Big Data analysis procedure; development of a fuzzy model to assign BEV users to stations with a criterion of convenience; use of a simulation procedure of all the charge events, in order to obtain a time profile of customer crowding at stations.

A demand-side approach to the optimal deployment of electric vehicle charging stations in metropolitan areas Despite all the acknowledged advantages in terms of environmental impact reduction, energy efficiency and noise reduction, the electric mobility market is below expectations. In fact, electric vehicles have limitations that pose several important challenges for achieving a sustainable mobility system: among them, the availability of an adequate charging infrastructure is recognized as a fundamental requirement and appropriate approaches to optimize public and private investments in this field are to be delineated. In this paper we consider actual data on conventional private vehicle usage in the urban area of Rome to carry out a strategy for the optimal allocation of charging infrastructures into portions (subareas) of the urban area, based on an analysis of a driver sample under the assumption of a complete switch to an equivalent fleet of electric vehicles. Moreover, the energy requirement for each one of the subareas is estimated in terms of the electric energy used by the equivalent fleet of electric vehicles to reach their destination. The model can be easily generalized to other problems regarding facility allocation based on user demand.

[2016]

Accelerated life tests of complete lithium-ion battery systems for battery life statistics assessment The paper investigates the performances of automotive lithium-ion battery systems, which are considered as one of the most promising candidates for the use on electric and hybrid vehicles. Indeed, lithium batteries show technical properties and features particularly suitable for these applications in which high energy and power densities are required. In order to investigate lithium-ion battery major technical limitations, a set of experimental testing activities has been carried on battery packs and systems, whose behaviours are expected to be significantly different from the test results on single cells. One of the most crucial challenge is the problem of the battery lifetime. Many approaches have been proposed in the relevant literature, but a lot of difficulties persist, being related to the incidence of many factors which do not allow to derive a quite general model able to describe in an exhaustive way battery

performances under different operating conditions. In the paper, a method is proposed which takes into account the randomness of the battery parameters, such as design maximum specific power and operating environment, in real operating condition, with reference to lithium ion batteries designed for a small electric bus (public transport service). Based on available experimental data, the lifetime probability distribution of these batteries has been estimated by means of a Weibull model.

[2016]

Accelerated life tests of complete lithium-ion battery systems A battery design method for lithium-ion batteries is discussed in the paper. The method takes into account the dependence of battery lifetime on different parameters, such as temperature, design maximum specific power, S.O.C., and relates it to the operating environment and economical aspect. The methods relies on a large set of experimental measurements, in particular accelerated life tests. The method allows to determine the optimal size, in terms of Life Cycle Cost, for a lithium ion battery designed for a small electric bus (public transport service).

[2020]

Electrical lithium battery performance model for second life applications The aging behavior of lithium cell has a profound impact on its performance in terms of energy and power efficiency, especially when it is considered in End Of Life (EOL) in automotive field. Lithium battery is considered in EOL if at 85-80% of nominal capacity. Today, the reusing of Electric and Hybrid Vehicles EOL batteries on stationary applications, giving a second life to these batteries, is a solution to reduce high potential cost of lithium batteries. Currently, there is a lack of investigation of the performances of these second life batteries. This paper depicts the performance results of five NMC cells at different SOH, where four of these cells are considered in EOL, so ready to be investigated for possible second use. By results, there are many way to correlate battery SOH and battery performance, e.g. an increase of the internal resistance and the constant-voltage (CV) phase charging duration, the change of the open circuit voltage shape curve. Finally, a battery model based on electrical equivalent circuit is build and implemented in Matlab/Simulink, which is validated by comparison between voltage experimental and simulated data.

[2020]

Optimal sizing and location of a fast charging infrastructure network for urban areas

[2021]

Modelling charge profiles of electric vehicles based on charges data This study highlighted the difference between fast and slow charging users' habits by analysing the occupancy at the charging stations. Aside from the charge duration, which was shorter for fast charges, distinct features emerged in the hourly distribution of the requests depending on whether slow or fast charges are considered. The distributions were different in the two analysed datasets. The investigation of CS power fluxes showed that results for the investment on a RES could substantially vary when considering synthetic input load profiles obtained with different approaches. The influence of incentives on the initial RES cost were investigated.

Natascia Andrenacci; Federico Karagulian; Antonino Genovese

[2022]

Influence of Battery Aging on the Operation of a Charging Infrastructure The increasingly widespread use of electric vehicles requires proper planning of the charging infrastructure. In addition to the correct identification of the optimal positions, this concerns the accurate sizing of the charging station with respect to energy needs and the management of power flows. In particular, if we consider the presence of a renewable energy source and a storage system, we can identify strategies to maximize the use of renewable energy, minimizing the purchase costs from the grid. This study uses real charging data for some public stations, which include "normal" chargers (3 kW and 7 kW) and "quick" ones (43 kW and 55 kW), for the optimal sizing of a photovoltaic system with stationary storage. Battery degradation due to use is included in the evaluation of the overall running costs of the station. In this study, two different cost models for battery degradation and their influence on energy flow management are compared, along with their impact on battery life.

Natascia Andrenacci; Mauro Di Monaco; Giuseppe Tomasso

[2023]

Comparing Charging Management Strategies for a Charging Station in a Parking Area in North Italy Via the analysis of a set of parking and journey information for vehicles traveling to the parking site at the University of Brescia (Italy), we evaluated the possibility of managing the electric recharging of these vehicles, which are hypothesized to be electric. The paper investigates charging optimization techniques that can limit the charge power peaks and distribute the energy demand throughout the day. A cost assessment for an auxiliary system consisting of a photovoltaic energy source (PV) and battery stationary storage (BSS) is also carried out. Optimal power management at the station with PV and BSS is introduced, and the performance of two feedback controllers based on the optimized results is compared with that of a real-time management algorithm in the presence of randomness in charging requests and insolation. The results show that the BSS degradation cost plays a primary role in determining the strategy to adopt to minimize the operating expenditure of a charging station.

Natascia Andrenacci; Giampaolo Caputo; Irena Balog

[2023]

Voltage-current based algorithm for the on-line estimation of equivalent internal resistance of LithiumCobalt-Oxide cells at different aging levels

10.1109/eeeic/icpseurope57605.2023.10194875

[2023]

A Literature Review on the Charging Behaviour of Private Electric Vehicles Electric mobility is one of the ways of containing greenhouse gas and local pollutants emissions in urban areas. Nevertheless, the massive introduction of battery-powered electric vehicles (EVs) is introducing some concerns related to their energy demand. Modelling vehicle usage and charging behavior is essential for charge demand forecasting and energy consumption estimation. Therefore, it is crucial to understand how the charging decisions of EV owners are influenced by different factors, ranging from the charging infrastructure characteristics to the users' profiles. This review examines the approaches used to investigate charging behavior and highlights the trends and differences between the results, remarking on any gaps worthy of further investigation. Natascia Andrenacci; Maria Pia Valentini

[2023]

A charge management algorithm for an unscheduled EV load demand

[2024]

Flexible Charging to Energy Saving—Strategies Assessment with Big Data Analysis for PHEVs Private Cars T he study shows that smart charging of PHEVs can be implemented to minimize the impact on the electricity grid. The implementation of optimized charging strategies can contribute to making PHEVs a valid, eco-sustainable alternative to conventional vehicles while also promoting the stability and efficiency of the electricity grid. The study aims to verify the effectiveness and efficiency of the flexible charging strategy by comparing the common charging operation (first in–first out) with other, less impactful charging schemes. Natascia Andrenacci; Giancarlo Giuli; Antonino Genovese; Giovanni Pede

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