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# Unconventional Hybrid System Control for Traction Microgrids

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***Abstract* - The power consumption of the Indian Railways is around 2.5 percent of the country's total electricity consumption. To reduce the consumption of electricity comes from power plants. so, we Hybridizing (it consists of P.V. and wind turbine generators and battery storage units) the railway substations with hybrid energy sources based on renewable energy sources and storage units connected to a dc bus may be a solution to contribute to the partial independence of energy producers in the sector of traffic rail. This project proposes a reversible, self adaptive, autonomous and intelligent distributed generator connected to dc bus control by multi agent system.**

***Keywords:*** Braking and tracking energy, Jade, MacsimJX, MATLAB Simulink, multiagent system (MAS), penalty costs, railway microgrid, renewable energy sources (RES).

## I. INTRODUCTION

The subscribed power exceeding cost weighing the energy bill of the railway networks actors; its reduction will undoubtedly alleviate this increase. The placement of a new dc substation and/or the existing dc substation upgrades are the solutions actually implemented. From an economic point of view, these solutions do not solve the problems related to the losses generated by the power routing from the substation to the trains running on the line. It also introduces other investment costs related to the transmission and distribution network. Moreover, in the case of the renewal or extension, if the substation is powered by fossil energy sources, the energy produced will have a direct impact on the environment and its cost will be high following the refraction of this type of energy source.

Reducing the subscribed power, eliminating the voltage drop in the line due to the acceleration and leading to the subscribed power exceeding and avoiding the voltage rise due to the deceleration by consuming the total of the regenerative energy not recovered by the other trains in the line, are the main issues related to the traffic railway. Indeed, it can occur that the regenerative power exceeds the consumed power, or the regenerated power is far from the consumed power. The techniques of the energy recovery are listed Authors have proposed an intelligent control to plan the regenerative energy recovery. In fact, the line voltage increase, occurring due to the regenerative braking energy, causes the damage of traction materials; also, the regenerative energy generates a bidirectional energy flow on the line. If it is not consumed, it can be exported to the main network.

A configuration of the substation that respects the reversibility without modifying the actual infrastructure, the proximity to the trains' consumption and facilitating the regenerative energy consumption that it is not recovered by the circulating trains is proposed in our work. It consists of hybridizing the substation by hybrid power generation system (HPGS) tied to a dc bus that it is directly connected to the catenary as depicted in Fig. 1. It offers all services brought by the hybrid systems and does not require any changes in the existing architecture of the substation. Linking renewable energy sources (RES) and storage units to the dc bus, connected to the catenary, is the hybrid substation (HSS) studied in our work. It consists of a photovoltaic and wind turbine generators and battery storage units. Two RES from different nature are combined, to minimize their discontinuity and also to avoid their oversizing that can occur if only one source is available. Following their main characteristic, the RES supply the railway line in complementarity.

A storage unit such as the battery is tied to the RES. It provides the energy necessary to meet the peak power demand and consumes the excess of regenerative energy in the line thanks to the associated converter. Indeed the interconnection of the RES and the battery to a dc bus in the catenary can be viewed as distributed generator (DG) that reduces the subscribed power thanks to the RES generation, provides the energy necessary during acceleration phases to suppress the subscribed power exceeding and eliminates the drop voltage in the line thanks to the battery discharge and the RES generation simultaneously, and avoids the voltage increase due to the deceleration process by consuming the energy excess, thanks to the battery charge.

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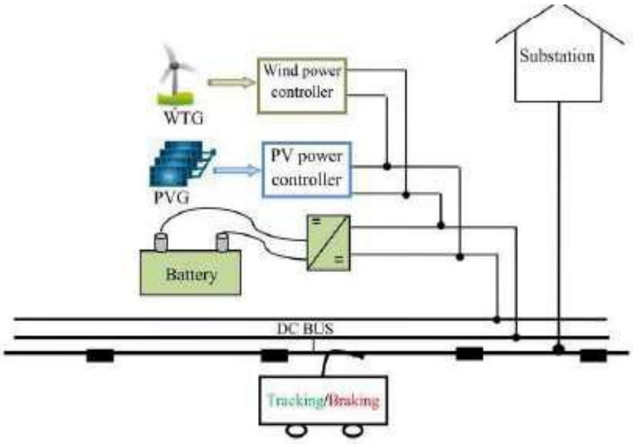


**Figure 1: Block diagram**

The trains will no more consume the energy needed for circulation only from the substation but from a judicious use of RES generated power *PRES*, battery power *PBattery*, and substation power *PSubstation* thanks to the distributed energy management (DEM)

$$P_{trains} = P_{Substation} + P_{RES} + P_{Battery}$$

The integration of the distributed generation such as RES in the railway network should meet several technical constraints The potential interest and the possibility of integrating RES in the railway substation have been studied where it was pointed out that in order to improve the efficiency and reliability of the system, hybridizing a stationary system based on RES in the traffic railway can only be achieved by thinking of an intelligent approach, because the maximum railway traffic consumption is rarely correlated with maximum RES production.

The HPGS consists of a multisource system with decentralized energy sources with different capacities and different generation. To derive all the benefits of the braking energy and to reduce the tracking energy cost and also in order to avoid disturbing traffic or the energy quality of the railway lines. The energy flow and information coming from each source should be controlled simultaneously while integrating the HPGS to the substation. That allows the judicious and effective use of each source. Therefore, a need for a DEM is raised. The objective of the proposed DEM is to design a reversible, active, intelligent, self-adaptive, and autonomous DG connected to the catenary. Thereby, a dc-bus distributed control where the HPGD is tied is required. Furthermore, the railway electrical network can be observed as a microgrid, because it is depicted as a chain of distributed loads when the trains are in acceleration mode and also as DGs when the trains are in deceleration mode. Having regard to this, a very sophisticated distributed dc-bus voltage control is highly recommended. This paper proposes DEM by multivalent system (MAS) to enable the implementation of a railway microgrid with HSS based on HPGS. MAS is extensively suggested as a suitable approach to manage complex distributed system such as the railway microgrid and it can give solution to a distributed control scenario. A large number of studies regarding the distributed control applications have been developed by MAS technology The subscribed power exceeding cost weighing the energy bill of the railway networks actors; its reduction will undoubtedly alleviate this increase.

The penalty costs related to the railway reflect the system's adaptation to energy consumption. If the energy production covers consumption, there is no penalty, and then the penalty cost is zero. On the other hand, if there is a certain lack or excess of energy, the penalty cost Cpenality depends on the square of the missing or surplus energy In the proposed railway microgrid, penalty costs are related to the integration of intermittent energy sources as RES and to the balance between supply and demand and the subscribed power exceeding. The penalty costs associated with the RES correspond to the risk of unavailability during peak periods; this cost is covered by the battery in association with the available RES.

Concerning the penalty costs related to the balance between supply and demand, it corresponds to the acceleration and deceleration phases and to the surplus of the unused consumed energy as in the case where the RES are available while the trains running on the line are running with a constant traction speed or at the trains start or stop, where the trains speed running on the line is zero. The penalty cost associated with this excess energy is totally covered by the battery for reuse in the event of peak or acceleration phases. Finally, the penalty cost related to the subscribed power exceeding is covered simultaneously by the RES and the battery.

**A) Railway Control by M.A.S.**

The control of the railway microgrid follows the same principle of a power flow control in a dc bus the current flowing in the line reveals different possible scenarios; a train or several trains brake, or a train brake while others accelerate. Therefore, the average current represents the outcome of the various possible scenarios that may occur. It is viewed by the dc bus as reversible load. The positive resultant current expresses the acceleration phase and the negative resultant current represents the deceleration phase.

The intelligence of the proposed control by MAS allows the battery to be charged from the RES generated power while trains are stopped and during deceleration periods, to reuse the stored energy during acceleration periods. It also allows the

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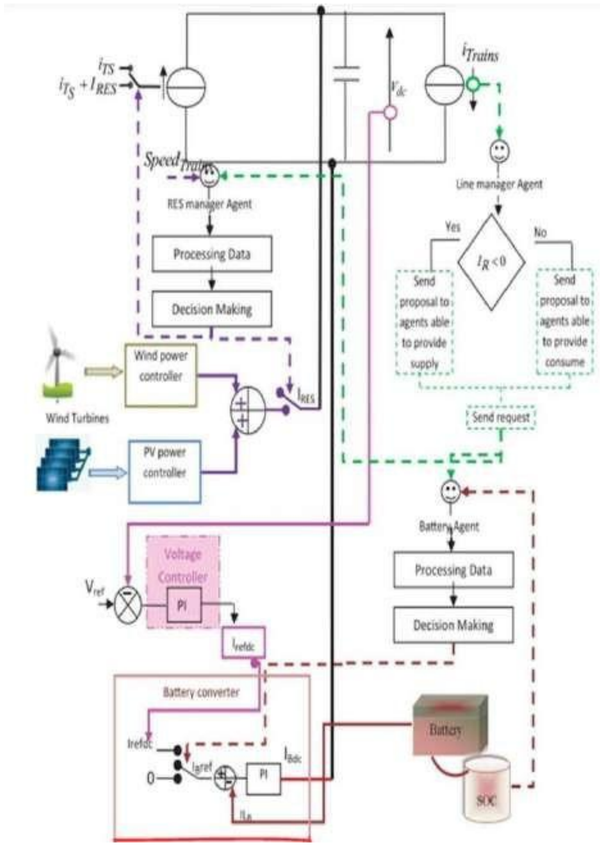
RES to reduce the subscribed power while the trains speed is constant. Using the MacsimJX tool there are three agents that receive three Simulink signals. All the necessary calculations are carried out by Simulink while the decision making is performed by the agents in the Jade environment.

The resulting current signal that informs about the various scenarios that may occur on the line is the input signal of the "line manager agent." The processing of these data by the agent indicates whether a request for energy supply is required, due to an acceleration in order to suppress the voltage drop on the line, or a consumption demand in order to remove the voltage increase due to deceleration is necessary. The "line manager agent" then sends this information to agents interested by this information and who can provide the supply or consumption of energy service to meet the acceleration and deceleration phases requirements. Actually, these agents are "battery agent" and "RES manager agent." On the other side, the "battery agent" receives from Simulink the signal indicating its state of charge (SOC).

If the proposal of the "line manager agent" is correlated with the SOC, the "battery agent" accepts the proposal and begins to supply the energy needed during the acceleration which is not recovered Maintaining the Integrity of the Specifications The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

## II. STUDY ON RENEWABLE ENERGY

Decentralized production means characterized by locating energy production facilities closer to the site of energy consumption. Allows for more optimal use of renewable energy combined heat and power, reduce fossil fuel and increase eco-efficiency. The advantage of decentralized wind generation appears at maximizing incomes from the production with minimal impact on the power system. Two characteristics coming from the unpredictable climate produce power. Automation of production of wind technology offers.




Uncontrollability on the generated production forecast established of the production 1 day early. We cannot give supply that comes directly from wind energy. it is difficult to anticipate electric production generated by wind turbines. Because forecasting tools are not designed to reproduce all variations of the wind. the models of forecast estimate the power by compiling the data and technical data of wind turbines. If the wind power generation is realized one day early then production is 10% adding wind power to the power system is beneficial but it causes some problems like voltage dips or frequency variations by this cost will increase. Wind turbines especially inductive machines absorb reactive power from the system and produce a low power factor if the wind turbine absorbs too much reactive power, the system becomes unstable. The wind turbine affects voltage depending upon the weather. Fixed: voltage is not affected because the ratio is fixed. Variable: reactive power affects voltage. Some factors contribute to voltage flicker in wind turbine aerodynamics, short circuit power, no. of turbines, types of the control system. For solution we can connect these turbines to transmission and distribution high voltage grid or connect energy storage. We need a wind farm because only one wind turbine will not give proper output for greater efficiency of the system. It should store energy during high wind speed and restore when there is no wind.

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## III. MALTI-AGENT SYSTEM

It is developed to control energy flow. M.A.S. is adaptive, self-aware, semi-autonomous, or autonomous. There are four types of agents:

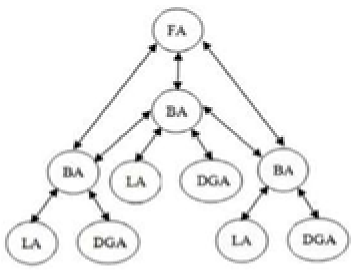
1) Facilitator agent
2) Bus agent
3) Load agent
4) Distributed generator agents

Facilitator agent: It act as a decision making manager, it designed to respond to an upstream fault.

Bus agent: It co-ordinate between F.A. and L.A. it designed to find post-fault by interacting with its L.A., D.G.A. and monitor bus parameters.

Load agent: L.A. monitors load parameters. During outage not enough power available then B.A. will send a control signal to L.A. to secure load by load shedding.

Distributed generator agents: It provide information to its B.A. during outage B.A. negotiate with its corresponding D.G.A. and see there is enough power for load.




## IV. SIMULATED RESULT

Two configurations are studied:

Railway line when D.G. is generated and aims to show the reaction of hybrid system tied to dc bus which is viewed as D.G. in different cases. Validates the strategy of energy management by M.A.S. and take full advantage of the capacity, characteristics, and limitations of each element in H.S. following a driving cycle scenario. The objective is to improve the efficiency and energy quality of the whole system by energy flow distribution and intelligent control.

## V. CONCLUSION

This paper deals the DEM by MAS in the railway microgrid with HSS based on HPGS to meet the limitations of rail transportation systems in terms of energy saving. The HPGS consists of a multisource system with decentralized energy sources with different capacities and a different generation; therefore, judicious use and integration of each element were respected. Reducing the subscribed power, eliminating the voltage drop in the line due to the acceleration and leading to the subscribed power exceeding and avoiding the voltage rise due to the deceleration by consuming the total of the regenerative energy not recovered by the other trains in the line, remain the main issues that should be taking into account while hybridizing the substation without modifying the existing architecture. Thereby, this paper meets the mentioned limitations and constraints by designing reversible, active, intelligent, self-adaptive, and autonomous DG connected to the catenary thanks to the distributed dc-bus voltage control by MAS. It was shown the ability of the proposed control to reduce the subscribed power and to omit the subscribed power overrun by the RES generation and the storage system which is represented by the battery. The penalty costs related to the subscribed power exceeding and the RES intermittence and also to the acceleration and deceleration were suppressed, thanks to the simultaneous control of the battery with the generation of the RES. The results also showed the stability and continuity of the system thanks to the effectiveness of the proposed control.

## REFERENCES

[1] R. R. Pecharroman, A. Lopez-Lopez, A. P. Cucala, and A. Fernandez Cardador, “Riding the rails to DC power efficiency: Energy efficiency in dc-electrified metropolitan railways,” IEEE Electrific. Mag., vol. 2, no. 3, pp. 32–38, Sep. 2014.

[2] S. Boudoudouh and M. Maaroufi, “Smart control in a DC railway by ˆ multi agent system (MAS),” in Proc. Int. Conf. Elect. Syst. Aircr. Railway Ship Propulsion Road Veh. Int. Transp. Electrific. Conf., 2016, pp. 1–6.

[3] Hajizadeh and M. A. Golkar, “Intelligent power management strategy of hybrid distributed generation system,” Int. J. Elect. Power Energy Syst., vol. 29, pp. 783–795, 2007.

[4] H. Ibrahim et al., “Integration of wind energy into electricity systems: Technical challenges and actual solutions,” Energy Proceedia, vol. 6, pp. 815–824, 2011.

[5] B. Robyns et al., Electricity Production from Renewables Energies. New York, NY, USA: Wiley 2012.

[6] M. Alvarez-Herault, “Architectures of the distribution future networks in the presence of decentralized production,” Ph.D. dissertation, Univ. Grenoble, Grenoble, France, 2009.

[7] R. Faranda and S. Leva, “Energetic sustainable development of railway stations,” in Proc. IEEE Power Eng. Soc. Gen. Meeting, Tampa, FL, USA, 2007 pp. 1–6.

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International Conference of Recent Trends in Engineering & Technology (ICRTET-2023)

[8] H. Hayashiya et al., "Necessity and possibility of smart grid technology application on railway power supply system," in Proc. 14th Eur. Conf. Power Electron. Appl., Bermingham, U.K., 2011, pp. 1–10.
[9] W. Khamphanchai, M. Pipattanasomporn, and S. Rahman, "A multi-agent system for restoration of an electric power distribution network with local generation," in Proc. IEEE Power Energy Soc. Gen. Meeting, 2012, pp. 1–8.
[10] W. Khamphanchai, M. Kuzlu, and M. Pipattanasomporn, "A smart distribution transformer management with multi agent technologies," in Proc. IEEE PES Innov. Smart Grid Technol. Conf., 2013, pp. 1–6.
[11] D. E. Olivares, C. A. Canizares, and M. A. Kazerani, "Acentralized optimal energy management system for microgrids," in Proc. IEEE Power Energy Soc. Gen. Meeting, Jul. 2011, pp. 1–6.
[12] H. Etemadi, E. J. Davison, and R. Iravani, "Adecentralized robust control strategy for multi-DER microgrids—Part I: Fundamental concepts," IEEE Trans. Power Del., vol. 27, no. 4, pp. 1843–1853, Oct. 2012.
[13] L. Kulasekera et al., "A review on multi-agent systems in microgrid applications," in Proc. IEEE PES Conf. Innov. Smart Grid Technol. India, Kerala, India, Dec. 1–3, 2011, pp. 173–177.
[14] S. Boudoudouh, M. Ouassaid, and M. Maaroufi, "Multi agent system ˆ in a distributed energy management of a multi sources system with a hybrid storage," in Proc. 3rd Int. Renewable Sustain. Energy Conf., 2015, pp. 1–6.
[15] S. Boudoudouh and M. Maaroufi, "Real time battery state of charge estimation in smart grid application by multi agent system," Int. J. Hydrogen Energy, vol. 42, pp. 19487–19495, 2017.
[16] S. Boudoudouh and M. Maaroufi, "Real time distributed systems modeling and control: Application to photovoltaic fuel cell electrolyser system," J. Eng. Sci. Technol. Rev., vol. 10, no. 1, pp. 10–17, 2017.
[17] F. L. Bellifemine, G. Caire, and D. Greenwood, Developing Multi Agent Systems with JADE. New York, NY, USA: Wiley, 2007.

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