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Integration of Distribution Generators & Optimization of Energy using Multi Agent System in Railway Microgrid

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ABSTARCT

Energy can be utilized in many applications in day to day life. According to traction it has major significance and complexity. Due to electrical energy consumption in railways is increasing, subscription of high amount of energy is going to vital burden for economy. To decrease electrical burden railway tends to use the Renewable Energy Sources. Hybridizing the railway substations with RES in storage elements directly connect to DC bus. Multi Agent System (MAS) has been proposed to provide energy control and management in the grid, because of their benefits of expandability, autonomy and reduced maintenance. MAS consists the smart grid and agents to adequate the energy consumption in running Locomotives. Integration of RES using MAS is simulated in MATLAB/Simulink environment.

Keywords: Railway Microgrid, Renewable Energy Sources, Multi Agent System, MATLAB/Simulink.

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I. INTRODUCTION

Electric Railway systems are known as one of the largest and highest-consumption end users in the utility. The railway network actions require more electrical energy that tends to subscription power to exceeds the limit. The reduction of subscription power is important to economy. In execution of new DC substation or upgradation of existing substation is the solution for the problem. From lucrative point of view, it is not the solution for the problems listed in the losses power distribution line. Addition of substation or upgradation of conventional energy sources to the substations directly leads to the environmental pollution. In view of these constraints, Renewable Energy Sources (RES) have to integrated with substations. As the reduction of subscription power and voltage drop at the acceleration and leading voltage level at subscription power is not fully recovered at the traction level is main issues related to the system, regeneration power is exceeds the subscription power and method seen in [1]. Authors in [2] proposed the recovery of regenerative energy recovery. In fact the regenerated power may damage the traction machinery. The braking power is bidirectional in the form that not consumed which may explode at main system and this function may contracts to system damage.

If the configuration does not effect the actual structure of the substation the proximity of the train consumption that may not recover the regenerative power consumption. The hybrid system consists of the Renewable Energy Sources (RES) and storage elements is directly connect to DC Bus.[3]. The proposed Hybrid Sub Station (HSS) consists the PV and Wind turbine generators (PVG and WTG) with storage. To minimize the discontinuity of power supplied, we need to employ renewable energy sources. RES along with Battery unit together called as Distribution Generator (DG). DG delivers the energy to substation where source is available at that time. RES may have the complexity characteristics to connect the Bus/Railway line. The storage element battery unit is connected with RES. The battery unit supplies the energy whenever peak load demand occurs. It also Consumes, suppress the regenerative energy to connected links. It provides the energy during different acceleration periods that simultaneously suppress the subscription power and voltage drop in the line. It also providing the energy to battery during discharge while the RES generates the power continuously. In deceleration period the excess energy consumption that leads to charge battery[4-7].

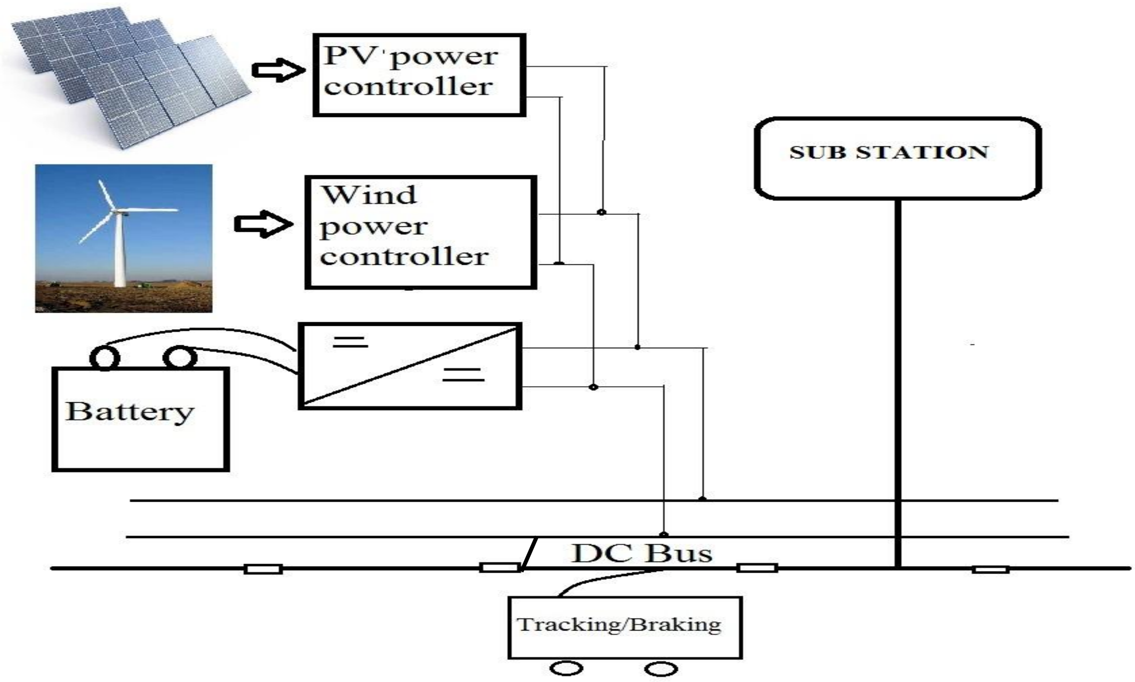

Fig. 1 HSS Architecture

According to power require for the train is $P_{trains} = P_{Substation} + P_{RES} + P_{Battery}$ ..(1)

equal to the power taken from the substation, generated power in RES and the battery power. it collectively seen as Distribution Energy Management(DEM). Hence,

Railway lines will see the technical constraints the possibility Integrating the RES through DG to it. Hybridizing a stationary system based on RES in the traffic railway can achieved by only intelligent control. The Hybrid Power Generation System (HPGS) having the different energy producing elements with different sources and ratings. Toreduce the tracking energy cost, we need to utilize regenerated energy at the braking. The energy contribution is informed continuously while integrating the HPGS to the substation. The objective of the proposed DEM is to design, reversable, achieve and self adaptive while DG connected to the system. Therefore, the DC bus used supplied where HPGS having less power. If we observe that the railway electrical network as microgrid, the distributed loads are train is at acceleration period and distributed generators at deceleration period. Hence, the control of DC voltage is very important. For the voltage control purpose, DEM proposes the Multi Agent System (MAS) to HSS based HPGS.MAS especially suggestive to manage the complex distribution system and it will give the solution for railway microgrid. MAS is widely used in many applications. For decreasing the subscription power we actually seems penalty cost function which gives cost membrane function for energy consumption[8-10].

If the amount of energy required for the bus is covered by subscription power there is no penalty else it is the penalty cost function. The penalty cost function $C_{penalty}$ is equal to unit cost element and square of excess energy E_{excess}needed.

$Cpenalty = Cu \times Eexcess^2$..(2)

Where,

Cu unit cost element

In the proposed railway microgrid the penalty cost related to the integration of distribution generator and RES associating during peak load demand. It is balance between supply and demand. Finally the penalty cost relates to subscribed power exceeding is covered simultaneously by the contribution of RES and battery.

II. MAS IN RAILWAY MICROGRID

The power flow principle is used for the DC bus. Current flowing is different because of train/s accelerates and decelerates several times. Therefore, the average current represents the DC bus reversible load. The positive current represents the acceleration period and negative current represents the deceleration period.

The intelligence of the MAS motivates to charge battery from RES, while the train/s stops and deceleration period. MAS supply back to the battery

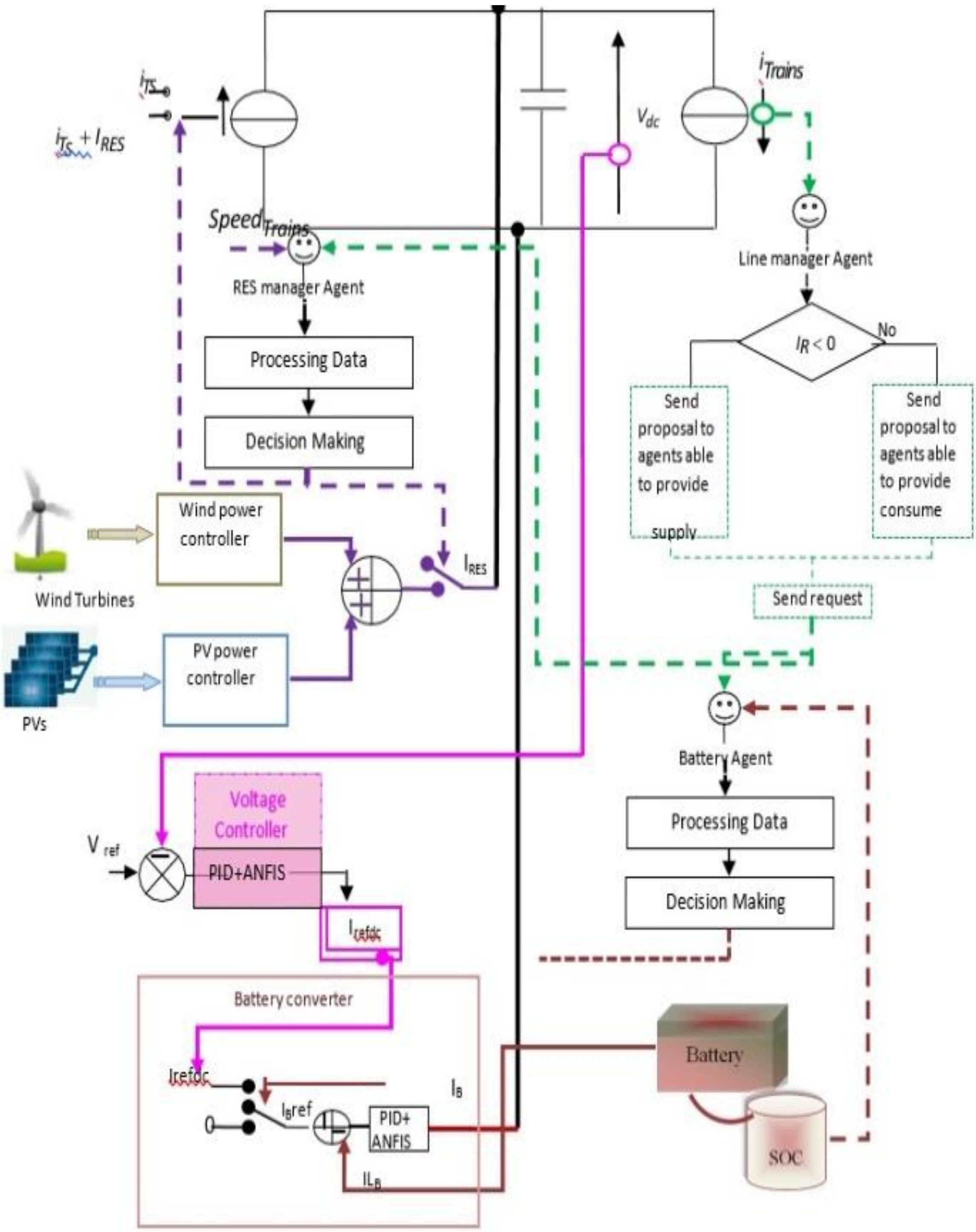

Fig.2 Flow chart for Railway microgrid

energy during acceleration phase, RES to reduce the subscription power. MAS was established three agents to receive the simulink signals, all are decision making elements while performing actions. The "line manager agent" has the input signal of resulting current signal which established at various scenario, the processing data of the signal data whether it is energy request signal or voltage drop on the line and above removing the voltage increase at deceleration phase is required. The sending data interested agents will take it and provide whether energy supplies or consumes to perform acceleration and deceleration phases, those

managing agents are "battery agent" and "RES manager agent". If the battery agent receives the data that signal indicates to its State Of Charge (SOC) then the signal is relates to SOC then "battery agent" starts to supply energy needed during acceleration which is not covered by RES.

The total deceleration period battery consumes the excess of energy while regenerative braking, RES generation which is not consumed at deceleration time. The battery agent sends the decision signal acceptance to converter is associated with current reference I_{refdc}which is calculated during voltage control. The battery agent may take or refuses the signal send by the "line manger agent" the SOC is not corelate to it while DC bus current control is supported by other agents, Otherwise the line manager agent performs to it.

The battery is current controlled in order to regulate the bus voltage and balance energy flow in DC bus. The I_{refdc}current through converters becomes I_{battdc} to regulate the voltage calculated. The voltage of DC bus is the function of capacitance in bus C_{dc}, the difference between line current and RES current I_{res} is bidirectional load where the Line current is nothing but $I_{substation}$and I_{trains}. It consumes the energy while acceleration phase and provides the energy while deceleration phase. The difference between these currents is the current of battery via I_{refdc}.

$$V_{dc} = \frac{1}{C_{dc}} \int (I_{battdc} + I_{res} + I_{substation} + I_{trains}) \quad .. (3)$$

The speed on the line is equal to zero and current controlled by battery is generated by RES. For this reason, battery consumes the RES power when the trains during start. Consequently, RES supplies the power in order to reduce the subscription power. On the other side the battery current controlling the line current and RES current. There is excess of power in line while speed is constant because RES generation will exceeds train moving with fixed speed. In this smart controlling the MAS assumes this is the case of DC bus the power flows are balanced which means the RES generated energy will integrated to dc bus.

There will be a zero reference current, $I_{refdc} = 0$ and the converter associated to the battery receives a set-point equal to zero $I_{Bref} = 0$. The RES manager agent receive signal from simulink and parallelly receives the line manager agent proposals. If the RES manger agent take information about train speed through line manager agent then the RES manager take decision to accept or reject the proposals. RES manager agent accepts the proposal and the resulting current supplies to the tracking phase while speed is varying.

RES manager agent will integrate zero current to DC bus if the traffic speed is constant. This can be considered as power flows are balanced. The generation of RES is constantly supplied directly to reduce the subscription power. The function of condition varying is given in below flowchart.

Fig 2. shows the proposed railway micro gird principle it performs the control of each agent receiving the signals and messages to control individually with corresponding elements. Every agent gathers data to functioning at their set periods while performing these agents are make decision wisely to achieve sustain results. Therefore, the agents are autonomous and self -adaptive in nature.

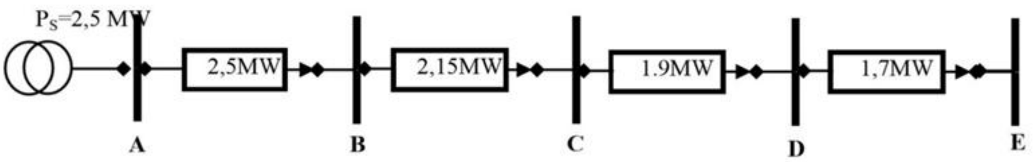

Fig 3. Available power in the railwayline(Ps=2.5MW)

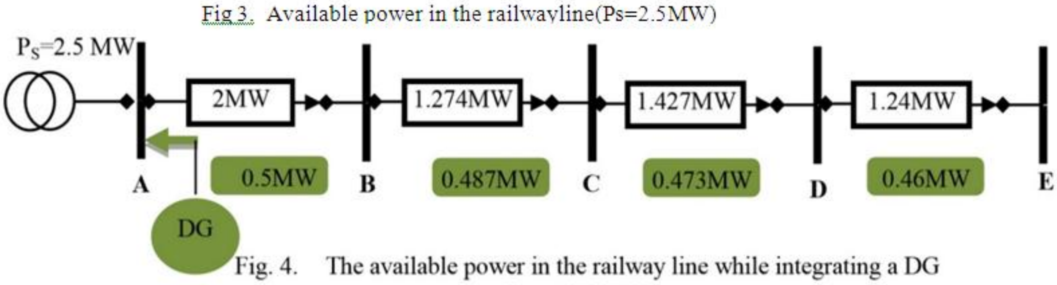

Fig. 4. The available power in the railway line while integrating a DG (P_{RES}=0.5 MW)

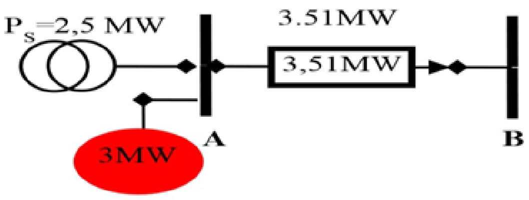

Fig 5.a The peak load demand near to substation consumption without a DG

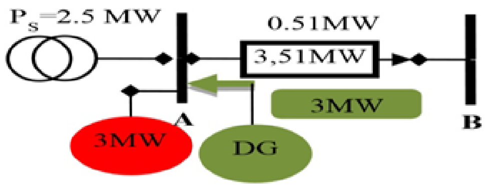

Fig.5.b The peak load demand near to substation consumption with a DG

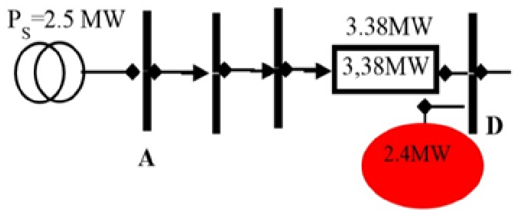

Fig. 6.a . The crossing point peak load demand consumption without a DG

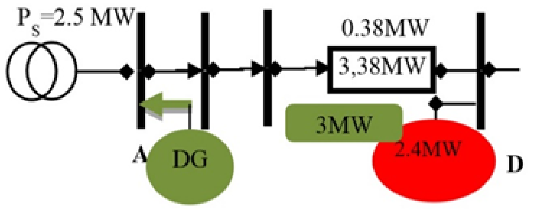

Fig. 6.b . The crossing point peak load demand consumption with a DG

III. CONFIGURATIONS AND RESULTS

The developed configurations are studied and simulated. Fig.3 represents the available power in the line. It is the subscribed power required for train acceleration. The subscribed power is equal to 2.5 MW. The assumed distance between two stations is 5km. Due to losses in the line, the available power decreased while going far away from substation. There are other developments configured. The DG is integrated to the line that will directly reduce the subscribed power then the DG integration makes subscribed power reduce to 0.5 MW. Fig.4 illustrated the function of DG integration. Therefore, the voltage drop across the system due to long distance between the substations is also reduced. DG despites the RES which their 0.5 MW is maximum power.

The RES generating power varies all the time. The objective in this case is not let the battery to turn ON and RES to reach maximum power. It will remove the voltage drop at peak load demand seen in applied above configuration in Fig.5(A) and Fig.5(B). The capacity of hybrid substation is 3MW which is tied to the DC bus. Fig. 5(a) shows peak load demand occurs near substation. It illustrates that the excess amount of energy is needed here is 1.01MW without the distribution generator. The subscription power requirement is 3.51MW. while unit cost element requires double energy of 0.505MW without the DG if we directly cost weighing element and it is penalty cost function. In Fig.5(b) illustrates the DG is tied to bus will reduce the peak load demand and subscription power.

The crossing point between two trains is considered as the second peak load demand. Fig.6(a) and fig. 6(b) illustrates the load required at point D. which is far from substation. Load require at point D is 2.4MW. fig 6(a) shows without DG load demand on bus is 3.38MW on bus. This exceeds the subscription power and penalty cost function. Fig 6(b) illustrate where DG is connected to bus and DG supplies the energy of 3MW for load demand, the remaining 0.33MW directly subscribed by substation. Otherwise, 0.88MW energy is penalty cost function in this load demand. This is the second peak load demand covered by the DG.

The regenerative braking/decelerationphase the RES manager Agent decides to supply the DC bus, in order to take advantage of both regenerative energy due to braking process and also consumes the total energy produced by RES, which battery unable to charge, and it can be discharged during critical periods.

For the simulation, the circulation cycle shown in Fig.7 was considered. The circulation circuit considered lasts 4.8 s and simulates three consecutive accelerations, and cruise phases at different speed values. The braking phase starts at 3.3s from 80 km/h, which represents the maximumspeed.

Fig.8 represents the resulting current of the different tracking and braking trains on the line following the circulation cycle shown in Fig.7 and Fig.9 shows the current generated by the RES during the simulation time. Fig.10 and Fig.11 show the battery reaction and the different currents on the line during the simulation respectively.

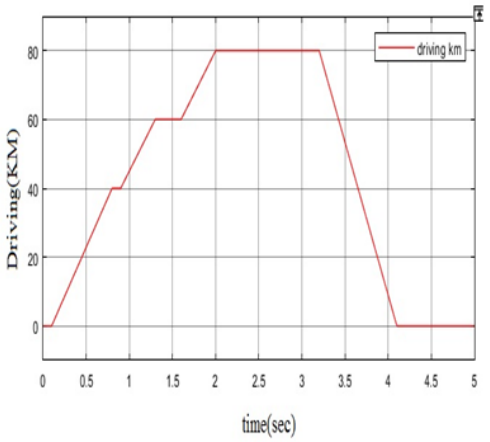

Fig 7. The considered Driving cycle

At the start and until 0.2 seconds (4% of the total cycle) , the speed on the linewas equal to 0. The aim is to take full advantages of the RES generation during the trains stop. In Fig.10 and Fig.11 it is shown that the battery takes control of the DC bus current and it is charged with the total current generated by the RES during this period. Fig.12 shows the SOC evolution during the simulation. It is indicated that it is equal to 60%, from which the 'battery agent' agrees to consume the energysurplus.

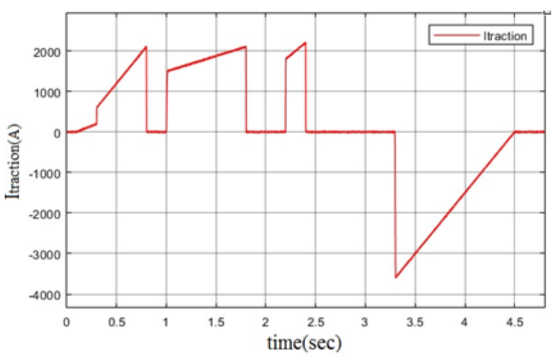

Fig.8 Resulting tracking and braking current

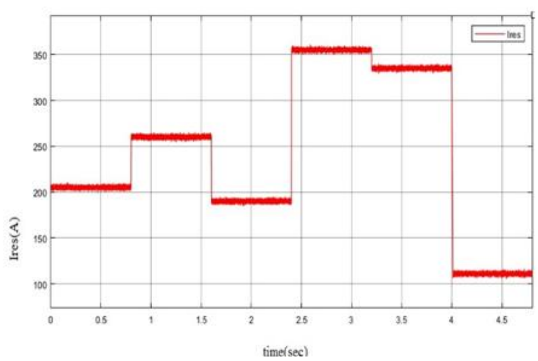

Fig 9. Current generated RES

Then three consecutive accelerations took place, the RES and the battery simultaneously supply and share the requested current during the three accelerations such that the battery covers the difference between the current resulting from various traction and braking operations on the line and the current generated by the RES. During the first acceleration the battery covered almost 88% of the current required by the acceleration while the RES covered 12%.

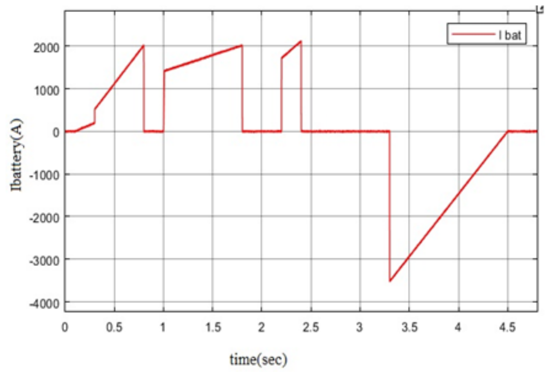

Fig 10. Battery DC-DC output current

Always in Fig.11, it is indicated that during the second acceleration the battery covered 86% of the acceleration energy and the RES provided the 14%.Finallythe third acceleration was covered at 90% by the battery and 10% by the RES. During the three consecutive accelerations the battery accepts to supply energy depending on its SOC as shown in Fig.12.

Between the three accelerations, the speed on the line is constant. Depending on the objective of the proposed control by MAS, it can be seen that the battery does not consume the excess of the RES and the battery current is zero during the periods when the speed is constant, because the energy management strategy by MAS desires that this excess of energy coming from the RES participates in the reduction of the subscribed power. So the 'RES manager agent' does not supply the DC bus by the RES but directly feeds the line. Fig.13 shows the subscribed power gain.

During the last phase, the trains are stopped. Consequently, their speed is equal to zero. The battery consumes the current coming from the RES which supply during this phase the DC bus following the 'RES manager agent' decision in order to achieve the DEM objectives in the proposedrailway microgrid.

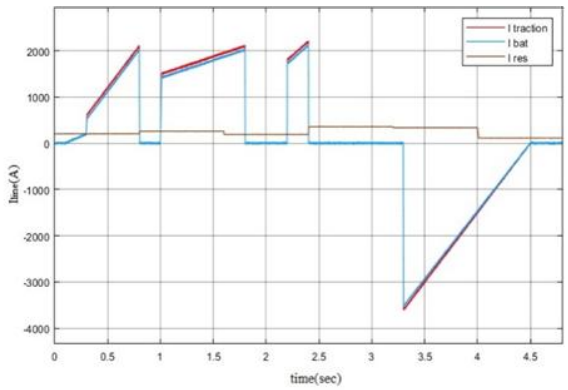

Fig.11 line current

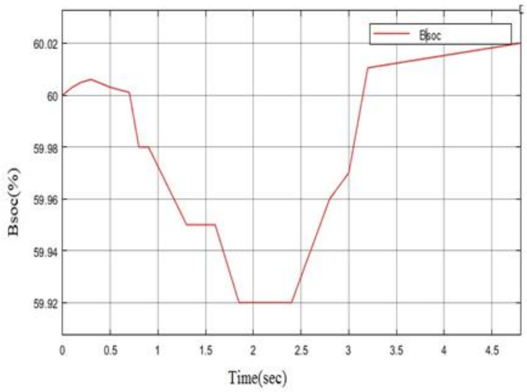

Fig.12 Battery State Of Charge

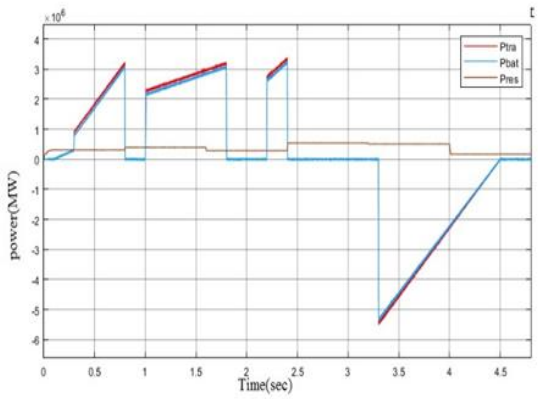

Fig.13 Power cycle

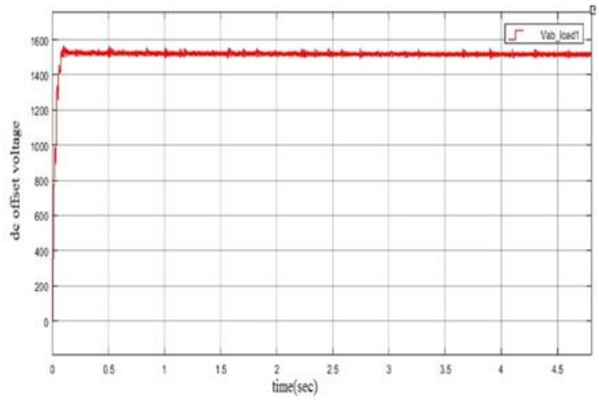

Fig.14 DC bus voltage

Fig.13 represents the power cycle during the acceleration and deceleration period. And fig.14 states that control of bus voltage during traction and braking period.

IV. CONCLUSION

The implementation of distribution energy management states the MAS in railway microgrid with hybrid substation will limit the high consumption of energy in transportation system. The HPGS consists a multi source system with different capacities will integrate with each element. While respecting the basic structure of the system reducing the subscription power, eliminate the voltage drop in the line due to acceleration and leading power level consumption in deceleration while breaking is performed. By this way subscription energy consumption will reduce in proposed model, the other constraints will say that MAS having the intelligent, adaptive and autonomous DG connected to DC bus. The overrun of RES generation and storage of the system represented by the battery. The RES intermittence at the acceleration and deceleration were suppressed subscription power in the penalty cost relation. The system integration with intelligent control will perform the results to stability and continuous mode.

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