SMART AC/DC LOW VOLTAGE DISTRIBUTION SYSTEM FOR BUILDING WITH DISTRIBUTED GENERATION AND ELECTRIC VEHICLES

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ABSTRACT

In this study, a smart low voltage distribution system is proposed for buildings with distributed generation and electrical vehicles. The proposed smart low voltage distribution system includes both AC distribution system and direct DC distribution system for the energy requirement of the loads. With the installation of DC distribution system, the restriction for distributed generation and consumer devices to be compatible with AC low voltage distribution system is eliminated. DC and AC distribution systems are interconnected through a rectifier for the supply of DC load increases from AC mains and for unidirectional power flow. Smart low voltage distribution system (SLVDS)is installed along with the smart distribution management system that utilizes smart grid technologies for the demand side management by also considering the electricity prices in deregulated market for increasing the power quality and energy efficiency of AC/DC low voltage distribution system. Smart demand side management, power quality monitoring system, smart control of distributed generation, smart charging of electrical vehicle, and similar subsystems are used in conjunction with smart distribution management system. By using the daily load duration curves for summer and winter seasons of the low voltage feeder supplying buildings, a smart demand side management that also takes into account the effects and energy unit prices of electrical vehicles charging systems and photovoltaic systems is introduced in this study.

Keywords: Smart Grid, DC Distribution, Electric Vehicles, Distributed Generation, Demand Side Management.

1. INTRODUCTION

The increase in the per capita consumption of energy along with the world population raises the energy requirement more with each passing day. That the energy requirement increases on one
hand and that the lifecycle of fossil fuels is restricted and that the gases arising by burning these fuels rise the global warming on the other hand bring the studies carried out with respect to energy into prominence. In 2008, the EU decided to reduce greenhouse gas at least by 20% in 2020 compared to 1990, to supply 20% of energy needs by 2020 from renewable energy sources (RES) and to reduce 9% energy usage by the 2016 compared to 2005 levels. [1-3].

The increasing energy requirement and the adverse effect of fossil fuels on environment made the use of RES a current issue. However, that the RES are generally small power is one of their important disadvantages. Furthermore, it is necessary to overcome significant difficulties in the integration of such sources with the available AC electric network owing to the fact that most of the RES generate DC power [4].

The increasing energy requirement has brought the more efficient use of available energy into prominence as well as new resource seeking. In recent years, it has been given importance that the newly designed devices use the energy efficiently [3]. However, it is not considered sufficient for energy saving that the new devices are designed to consume less energy. In addition to this, it is still carried on seeking for reducing energy losses occurred during the course of transmitting the energy consumed by the devices to the devices through the power plants. Distributed Generation (DG) are close to the end user helps in reducing the transmission, distribution and transformation losses of energy is one of the significant advantages of such sources.

In recent years, the demands for high power quality are increasing day by day due to the devices sensitive to power disturbances as well as the increasing energy demands of electricity consumers [5]. Power quality problems can cause processes and equipment to malfunction or shut down[6]. During the past decade, there have been several efforts to assess the cost of poor power quality for individual consumers and companies [7].

In houses and offices, the use of electronic devices consuming DC energy is rapidly increasing [8]. In addition to this, significant amount of DC energy will be required for electrical vehicles (EV) to be charged within the next years [9]. The recent developments indicate that a considerable part of the energy used in the buildings will be consumed as DC. That many RES available at end users side generate DC energy reveals the insufficiency of the available AC network infrastructure.

The requirement for a new network that is more advanced than today’s network infrastructure is revealed for the available electric energy systems both to include DG and to meet the demand for high power quality and energy efficiency. A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies [10].SmartGrid aims to achieve flexible, accessible, reliable and economic future electricity networks [11].

The subject of DC distribution system, which has significant advantages for electric energy to be used efficiently in houses and commercial buildings, for the high power quality demands of devices to be met and for the DG to be integrated to the network more easily, has been an essential field on which the researchers make their studies concentrate in recent years [12-20].

This study is related to the SLVDS which meets the energy requirement of DC and AC loads available in the buildings, which will facilitate the connection of DG to the network, which will improve the energy efficiency in the building by reducing the transformation losses, which will meet the high power quality demand, which is designed so that it will reduce the adverse effects of harmonics of nonlinear loads on AC network and which is operated flexibly. In the final chapter, there is given a study concerning the demand side management in a low voltage distribution system (LVDS) in which DC and AC systems are used together.
2. PROPOSED LOW VOLTAGE DISTRIBUTION SYSTEM

Nowadays, AC has been preferred in the generation, transmission and distribution of electric energy. The electric distribution systems feeding the buildings are also installed and operated as AC [21]. The history showed that new houses and commercial buildings are constructed as the population increases and new ones are added to the devices used in daily life depending on technological developments as the level of welfare raises. The share of the energy amount used in houses and offices within the entire consumption is increasing with each passing day [22].

In recent years, a rapid increase has been seen in the number of the devices operated with direct current, such as personal computers, mobile phones, sound and video devices, lighting with LED and so on. In addition to all of these devices, AC/DC transformation is required for charging the EVs being a significant electrical load of buildings. A considerable part of electric energy is lost through energy transformations. Moreover, the efficiency of these harmonic currents of rectifier decreases by causing additional losses in AC system [23].

When the high quality energy requirement of loads is considered, the energy storage is brought into prominence promptly and electric energy is stored as DC [24,25]. The UPS systems are used for such devices that are sensitive against power disturbances. The UPS systems used have adverse effect on the energy efficiency due to their losses.

Within the last ten years, the electric power sector has been in a state of significant change and the restructuring studies for ensuring more liberality and freedom in the operation of the electricity market have accelerated. The electric distribution network has gone through a structural change along with the liberalization in the energy market in parallel with the increase in the use of DG [26].

Notwithstanding the considerable increases in the number of DG, it cannot be expanded sufficiently due to the crucial difficulties encountered in connecting most of the small power generation plants generating DC energy to AC distribution network. A considerable part of DG generate DC energy and are connected to AC system through DC/AC transformers [27].

A variety of reliability indices for distribution systems have been defined by IEEE Working Group on System Design [28]. System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) are considerably high in developing countries [29]. It is possible to reduce the adverse effect of interruptions on consumers by means of small power generation plants. In addition to this, the use of various energy storage opportunities along with the DG will improve the reliability [30].

Upon the inclusion of LED lighting and EV charging systems to the prevalence of DC energy use in consumer devices in recent years, the ratio of DC energy use in houses and commercial buildings has been considerably increased. However, the requirement for DC energy is still supplied from rectifier AC/DC transformers due to the existing LVDS.

The idea of bringing the devices consuming DC energy in buildings (EV charging, LED lighting, Computer and electronic devices, etc.), the devices storing the energy as DC (Flywheel, Ultra capacitors and Battery) and generating DC energy (Small wind turbines, Micro turbines, Fuel cells, PV) and DC refrigerator and DC Freezer which are still operated by AC voltage, but which can be designed subsequently so as to be operated by DC voltage together in a common DC bus as shown in the Figure.1 grows stronger day by day.

The requirement for DC low voltage distribution system will be increased more because of the increase in DC energy use ratios in buildings upon designing such devices as lighting technologies, cooking and heating systems, which do not have to be operated by AC, but which are designed so as to be operated by AC voltage due to the reason that the electricity is distributed by AC voltage, so that they will be operated by DC voltage. In literature, the techno-economic analysis of DC distribution system presented the difference between AC and DC [12-14].
The advantages of using DC LVDS in supplying power to buildings can be summarized as follows.

- That the integration of small power DG to DC system is easier than the integration to AC system will contribute to the expansion of DG.
- Since the DG and DC energy storage capacity will meet the emergency requirement against network disconnections for a certain period, there will be reliability increase.
- Charging of EV and resupply of the building from electrical vehicles (V2G) become simpler.
- As the problems regarding AC voltage inferiority will be considerably reduced by DC voltage, the problem of breakdown or malfunction of sensitive electronic devices fed by DC voltage due to energy inferiority will be reduced.
- With the supply of DC devices from DC system and the decrease in the number of rectifier, the voltage inferiority and additional losses caused by harmonic currents run by DC devices to AC system will be reduced.
- The number of AC/DC and DC/AC converters will decrease. The decrease in the number of converters will reduce the operating costs by reducing losses while it reduces the installation costs.

The most crucial problem in DC distribution system, however, is that DC voltage values of devices are very different from each other and that there is no standardization with regard to DC voltage as in AC system. There are so many different voltages used in feeding DC devices due to the lack of standard. This leads to the increase of the requirement for the number of DC/DC converters. The decrease of both the number of DC/DC converters and their costs is one of the challenges required to be overcome for the transition to DC distribution system.

In addition, even though it is possible for many devices that are still operated by AC voltage to be designed and operated by DC voltage, this conversion will lead to significant costs. As of today, it is too early for the available AC LVDS to be fully superseded by DC LVDS. It will be more suitable method that the LVDS is performed through both AC and DC system from the low voltage side of distribution transformer. Furthermore, the common use of AC and DC for the low voltage distribution will gather the advantages of AC system and DC system. During the design stage of the devices, developing more liberal designs without the necessity to choose AC or DC will give chance to the occurrence of the optimum designs in terms of energy use in the long term.

DG connected to AC network causes short circuit power increase in the existing network. The increase in short circuit power reveals the necessity to renew the circuit breakers. In addition to this,
in the case of energy flow to AC system by consumer, the requirement for renewing the protection systems that are designed according to unidirectional feeding arises.

Furthermore, it will be a more suitable solution to support the existing system with DC distribution instead of renewing it in order to meet the load increase in considerable amount arising from the electrical vehicle charging stations.

For the buildings, selecting DC energy generation so as to supply DC loads and not letting energy flow to AC system are considered as the optimum structure in which AC and DC distribution systems are used together. The cost will be reduced as well by the use of rectifier instead of inverter in interconnecting AC and DC networks due to unilateral energy flow. The prevention of energy flow from DC system to AC system will eliminate the problem of short circuit power increase in AC system. In addition to this, the requirement for the protection systems installed according to unilateral feeding to be redesigned will be eliminated because there will be no energy flow to AC medium voltage distribution system.

A model system for the proposed AC and DC distribution system is given in the Figure. 2. This model system includes DC loads available in the building, a PV system as DC DG and Ultra capacitor as DC energy storage unit and a DC distribution system feeding the building equipped with EV charging system. It is composed of an AC distribution system feeding AC loads available in the building from AC network. There is also available a rectifier that allows for unidirectional transition between AC and DC LVDS.

In recent years, PV has been preferred as the DG due to the reason that PV roof systems are commonly used in buildings. It is supported with ultracapacitors which are energy storage means in order to generate higher quality DC voltage by meeting the changes in DC energy generated from solar energy. EV charging station the numbers of which are expected to increase in the future years is included into the model system [31].

In the proposed network model, a DC low voltage distribution system has been created by interconnecting DC systems of different buildings. The benefits of this system can be summarized as follows.

![Figure.2](image_url)
The number of rectifier has been reduced between AC and DC systems.

It has provided the opportunity for DC resources to back-up one another.

It has allowed meeting an increase in DC loads in any building with a decrease in another building. In other words, the requirement for installed capacity of DC resource will be reduced due to synchronization.

It allows for planning the charging of more than one electrical vehicle.

Ensuring the voltage quality in DC distribution system will be easier than ensuring the voltage quality in DC bus of any building.

The energy flow is made unidirectional via diodes in DC system whereas the supply of failure points by resources causes reliability problem in terms of resource and network in AC system.

The rectifier will provide support from AC network in the event that the power generated from the RES does not meet the demands of DC loads.

In case of power outage in AC system, AC loads will be disabled automatically due to unidirectional feeding. If there is power in the solar system with ultracapacitor, the block will carry on feeding the entire of DC loads in the building or urgent DC loads by remaining in working condition.

It is seen that the proposed LVDS is considerably complex in terms of operation when compared with the conventional distribution systems as well as their superiorities. The use of the LVDS proposed in this chapter together with the smart network technologies that show rapid development each passing day will eliminate the potential challenges.

3. SMART LOW VOLTAGE DISTRIBUTION

In the proposed low voltage distribution system, the communication infrastructures, smart algorithms and technologies are required for increasing the energy quality and energy efficiency, for obtaining the tariff data of the electricity market as online, and for optimizing the energy consumption and energy generation by DG.

In the proposed LVDS, smart demand side management (SDSM) is required for managing DC and AC load demands together, power quality monitor system (PQMS) for monitoring of DC and AC LVDS, smart control of DG (SCDG) for the optimization of energy generation of different DG units by taking account of load demands, smart control of EV (SCEV) for determining charging time and duration of vehicles by monitoring daily load duration curve and online energy unit prices, and similar subsystems. The main control center function will be performed by smart distribution management system (SDMS) in the operation of LVDC that will gather all these subsystems and that are proposed with its additional features. For SLVDS arising by the use of SDMS in conjunction with the proposed LVDS, an example network model is given in the Figure.3.

SDMS will form an environmentalist system that will be able to sense overloads with its real-time communication infrastructure, will regulate the energy flow directions, will optimize the use of RES and that will reduce the user costs. SDMS is based on real-time data collection. SDMS computers for rapid decisions analyze this data, most of the problems that might arise are avoided by preventive measures or it is ensured that the distribution system repairs itself by eliminating the problems arising or by isolating from the distribution system. It is possible to prevent disconnections by means of fault status and overload control.

In conventional approach, the management of distribution network and loads are comprehended as such processes that are independent from each other. With the gradually increasing number of DG, a change has begun even if it is slow. In the demand side management, the loads and DG should be evaluated together.
Figure 3: An example of Smart low voltage distribution system

3.1. Smart demand side management

Ensuring balance between generation and consumption in power systems is essential in terms of keeping the frequency constant and it is obliged to suffer from economic and social costs of blackouts arising from not achieving the balance.

In such cases that one of the large power generation plants is broken down or that the energy demands of customers cannot be met by the available generation resources in peak times, power outage are made unavoidably. For ensuring the network reliability, it is required both to use the restricted energy sources in the most efficient manner and to manage the timing and amount of the energy demand of customers.

The application and evaluation studies that will affect the electricity consumption in terms of amount and time are designated as demand management [31]. Besides conventional demand management techniques, one of the most important methods in reducing the peak demands is to determine the prices on an hourly basis under free market conditions, to provide the customers with information about prices as online and to change the customer attitudes. If very low or high prices
occur in the market during the day, the necessary interventions can be made by means of the SDSM techniques.

Smart management systems are required for the demand response in DC distribution system to which DC loads, DC resources and DC storage units are connected and in AC network fed by AC loads and network. With the SDSM algorithms, it will be possible to manage many loads such as EV charging. With the real-time demand management, the overall generation and consumption balance will be contributed by locally ensuring the balance between generation and consumption in the buildings.

Smart charging of electrical vehicle. In the near future, the EV will be the new type of loads of the distribution transformers. However, the available transformers are not installed by considering such loads. For this reason, it is still carrion on seeking new ones in order to prevent many EV charging stations from bringing overload to the distribution transformers. It is necessary to encourage the generation resources that are distributed at the level of end user in order to reduce the influence of electrical vehicles on distribution systems. DC distribution system available in the LVDS proposed in this study will contribute in solving the problem since it will make the connection to DG network easier. The adverse effects of EV on the existing network can be reduced by the connection of EV charging system and DC DG to the same DC network.

Vehicle to Grid systems (V2G) is equipped with capabilities of bidirectional energy flow [32]. EV has such technical features that can supply power to the building electric system to which it is connected when necessary. The cost of energy storage in vehicles is considerably higher when compared with electric energy generation by conventional methods. For this reason, it is appropriate for it to be used in peak times which are much shorter than supplying base load and during which energy is costly. The most of the studies carried out are related to the charging capacity required for charging EVs [33, 34].

With SCEV and SDSM algorithm, it will be possible to schedule charging by using the data concerning the number of vehicles that are capable of rapid and slow charging at the same time and on customers’ vehicle use attitudes as well as the load data of electric energy distribution transformer.

Furthermore, with a SCEV, it will be also possible to use a certain part of battery capacities in order to supply power to the network as DC energy storage unit and to make charging optimization for all EV connected to DC system by intercommunication over a DC bus at the hours when the vehicles are not in use [35].When the vehicle batteries are used as the network storage capacity, the Calculation of battery losses is an important issue in terms of pricing in energy market. If low battery costs are achieved, it is possible to reduce the usage costs of the vehicle by remaining connected to the network.

Electrical vehicles are considered as an alternative way in order to minimize the common petroleum dependence and greenhouse gas emissions in transportation sector. However, it does not seem possible to reduce the adverse effects of EVs on the network without using smart technologies.

1.1. Smart distributed generation and storage device management

The efficiency has gained more importance in the generation, transmission, distribution and use of electric energy upon the signature of Kyoto protocol by the countries in order to reduce the gas emission. The renewable and other small power DG are connected to the network at low voltage level. The energy that is generated as DC is transformed and supplied to the network as AC. The efficiency decreases due to the energy lost in DC/AC inverters. On the other hand, the amplitude, phase and frequency should be compatible in AC system whereas only voltage amplitude should equal same in order to connect to the network in DC system [24].

Storage devices and generation control may constitute beneficial tools to optimize electricity generation [36]. Since DGs that run intermittently like wind and solar power plants are not reliable
sources in meeting the customer demands, it is required to improve the energy storage capacity of the network. There occur difficulties in dimensioning the network for DG at different size and in different location along the distribution system. The protection requirements of the distribution networks to which DG units are connected will considerably vary [37]. The protection systems programmed according to unidirectional power flow may become ineffective. The reclosing systems of DG units may disturb. The operation sequence of the protection devices may be important during the course of fault. The method of fault localization may become invalid due to DG unit. When an error occurs, the current operational application of a distribution network may require the disconnection of DG units from the network. DG system protection can prevent the working condition of the block by preventing the fault from feeding DG unit. Because of that, DG unit is unnecessarily inactivated during a fault; unnecessary opening in feeders, synchronization loss in synchronous generators, overspeed and overflow in asynchronous generators may occur.

The outage of DG units makes DG units more important since it may cause power quality problems locally and it may induce the occurrence of stability problem within the entire system [38]. In order to overcome the problems mentioned in brief above, there are required smart DG management algorithms that fulfilling the monitoring and controlling function through bidirectional information flow between the distributed generation plants connected to either DC system or AC system and all points of loads. The inclusion of such storage units as ultracapacitor, flywheel and battery connected to DC system in particular into these smart management algorithms is essential for improving the reliability of DGs. If necessary, the storage capacity of electrical vehicle batteries can also be utilized.

In SLVDS proposed in the Figure. 3 above, an ultracapacitor is used together with PV system for minimizing the changes that might occur within day in PV system as far as possible. First, PV system having ultra capacitor feeds DC loads and support is provided from the network in case of necessity. However, it is required that the energy supplied from solar energy will have the capacity to help in feeding urgent DC loads in case of network outage. In order to generate energy in greater amounts, the surface area and number of solar panels can be increased.

Under ideal conditions, there should be a perfect conformity between conventional power plants and RES such as solar and wind power plants. In the events where a perfect conformity cannot be ensured, the energy storage units will contribute to the network conformity by being discharged.

A more reliable network structure will be created by combining the distributed generation resources and the storage system opportunities by means of the smart technologies.

4. A CASE STUDY: DEMAND SIDE MANAGEMENT

In this chapter, there is given a case study concerning the demand side management in the low voltage distribution network including daily load duration curve, EV charging system and PV system based on SLVDS given in the Figure. 3. In the low voltage distribution system, the daily load duration curve for winter (Figure.4) and summer (Figure.5) seasons of the feeder that supplies power to five houses are used. The daily load duration curve is separated as DC load duration curve and AC load duration curve taking account of DC devices used in the buildings and the characteristics of such devices [39]. In these buildings, DC devices are used in conjunction with ultra capacitor for the power derived from PV roof and PV system to be regular. Apart from the devices available in these buildings, one electrical vehicle that requires charging after turning back from work in three houses. If the solar system remains incapable of meeting the requirement of DC loads, there is a rectifier. For this study, the rectifier and cable losses are disregarded. A smart charging station is required for balancing DC load of the electrical vehicle charging station and so that it will step in at the most economic time in the scheduled system.
**Figure 4:** Load curve along a typical Winter day

**Figure 5:** Load curve along a typical summer day

**Figure 6:** Load curve with EVs consumption along a typical winter day for the smart charging
EV charging units can be operated as three-phase or single-phase. Three-phase charging provides higher power and more rapid charging opportunity. However, buildings do not include three-phase system all the time. Single-phase energy can be supplied more commonly. The single-phase charging current is generally at the degree of 10 A and rapid charging current at the degree of 30 A. The single-phase and standard charging process usually takes 6 hours. By taking account of the load duration curve, slow charging is preferred by the smart charging system.

The multi-time tariff treatment of the distribution company from which the buildings purchase energy is between 06:00-17:00 as standard, between 17:00-22:00 as peak and between 22:00-06:00 at night. For residences, the tariff charges of 2010 for these tariff periods are 0.118, 0.188, 0.071 $/kWh in the same order \[\]. Since there is no energy generation in PV system at night, the period between 22:00-06:00 during which energy is the cheapest in triple tariff system from the network over a rectifier for charging of the electrical vehicles prefer the smart charging system.

The smart charging system determines the period between 22:00-06:00 as the most appropriate hours in terms of DC and AC network loading as well as in economic terms.

The energy generated in PV system of 50 m2 and 500 W in each house is insufficient to meet the requirements of DC devices in the buildings. If the energy generated in PV system is more than the requirement, the rectifier between AC and DC systems will prevent it.

In this study, when DC load duration curve in the Figure. 4 and Figure. 5 is examined, the nighttime during which DC load is lower is preferred for preventing electrical vehicles from overloading DC system. The influence of normal charging of EV charging on the daily load duration curve for winter season is given in the Figure. 6 and on the daily load duration curve for summer season in the Figure. 7. It is seen that EV charging systems cause significant increases in DC load duration curve. Since there is no energy generation in PV system at night, DC energy is supplied from the network over a rectifier.

When the DC daily load duration curves for winter and summer seasons are examined in the Figure. 8 and Figure. 9, PV system does not meet the daytime requirement for DC energy generated.

The Figure. 10 was used for the electric energy generated by PV roof systems in the buildings in summer and winter periods. The instantaneous changes in output powers of solar cells within daytime by the use of solar cells together with ultra capacitor were not taken into consideration.
Figure.8: Load curve with PV generation and EVs consumption along a typical Winter day for the smart charging

Figure.9: Load curve with PV generation and EVs consumption along a typical Summer day for the smart charging

Figure.10: Power of PV system based on solar radiation, Istanbul, Turkey, 2009
Due to the reason that PV system does not supply DC load in daytime, the surface area and number of the solar panels can be increased in order to increase the energy amount generated. However, it is not possible to increase the surface area and number of the solar panels as there is no space on the rooftop. However, it is possible to increase only in rural section where the land costs are not high.

Due to the reason that PV system does not supply DC load in daytime and that no DC energy is generated at night, the requirement may be met through a fuel cell that will be able to generate energy during day and night for the requirement of DC distribution network. However, DC system and DC DG should be designed so that DC load is supplied since it is assumed that there will no energy flow from DC low voltage distribution system to the direction of AC network.

5. CONCLUSION

In the future, it is expected that the electrical vehicles charging systems connected to the low voltage distribution system will rapidly become widespread. In the available low voltage distribution system, the requirement for upgrade will occur due to the problems of voltage collapse and overloading of network components during charging a large number of electrical vehicles at the same time. The sufficient-sized DG meets the requirement for upgrade through the connection of the low voltage distribution system to the building side where the electrical vehicle charging systems are installed. The hybrid low voltage distribution system to which both AC and DC low voltage distribution systems are connected over a rectifier from the low voltage distribution transformer will be an appropriate network model for meeting the future requirements.

The advantages of using AC and DC together for low voltage distributions are summarized below.

- During the design stage of the devices, developing liberal designs without the necessity to choose AC or DC will give chance to the occurrence of the optimum designs in terms of energy use in the long term.
- The restriction that the new consumer devices and power generation always have to be AC will have been eliminated.
- Both the difficulties encountered in connecting small power DG to AC LVDS and the requirement for DC energy source required for EV charging will accelerate the expansion of DC LVDS.
- The interconnection of DC and AC systems via a rectifier prevents the energy flow from DC DG to AC network. Because of this, the requirement for making change in the protection and operation of electric distribution system designed according to unidirectional feeding will be eliminated.
- It is expected that the collocation of AC and DC distribution systems will become widespread with the development that will occur in relation to the standards.

While operating AC and DC LVDS, smart technologies are required as well as the standards. The advantages of co-management of AC and DC LVDS by means of smart technologies are summarized below.

- The interconnection of a DC LVDS and DC MicroGrids belonging to more than one building allows for the co-management of DC load demands and DC DG.
- In order to reduce the adverse effect of EV on LVDS the number of which is increasing rapidly, it will be possible to design SCEV systems that use AC load profiles, DC load profiles,
online data and tariff information of the electricity market in determining charging periods, start time for charging and charging technique.

The most essential problem in DC LVDS is that DC voltage values of devices are very different from each other and that there is no standardization with regard to DC voltage as in AC system. The decrease of both number and costs of DC/DC converter is one of the difficulties required to be overcome for the transition to DC distribution system. In spite of all difficulties, it is expected, in the long term, that DC LVDS will become widespread along with AC LVDS feeding the buildings.

REFERENCES


