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Reviews: The Impacts of Electric Vehicles (EVs) and Renewable Energy Resources (REs) on The Distribution Power Network

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***Abstract*— The conventional Medium voltage (MV) and Low Voltage (LV) distribution power network had the power flow in one direction, which flows from the power plant (calls central generating) downward to the consumer. However, this power flow direction is starting to change, and hence it is becoming the Bi-directional. Because the accommodating of Renewable Energy resources (REs) such as wind turbine, Photovoltaic (PV) and Electric Vehicles (EVs) etc. In addition, the uses of power electronic devices such as converter (stabilises the use of voltage), inverter (inverses between AC-DC or DC-AC) and charger (supports EVs) are also dramatically increasing, and thus it is also effected the Power Quality (PQ) on the distribution network as same as the power flow.**

According to the impacts of the REs and EVs, the distribution network must face the challenge. The demand of electricity such as the consumers' behavior, types of REs, charging/un-charging EVs is necessary to investigate. This investigation will be more complicated as the variations in demand profiles. These large data in the network can be called the 'Big data' of the power network. The 'Big data' can increase the development in the monitoring and controlling systems of the network, and hence it is allowed the network to become smart network.

The distribution network must have the ability and capability to accommodate the REs and EVs. Therefore, the standards and regulations of REs and EVs connection, standards and regulations of Feed-In-Tariffs (FIT), the revision of Power Purchase Agreement (PPA) between provider and consumer, smart meters, smart On-Load Tap Changer Transformer (OLTC), smart EVs Car Park, Smart Energy Storage, smart Artificial Intelligent (AI) to manage Big Data, etc. are necessary required to study.

Keywords—Distribution power network, Electric Vehicles (EVs), Renewable Energy Resources (REs), Smart network,

I. INTRODUCTION

The REs is continually growth in 2019 as can be seen in Fig. 1 [1]. The growth rate of REs is due to the change of regulations in the power market. Accordingly, this REs is generally included hydropower, wind power, photovoltaic (PV), bio-power, geothermal, tidal and wave energy etc. Therefore, 4 main keys for the smart network, which are the modern monitoring system, modern controlling system, the 'Big Data' server and smart AI (such as machine learning approaches) are required to analyse and allow control at the authorities' levels in the power network [2-16].

The incorporating between the smart meters and smart AI for 'Big Data' server, which supports an interpretation model for the properties of neural networks as same as a learning algorithm are allowed to optimise and manage the power flow in the network with high penetration levels of REs and EVs. This means that the smart meters can be used in conjunction with other smart controllers at the local levels.

In Fig. 2 shows the data acquisition technique, which using existing fibre optic cable, Wi-Fi or satellite to retrieve/update data from smart meters. The power flow management technique by gathering local data via smart meters and providing local data via the 'Big Data' server (or central data bank) to the other smart controllers at public areas has shown in Fig. 3. Moreover, Fig. 4 has described the send/receive signals from the local levels, which include bus location, voltage profiles, Power Factor (PF), energy consumption, Total Harmonic Distortion (THD), generated power of REs, charging time of EVs, fault status and price tariff. In addition, it can be seen that the all smart controllers in the network are acquired the data directly from either at the local or central data bank levels as shown in Fig. 5. This allows the concern of the owner right and more security to manage at the local level, especially residence area.

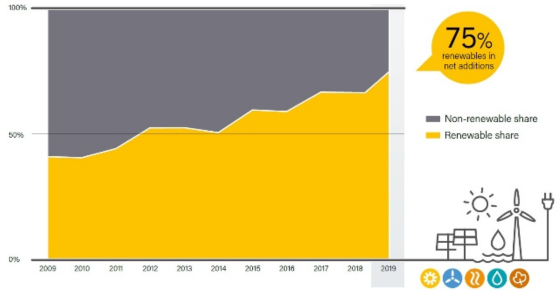


Fig. 1 Annual share of renewable and non-renewable energy during 2009-2019 [1]

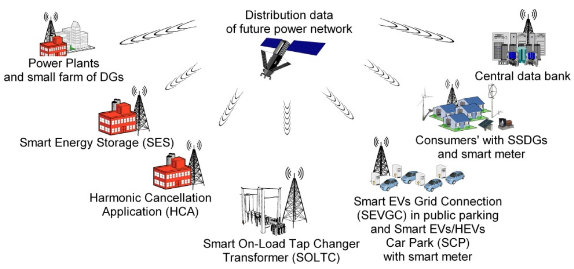


Fig. 2 Typical data acquisition of the smart network

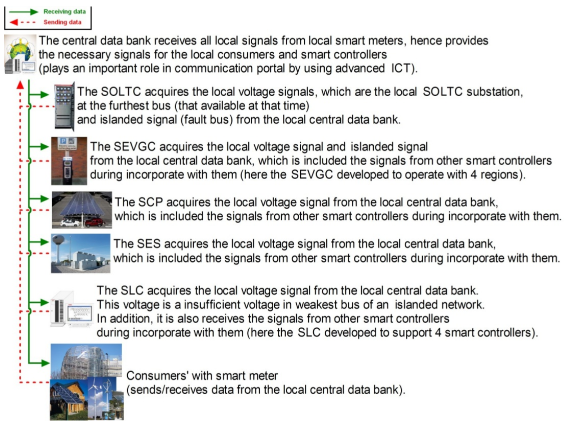
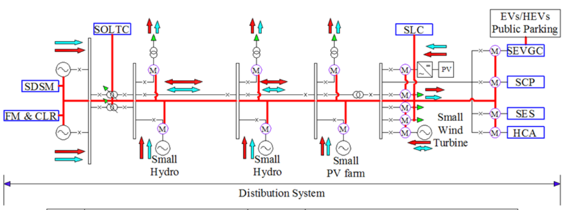


Fig. 3 Typical schematic of the smart AI to manage 'Big Data'



Legend	Details	Legend	Details
×	Breaker	SDSM	Smart Demand Side Management Control
→	Loads	SOLTC	Smart On-Load Tap Changer Transformer
-⦶-	Transformer	FM & CLR	Fault Level Monitor and Fault Current Limiter
	On-Load Tap Changer Transformer	SEVGC	Smart EVs Grid Connection
	Generation Unit	SCP	Smart EVs/HEVs Car Park
	Active Power	SES	Smart Energy Storage Systems
	Reactive Power	SLC	Smart Load Controller
	Inverter DC-AC	HCA	Harmonic Cancellation Application
Ⓜ	Smart Meter		Fibre Optic Cable or Communication Signal

Fig. 4 Typical control diagram of the smart network

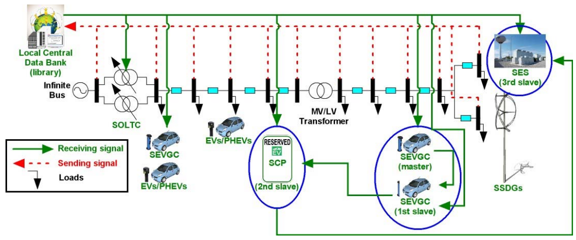


Fig. 5 The smart AI, and 'Big Data' server incorporates with smart controllers

II. REQUIREMENTS ON THE SMART NETWORK

It is well known that the smart network is required the smart, learning algorithm and secure functions to respond the unforeseen condition. These functions must have the rapid response in the real-time monitoring and controlling. The 'Big Data' server (or central bank data can possibly locate any elsewhere in the network, which is similar to the mobile phone network station. Therefore, the following requirements that investigate and analyse to develop and implement the smart network are discussed as follows [1-16]:

1. All residence at the local level must have smart meters that allows the updating data (such as location, demand and PQ profiles) and controls some major load as converters/inverters of REs, charger unit of EVs. These data can directly access by the local controller and the central data bank.
2. The advanced Information Communication Technology (ICT) is required as the smart network is needed the rapid respond of the monitoring and controlling systems.
3. All smart controller must have protection system for the network as well as self-protection. To ensure the voltage, phase and frequency within the limits and the safety during connect/disconnect the device, the Phase Lock Loop (PLL) and/or relay protection devices are offered as optional function.
4. The 'Big Data' server (or central bank data) must acquire all status in the local levels. This ensures the performance of the smart AI. Because the smart AI is needed to operate with regarding the safety of network and local levels, for example the RCBs can immediately use passive/active detections during the loss of main or cable fault at any load feeder.
5. The accommodating of REs and EVs will be increasing in the future as its technologies are continually developed, and therefore the REs should have the Energy Storage System (ESs) as same as the EVs should has Vehicle-to-Grid (V2G) function. These functions can support the supply/demand in the smart network, and also allow the flexibility of pricing Tariff.

6. The smart network must have high stability and reliability during the peak demand. The smart AI must have learning algorithm to analyse the supply/demand in the network, and hence it allows the suitable operation.

7. The electricity provider and main operator must consider the installation location of large number of REs and EVs carpark as their capacity is significantly affected the voltage profiles and the PQ of network.

8. All bus faults must report to the local and central levels, and then all smart controller can access to make the suitable operation.

9. In islanding operation case, all secondary side of ON-Load Tap Changer transformer of LV network must provide an extra isolated (local) grounding system to support the islanded network as well as all REs must integrate the controller that voltage and frequency within the limits.

10. In islanding operation case, load shedding management must be allowed in order to maintain between supply and demand in the islanded network. That means load priority is necessary to achieve.

11. Standards and regulations of connecting REs and EVs are needed to revise. This ensures its safety operation and allows the flexibility of electricity market.

III. CONCLUSION

The proposed smart technique and controllers must incorporate either in independently mode or in corporately mode with other smart controllers in that central and/or local levels. The mains successful keys are the smart monitoring system, smart controlling system, ‘Big Data’ handling system and smart AI with learning algorithm. Moreover, it is supported the FIT at dynamic levels, and then it lets more electricity provider to participate in the electricity market. This ensures the better price of electricity for consumers, the stability and reliability in the network as same as more flexibility operation. This also supports the provider of REs.

In addition, the advanced ICT is also required for instance, the existing fibre optic cable, Wi-Fi or satellite to retrieve/update data between the local and central levels. In addition, the smart meters must have a two-way communication, and then it is allowed the updating data between the local and central levels as well. Then, the bus location, voltage profiles, PF, energy consumption, THD, generated power of REs, charging time of EVs, fault status and price tariff at the local levels are acquired to available in the ‘Big Data’ server (or central data bank) and support the other smart controller.

Accordingly, the converters and inverters that incorporate with REs must comply with standards and regulations such as IEEE-519, IEEE-929 and EN50160 as same as the charger of EVs such IEEE-2030.1.1, IEC 61851-1, IEC 61851-21 and EN1987-1. This ensures the generated THD is within the limits. However, the level of THD can be raised due to the combination of REs converters and/or inverters, which operates less than 10 percent of its rating, and this is also similar to the EVs that operates at charging mode with low level of batteries. These is effected from the variation of the duty cycle to maximise its performance. Therefore, the filter devices such as passive and active are also considered to mitigate the level of THD in the network as well.

It can be concluded that the standards and regulations of REs and EVs connection and FIT, the revision of PPA, smart meters, smart On-Load Tap Changer Transformer, smart EVs carpark, Smart Energy Storages, ‘Big Data’ serve, smart AI, etc. are necessary required to smart network.

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