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A Generic Scenario of a Load Flow Study in SAARC Countries Super Grid Using High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC)

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Abstract—The effective solution for the bulk power transmission to a larger distance is only possible with the utilization of the two technologies. Firstly, High Voltage Alternating Current (HVAC) which gives us fewer losses in order to cover larger distances. Secondly High Voltage Direct Current (HVDC) Voltage Source Convertor (VSC) which converts the AC Power into DC power and which provide better active and reactive power compensations during transmission of an electrical power to a large distance. The main idea behind this research is the Load Flow model implementation of the future SAARC Countries Super grid technology, using High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) using voltage source convertors (VSC), and then analyzed different factors, which will lead us to the conclusion than instead of using Ultra-High Voltage AC as an interconnection between different SAARC Countries Grid Stations, we can utilized Ultra-High Voltage DC as an effective solution for bulk power transmission (Active Power) especially of Renewable energy for Covering larger distances, and so in order to interconnect different SAARC Countries Grid Stations with one another for the exchange of Electrical Energy. This Research work also Summarizes an overall picture of the SAARC Countries Super Grid Technology which is not implemented so far, and which will used these above technologies in order to provide a secure and sustainable Electrical Energy to different SAARC Countries.

Index Terms— High Voltage Alternating Current (HVAC), High Voltage Direct Current (HVDC), South Asian Association for Regional Cooperation (SAARC), Da Afghanistan Breshna Sherkat (DABS), State Electric Company (STELCO), Maldives Electricity Bureau (MEB), Ministry trade and industries (MTI).

1 INTRODUCTION

Saarc Countries have much to worry about, when it comes to the consumption of an Electrical Energy [1]. There is a need to reevaluate the design of current electrical power system in Saarc Countries in order to provide secure and sustainable supply of electrical power to these countries. Therefore the implementation of this type of Super Grid in SAARC Countries will provides benefits to theses countries, not only in terms of exchanging electrical energy with one another, but also in terms boosting the electricity markets values in these countries. This SAARC Countries Super Grid is basically based on a renewable energy resource i.e. (Wind Farms), which takes electrical energy produced from an On-shore or Off-shore wind resources of each SAARC country and provide it to onshore load centers of each SAARC country. Moreover theses wind farms resources of each SAARC Country is also interconnected with one another in the form of Super Grid Technology, So in order to support each SAARC Country in case of any Contingencies Failures. This Project offers potential benefits for all participants of SAARC Countries i.e. (Afghanistan, Pakistan, India, Maldives, Sirilanka, Bangladesh, Bhutan and Nepal). Such a Super grid is likely to build using High Voltage Direct Current (HVDC) Voltage Source Convertor (VSC) technology [2].

As an increasing demand for electricity generation is growing day by day, so the best and reliable option is to generate electrical energy with renewable energy sources. Electrical Energy generated from renewable energy resources helps us to keep the environment clean and also provide benefit to their customers in terms of providing cheap electricity [3]. On basis of these facts, the SAARC Countries Super Grid is totally dependent on renewable energy resources i.e. On-shore or Off-shore Wind Turbines. These On-shore or Off-shore Wind Turbines are interconnected with the help of Super Node in the form of clusters.

As we know the fact that, wind turbines continuously need wind for generation of its Electrical Energy. So, therefore the best scenario to generate Electrical Energy from these wind turbines lies in the fact of placing these wind farms in such a place which is rich in terms of wind potential [4].

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As the rating of wind turbine is increasing day by day, with (Seven and the half Mega Watt) units are already available, and (Ten Mega Watt) Units are also under development [5], so therefore it is estimated, that On-shore or Off-shore wind farms installing capacity should be increased in the nearby future [6].

Different Studies about On-shore or Off-shore wind farms realized the fact that multi-terminal DC grid network is the most effective and efficient method of connecting large amount of wind farms with one another [5-6]. Moreover, these Multi Terminal DC Grid Network will also increase the electricity market between different SAARC countries [7].

However, before implementing this type of multi-terminal DC Grid network in order to implement the future SAARC Countries Super grid, there must be some technical issues that should be keep in mind [8]. And the most important one is the choice of HVDC converter topology, i.e. which type of convertor topology is used for HVDC convertor station, so in order to maximize the overall efficiency of the system [9–12], The second one is the need of dc to dc converters [13-14], The third one is the need for protection schemes [15–21], Fourth one should be a dynamic stability issues in SAARC Super gird [19–21], and the final one will be Load flow Study strategies of MTDC Grid Network.

The focus of this research work is the Load flow Study Strategies that will help us to improvise the power flow or load flow in SAARC Countries Super Grid.

2 IMPLEMENTATION OF SAARC COUNTRIES SUPER GRID

2.1 Wind the SAARC Countries Energy Resource

The SAARC Countries Super Grid Concept is inherently based on the nature of wind. On-Shore or Off-shore wind is the major SAARC Countries Energy Resource, wind is clean, i.e., the conversion of wind energy into electrical energy emits no CO_2 and other greenhouse gases, moreover once the construction of wind farm is completed, and it can go on producing electricity indefinitely [22].

2.2 Super Node Concept

The concept of super node, that is used in the SAARC Countries Super Grid Technology is basically for the continuity of Electrical Energy supply to their on-shore AC grid Station i.e. If there is a fault occurred in one part of the system, and its generation goes down, than with the help of a Super Node Concept, we can accommodate that part of the system without interrupting the Electrical Energy Supply, with the establishment of such Super node, we can accomdate each SAARC Country in terms of exchanging electrical energy with one another, and also in terms boosting electricty market strategies in each SAARC Country, so that a successful trade off electricity has been established between these SAARC Countries. Below figure shows a clearly differentiation of today's point to point electrical power system, and the implementation of SAARC Super Grid Technology by utilizing the concept of Super Node.

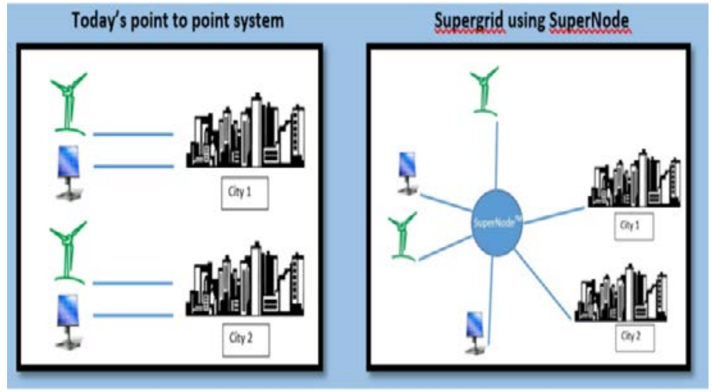

Figure.1. SAARC Countries Super Grid using the concept of Super Node [29]

3 TECHNOLOGY

Deregulation and privatization are posing new challenges to high voltage transmission lines. High-voltage Transmission Scenario, such as High Voltage Alternating Current (HVAC), and High Voltage Direct Current (HVDC) provide the necessary features to avoid technical problems in heavily loaded power systems, thus increase the transmission capacity and system stability very efficiently and assist in preventing cascading disturbances [23]. The future SAARC Countris Super Grid is based on these two technologies, thus allowing the transport of electricity over very long distance, when and where it is needed.

3.1 HVAC vs HVDC Technology based on (Break-Even Distance)

The table below compares the High Voltage Alternating Current (HVAC) & High voltage direct current (HVDC) Technology for implementing a Super grid. It is clearly observable from the below table that for covering larger distances, High voltage direct current (HVDC) Technology is more favorable as compared to High Voltage Alternating Current (HVAC) Technology due to following Reasons [23].

Table 1. Comparison of HVAC with HVDC

HVAC	HVDC
1) Inductive, Resistive and Capacitive Losses.	1) Only Resistive Losses.
2) Skin Effect.	2) No Skin Effect.
3) Frequency Issue.	3) No Frequency issue.
4) Not Suitable For longer distance Transmission.	4) Suitable For longer distance Transmission.
5) Suitable for Low Power Transmission.	5) Suitable for High Power Transmission.

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The generation of electrical energy is always in AC form. Similarly, before providing it to the end user, it must be in AC form. The losses and costs incurred in the power transmission are proportional to the distance of transmission, i.e. they are relatively small for the small distance power transmission and increase with the increase in the distance required for the transmission. To overcome these loses (both electrical power and transmission line cost) the electrical power must be converted to DC and later back to AC. However, these converter stations have the cost of their own. Therefore, it is required to know the minimum transmission distance where the AC transmission is no longer feasible.

Figure.2. describes the break-even distance point where High voltage direct current (HVDC) is more favorable as compared to High Voltage Alternating Current (HVAC), graphically.

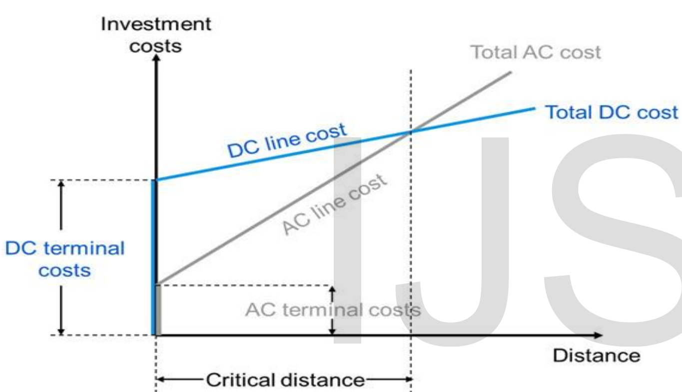

Figure.2. Comparison between HVDC and HVAC (over-head Transmission) [30]

In over-head transmission line this break-even distance is generally 400 km to 600 km. But the transmission system based on sub-marine cables (Off-shore Wind Farms), this break-even distance is much less than over-head transmission i.e. approximately 50 km.

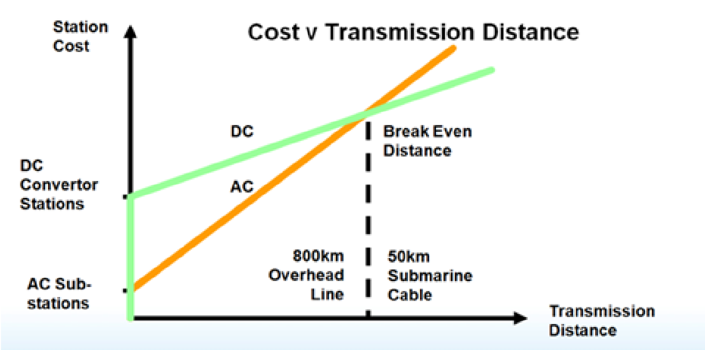

Figure.3. Comparison between HVDC and HVAC (Sub-Marine Cable Transmission) [30]

4 Energy Scenario (SAARC Countries)

4.1 India

India had an installed power generation capacity of 210 GW as of November 2012, which is about 154 times the installed capacity in 1947 (1362 MW). In all renewable energy fronts, India is currently ranked 5th in the world. With a total generating capacity from renewable sources being about 30 GW, mostly obtained through wind (18.3GW), small hydro (3.4GW), biomass (1.2GW) and solar (1GW). The main renewable energy sources in India are wind energy, solar energy, biomass and waste and hydro energy [24].

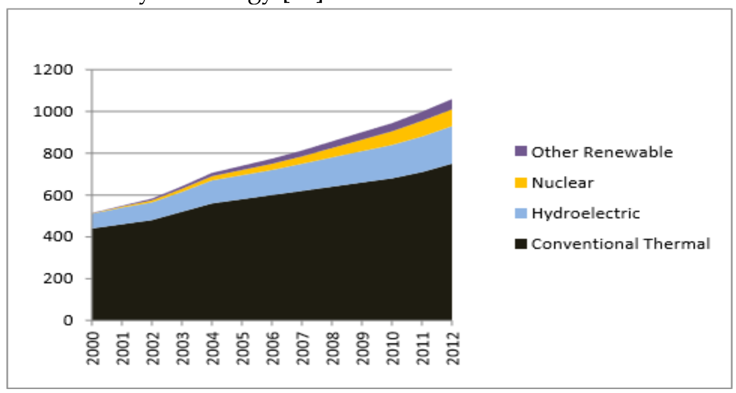

Figure.4. Indian electricity generation from different resources [24]

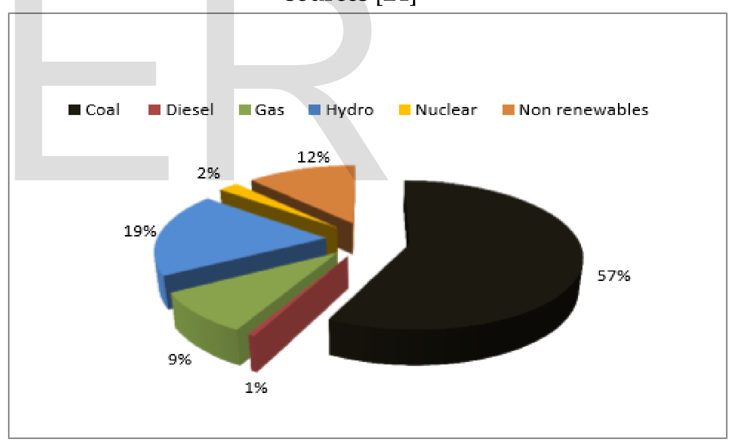

Figure.5. Indian electricity generation (over all installed Capacity) [24]

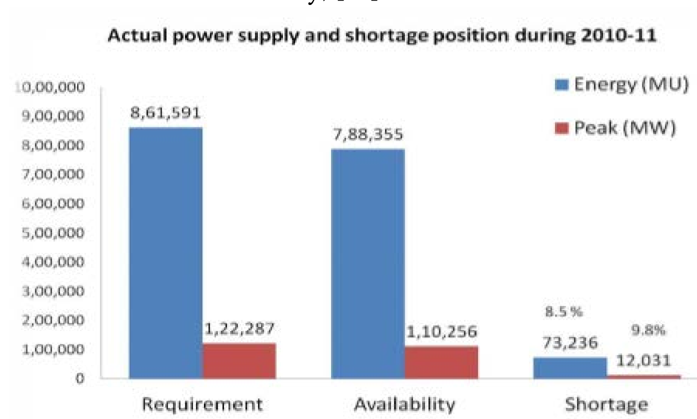

Figure.6. Power supply and shortage position (2010-2011) [24]

4.2 PAKISTAN

Pakistan's per capita/year energy use is 12.7 MMBTU compared with 65 MMBTU/capita/year for the world each for hydro and nuclear. The super grid can to a large extent provide Pakistan with a reliable electricity system involving electricity integration from the renewable energy sources as well as energy imports from neighboring countries [24].

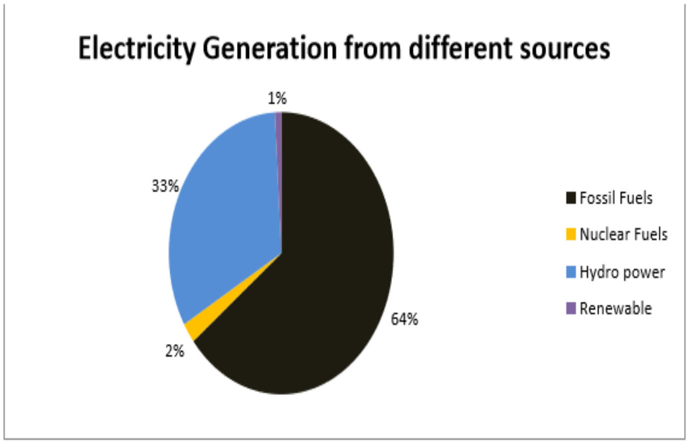

Figure.7. Electricity generation from different sources in Pakistan [24]

Figure.8. Location of Sindh valley in southern Pakistan [24]

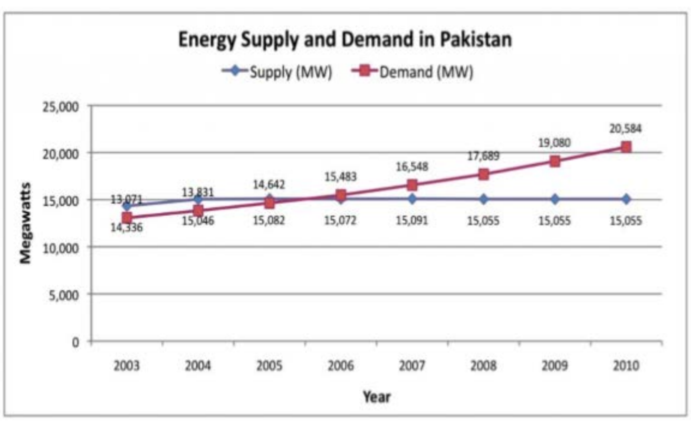

Figure.9. Energy Supply and demand in Pakistan [24]

4.3 BHUTAN

The potential of hydropower in the country is enormous to not only satisfy its domestic demand but also export the electricity to India and China. With the commissioning of the 1020 MW hydroelectric power station that was completely financed by India in 2006 the total generation of the country tripled. However this represents only 5 percent of the total hydroelectric potential of the country estimated at 30 GW [24].

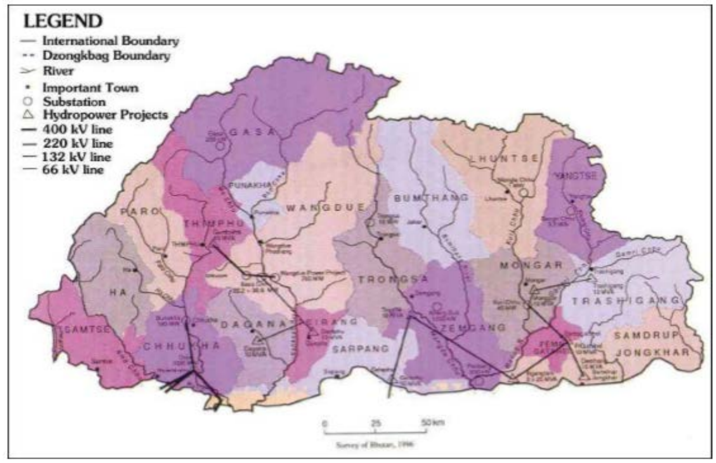

Figure.10. Bhutan international and national borders with transmission level knowledge [24]

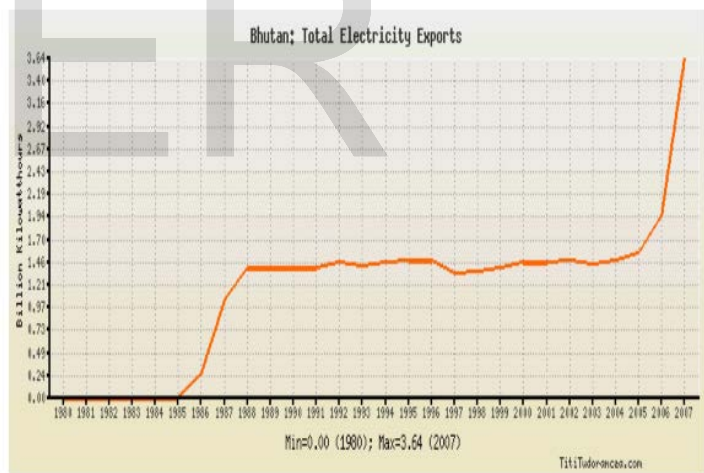

Figure.11. Bhutan electricity export [24]

4.4 BANGLADESH

The total installed capacity was 4005 MW in the financial year 2000-01 which has increased to 6685 MW in FY 2010-11 with an annual increasing rate of 6.62 percent. Continuation of this rate indicates that the projected generation would be 4828 MW by 2015 which is far shy from the vision of 11500 MW generations by 2015 [24].

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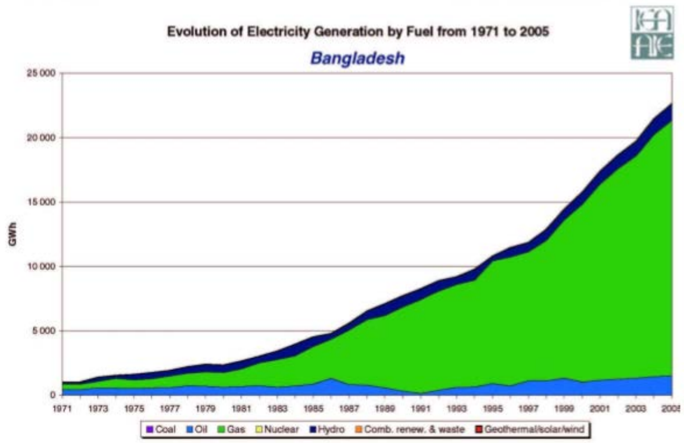

Figure.12. Fuel electrical power generation from (1971-2005) [24]

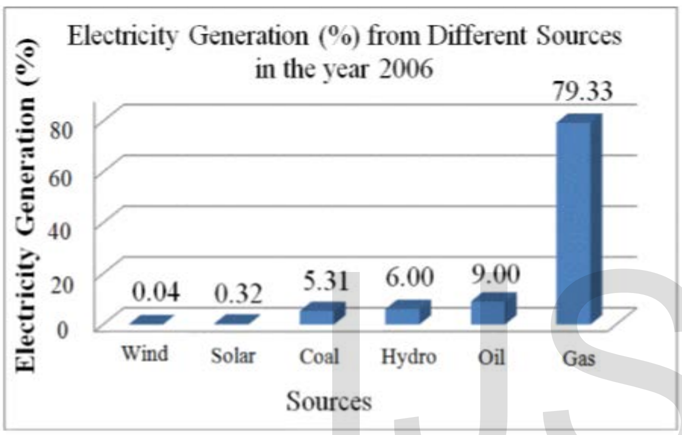

Figure.13. Electricity generation from different resources in 2006 [24]

4.5 SIRILANKA

In 2011, the maximum recorded electricity demand in Sri Lanka was 2163.1MW. In order to achieve that demand and to satisfy the electricity requirement in Sri Lanka, 139 Grid connected power plants with total installed capacity of 3140MW were operating in 2011. Out of those power plants, 23 were owned and operated by Ceylon Electricity Board including 16 hydro plants, 6 thermal plants and 1 wind power plant [24].

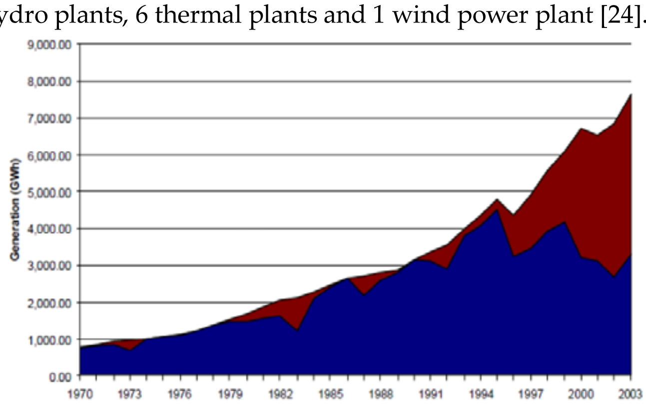

Figure.14. Variation in Electricity generation distribution from different sources in Sri Lanka from 1973 to 2003 [24]

4.6 NEPAL

The country has a potential of nearly 83000 MW of Hydroelectricity out of which only about 280 MW has been developed. At present only around 1.5% (613.5 MW) of feasible hydropower potential (32000 MW) has been developed yet and around 40 percent of the total population has some form of access to electricity [24].

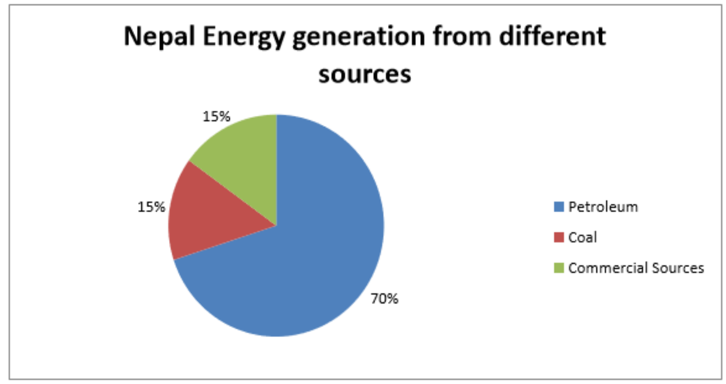

Figure.15. Electricity generation from different sources in Nepal [24]

4.7 AFGHANISTAN

Afghanistan generates around 600 megawatts (MW) of electricity mainly from hydropower followed by fossil fuel and solar. Officials from Da Afghanistan Breshna Sherkat (DABS) estimate that the country will need around 3000 MW to meet its needs by 2020 [25].

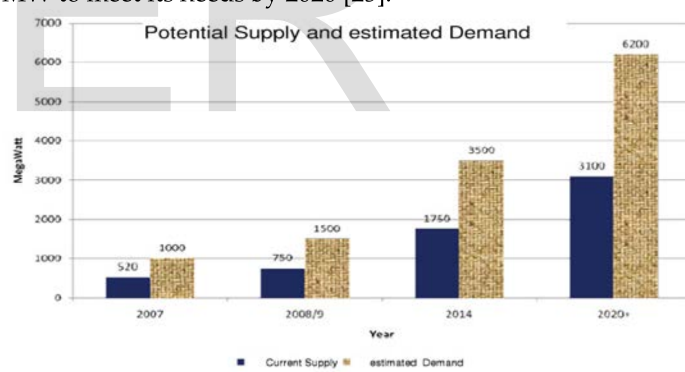

Figure.16. Potential Supply and Estimated Demand of Afghanistan [25]

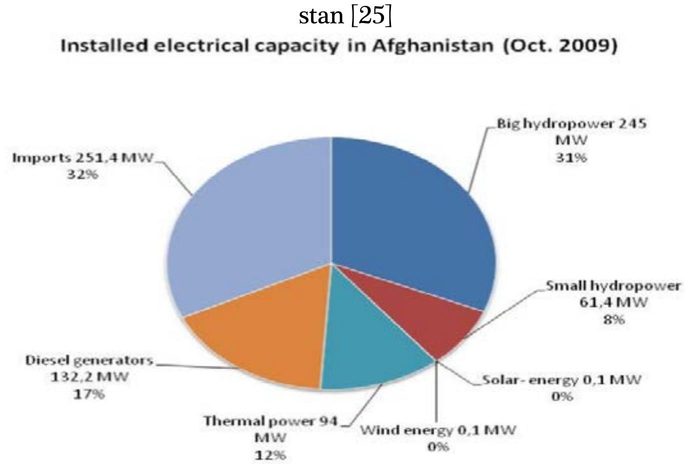

Figure.17. Installed Capacity in Afghanistan (Oct. 2009) [25]

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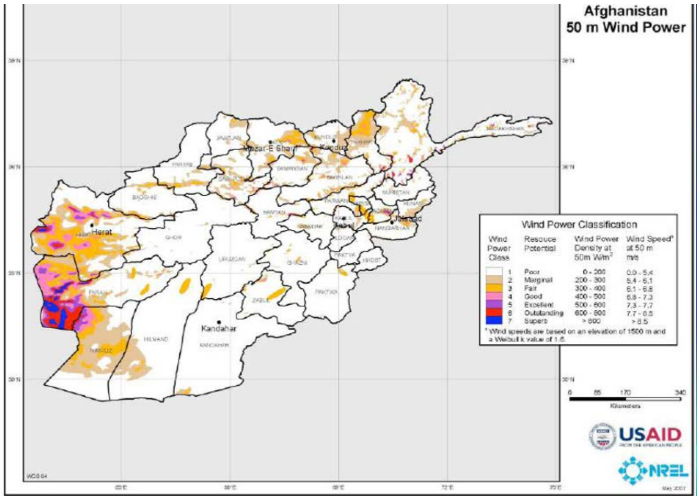

Figure.18. Wind Potential of Afghanistan [25]

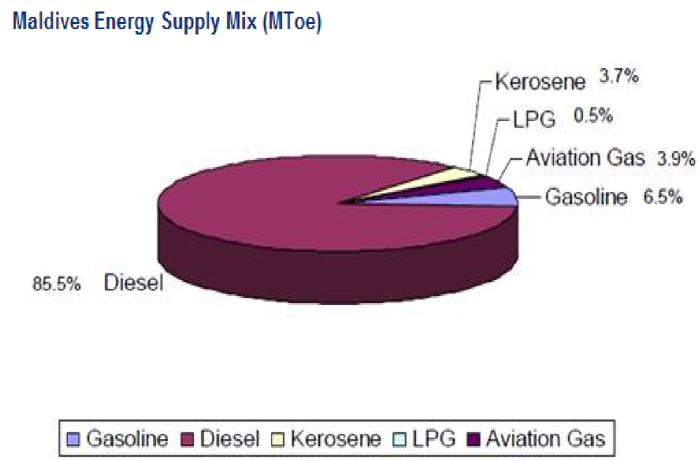

Figure.19. Maldives Supply of Electrical Energy [26]

4.8 MALDIVES

Since Maldives is a small nation consisting of 1,190 tiny islands lying at the equator. The number of islands inhabited remains at 200, while another 87 islands are specially developed as tourist resorts. Hence, each island has to have its own electric power generation system and other basic infrastructure. Total installed capacity was 106.2 MW in 2008. About 33% of the generation is through the State Electric Company (STELCO). In 2009, the Company operated 15 power systems in 18 islands, providing electricity to 46% of the population. STELCO now has an installed capacity of 53 MW and over 70% of generation is consumed by the capital. The Maldives Electricity Bureau (MEB), chaired by the ministry trade and industries (MTI), regulates STELCO and the private power providers [26].

5 SUPER GRID MODEL (SAARC COUNTRIES)

Below figure shows the model of Super Grid connecting SAARC countries with one another.

This figure summarizes an over all picure of SAARC countries Super Grid, in which SAARC countries are interconnected with one another through High Voltage Direct Current (HVDC) in the form of Cluster, and the corresponding AC Grid Station of each country is connected with one another in the form of a ring transmission Network through High Voltage Alternating Current (HVAC).

The Overall advantage of such type of Super Grid is that that every AC Grid station of each SAARC country should receive a balanced power due to the well balancing interconnection provided by such Super Grid Technology.

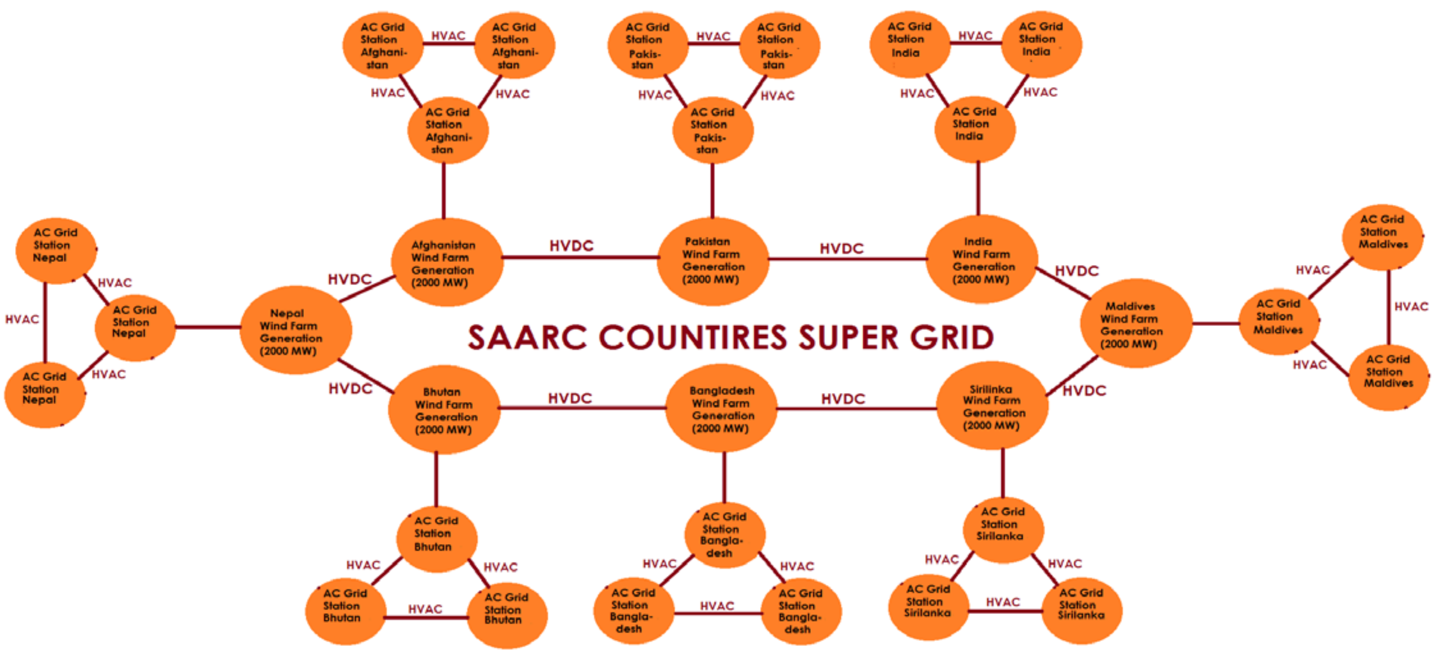

Figure.20. SAARC Countries Super Grid Model

6 Super Grid Model (Matlab Implementation)

Consequently, the formation of super grid in order to interconnect Saarc Countries with one another, is basically a high voltage DC Transmission system, that will actually provide a required platform to interconnect different Saarc Countries with one another, in order to provide a tradeoff electricity between these countries. Thus the Super Grid for Saarc countries leads to an inter connection of national grid markets, and therefore completely transform the way the electricity is produced, transmitted and consumed in each Saarc country.

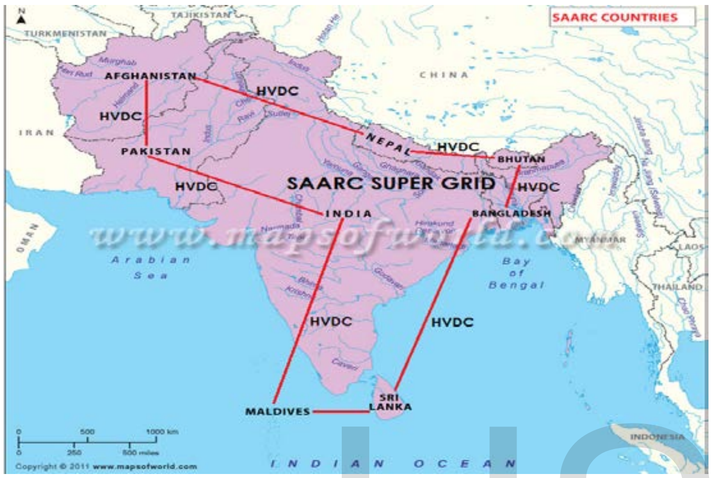

Figure.21. SAARC Countries Super Grid Model [31]

The Matlab Model of SAARC Countries Super Grid is shown in figure 22. This model shows the interconnection of eight countries that is included in South Asian Association for Regional Cooperation (SAARC). Each Country provides the wind farm generation of 2000 MW to there three On-shore AC Grid station, which are interconnected with one another in the form of ring transmission network of 500Kv AC Transmission Lines. The load of 100 MW is actually connected at each of the three on shore AC Grid stations of each SAARC Country. Moreover the phenomena of High Voltage Direct Current (HVDC) is utilized for the sharing of Electrical Energy between each SAARC Country.

This SAARC Countries Super Grid model is a Forty Eight (48) Bus Network model. The outputs of this implementation of SAARC countries Super grid model in matlab is shown in the Below figures. This output analyzed the fact of receiving balanced Electrical power of 604.8 MW at each of the AC Grid station of each SAARC country. This availability of same electrical power at each of the AC grid station of each SAARC country is due to the utilization of a super node concept.

Moreover, the output of above model also shows the electricity tradeoff between different SAARC countries, such as a tradeoff of electrical power of rating 486.7 MW is actually available between each SAARC country at the distance of about 1000 Km, which is covered through 500Kv DC Transmission Lines. Due to the large distance between each SAARC country, this tradeoff electrical power is only acheivablw with the utilization of High Voltage Direct Current (HVDC) Voltage Source Convertors (VSC).

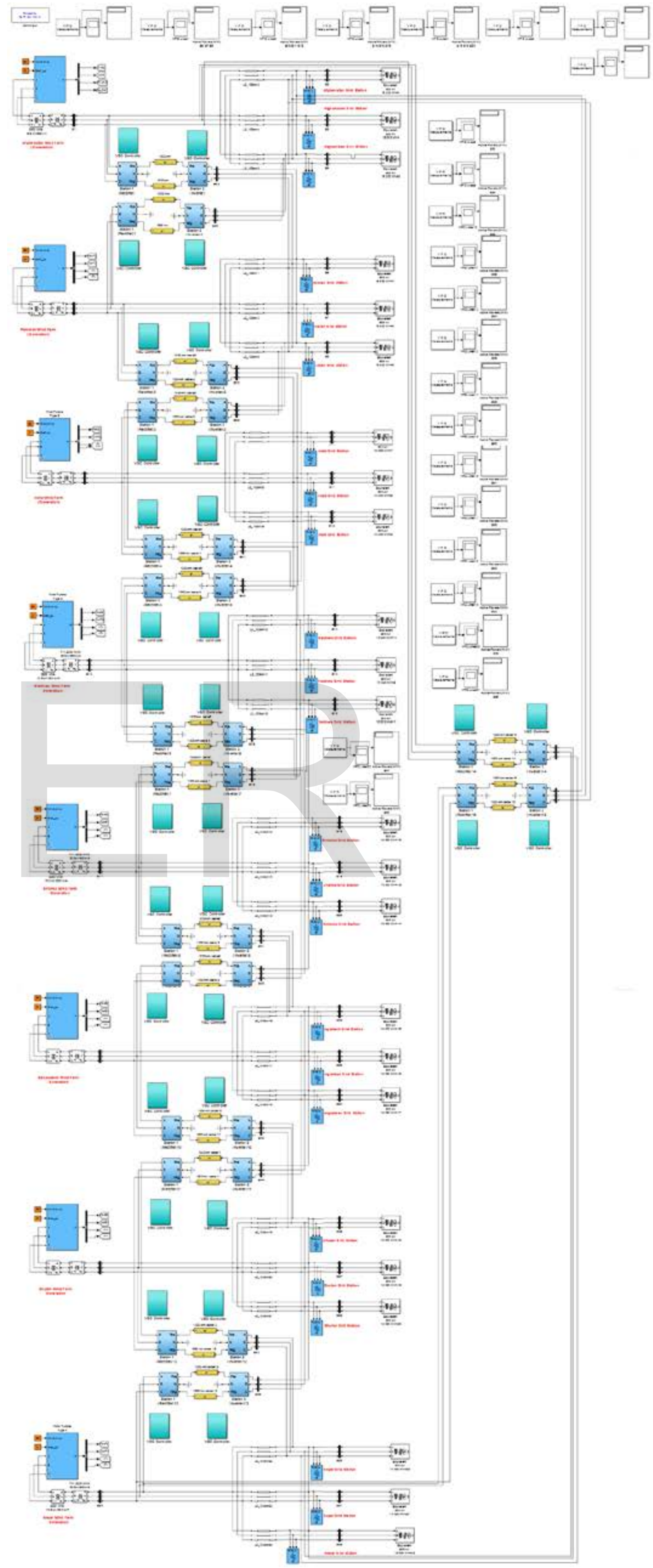

Figure.22. SAARC Countries Super Grid Model (Matlab)

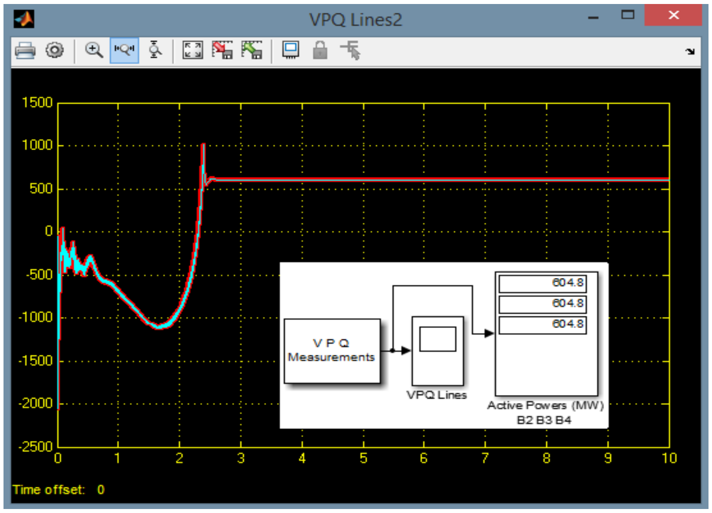

Figure.23. Output at Buses B2, B3, B4 (Afghanistan AC Grid Station)

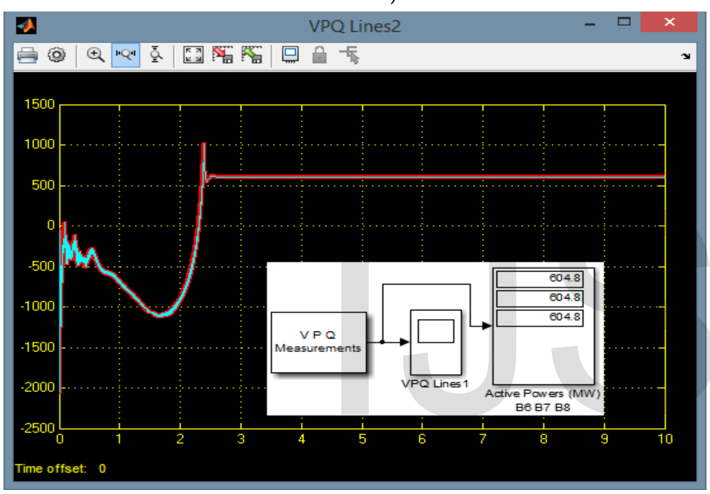

Figure.24. Output at Buses B6, B7, B8 (Pakistan AC Grid Station)

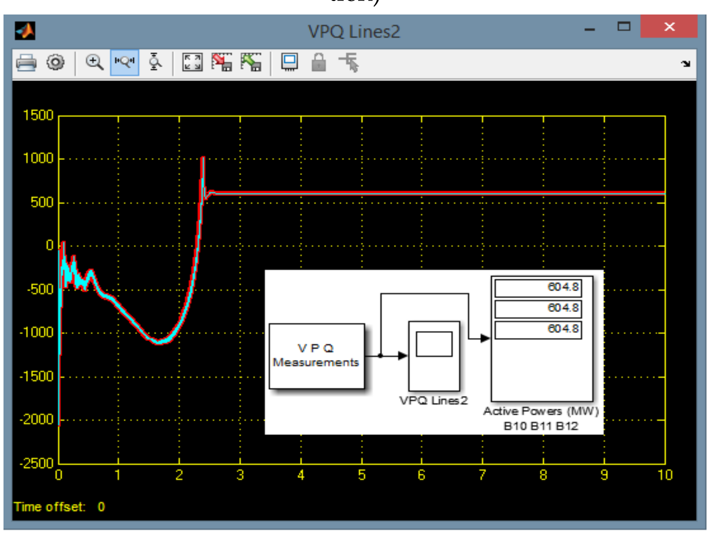

Figure.25. Output at Buses B10, B11, B12 (India AC Grid Station)

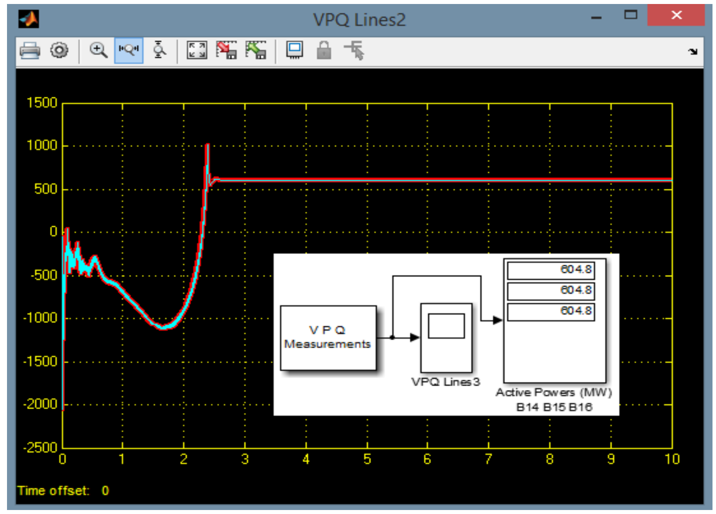

Figure.26. Output at Buses B14, B15, B16 (Maldives AC Grid Station)

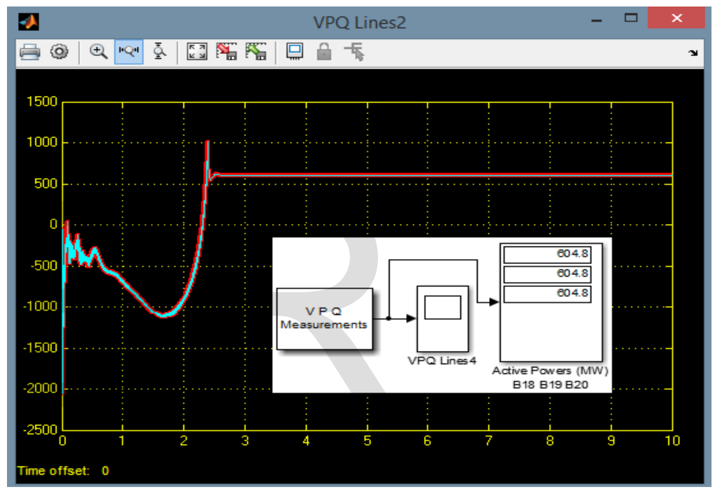

Figure.27. Output at Buses B18, B19, B20 (Sirilanka AC Grid Station)

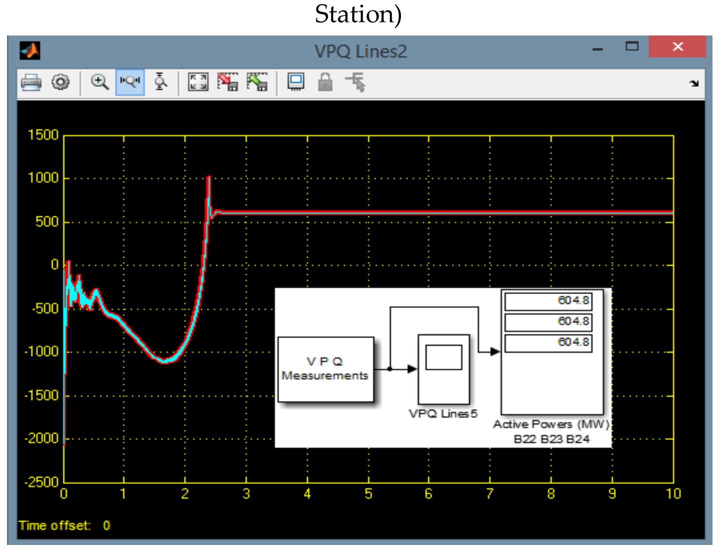

Figure.28. Output at Buses B22, B23, B24 (Bangladesh AC Grid Station)

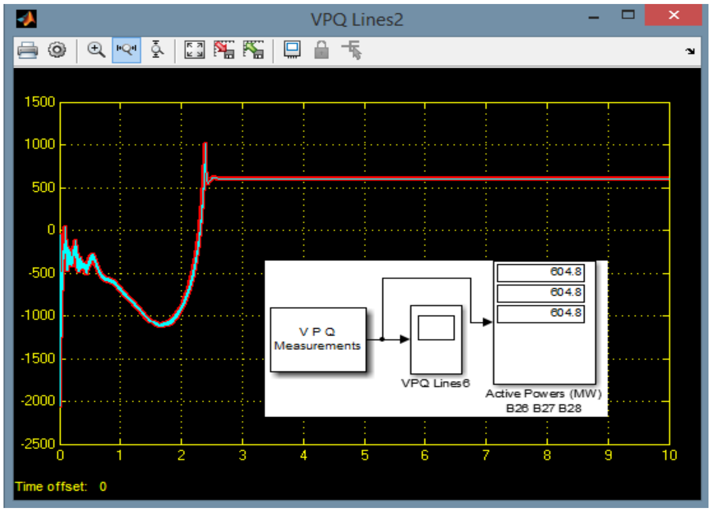

Figure.29. Output at Buses B26, B27, B28 (Bhutan AC Grid Station)

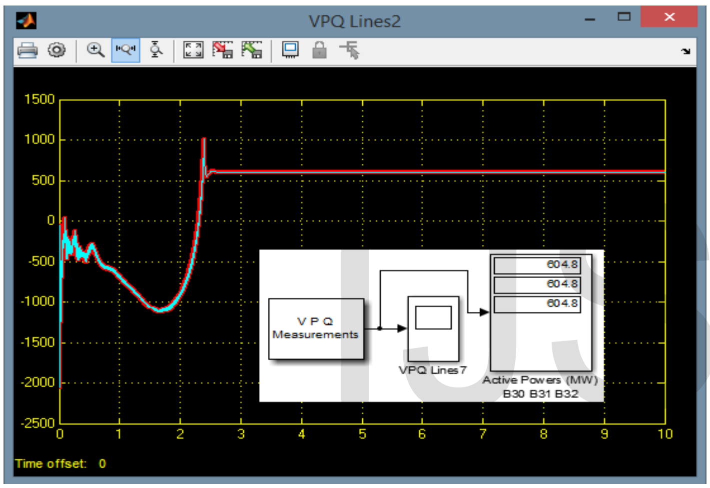

Figure.30. Output at Buses B30, B31, B32 (Nepal AC Grid Station)

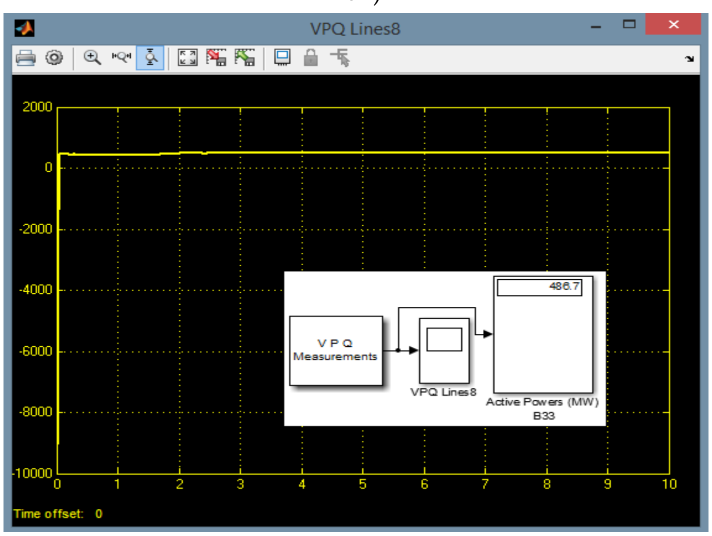

Figure.31. Output at Bus B33 (Sharing of Electrical Energy between Afghanistan and Pakistan Wind Farm Generation)

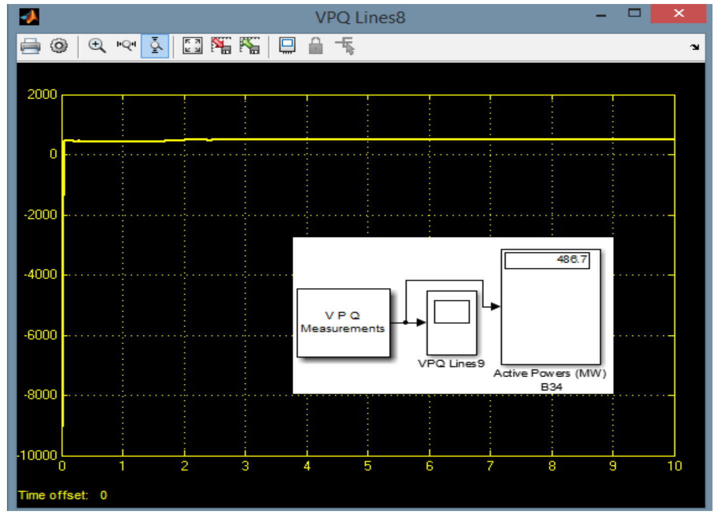

Figure.32. Output at Bus B34 (Sharing of Electrical Energy between Afghanistan and Pakistan Wind Farm Generation)

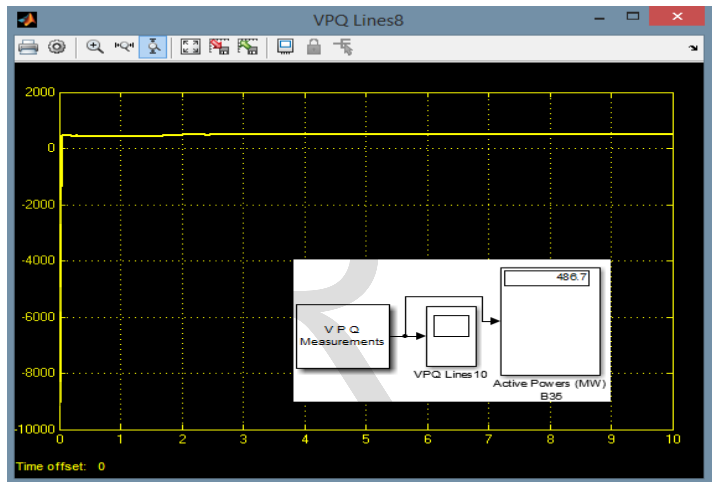

Figure.33. Output at Bus B35 (Sharing of Electrical Energy between Pakistan and India Wind Farm Generation)

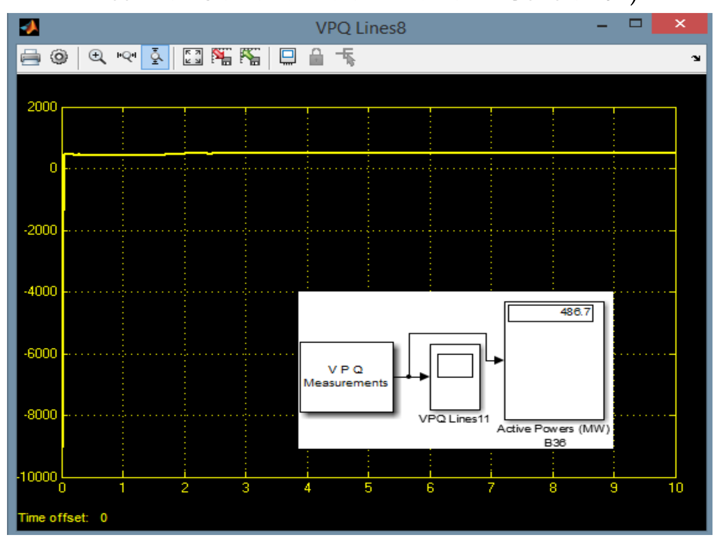

Figure.34. Output at Bus B36 (Sharing of Electrical Energy between Pakistan and India Wind Farm Generation)

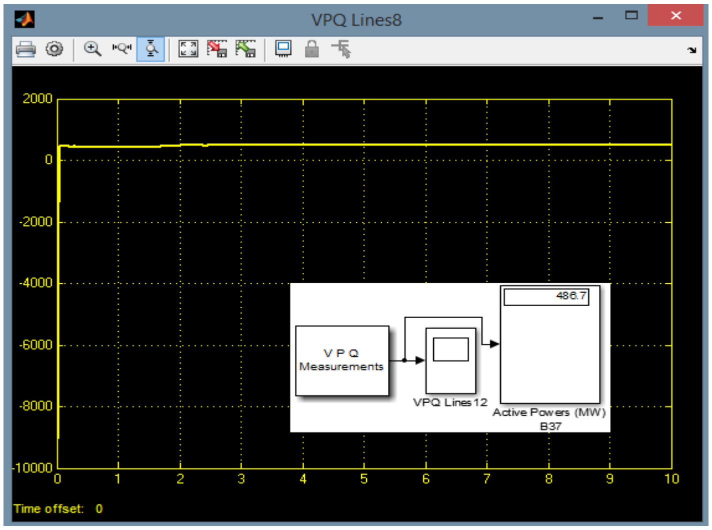

Figure.35. Output at Bus B37 (Sharing of Electrical Energy between India and Maldives Wind Farm Generation)

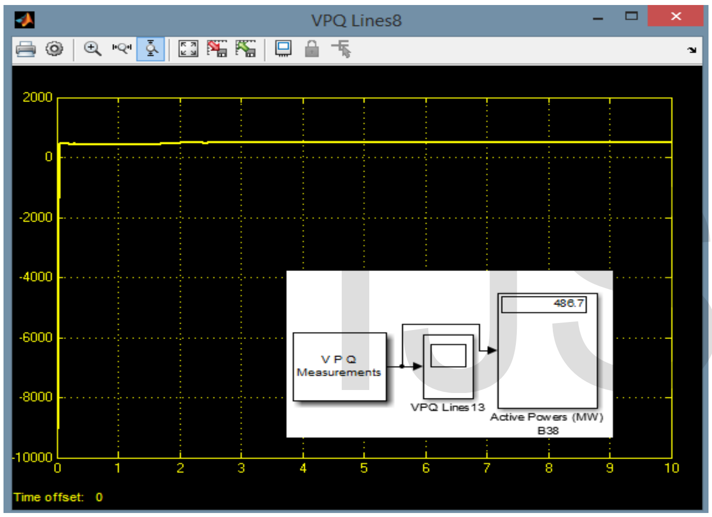

Figure.36. Output at Bus B38 (Sharing of Electrical Energy between India and Maldives Wind Farm Generation)

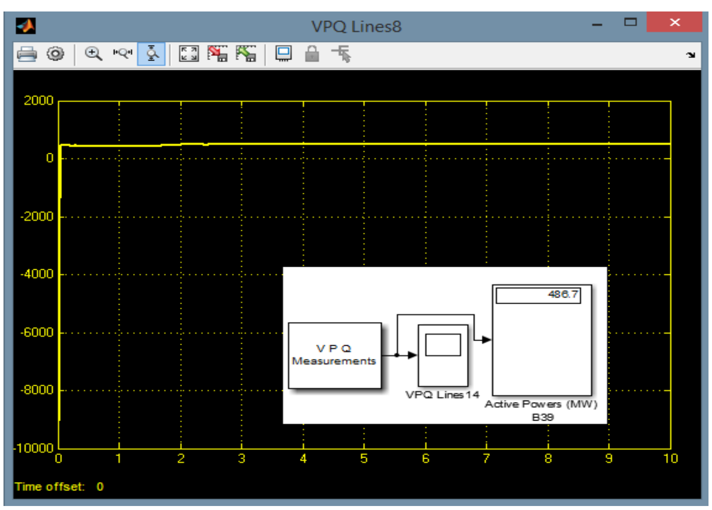

Figure.37. Output at Bus B39 (Sharing of Electrical Energy between Maldives and Sirilanka Wind Farm Generation)

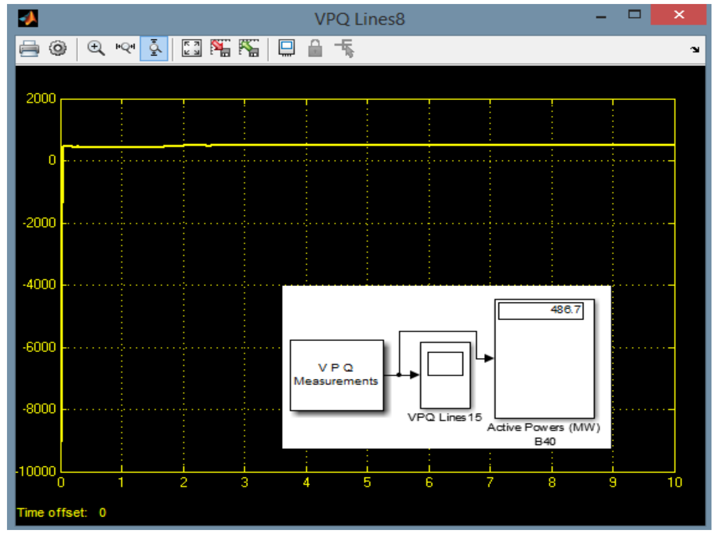

Figure.38. Output at Bus B40 (Sharing of Electrical Energy between Maldives and Sirilanka Wind Farm Generation)

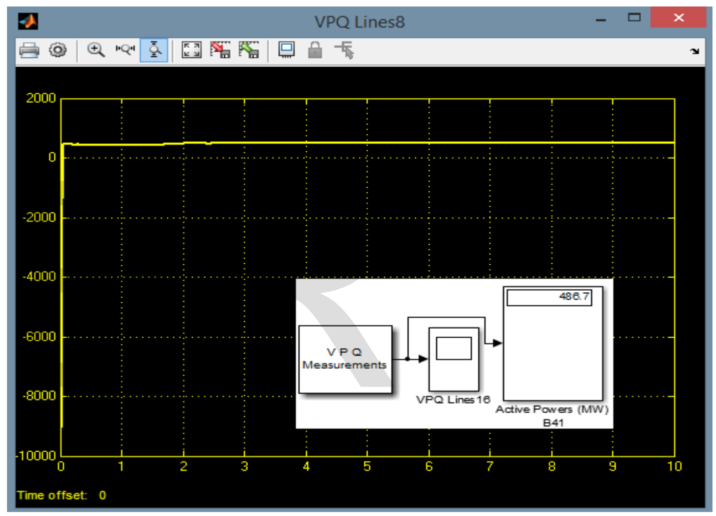

Figure.39. Output at Bus B41 (Sharing of Electrical Energy between Sirilanka and Bangladesh Wind Farm Generation)

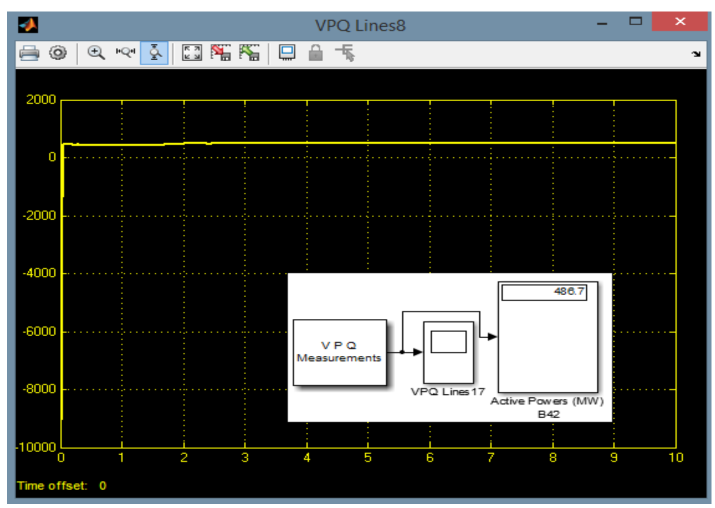

Figure.40. Output at Bus B42 (Sharing of Electrical Energy between Sirilanka and Bangladesh Wind Farm Generation)

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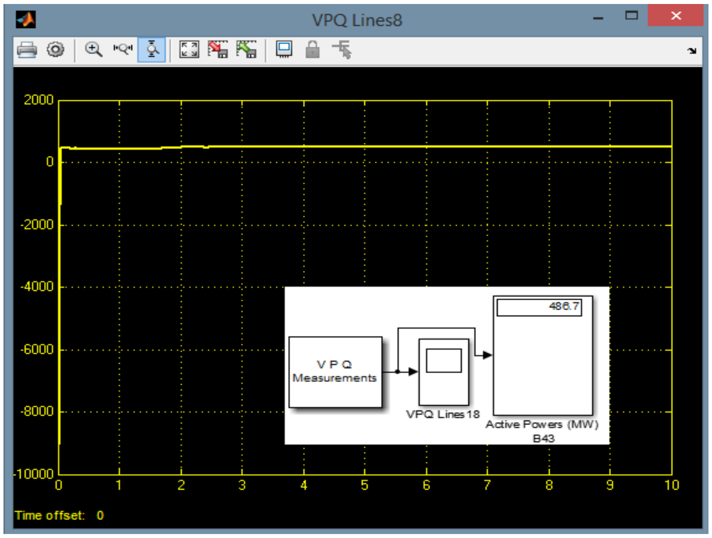

Figure.41. Output at Bus B43 (Sharing of Electrical Energy between Bangladesh and Bhutan Wind Farm Generation)

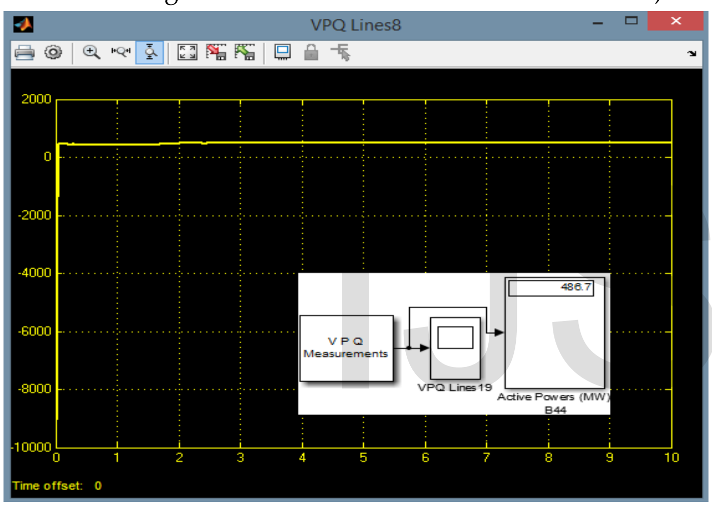

Figure.42. Output at Bus B44 (Sharing of Electrical Energy between Bangladesh and Bhutan Wind Farm Generation)

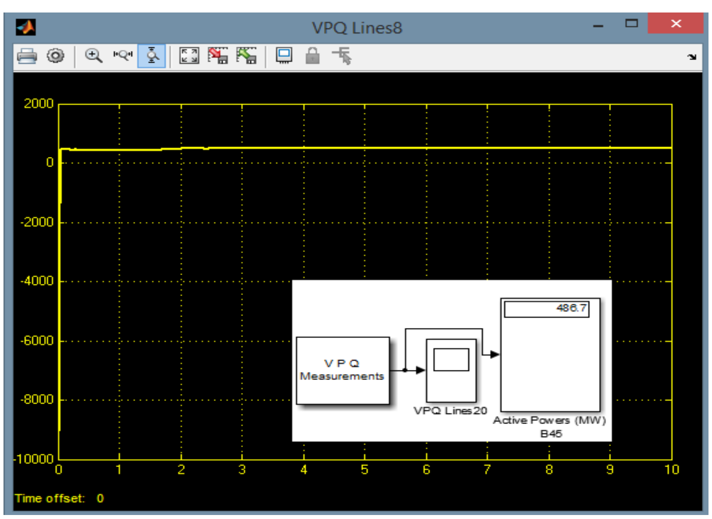

Figure.43. Output at Bus B45 (Sharing of Electrical Energy between Bhutan and Nepal Wind Farm Generation)

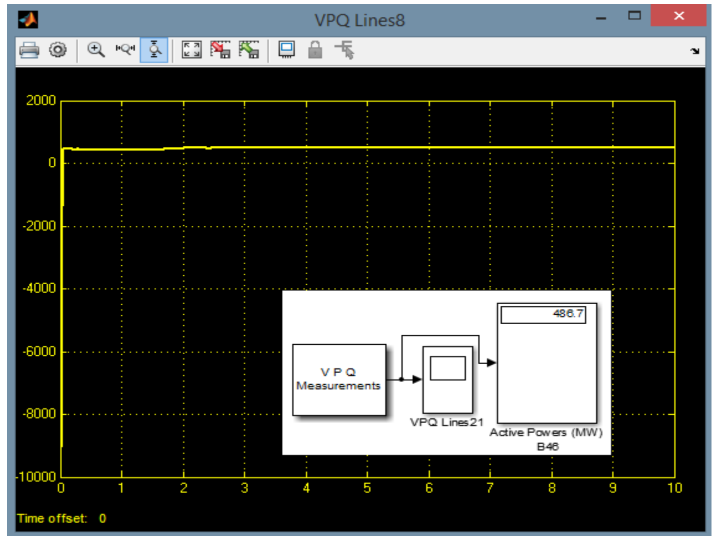

Figure.44. Output at Bus B46 (Sharing of Electrical Energy between Bhutan and Nepal Wind Farm Generation)

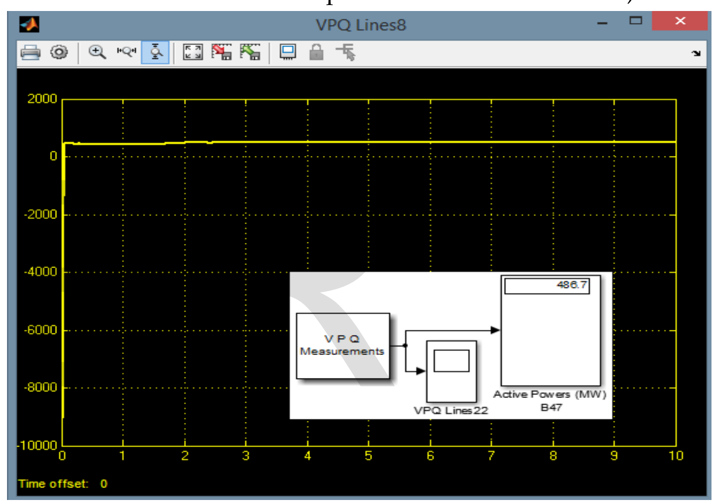

Figure.45. Output at Bus B47 (Sharing of Electrical Energy between Nepal and Afghanistan Wind Farm Generation)

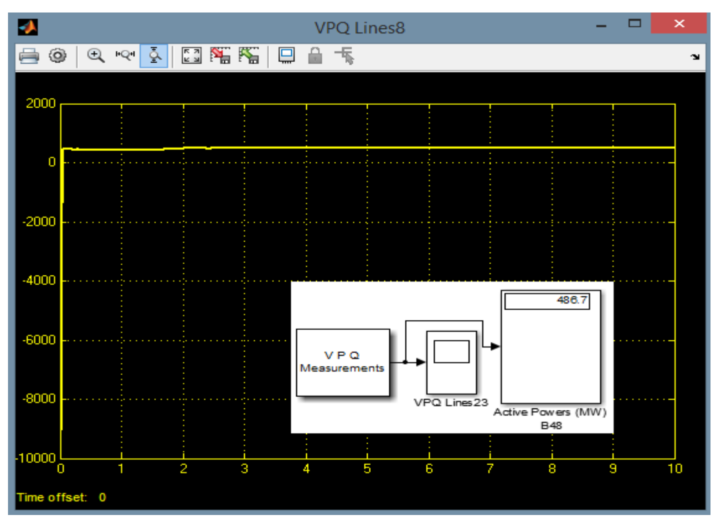

Figure.46. Output at Bus B48 (Sharing of Electrical Energy between Nepal and Afghanistan Wind Farm Generation)

6.1 SAARC Countries Super Grid Model (Matlab Ouput)

Table 02: Sharing of Electrical Power Between different SAARC Countries

Buses	Sharing of Electrical Power between Afghanistan and Pakistan	Buses	Sharing of Electrical Power between Pakistan and India	Buses	Sharing of Electrical Power between India and Maldives	Buses	Sharing of Electrical Power between Maldives and Sirilanka
Bus B33	486.7 MW	Bus B35	486.7 MW	Bus B37	486.7 MW	Bus B39	486.7 MW
Bus B34	486.7 MW	Bus B36	486.7 MW	Bus B38	486.7 MW	Bus B40	486.7 MW
Buses	Sharing of Electrical Power between Sirilanka and Bangladesh	Buses	Sharing of Electrical Power between Bangladesh and Bhutan	Buses	Sharing of Electrical Power between Bhutan and Nepal	Buses	Sharing of Electrical Power between Nepal and Afghanistan
Bus B41	486.7 MW	Bus B43	486.7 MW	Bus B45	486.7 MW	Bus B47	486.7 MW
Bus B42	486.7 MW	Bus B44	486.7 MW	Bus B46	486.7 MW	Bus B48	486.7 MW

Table 03: Receiving Power in each of the AC Grid Station of each SAARC Country

Buses	Receiving Electrical Power at Afghanistan AC Grid Station	Buses	Receiving Electrical Power at Pakistan AC Grid Station	Buses	Receiving Electrical Power at India AC Grid Station	Buses	Receiving Electrical Power at Maldives AC Grid Station
Bus B2	604.8 MW	Bus B6	604.8 MW	Bus B10	604.8 MW	Bus B14	604.8 MW
Bus B3	604.8 MW	Bus B7	604.8 MW	Bus B11	604.8 MW	Bus B15	604.8 MW
Bus B4	604.8 MW	Bus B8	604.8 MW	Bus B12	604.8 MW	Bus B16	604.8 MW
Buses	Receiving Electrical Power at Sirilanka AC Grid Station	Buses	Receiving Electrical Power at Bangladesh AC Grid Station	Buses	Receiving Electrical Power at Bhutan AC Grid Station	Buses	Receiving Electrical Power at Nepal AC Grid Station
Bus B18	604.8 MW	Bus B22	604.8 MW	Bus B26	604.8 MW	Bus B30	604.8 MW
Bus B19	604.8 MW	Bus B23	604.8 MW	Bus B27	604.8 MW	Bus B31	604.8 MW
Bus B20	604.8 MW	Bus B24	604.8 MW	Bus B28	604.8 MW	Bus B32	604.8 MW

7 Future Advancements in SAARC Super Grid

My Focus in this Research work is to utilized HVAC Technology and HVDC (VSC) Technology in order to analyze the load flow study of future SAARC Super Grid.

There is also some more advancements that should be consider in order to complete the full structure of SAARC Super Grid.
These Advancements includes certain factors, Such as,

1) The Utilization of HVDC (LCC) in order to transmit a large amount of power to larger distance.
2) The Inter-Connection of On-Shore AC Grid stations with one another in order to provide more secure and Sustainable Supply of Electrical Energy to the Receiving Side.

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7.1 Utilization of HVDC (LCC) in Future SAARC Super Grid

As we discussed in this Research work that HVDC (VSC) is the Optimum solution for interconnection of wind farms with one another.

But, in future, the Utilization of HVDC (LCC) should also considered in order to fully implement the SAARC Super Grid.

The importance of HVDC (LCC) is lies in the transfer of bulk power to a larger distances with smaller losses.

Below Table explains that why it is necessary to used HVDC (LCC) Technology in Future SAARC Super Grid.

Table.04 HVDC (VSC) VS HVDC (LCC)

Technology	Maximum installed	Maximum Currently installed/Planned	Maximum Achievable rating in Near 2020
HVDC (VSC)	0.5GW; +-200 KV	1GW; +-320 KV 0.7 GW; 500 KV	2GW; +-500KV
HVDC (LCC)	7.2GW; +-800KV	7.2GW; +-800KV	7.2GW; +-800KV

So, the above table shows that, with the utilization of HVDC (LCC), we can transfer a bulk power i.e. 7.2 GW with the help of +-800Kv transmission line, which cannot be possible with the utilization of HVDC (VSC) [27].

7.2 Inter-Connection of On-shore AC Grid station with one-another

One more advancements that occurred in future SAARC Super Grid is the interconnection of Onshore AC Grid Stations with one another.

This can be done with the help of two Technologies that is currently available to us.

1) HVAC (If the distance between different On shore AC Grid station of different SAARC countries is less than the break-even distance of combined HVAC and HVDC).
2) HVDC (LCC) (If the distance between different on shore AC Grid station of different SAARC countries is greater than the break-even distance of combined HVAC and HVDC). This technology is used when we interconnecting SAARC countries that are far away from one another.

8 Problems Assessments in SAARC Super Grid

The main Problem that lies in the future SAARC Super Grid is DC Circuit Breakers, As SAARC Super Grid is actually based on High Power Generation and Transmission Scenario.

So, therefore the Utilization of DC Circuit breakers is necessary in order to interrupt the high power current during fault conditions.

But high power current interruption DC Circuit breakers are not implemented so far, Recently Alstom Company announces the implementation of DC circuit Breakers in order to provide a secure supply, and secure interconnection between wind farms that are far away from one another, and so in order to implement the Super Grid Technology [28].

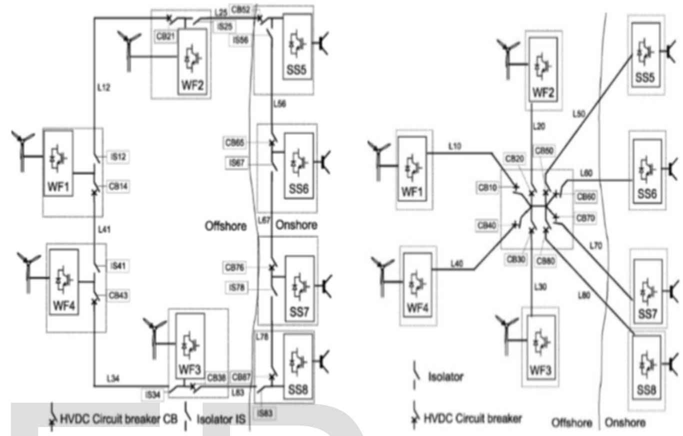

Figure.47. DC Circuit Breakers utilization in Ring Topology and Star Topology [32]

9 Conclusion

This Research work describes the fact, that in order to transmit the Electrical power to a larger distance with a minimum losses than Ultra-High voltage DC is the most effective solution for it. At the start of this Research work, I describes different facts which will lead us to the conclusion than instead of using Ultra-High Voltage AC we can used Ultra-High Voltage DC as an effective solution for bulk power transmission especially of Renewable energy. Than after this, I proposed different solutions and describes different configuration using Ultra High Voltage DC and Ultra Voltage AC, in order to provide an Optimum Results for different Situations, So that the bulk generation power can be transmitted securely and sustainably to a larger distance with minimal losses. Than at the end, I concluded the discussion by providing an overall picture of the SAARC Super Grid Technology which is not practically implemented so far, and which will used these above technologies in order to provide a secure and sustainable Electrical Energy to different SAARC Countries.

References

[1] S. Gordon, “Super grid to the rescue”, Power Engineer, vol.20, no.5, pp.30, 33, Oct.-Nov. 2006.

[2] H. Ergun, J. Beerten, and D.V. Hertem, “Building a New Overlay Grid for Europe”, Power and Energy Society General Meeting, 2012 IEEE , pp.1,8,

22-26 July 2012.

[3] M. Kay, "Sustainable energy without the hot air", Uit Cambridge Ltd, Cambridge, UK, 2008, pp, 1-383.

[4] P. Bresesti, W.L. Kling, R.L. Hendriks, and R. Vailati, "HVDC connection of offshore wind farms to the transmission system", IEEE Transaction, Energy Convers, 2007, 22, 37–43.

[5] D.J. Bang, "Design of Transverse Flux Permanent Magnet Machines for Large Direct-Drive Wind Turbines", Ph.D. Thesis, Delft University of Technology, Delft, the Netherland, 2010.

[6] European Offshore wind industry, key trends and statistics; 1st half 2015, [http://www.ewea.org/fileadmin/files/library/publications/statistics/European_offshore_statistics_2013.pdf]

[7] "London Array; The world's largest offshore wind farm", [http://www.londonarray.com/2012/10/29/worlds-largest-offshore-wind-farm-generates-first- power/ (accessed on 21 December 2012)]

[8] J.D. Decker, J. Tambke, J. Volker, and K.M. Knapl, "An offshore transmission grid for wind power integration: The European techno-economic study Offshore Grid", in Power and Energy Society General Meeting, 2010 IEEE , vol., no., pp.1-8, 25-29 July 2010.

[9] W.L. Kling, R.L. Hendriks, and J.H.D. Boon, "Advanced transmission solutions for offshore wind farms", in Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE , vol., no., pp.1-6, July 2008.

[10] M. Roggenkamp, R. Hendriks, "Market and regulatory aspects of transnational offshore electricity networks for wind power interconnection", Wind Energy 2010, 13, 483–491. Energies 2013, 6 24

[11] A. Garces, M. Molinas, "A Study of Efficiency in a Reduced Matrix Converter for Offshore Wind Farms", in Industrial Electronics, IEEE Transactions on , vol.59, no.1, pp.184-193, Jan. 2012

[12] R.B. Gimenez, S.A. Villalba, J.R.D. Derlee, S.B. Perez, and F. Morant; "Diode-Based HVDC Link for the Connection of Large Offshore Wind Farms", in Energy Conversion, IEEE Transactions on , vol.26, no.2, pp.615-626, June 2011

[13] D. Ludois, G.V.K. Manan, "An examination of AC to HVDC power circuits for interconnecting bulk wind generation with the electric grid", Energies 2010.

[14] S.J. Shao, V.G. Agelidis, "Review of DC system technologies for large scale integration of wind energy systems with electricity grids", Energies 2010, 3, 1303–1319

[15] N. Denniston, A. Massoud, S. Ahmed, and P. Enjeti, "Multiple-Module High-Gain High-Voltage DC–DC Transformers for Offshore Wind Energy Systems", in Industrial Electronics, IEEE Transactions on , vol.58, no.5, pp.1877-1886, May 2011

[16] A. Lopez, R. Diez, G. Perilla, and D. Patino, "Analysis and Comparison of Three Topologies of the Ladder Multilevel DC/DC Converter", in Power Electronics, IEEE Transactions on , vol.27, no.7, pp.3119-3127, July 2012

[17] K. D. Kerf, K. Srivastava, M. Reza, D. Bekaert, S. Cole, D.V. Hertem, and R. Belmans, "Wavelet- based protection strategy for DC faults in multi-terminal VSC HVDC systems", IET Gener. Transmission. Distribution. 2011, 5, 496–503.

[18] T. Lianxiang; B.T. Ooi, "Protection of VSC-multi-terminal HVDC against DC faults", in Power Electronics Specialists Conference, 2002. Pesc 02. 2002 IEEE 33rd Annual, vol.2, no., pp.719-724 vol.2, 2002

[19] J. Candelaria, J.D. Park, "VSC-HVDC system protection: A review of current methods", in Power Systems Conference and Exposition (PSCE), 2011 IEEE/PES , vol., no., pp.1-7, 20-23 March 2011

[20] J. Glasdam, C.L. Bak, and J. Hjerrild, "Transient studies in large offshore wind farms employing detailed circuit breaker representation", Energies 2012.

[21] V.Hertem, M. Ghandhari, and M. Delimar, "Technical limitations towards a Super Grid, A European prospective," IEEE International Energy Conference and Exhibition, 2010.

[22] M. Claus, D. Retzmann, D. Sorangr, and K. Uecker "Solutions for Smart and Super Grids with HVDC and FACTS" Technical article "Siemens", 17th Conference of the Electric Power Supply Industry, 27 - 31 October 2008.

[23] J.W.Feltes, B.D. Gemmell, and D.Retzmann, "From Smart Grid to Super Grid: Solutions with HVDC and FACTS for grid access of renewable energy sources", IEEE Power and Energy Society General Meeting, 2011.

[24]http://www.geni.org/globalenergy/library/technical-articles/transmission/smart-grid/supergrid-modelling-risk-assessment-indian-subcontinent-farhan-beg.pdf

[25] http://carnegieendowment.org/files/Presentation_-%20Ashraf.pdf

[26] http://www.sari energy.org/pagefiles/countries/maldives_energy_detail.asp

[27] R.L. Sellick, M. Akerberg, "Comparison of HVDC Light (VSC) and HVDC Classic (LCC) site aspects, for a 500MW 400kV HVDC transmission scheme", in AC and DC Power Transmission (ACDC 2012), 10th IET International Conference on , vol., no., pp.1-6, 4-5 Dec. 2012

[28] Z. Ganhao, "Study on DC Circuit Breaker," in Intelligent Systems Design and Engineering Applications (ISDEA), 2014 Fifth International Conference on , vol., no., pp.942-945,15-16,June,2014,doi: 10.1109/ISDEA.2014.208.

[29] http://mainstreamrp.com/mainstream-unveils-first-3d-scale-model-of-the-supernode/

[30] http://new.abb.com/systems/hvdc/why-hvdc/economic-and- environmental-advantages [

[31] http://www.mapsofworld.com/saarc-member-countries.htm

[32] http://www2.ee.ic.ac.uk/patrick.sterling10/yr2proj/TechGrids.htm