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Abstract

This paper is the result of a study carried out to analyse the decision of Power Grid Corporation of India Limited (POWERGRID) to use polymer insulators in their operations. The paper includes a cost-benefit analysis keeping in mind the technical, environmental and socio-economic concerns caused by the import of polymer insulators from China, over ceramic insulators manufactured by in-house Indian manufacturers. The paper also provides recommendations, from the perspective of the Government of India's push towards Make in India campaign.

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Background

1. Insulators are used in power transmission overhead lines to provide mechanical support and electrical protection. They are classified on the basis of material as well as voltage levels. On the basis of material used, insulators are broadly categorised into three segments: Ceramic/Porcelain insulators, Composite/Polymer insulators and Glass insulators. With respect to voltage levels, the size of the insulator increases with increase in voltage levels.

2. India's domestic insulator industry manufactures various types of insulators in all ranges, for LT (Low Tension), HT (High Tension) and EHT (Extra High Tension). These insulators are used in the transmission and distribution network, and electrical traction systems (railway, trolley bus, tramway etc.) or in equipment like surge arresters, circuit breakers, disconnectors and instrument transformers. The major customers for insulators are thus the Central power sector, state electricity boards, distribution companies, private sector power transmission companies and railways. Indian manufacturers also cater to foreign markets and their products are supplied to more than 75 countries including Europe, USA and Latin America. This reflects well on Indian technological capability to supply high quality products.

3. India's domestic Ceramic/Porcelain industry has served the country's power sector needs for over five decades and as of now, provides employment to over 75,000 people. It has four major players including BHEL (Bharat Heavy Electrical Limited, a 'Navratna' organisation and a public sector unit) and also about 25 to 30 MSME's (Micro, Small and Medium Enterprises). The Porcelain industry has adequate capacity and capability to meet the highest voltage level of 1200 kV AC and 800 kV DC. It has developed and supplied, on free of cost basis, insulators for India's prestigious 1200 kV Experimental Transmission Line and Substation Project.

Statement of Problem

4. India needs a judicious mix of both Ceramic/Porcelain insulators and Composite/ Polymer insulators. Both these technologies are in the best interest of domestic industry and the country's power sector, based on varied application and life cycle needs.

5. Power Grid Corporation of India Limited (POWERGRID), is an Indian state-owned electric utility company headquartered in Gurugram, India. POWERGRID transmits about 50 percent of the total power generated in India on its transmission network. POWERGRID had earlier engaged in large scale import of Ceramic/Porcelain insulators from China. However, after the imposition by the Government of India of Safeguard Duty in December 2102[1] , and later the Anti Dumping Duty in September 2014[2], POWERGRID dispensed with the import of Ceramic/Porcelain insulators and started large scale imports of Composite/Polymer insulators, again from China. The import of higher specification 31 mm/kV Composite Polymer insulators, largely sourced from China, are being used to replace Ceramic/Porcelain insulators of lower specifications 20 mm to 25 mm/kV which were made in India citing better performance (while the higher specification 31 mm/kV Ceramic/Porcelain insulators are also available in India as an option to improve performance).
6. The replacement of Ceramic/Porcelain insulators with Composite/Polymer insulators, as is being done now by POWERGRID will spell the death knell of the domestic Ceramic/Porcelain industry. In times to come, cheaper imports of Composite/Polymer insulators from China will also have a negative impact on India's polymer industry, which will wither and die.
7. This decision by POWERGRID, has ostensibly been taken on the grounds of higher efficiency, enhanced performance and reduced costs. These assumptions are however questionable and do not stand a closer scrutiny. When life time costs are considered, the costs of Composite/Polymer insulators is many times higher than Ceramic/Polymer insulators. The decision also severely endangers domestic industry and the energy security of India and goes against the grain of the government's Make in India Programme.

Problem Analysis

8. The decision by POWERGRID to replace Ceramic/Porcelain insulators with Composite/Polymer insulators by importing the latter from China has been done on the grounds of getting newer technology and in reducing costs. On the face of it, this is a good business proposition, but a deeper analysis reveals that such a blanket decision has little merit, both on technology and cost parameters.

The Cost Factor

9. In terms of cost, it is true that Composite/Polymer insulators are cheaper than Ceramic/Porcelain insulators. Considering any circuit of fixed length, the cost of Ceramic/Porcelain insulators is three times that of Composite insulators. However, when lifetime costs are considered, the Ceramic/Porcelain insulators work out far cheaper. Porcelain,

being an inert material, has a life cycle of 35 to 40 years as against Polymer which is an organic material and has an average life cycle of only 8 years. Polymers thus have less durability and their life-cycle is one-fifth of that of a ceramic insulator. Hence, when life-cycle costs are considered, the Ceramic/Polymer insulators score handsomely over Composite Polymer insulators.[3] With a five times greater life cycle, the life time costs of Ceramic/Porcelain insulators is just about one-third of the life cycle costs of Composite/Polymer insulators. If we include the maintenance charges and shutdown costs and also factor in inflation, then the polymer insulator becomes an even more expensive option than ceramic and would burden the exchequer with many hundreds of crores of additional cost. A cost-analysis chart is attached as an Appendix to this paper to highlight the above point.

Quality Concerns

10. It is a matter of concern that India's Central Power Utility, POWERGRID, has replaced/is replacing 20-25 mm/kV Porcelain Insulators with 31 mm/kV Polymer Insulators (largely imported from China), despite higher quality and efficient variants available in porcelain. POWERGRID'S aggressive diversification into intra-state projects comes at a time when the Central Government has approved the 'Saubaghya Scheme,' to address the gaps in its rural electrification programme and to facilitate last mile electricity connectivity to homes. With this push, even State Utilities are forced to follow suit, dealing a severe blow to the Ceramic/Porcelain insulator industry. It is on record that such concerns have repeatedly been expressed in research papers presented in International and National Conferences (at IISc, Bengaluru) and in Journals, but for some reason, these concerns remain unconsidered.

The Security Dimension

11. There is a worrying security dimension too, in the decision by POWERGRID to import polymer based insulators from China. The impact is already being felt in the Ceramic/ Porcelain industry in India, which will close down if adequate orders are not received. BHEL has already closed down its plant in Bengaluru last year. The three bigger players in the private sector will also shut down their plants, once they become economically unviable, but this being just a small part of their business empires, they will hardly feel the pinch. However, they are unlikely to ever enter this market again. That will be India's loss. The MSMEs will be seriously impacted and they will not have the capacity to reenter the market once they close down. The burden will ultimately fall on the 75,000 workers rendered jobless. With cheaper polymers from China, India's polymer insulators too, will not be able to withstand the competition. That will leave the field with only the Chinese as players as the sole or rather the main suppliers of insulators. As insulators are put on every electric pole, it means that the Chinese will

have a foot inside India's electric supply system. With a Chinese monopoly over the Indian insulator market, they in effect exercise a leverage over India which can lead to grave security risks in the future.

The Chinese Experience of Composite Insulators

12. In a research paper written by five Chinese scholars, F. Zhang, Z. He, Y. Liao, G. Wang and B. Luo, titled "Research on the Adhesiveness between Core Rod and Sheath for Composite Insulators on the Transmission Lines," which was presented at the 13th INSUCON Conference, Birmingham, UK 2017, the problems associated with Composite Polymers has been highlighted. Composite insulators have been widely used around the world for their light weight, convenient installation, excellent preventing pollution problem and easy maintenance. In China alone, more than 2.2 million composite insulators had been applied till the end of 2006, and more than 800,000 composite insulators had been used on 110 kV and above transmission lines till June 2012 by China Southern Power grid. As of now, composite insulators have been applied in over 30 countries all across the world. However, with the increase of service time and the influence of environmental factors, ageing problem of composite insulators has emerged gradually and lots of operation accidents are caused by the defects of composite insulators. The authors go on to state as under:

    "In recent years, several corrosion fracture accidents of composite insulators occurred in China, among which fracture accidents happened in five composite insulators, of two 500 kV AC transmission lines of Zhejiang power line in 2002, five composite insulators of five 500 kV AC transmission lines of Shandong power grid during May 2008 to August 2012 and four composite insulators on four 500 kV transmission lines of China Southern power grid during November 2010 to January 2013. Worse still, drop line faults caused by the fracture of composite insulators may emerge, which would lead to huge property loss and even casualties. In a word, the composite insulator fracture problem is a great threat to the stable operation of power system, and thus it has attracted widespread attention."[4]

13. The concerns being expressed by Chinese scholars, based on their experience of the use of polymers in China need to be taken note of as mindless import of composite polymers will have a similar effect on stability of the Indian power grid.

The Environmental Impact

14. The environment also has an impact on the use of polymers. Polymers, being organic, get degraded over time and with high exposure to UV rays. The Central Electricity Authority of India (CEA), the regulatory body which advises the government in framing

of energy policy and development of energy systems, has, in a recent missive to the Power Ministry, advised caution in selecting polymers for use in the insulator industry. The CEA has stated as under:

"While Polymer insulators, in short term, do have a better online performance under polluted atmospheric conditions; being an organic material, it suffers from gradual decline in performance due to ageing. It is also well established that the polymeric material is very sensitive to UV radiations, especially when they are used in Indian weather conditions, where in a year the period of sunshine is very long. Pollution combined with exposure to UV radiations has a significant effect on ageing….Polymers, being organic age gradually and the performance declines. The ageing is faster in high UV areas such as India. Once ageing starts, pollution/ salinity can further accelerate it".

15. As per the CEA, considering the pattern of failure, unpredictable life expectancy, limited indigenous capability, major dependency on imports, non-availability of effective condition monitoring techniques and tools for condition assessment of Polymer Insulators, abundant caution must be exercised in selecting Polymer Insulators. CEA has also explicitly recommended restricting the use of Polymer Insulators to highly polluted areas and coastal areas, which have high atmospheric saline concentration. Utilities in the US are now moving out of polymers and switching back to Ceramic/ Porcelain insulators. Even China, despite being the biggest producer of composites, due to several breakdowns has started moving away from polymer insulators.

Impact on Make in India Programme

16. Finally, it is incomprehensible, that when the nation is being propelled towards a "Make in India" culture, implying that India will reduce its dependence on imports, a domestic industry which has so ably supported the nation over decades is being suffocated by imports of polymers from China. This goes against the very grain and ethos of the Prime Minister's campaign.

CONSEQUENCES

17. The decision of POWERGRID to import polymer-based insulators from China has the following consequences:

    I. Over the long term, the country will incur much higher costs with the replacement of Ceramic/Porcelain insulators by Composite/Polymer insulators. Polymer insulators have limited shelf life, which stands further reduced in areas with high UV rays impact. While initial costs of Composite/Polymer insulators is low, the

total lifetime costs are nearly three times that of Ceramic/Porcelain insulators. This is over and above stoppage and replacement costs, which will be many times higher.

II. Lack of demand will result in the closure of the domestic Ceramic/Porcelain insulator industry leading to the unemployment of over 75,000 workers, presently employed in the industry.

III. Over the medium term, cheap import of Chinese polymer will lead to the death knell of India's Composite/polymer insulators too.

IV. It will lead to a situation wherein Chinese insulators will dominate the Indian market, giving a foreign country a foothold in India's electric energy sector. This can have serious economic and security implications as it increases the vulnerability of the power sector to foreign manipulation.

V. It goes against the ethos of the "Make in India" campaign of the Prime Minister and sends a wrong signal to the environment.

RECOMMENDATION

18. It is recommended that the Ministry of Power re-examines the issue of use of imported Composite/Polymer insulators as replacements for the domestic Ceramic/Porcelain insulators and that POWERGRID be directed to abstain from future imports of the same for such purpose. Further, the country should have a balanced use of Ceramic/ Porcelain and Composite/Polymer insulators, with use of the latter restricted only to high pollution and coastal areas.

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References:

[1] *Notification No. 5/ 2012-Customs (SG) of December 2012*

[2] *Notification 11/2015-Customs (ADD) of April 2015*

[3] *Amin, M., Akbar, M. & Salman, M. Sci. China Ser. E-Technol. Sci. (2007) 50: 697. https://doi.org 10.1007/s11431-007-0053-x*

[4] *A copy of the paper is available at https://ieeexplore.ieee.org/document/8097172/*

APPENDIX

(Refers to para 9)

ADDITIONAL LIFE CYCLE COSTS INVOLVED IN CASE OF TRANSMISSION LINES USING POLYMER INSULATORS

Assumption: There are 2 (two) 400 kV Single Circuit Transmission Lines (A) and (B) charged simultaneously Most conservative scenario—considering only Single Suspension Strings and 100 km length

	TL (A) with Porcelain Insulators	**TL (B) with Polymer Insulators**
Length of Circuit (km)	100	100
Power	500 MW	500 MW
Insulator type	PORCELAIN	POLYMER
Rating	120 KN A/F	120 KN
String	S/S	S/S
Number of Units/Phase	23	1
Number of Phases	3	3
Number of Insulator Units/Tower	69	3
Total Number of Towers (Ruling span—400 M)	250	250
Average cost of each insulator string (Rs) Rs 750/- Porcelain disc insulator, Rs 6000/- Polymer assumed	17250	750
(A) TOTAL COST OF INSULATORS IN 100 KM LINE (Rs LAC)	**129.38**	**45**
Assumed Life of Insulators (Years)	40	8
Assumed frequency of Replacements (Years)	40	8
Number of replacements in 40 years	0	4
(B) Cost of Insulators for Replacement in 40 Year Period. (Price of Polymer retained at Rs 6,000/- Polymer as above)	**0**	**180**
(C) TOTAL INSULATOR COST OVER 40 YEARS (Rs. Lac)	0	225
(D) Labour Cost for Replacement (Rs Lac) @Rs 4000/ string x 750 x 4	0	120
(E) Shut down time for Replacement (Assuming 3 Towers/ day/Gang and 3 Gangs working on the line = 9 Towers/ day Number of days for 750 TOWERS over 40 years will be	**0**	**333**
ESTIMATED LOSS OF TRANSMISSION DURING NON-AVAILABILITY OF TRANSMISSION LINE FOR 333 DAYS (500000 KW x Rs 5/- per unit x 333 Days (Rs Lac)	0	39,960
TOTAL LIFE CYCLE COST WITHOUT SHUT DOWN COST (A+B+C+D) (Rs Lac)	**129.38**	**345**
TOTAL LIFE CYCLE COST WITH SHUT DOWN COST (A+B+C+D+E) (Rs Lac)	**129.38**	**40,305.00**

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