Comments and Suggestions on Draft Paper on Reconductoring of Transmission Lines in ISTS

Prayas (Energy Group), 20th July, 2023

Considering the existing transmission network of over 4,72,345 circuit km (220 kV and above voltage level) as on May, 2023, reconductoring of existing transmission lines with high-capacity, high-performance conductors can preserve the right of way (RoW) and increase transmission capacity of a line at lower costs and lower gestation periods.

CEA's initiative to identify implementation modalities for reconductoring the transmission lines in the ISTS network is very timely and extremely important given the expected growth in transmission capacity in the coming years. According to Powergrid, the sectoral outlook for transmission includes investment of ₹ 1,90,000 cr in ISTS, ₹ 1,96,000 cr in InSTS and ~ ₹ 20,000 cr for cross border integration by 2030[1]. This translates to roughly ₹ 60,000 cr/year, each year for the next seven years.

The paper covers planning of reconductoring, approval and mode of implementation. Our suggestions in this regard are detailed below.

1. Broad potential of reconductoring appears quite high

The first table below show the status of transmission lines in the country in terms of length (ckm) disaggregated by different voltages and ownership.

Status of Transmission lines (Source: CEA, units in ckm)

At the end of	± 500 kV HVDC		400 kV		220 kV		Grand Total	
	Central	Total	Central	Total	Central	Total	Central	Total
At the end of 6th plan (31st March, 1985)	-	-	1,831	6,029	1,641	46,005	3,472	52,034
At the end of 7th plan (31st March, 1990)	-	-	13,068	19,824	4,560	59,631	17,628	79,455
At the end of 8th plan (31st March, 1997)	1,634	1,634	23,001	36,142	6,564	79,600	31,199	1,17,376

Note: 1. Till 8th plan, transmission lines and substations were either owned by central or state companies.
2. Assets created by the end of 7th plan have already completed 33 years of their useful life.

The table below shows the transmission lines which were commissioned between 1985-90 (present age> 33 years) and between 1990-97 (present age > 26 years).

Broad Potential for Reconductoring of Transmission lines (in ckm)

Broad Potential for Reconductoring	± 500 kV HVDC		400 kV		220 kV		Grand Total	
	Central	Total	Central	Total	Central	Total	Central	Total
Commissioned between 1985-1990, life > 33 years as of March, 23	-	-	11,237	13,795	2,919	13,626	14,156	27,421

[1] https://www.powergrid.in/sites/default/files/financials_presentations/InvestorPresentationFY23.pdf

Commissioned between 1990-1997, life > 26 years as of March, 23	1,634	1,634	9,933	16,318	2,004	19,969	13,571	37,921

Note: We have not considered network elements commissioned before 1985 for reconductoring, as it is not clear if they are still being utilised.

As is clear from these tables, presently, reconductoring can potentially be done for centrally-owned lines with length of around 11,237 ckm (400 kV) and 2,919 ckm (220 kV). Over the next 5 years, further 9,933 ckm (400 kV) and 2,004 ckm (220 kV) will be available for reconductoring. **Thus nearly 21,170 ckm of 400 kV central lines, which are 19% of the total existing 400 kV centrally owned lines would be available for reconductoring over the next 5 years.**

If one were to consider reconductoring in InSTS lines as well, then presently, reconductoring can potentially be done for state-owned lines with length of around 2,558 ckm (400 kV) and 10,707 ckm (220 kV). Over the next 5 years, further 6,385 ckm (400 kV) and 17,965 (220 kV) will be available for reconductoring. Considering the potential at 220 kV for InSTS lines, reconductoring at InSTS level should be pursued as well.

2. Establish Working Group / Committee under CEA/CTU with wider stakeholder representation including STUs, Industry, ERCs

CEA should form a working group or a committee with representation from CTU, CERC, Industry, STUs, SERCs and other sector experts to prepare a detailed report on reconductoring, outlining the potential for reconductoring, cost benefit analysis, prioritisation for reconductoring, policy and regulatory issues involved and way ahead towards institutionalising it.

It can begin with a review of past and ongoing reconductoring projects, some of which are noted below:

1. Reconductoring of Dulhasti-Ratle LILO tap Point of Dulhasti-Kishenpur 400 kV line (approx. 13 km) implemented through twin moose conductor with Quad moose conductor in matching time frame of Pakaldul HEP generation.
2. Hiranagar- Kathua 132 kV D/C line, 152 km (Reconductoring)

Source: NRPC

3. Farakka-Malda Transmission Line (India's first 400 kV D/C Twin Invar Reconductoring project)

Source: Sterlite

4. Reconductoring of Rangpo-Gangtok 132 kV D/C line
5. Reconductoring of Melriat (GIS) – Zuangtui 132 kV ASCR Panther S/C
6. Reconductoring of Aizwal – Luangmual 132 kV ASCR S/C line
7. Similar lines in NE Region Expansion Scheme- XX

Source: CTU

8. Live-line reconductoring project, upgrading the Naganathapura to Malgudi 66 kV transmission line in Bengaluru for Karnataka Power Transmission Corporation Ltd.

Source: Sterlite

This itself can bring to light the larger challenges and opportunities in reconductoring and the extent to which current system can be modernised through reconductoring. Also, the study can help in understanding the time and cost-benefit aspects of reconductoring.

The working group can also look at other issues related to reconductoring. These could include but not limited to

1. Defining scope of reconductoring: The paper defines reconductoring as *"reconductoring is a process of stringing of new conductors on existing towers using the same RoW to increase the thermal capacity of transmission lines. However, this may require modification or replacement of some towers in cases where load bearing capacity of tower is not sufficient. The scheme may also require replacement of terminal bay equipment with high rating equipment commensurate with rating of new conductors."*
   Thus, reconductoring of lines may need further actions likes strengthening of towers or increasing the transformation capacity at the end of a line or AC-DC convertors in case an AC line is converted to a DC line. Hence, a clear definition of reconductoring and its scope should be devised.
2. Reconductoring cost benefit analysis could also build scenarios for integrating large scale storage at some specific locations.
3. Project selection criteria: As noted in the paper, '*As per Section 38 (2) of the Electricity Act, 2003, the Central Transmission Utility (CTU) is responsible for development of an efficient and coordinated inter-state transmission system (ISTS). Accordingly, the CTU, in consultation with stakeholders and after system studies, draws proposal for new elements in ISTS or augmentation including reconductoring'*.
   However, the paper has not provided any details on a potential framework or relevant criteria based on which any project/element will be selected for reconductoring. As per our understanding, following projects should be considered in priority for reconductoring by CTU if they are:
   - Near its end of useful life
   - Critical for grid and upgradation of power capacity is recommended (by CTU or Grid operator) for such transmission project
   - Near load or generation centres and facing congestion issues
   - Facing Right of way issues.

Criteria such as those noted below should be part of a clear framework for assessing the viability of reconductoring and for selecting a project for reconductoring:

a. Expected Increase in Power flow in future
   - Line near generation or resource potential sites or load area

b. Criticality of line
   - Repeated instances of frequent outages or dependency of grid on the line (contingency or congestion issued faced due to outage of line)
   - Availability of alternate power routing options during construction time if live-line reconductoring not possible.

c. Time and cost evaluation
   - Time and cost needed to build a new line
   - Time and cost to reconductor

d. Useful life remaining for the existing line
   - Line, tower, associated equipment

e. Capacity increment due to reconductoring if applicable
   - Due to material change and possible conversion from AC to DC if feasible and desired

f. Other Possible Benefits
   - Reduced litigations or environmental/ clearance issues
   - Can this improve two-way power flow from same line?
   - Changing single ckt line to double ckt line

- Improved grid reliability

3. Start with pilot projects under the RTM route

As mentioned in the paper, both the RTM and TBCB route for reconductoring have their own issues in implementation. The largest cost saving in re-conductoring lies in the savings in towers, land (RoW) and project construction time. We suggest a phased approach; in the first phase, it might be better to select 2-4 projects in consultation with CEA and CTU for reconductoring under the RTM route and allocate them to Powergrid, since they are the only ones who will have near end-of-life transmission assets in ISTS. Pilot projects could consider both types of assets, a) near end-of-life projects where re-conductoring will add value as well as b) projects with say 10 years of life left but where due to load growth, congestion, RoW issues etc., reconductoring can add value.

Going forward, another potential option is for end-of-life projects, where the license period is also ending. In this case, the approach can be to transfer the ownership of the land, lines and towers to a SPV (if feasible and legally tenable) and then bid out the entire project for reconductoring. Obviously, this will be subject to license conditions, contractual arrangements, and other legal aspects.

This will give the sector a better understanding on what issues can emerge and how they can be resolved. This experience can help in easing the implementation of large scale reconductoring not only in ISTS but also in InSTS in the future.

4. Regulatory acknowledgement/approval for reconductoring

CERC has issued Planning, Coordination and Development of Economic and Efficient Inter-State Transmission system by Central Transmission Utility and other matters Regulations[2] dated 23rd July 2018. The primary purpose of these regulations is to lay down principles to be followed for planning process, ensure participation of stakeholders in the planning process, bring transparency in the process and demarcate roles of various organisations in the process. The regulation does mention reconductoring as one of the options to be considered while planning the ISTS network.

> *7(7) While planning the transmission system, options of upgrading the existing ISTS in place of building new transmission lines such as increasing line loading through use of compensation,* ***reconductoring****, etc., for optimally utilizing the existing assets, should also be considered.*

However, it is unclear whether such reconductoring projects have the requisite framework in place as per existing regulations. This relatively new concept of reconductoring needs adequate regulatory clarity in various applicable regulations such as tariff regulations, grid code regulations, license regulations and ISTS planning regulations.

CERC's Approach Paper, on 'TERMS AND CONDITIONS OF TARIFF REGULATIONS For Tariff Period 1.4.2024 TO 31.3.2029' does not explicitly mention re-conductoring as an option. The draft tariff regulations emanating from the Approach paper should detail out the regulatory process and bring in clarity for reconducting of ISTS lines. Clarity on any changes in the transmission licensee terms and conditions would also be helpful. In case TBCB approach is adopted for reconductoring, suitable changes can be suggested in MoP's Standard Bidding Documents (SBDs) for transmission projects.

The Manual on Planning Criteria is prepared by CEA and covers the transmission network planning philosophy, the information required from various entities, permissible limits, reliability criteria, broad

[2] https://cercind.gov.in/2018/regulation/Transmission.pdf

scope of system studies, modelling and analysis etc. and gives guidelines for transmission planning. While reconductoring is mentioned in the context of RoW issues (6.7.3) as noted below, reconductoring in addition to upgradation to higher voltages, use of multi-voltage level and multi-circuit transmission lines, HVDC etc. should be explicitly part of techno-economic analyses in the planning studies.

> *6.7.3 Central Electricity Authority (Technical Standards for Construction of Electric Plants and Electric Lines) Regulations, 2022, provides that, Right of way for transmission lines shall be optimized keeping in view the corridor requirement for the future by adopting suitable alternative of multi-circuit or multi-voltage lines as applicable. Following may be adopted to optimise RoW utilisation:*
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> - *Application of Series Capacitors, FACTS devices and phase-shifting transformers in existing and new transmission systems to increase power transfer capability.*
> - *Up-gradation of the existing AC transmission lines to higher voltage using existing line corridor.*
> - ***Re-conductoring of the existing AC transmission line with higher ampacity conductors**.*
> - *Use of multi-voltage level and multi-circuit transmission lines.*
> - *Use of narrow base towers and pole type towers in semi-urban / urban areas keeping in view cost and right-of-way optimization.*
> - *Use of HVDC transmission – both conventional as well as voltage source convertor (VSC) based.*

In addition to this, CEA has issued Guidelines on rationalized use of High Performance Conductors (HPC)[3] in February, 2019. The guidelines, while suggesting use of HPC in certain cases, has given a critical view on the subject.

> *"1.6. High Performance Conductors can be considered for reconductoring of existing lines and can also be used in new lines. Depending on the type of conductor, the cost of such conductor may vary between 1.5 to 5 times the cost of conventional ACSR/ AAAC conductors. Other than the cost of power conductor, cost of additional ohmic loss at elevated temperature, conductor accessories, insulator hardware, de-stringing of conventional power conductor, re-stringing & installation of High Performance Conductors are to be considered before deciding whether installation of High Performance Conductors is economically justifiable. The terminal equipment rating at substations also needs to be examined for enhancement of power transfer in a line. Moreover, for new lines, proper system studies need to be carried out to identify the corridors for use of such conductor.* ***The use of HPC conductors need to be considered on case to case basis based on techno-economic analysis over the life cycle****. After considering the life-cycle cost, the overall project costs may, in some cases, be less even after higher cost of the conductor and accessories.*
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> *5.0(A)(f) In Intra-State Transmission System, requirement of such conductor is expected at 220 kV, 132 kV and 66 kV level.* ***The requirement of such conductor may not be much in Inter-State Transmission System (ISTS), which is dominated by 400 kV and 765 kV network. In case of ISTS lines, the High Performance Conductors would be a good substitute to Quad bundle ACSR and AAAC conductor, particularly at 400 kV level when line length is short.***

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[3] https://cea.nic.in/old/reports/others/ps/psetd/guidelines_conductors.pdf

5.0(B) Similarly, some scenarios wherein an alternative method of uprating will be more attractive than reconductoring with HTLS are the following:
i) Structures or foundations of the existing line are in poor condition.
ii) Existing line is in good physical condition, and the rating is to be increased by less than 20%.
iii) If the line is above 400 kV, reconductoring with HTLS conductors is not typically required because the existing thermal rating is already much higher than the limits on power flow related to voltage drop and phase shift."

The 2019 guidelines also highlight some pertinent technical issues like need of sag clearance re-calculations, load carrying capability of towers, need of new accessories, wide variation in cost of high performance conductors, etc. Guidelines also discusses aspects of cost-benefit analysis and criteria for technical evaluation of bids for different types of High Performance Conductors.

The technical committee, which formulated above 2019 guidelines has made many relevant recommendations, prominent of which are as follows:

"13.2 High Performance Conductors should be considered in those corridors where the power transfer over the line is constrained due to thermal loading of conductor. In Intra-state transmission system, requirement of such conductor is expected at 220 kV, 132 kV and 66 kV level. However, application of High Performance Conductors may not be cost effective for HVDC system and for 765 kV voltage level.

13.5 The use of High Performance Conductors need to be considered on case to case basis based on techno-economic analysis over the life cycle.

13.12 Environment impact assessment of HPC lines passing through forest areas needs to be done."

Hence, it will be important to consider these guidelines while planning for reconductoring.

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