Implementation of Rural Electrification Scheme – RGGVY, in Uttar Pradesh

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Abstract-- Based on a survey of more than 2000 villages, in this paper, an attempt has been made to point out the defects and shortcomings in the high voltage distribution system (HVDS) installations built under the Rajeev Gandhi Gramin Vidyutikaran Yojana (RGGVY) of rural electrification. Avoiding these could have made the installations much better. Also, it could have been cost-effective and could have resulted in earlier completion of the project.

I. Introduction

RAJEEV Gandhi Gramin Vidyutikaran Yojana (RGGVY) is an ambitious scheme of Government of India for rural electrification. Rural Electrification Corporation (REC) was the nodal agency for the scheme. The scheme adopted high voltage distribution system (HVDS) for electrifying the villages. In the system, 11 kV, high voltage overhead lines were built and 10 or 16 kVA, 11/0.230 kV, single phase pole mounted transformers were used. In some districts, 25 kVA, 11/0.4 kV, 3 phase, double pole mounted transformers were also installed. Consumers were supplied through air-bunched cables from the distribution boxes, installed along with these transformers.

In this paper, an attempt has been made to point out defects and shortcomings in the installations built under the scheme. Some of these are inherent in the technical specifications prepared by the distribution companies while others are made during the execution of work which could have been completely avoided. Factors causing these are also investigated.

Observations made in the paper, are based on inspection of more than 2000 villages electrified under the scheme. These inspection were performed during the period from August, 2006 to August, 2009.

II. Factors Affecting the Quality of Work

For the execution of project, contracts were given mainly to big names in Indian electrical industry. Aim of involving working agencies other than the distribution companies, was to ensure the good quality of work. However, the aim was only partially achieved. Factors affecting the quality of work are as follows:

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A. *Lack of proper supervision:*

The working agencies did not have prior experience in rural electrification work. Also, they did not have necessary human resources. Most of the companies relied on the retired personnel of the state electricity boards/corporations and these people could not change their working habits as per the requirement of the scheme. Even the agencies were somewhat negligent about the execution part as their priority was the supply of materials which was more profit making.

At next stage, at district level, the working agencies employed local contractors. They were given village-wise contract for execution of work. Initially, there were not enough contractors but the amount involved in the scheme attracted civil contractors, local public representatives, small politicians, etc. Though these contractors did not have any experience in this field, they used all means to get the contract for maximum number of villages. Some of these contractors employed sub- contractors to carry out the work, obviously at lower rates.

At last stage, there were not enough labours to carry out the work simultaneously in all districts of the state. Only the labours working for the contractors of state electricity boards/ corporations were available. Due to high demand, many unskilled labours were also involved. These labours changed the contractors very frequently with increase in their wages. So finally the labours working for the state electricity boards/ corporations with unskilled ones were to execute the work, the contractors were not capable of supervising and the working agencies had the persons cultured in the state electricity boards/ corporations or inexperienced ones for supervision. Thus, there was nothing to expect improvement in the quality of work

B. *Negligence by distribution companies:*

For each district, the working agency got the survey done, prepared the line diagram and got it approved by the distribution companies. But though the installations were finally to be taken over by the distribution companies, up to assistant engineer's level, there was no involvement of employees of these companies at the planning or execution level of the project. Its consequences were two fold. First, the contractor faced lot of difficulties in erecting the poles and providing the stays. Contractor and the working agency had to tackle the objections, raised by land owners, on their own and the supplier was not of any help in selecting proper right of way for overhead lines. These improperly located poles and stays had resulted in frequent road accidents, causing damage to the installations. On the other hand, contractors enjoyed freedom in erecting the poles and providing the stays. After erecting the poles and providing the stays at their will, the contractor gave the executed line diagram and the agency got it again approved. Thus, there was no meaning of prior approval of line diagram as there was no one to look after its execution. Clearly, no effort was made to make the installation cost-effective. Contractors erected maximum number of poles and built unnecessarily lengthy overhead lines. There are examples of constructing parallel lines for different villages on both sides of roads, tapping from a much distant pole of existing line, constructing long sections of overhead lines and not providing transformers at the end of these, etc. This misuse of fund could have been stopped by active involvement of distribution companies at planning and execution levels.

C. Non-completion of Work:

Erection of poles, providing stays, stringing of conductors and mounting of transformers do not need much skill and are most profit making. After completing these work, contractors got payment up to 70% of the bill. Also, as materials were used unrestrictedly, much of the materials were left with them. These contractors never turned up to complete the work. Later, agencies were to employ other contractors or their own teams to complete the work such as guarding and earthing. In this way, the completion of work was delayed and involvement of different groups resulted in defects of different nature.

D. Poor Quality of Materials:

Materials were supplied by the working agencies and their quality was to be ensured by the distribution companies. Though specific investigation in this regard was not done but compromise with quality was observed in following materials-

1) Poles:

8.5 and 9.0 metre PCC poles were used in the project. Demand of large number of these poles arose with the commencement of execution of the scheme. Units producing such poles were not able to meet the demand. Many new units were established especially for the project. Compromise with quality of these poles is readily observed. Poles were supplied with improper curing. As a result, appreciable bending of poles was very common. Also, it caused breakage of large number of poles during transportation and handling.

2) Galvanised materials:

Rusting of galvanized materials such as GI wires, stay wires and metallic fittings was seen in some of the districts. Clearly, galvanization of these was not proper.

3) Danger boards:

Danger boards, used by one of the major working agencies, were faded and their printing was unrecognizable. Use of such danger boards was useless.

4) Under-gauge wire:

One of the working agencies supplied thinner GI wire for 8 SWG, GI wire and resisted much before replacing it.

5) Improper length of electrodes:

In some villages pieces of electrodes were used for earthing.

III. Defects and Shortcomings in Installations

To energize a high voltage installation, rule 63 of Indian Electricity Rules, 1956 necessitates approval in writing by the electrical inspector. During this inspection, it was found that the factors discussed above – lack of proper supervision at contractor's or agency's level, involvement of unskilled labours, negligence by distribution companies, contractor's motive to maximize the profit and their habit to leave the work incomplete, and supply of inferior quality of materials, had resulted in the technical defects and shortcomings in the installations built under the scheme. Some of these are inherent in the technical specifications prepared by the distribution companies and others are made while executing the work.

A. Defects and Shortcomings Inherent in Technical Specifications:

There was no uniformity in the technical specifications prepared by the different distribution companies. Also, these were not same for the different districts under the same distribution company. These specifications violate some of the provisions of Indian Electricity Rules, 1956. These are as follows- (rules quoted hereafter are those of Indian Electricity Rules, 1956.)

1) Earthing of neutral terminal:

Rule 67(1A)(a) provides for the earthing of neutral terminal of transformer by not less than two separate and distinct connections. Whereas, in the project single earthing of neutral terminal by 8 or 6 SWG GI wire was provided.

2) Earthing of metallic parts:

Rule 67(1) read with 67(6) and 61 provides for the earthing of frames of transformer and distribution box, respectively, by not less than two separate and distinct connections. Whereas, only single earthing of the metallic parts by 8 or 6 SWG, GI wire was provided in the scheme.

3) Earthing of surge arresters:

According to rule 92(2) *the earthing lead for any lightning arrester shall not pass through any iron or steel pipe, but shall be taken as directly as possible from the lightning arrester to a separate earth electrode and/or junction of the earth mat already provided for the high and extra high voltage sub-station subject to the avoidance of bends wherever practicable. Also, a vertical ground electrode shall be connected to this junction of the earth mat.* For the surge arresters, GI strips of suitable dimensions should have been used for earthing but in the scheme 8 or 6 SWG, GI wire wound on the pole, with other earth-wires, was used. Thus, neither the thickness of the earth wire was appropriate nor any consideration was given to avoid bends in it.

B. Defects and Shortcomings Caused During the Work:

Defects and shortcomings of installations made during the execution of work are of various nature. Frequent ones are as follows:

1) Improper grouting of supports and stays:

In RGGVY, 8.5 metre PCC poles were used as supports for 11kV overhead lines. However, some of the working agencies had employed 9.0 metre PCC poles for 11/0.230 kV substations. Grouting of each support was to be done. Dimensions for grouting as per the Rural Electrification & Secondary System Planning Organisation, Lucknow (RESPO) standard [1] are 450 mm×450 mm×1500 mm. The working agencies paid such good rate for grouting of supports and stays that some contractors engaged sub-contractors, at 25% to 40% lower rates, to do the work. In this way, these contractors earned a profit of 25% to 40% of the amount paid for grouting of supports and stays, without doing any work. The contractors / sub-contractors resorted to all unfair means such as doing grouting for a depth of 300mm or so, using sub-standard material for grouting or not doing grouting at all, etc., for making profit. As there was no handy way to verify the depth and quality of grouting and the working agencies were not cooperating for it, the verification was very difficult and time consuming. Anticipating these difficulties in verification, the grouting was not done properly and the amount spent for this purpose was largely pilfered.

Technically, if stays were not properly tightened, it would have been better to erect the poles without grouting. Once the pole is grouted, any bending moment acting on it localises at the ground level, i.e., from where the grouting starts, and that results in appreciable permanent bending of poles.

2) Improper mounting of F-clamps:

In a significant number of PCC poles, holes provided on the top for fixing F-clamp were not matching those of the clamps. In this case, the F-clamp was mounted by clamping it with pole using D-clamps. The F-clamps mounted so were free to incline either side laterally. It would have been better to weld the F-clamp with a D-clamp before mounting it in such a way.

3) Improper right-of-way for overhead lines:

Proper right-of-way for overhead lines was not selected. At some places, pin insulators were found mounted on the trees to provide clearance from them.

4) Improper anti-climbing device:

For anti-climbing device barbed wire is to be wound for a length of 900 mm with a pitch of 15 mm [1]. But the anti-climbing devices used by the working agencies were usually found improper. The barbed wire was wound for insufficient length and inter-turn spacing was also not appropriate for its purpose.

5) Improper / no contact of earth wire with metallic fittings:

Rule 90(1) requires earthing of each pole and metallic fittings attached thereto. In the scheme continuous earth wire was not provided, instead each pole and attached metallic fittings were earthed individually. The earth wire used was 8 or 6 SWG, GI wire. Contact of the earth wire with the metallic fittings was usually not ensured. Frequently, it was not found in proper contact with cross-arm. In some villages, earth wires were starting from the cross-arm, leaving the F-clamp unearthed. Wires embedded in PCC poles were also used for earthing. For it, two pieces of GI wires were used for connecting the metallic fittings to the top hook of the pole and other for connecting the bottom hook to the earth electrode. However, continuity of the earthing was always questionable as contact of the GI wires with the hooks was not properly made and also that of the embedded wire could not be ensured.

At double-poles, the earth wires used were not in contact with the TPMO channels, cross-bracings and the TPMO handle. Few agencies used the wires embedded in PCC poles for earthing of double poles also, thus leaving the cross-bracings and TPMO handle unearthed.

6) Indiscriminate use of stays:

Contractors used the stays very indiscriminately. Profit in it made them to do so. Use of 3-4 stays for single poles and 6 stays at double poles was much frequent. Most of these stays were unnecessary as rarely any stay in a village was found tight. In some cases, even their proper direction was not ensured. Thus, providing large number of stays without bearing any tension and in inappropriate direction was of no use.

7) Improper height of TPMO handle:

At sectionaliser double poles, no effort was made to ensure proper height of the TPMO handle. Usually, it was found fitted at low height, varying from 1′ to 5′. It was not suitable for proper operation of the handle.

8) Improper mounting of surge arresters:

In the scheme, surge arresters were provided at each sub-station. Suitable position of mounting them is as close as possible to conductors of the overhead line. As per the REC construction standards F-13 and F-19, also approved by the Electrical Safety Directorate of Government of Uttar Pradesh, the surge arresters were to be placed just below the fuse set, on a separate channel. However, later they were clamped on the transformer’s body or on its HT bushings. Resistance of these surge arresters becomes negligible at high voltages. In the first case, on the arrival of surge or lightning stroke, if a surge arrester breaks and its clamp comes in contact with the earth wire, a path parallel to the earthing conductor, through transformer’s body, is created. Resistances of both paths are comparable and that of the alternative path is expected to be lower. Thus, instead of protecting the transformer from a surge or lightning stroke, surge arresters mounted so make it more prone to these strokes. In the second case, in a case of breakage of a surge arrester, the HT bushing of the transformer may get damaged. Clearly, the agencies had violated the approved drawing and had mounted the surge arresters in a position which was technically not suitable.

9) Limited use of longer supports:

Generally, the working agencies employed 8.5 metre PCC poles for construction of overhead lines. They avoided use of longer poles. With these PCC poles, it was difficult to ensure safe clearance from the ground, houses, structures and other overhead lines. These agencies used extension channels clamped on the PCC poles, for the purpose. These channels increase the height but obviously their reliability is poor as compared with that of a support of longer length.

10) Unsafe clearance of overhead lines from buildings: Rule 80 provides that where an 11 kV overhead line passes above or adjacent to any building or part of a building, it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than 3.7 metres. The horizontal clearance between the nearest conductor and any part of such building shall on the basis of maximum deflection due to wind pressure, be not less than 1.2 metres. However, no consideration was given to ensure these minimum clearances, in the villages electrified during the initial phase of the scheme. A large number of such cases were resulted due to constructions / alterations made after the erection of overhead lines. In the villages, people started constructions / alterations to save their plots from being used for construction of overhead lines because their objections were not properly addressed by the contractors / working agencies. Attempt to ensure proper clearances, started only when it was brought into notice by the electrical inspectors. As a result, in the villages, these clearances were ensured by diverting the routes, dismantling the lines, using vertical extensions or cantilevers, inserting new poles in the lines, using disc insulators or by removing a conductor from the lines. Due to the consideration made in this regard, such cases were few in the villages covered later in the sceme.

11) Unsafe clearance above ground of the lowest conductor:

As per rule 77, conductor of an 11 kV overhead line or any part thereof shall not be at a height less than

(a) *if erected across a street* *6.1 metre*
(b) *if erected along a street* *5.8 metre*
(c) if erected elsewhere than along or across any street *4.6 metre*

At some places, conductors of overhead lines were found at lower height than the above thus making them unsafe. Most of these resulted due to the constructions/ alterations made after the erection of overhead lines. Procedure to be adopted for erection of or alteration to buildings, structures, flood banks and elevation of roads, etc. is laid down in rule 82. It ensures safe clearance above ground of the lowest conductor of the overhead line during and after completion of such work. But, there was no coordination between the working agencies of RGGVY and those involved in civil works such as construction of roads, culverts, elevation of roads or flood banks, etc. As a result, ensuring the safe clearance above ground, of the lowest conductor of the overhead lines is neglected.

In cases, taken into notice at the time of inspection, the said clearance was ensured by inserting new poles in overhead lines, relocating the existing poles, using extensions on poles or by dismantling the overhead line.

12) Unsafe clearance of the lines from existing overhead lines at crossings:

As per rule 87, where an overhead line crosses or in proximity to another overhead line, guarding arrangements shall be provided so as to guard against the possibility of their coming into contact with each other. Where an 11 kV overhead line crosses another overhead line clearances shall be as given in Table 3.1

It is also required that where two overhead lines cross, the crossing shall be made as nearly at right angles as the nature of the case admits and as near the support of the line as practicable and support of the lower line shall not be erected below the upper line. In other words, overhead line shall not be constructed above the supports of the existing line.

TABLE 3.1: OVERHEAD LINE CLEARANCES

Voltage category	Minimum value (m)
Up to 66 kV	2.44
110 kV	2.75
132 kV	3.05
220 kV	4.58

The existing lines of the distribution companies have no uniformity. Supports used in them are of different types and are of varying height. Metallic rail, joist and tubular poles, latticed steel structures, PCC poles and wooden poles are in use. Even broken poles, poles with damaged cross-arm and poles without cross-arm are being used. As a result, conductors of existing lines have varying clearance from the ground. To make a proper crossing of these existing lines, i.e., to ensure the required ground clearance and to maintain the minimum safe clearance between the conductors of the two overhead lines, with 8.5 metre PCC poles only was quite difficult. Thus, at such crossings vertical extensions were employed to raise the height of the supports. At few places, where conductors of the existing higher voltage overhead line had less clearance from the ground, crossing of the higher voltage line by 11kV overhead line from above was accepted. Violation of the said rule was observed as follows:

(a) Clearance between the conductors of two overhead lines was less than the safe one.
(b) Guarding between the overhead lines, to guard against the possibility of their coming into contact with each other, was found improper.
(c) Clearance between the guarding and the conductors was found improper.
(d) Attempts were not made to make the crossings at right angles.
(e) No attempt was made to make the crossings near the support of the line.
(f) Overhead lines were constructed above the supports of existing low voltage (230 V, single phase), medium voltage (400 V, 3-phase), high voltage (11 kV) and defunct telephone lines. Supports were also erected under the existing higher voltage overhead lines. In Basti district, during erection of 9.00 metre PCC pole for 33 kV line, below the 132 kV overhead line, the pole fell on the conductor of the line. Fortunately no casualties occurred. The incident could have been avoided if the crossing was made near the support of the 132 kV line and the poles were erected far from the overhead line.

(g) In few villages, stays of the newly constructed 11 kV overhead lines were found in contact with the conductor of the existing low or medium voltage lines.

13) Excessive joints in conductors:

Rule 75 requires that joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95% of that of the conductor and the electrical conductivity not less than that of the conductor. As per proviso to the rule, no conductor of an overhead line shall have more than two joints in a span. Though rare but conductors having more than two joints in a span were found.

14) Improper Jumpers and connecting/terminating leads:

In the installations constructed under the RGGVY scheme, jumpers and connecting/terminating leads were found violating the recommendations made under section 11 [2] as follows:

(a) None of the working agencies employed PG clamps for proper jumpering. They relied on hand made joints. Most of these, improperly made joints, become hot-spots during normal operating conditions and as a result these jumpers get burnt frequently.
(b) Minimum clearance of 0.3 metre was not maintained between jumpers or connecting/ terminating leads and non- current carrying metallic parts such as cross arm, guarding, channels, etc. Especially at sectionaliser double poles, they were found at unsafe distances mainly from the stays and guarding.
(c) At pole mounted 10 or 16 kVA sub-stations, leads terminating at the transformer or surge arresters were of 1 to 3 strands of conductor. Insisting continuously, most of these were replaced later by complete conductor.
(d) Pin insulators were used in inverted vertical or in horizontal position for fixing the jumpers and connecting/ terminating leads. These insulators are not meant for use in such positions, as the inside of rain-shades is exposed.

15) Use of inappropriate insulators:

Use of appropriate insulators, in overhead lines, is recommended in Section 8.2 [2]. It was found violated in the construction of the 11 kV overhead lines, as follows:

(a) Single cross-arm with pin insulators was used at pole positions having a bend up to 90^o,
(b) A set of pin with a set of disc insulators was employed at pole positions having a bend of 90^o,
(c) When asked to use double cross-arms, with pin insulators, for bend of 10^o to 30^o, one of the agencies used double cross-arms fitted back to back, making the addition of another cross-arm useless,
(d) Single cross-arms with pin insulators were found employed at dead ends of lines.

16) Improper guarding:

If a live conductor of an overhead line breaks and falls on the ground the circuit fuse will blow or the circuit breaker will trip to render the line electrically harmless. But in practice it may not happen due to the high resistance involved in the circuit. In order to ensure the blowing off of a fuse or tripping of a circuit breaker, protective guarding is provided to the conductors of an overhead line. Rule 91 requires such guarding for every overhead line erected over any part of street or other public place or in any factory or mine or on any consumer's premises. In addition an Inspector may by notice in writing require the owner of any such overhead line wherever it may be erected to provide protective guarding.

In RGGVY, the working agencies were not doing the guarding willingly. They felt it as a burden unnecessarily imposed over them. They were neither doing it as per the agreement nor as asked by the Inspector. Instead they made all excuses to avoid it.

Regarding the guarding of conductors of an overhead line, the provisions are as follows:

(a) Minimum factor of safety for guard wires shall be 2.5 based on the ultimate tensile strength of the wire [rule 76(1)(b)].
(b) Every guard wire shall be connected with earth at each point at which its electrical continuity is broken [rule 88(2)].
(c) Every guard wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel shall be galvanized [rule 88(3)].
(d) Every guard wire or cross-connected system of guard wires shall have sufficient current-carrying capacity to ensure the rendering dead, without risk of fusing of the guard wire or wires till the contact of any live wire has been removed [rule 88(4)].
(e) Distance of the cross-lacing from the pole should not exceed 750 mm and the distance between two adjacent cross-lacings should be 2-5 metres. These values are taken from specifications prepared by RESPO [1] and REC.
(f) Though recommended in other context, section 14.3 [2] requires the longitudinal earth wires to be located at a horizontal distance outside the conductors of not less than two-thirds of the vertical distance between the lowest adjacent high voltage conductor and the earth wire or 200mm, whichever is greater. This criterion is important where the distance between the conductor and the guarding wire is excessively high or wherever all the conductors were placed on a single side of the pole.

The shortcomings observed in the installations constructed under the RGGVY scheme are as follows:

(a) Protective guarding was not provided to the conductors at the required places.
(b) 10 SWG GI wire was used as guard or cradle wire which did not conform to the required specification.
(c) Wires used by some of the agencies were found rusted which meant that they were not properly galvanized.
(d) Distance between the pole and the cross-lacing or between two adjacent cross-lacings was found much higher. In some cases, it was found to exceed 10 metres.
(e) None of the agencies ensured proper earthing of guarding.

(f) As mentioned above, instead of using poles of suitable length, vertical extensions and cantilevers were used to provide clearances from ground, houses, etc. Wherever vertical extension was employed, only conductors were raised and the guarding was left at its original height and its width was also not increased. Also, in case of use of a cantilever, conductors were shifted laterally but no attempt was made to properly shift the guarding accordingly. Further, width of guarding of conductors between a double pole and a single pole was usually found improper. Either the width of guarding channel at the double pole or the width of the cross- lacings used was found unsuitable.

17) Improper earthing at sub-stations:

In the scheme, at 11/0.230 kV, 10 kVA sub-stations only three earthing electrodes were to be used – one for neutral terminal of the transformer, one for surge arresters and one for metallic fittings along with the transformer and distribution box bodies. But as given below, these earthings were not done properly.

(a) Separate pipe electrodes were to be used for the earthing of neutral and surge arrestors and rod electrodes were to be used for the earthing of poles and metallic fittings. But no discrimination was made between these two types of electrodes.
(b) Electrodes were found missing. Instead of three only one or two electrodes were used at these sub-stations.
(c) None of the working agencies employed nuts and bolts to ensure proper contact of the earth-wire with the electrode.
(d) All the earth-wires were found connected to a single earth electrode while others were left without connection.
(e) Earth electrodes were found 1′-2′ above the ground.
(f) Instead of earthing separately, any two or all were earthed jointly.
(g) Single aluminum strand of conductor was used for earthing.
(h) Earth-wires with improper joints were used. Thus, electrical continuity of these earth-wires was not ensured.
(i) Earth-wires were not found in proper contact with the transformer body, distribution box body or the neutral terminal. They were not properly connected with the bolts provided for.
(j) 10 SWG GI wires were used for earthing.
(k) Earth-wires were not connected to electrode; they were buried in the ground without any electrode.

IV. CONCLUSIONS

In this paper, an attempt has been made to point out the defects and shortcomings of high voltage distribution system (HVDS) installations, constructed under the RGGVY scheme for rural electrification. Defects inherent in the technical specifications and those resulted during the execution, both were addressed. These defects and shortcomings could have been easily avoided by paying proper attention during the construction and the installations would have been much better. Also, reporting and rectification of these defects and shortcomings and re-inspection of these installations were quite time consuming. So, avoiding the defects and shortcomings could have resulted in early completion of the project

V. REFERENCE

[1] Construction Manual, Rural Electrification & Secondary System Planning Organisation, U. P. State Electricity Board, Lucknow, April, 1978.
[2] Code of practice for design, installation and maintenance of overhead power lines, Indian Standard IS: 5613 (Part 1/Section 2) – 1985.