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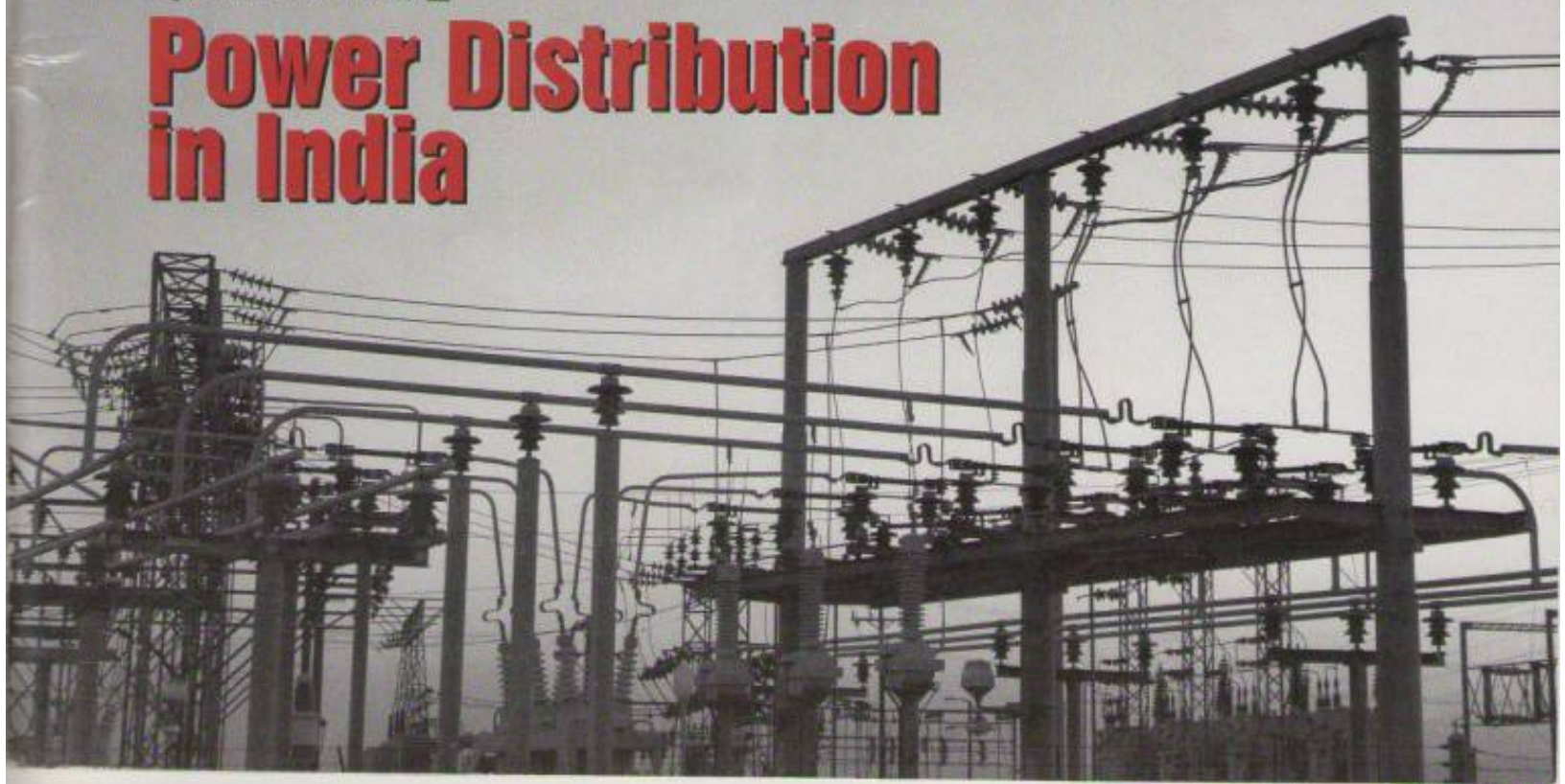


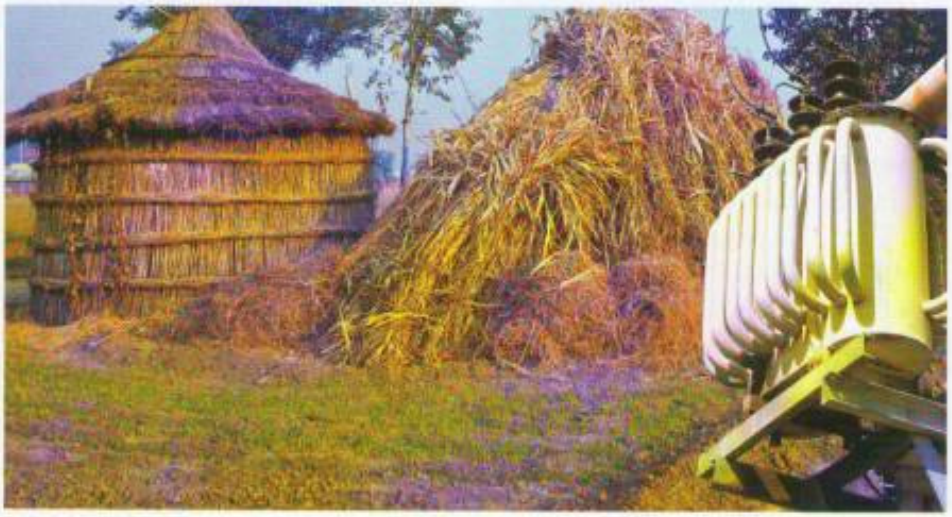
Pilot Advanced Transformer

An innovative concept in rural power management in Gujarat

Until the late 1980s, all rural feeders in Gujarat were provided 24x7 three-phase power supply. This was a period of limited demand and adequate supply. With increasing agricultural demand and rapid load growth, it became difficult to meet the demand due to generation capacity limitations. This resulted in the introduction of load shedding and rostering. The number of no-supply hours increased to 8-12 hours and rural feeders were required to be switched off during the morning and evening peak hours. Rural households were also connected on the feeders used for agricultural users, and therefore faced power cuts during this period.

In order to meet the requirements of the rural population during evening peak hours, a two-phase power supply system was introduced. However, under this system, only one phase received power at the full voltage level at the low tension (LT) end, while the remaining two phases got supply at a lower voltage. Therefore, all single-phase consumers were connected to the phase with full voltage. It was decided that the primary phase at the high tension (HT) level, which was being disconnected, may be looped with the connected phase on the load side. This ensured that full voltage was available at least in two phases on the LT network, thereby minimising low voltage issues for rural residential connections. With this, the load rostering system was modified to 8-14 hours of three-phase power supply, 10-12 hours of single-phase power supply and 3-4 hours of no power supply as per generation and peak hours.

This system worked satisfactorily for a period. However, agricultural consumers gradually started using phase converters with the single-phase supply to run agricultural pump sets for irrigation purposes. The use of phase converters became so widespread that the load during single-phase power supply was higher than that during three-phase supply. As the agricultural connections were scattered over a large area, it was difficult to stop these users from using phase converters. Agricultural consumers were increasing the area of irrigation and groundwater levels were thus getting depleted. This significantly increased the energy requirement of rural feeders as pumps of much higher capacities than authorised were deployed by agricultural consumers. This had an adverse impact on the power system resulting in the failure of distribution transformers, generation of negative sequence components, low voltages and poor quality of supply with overloading of the network including frequent snapping of overheated line conductors. This became a vicious cycle. All measures for energy or water conservation were unsuccessful as agricultural consumers were paying tariffs on a flat horsepower basis with no incentive to curtail consumption. This caused huge power losses in the agricultural sector.



In this scenario, it was necessary to introduce a foolproof system, which restricted energy misuse through phase converters and catered to the lighting requirements of rural households, hamlets and farmhouses. In response, the Gujarat discoms initiated a feeder separation programme through state government support. In 2003, the government launched the Jyoti Gram Yojana (JGY) for the segregation of agricultural feeders from village feeders. The agricultural feeders were restricted to three-phase power supply only for 8-10 hours a day for irrigation purposes. Meanwhile, the rural feeders (called JGY feeders) were fed with three-phase power supply for 24 hours.

Under the programme, which was completed in September 2006, 56,308 km of HT lines, 22,146 km of LT lines and 18,724 transformer centres were built at an investment of Rs 12.9 billion. All 18,000 villages and 12,000 hamlets started receiving uninterrupted three-phase power supply. With this segregation, exclusive agricultural-dominant feeders were used. The initiative had a major impact on consumer satisfaction levels due to the provision of 24-hour power supply. Further, a qualitative change in the standard of living was witnessed due to the creation of job opportunities on account of industrial development.

However, due to the supply of only 8 hours on agricultural-dominant feeders, people residing in the farmhouses and hamlets were deprived of electricity for the remaining 16 hours. This became a major concern for the discoms. To address this issue, Uttar Gujarat Vij Company Limited (UGVCL), one of the state's four discoms, came up with an innovative system the special designed transformer (SDT), for single-phase supply for the remaining 16 hours with precautions for avoiding the use of phase converters. The system was proposed by R.B. Patel, deputy engineer, UGVCL, in March 2005.

SDTs are installed on the premises of the HT substation (supply end) for its easy monitoring by discom officials. Following the introduction of an indigenously developed SDT system on most of the required feeders across the four discoms, the farmhouses started receiving 24-hour supply for lighting purposes. At present, 4,530 of the 5,456 agricultural-dominant feeders in Gujarat (83 per cent) have SDT installations. At UGVCL, 2,304 of 2,403 agricultural-dominant feeders (96 per cent) have SDT installations.

While putting an SDT in service, the key limitation is that one of the three winding terminals of the SDT is required to be earthed and the entire load current equal to the SDT capacity or higher passes through the earth. This necessitates precautionary measures during the erection of earthing, periodic maintenance and reactivation of earthing when current passes through earth. Therefore, a system which can accommodate these requirements; overcome system constraints; provide a cost-effective, maintenance-free and safe solution; and meet the huge power demand during planned load shedding was required.

The pilot advanced transformer (PAT), jointly invented by R.B. Patel, UGVCL, and Harendra Shukla, Vidhia Electrotrans Industries, is currently meeting all these requirements. Gandhinagar-based Vidhia Electrotrans Industries provided all shop floor facilities and infrastructural amenities with technical experience and know-how for research and development. The PAT scheme was commissioned at UGVCL in April 2012.

The main objective of this invention was to provide a foolproof system that can allow single-phase supply to hamlets and farmhouses on agricultural-dominant feeders without the earthing of any winding terminal and leeway for the use of phase converters. Given that the conventional earthing connection and the huge earthing cost are eliminated, the PAT is a cost-effective, maintenance-free and safe option. Further, the system with PAT could meet the power demand from consumers residing in farmhouses, which was a limitation in the case of SDTs.

The PAT has resulted in energy conservation of 30 per cent with respect to single-phase lighting load. Further, there has been a 66 per cent reduction in the "no-load" losses of distribution transformers. Also, energy savings of around 90 per cent have been achieved by eliminating electricity misuse through phase converters.

PAT is a system with a planned load shedding transformer without earthing and has the ability to supply 24x7 power to rural consumers during planned load shedding on agricultural feeders, with restrictions on usage of phase converters. Such transformers can be designed and installed at the 33/11 kV, 66/11 kV, 132/11 kV, 66/22 kV and 132/22 kV substations at the HT level (sending end) of the feeder. A distribution system involving a PAT includes a gang-operated changeover switch, a current transformer and a relay. The system is connected to any two phases of the conventional substation power transformer. By operating the gang-operated changeover switch in one position, three-phase power supply is fed into the feeder. By operating the switch in another position, two-phase supply is fed to the PAT, which appears in the circuit and feeds single-phase power to all consumers on agricultural-dominant feeders.

The key results of the SDT/PAT scheme are as follows:

- No power cut/load shedding in the entire state
- Uninterrupted power supply to all 18,000 villages and 12,000 hamlets
- 24x7 power supply to people living in farmhouses, hamlets and deepest rural areas
- The sensitive part, earthing of the winding of the SDT, is fully eliminated, resulting in a safe and secured system
- A huge demand for lighting load is being met easily
- The payback period for the scheme was a little over one year
- Small-, medium- and large-scale industries have been the key beneficiaries.
- Power-intensive auto industry players such as Tata (Nano), Maruti-Suzuki, Hyundai and Ford have set up base in Gujarat
- Gujarat has become a leading state in power distribution. The state discoms have received prestigious awards. ■

R.B. Patel, Deputy Engineer, and
A.R. Vakhariya, Deputy Engineer, UGVCL

Snapshot of SDT/PAT in Gujarat

Total SDTs/PATs installed in Gujarat (no.)	4,530.0
Average savings by SDTs/PATs (units per day per feeder)	2,500.0
Annual energy savings (MUs)	4,100.0
Annual cost savings (Rs billion)	12.3
Total project cost (Rs billion)	12.9
Payback period (months)	12.5
Savings in maximum demand (MW)	1,500.0

Source: UGVCL