The Electricity Distribution Network and Power Transformers, Mr Paul Dyer - UK Power Networks

Mr Dyer said that UK Power Networks received electrical power at 132kV and supplied it at 230V, though some larger customers have feeds at 11kV (or 6.6kV, but preferably upgraded to 11kV if new equipment is needed). They employ over 6000 staff and 3000 contractors. Their income is derived from DUoS (Distribution Use of System) operators. They are regulated by OFGEM, apart from a special services division.

Mr Dyer said that as far as he is aware there was no integrated national plan for future demands by, for example, electrically powered road transport. Current planning is in five year periods (though there was a brief change to eight years) – the next plan will be in 2023.

132kV is the highest voltage used for Distribution operators in the UK, except for Scotland where 400kV is used. (Higher voltages used in England and Wales are operated by National Grid.) Within their areas they use intermediate distribution voltages of 33kV and 11kV; though direct 132kV:11kV conversion is done on new systems. All distribution is by buried cable in London, but overhead lines are used by EPN and SPN.

The system as it stands was designed top down with distribution from power stations to customers. It was not designed for infeeds of power along the distribution system, such as from wind farms or even solar power from domestic properties. Provided these infeeds are less than the load on the system then they merely act to reduce demand – otherwise control equipment will sense that something is wrong and could shut down parts of the network. Conventional power stations have 'spinning reserve' – if there is a sudden demand (perhaps created by equipment failure) generators can take the load and quickly return to normal. Some generators are run on no load in case this happens. Wind power can deliver a steady current, but not suddenly ramp up.

Developing the system to utilise a growing proportion of (irregular) solar power is ongoing, with various storage techniques being developed.

Large power transformers have dimensions in metres and weigh many tons. They have steel magnetic cores, primarily of iron with carbon and other elements added to reduce losses. The core is made up of steel laminations, whose losses diminish the thinner they are made. Insulated copper windings have to be large enough to minimise resistive losses but still fit round the core. A typical 11kV:230V transformer will have no load losses of 800W, total losses rising to 12kW at full load. The transformer is enclosed by an earthed steel case fitted with insulators for the connections. An insulating oil transfers heat from the core and windings to a radiator (cheaper if mounted on the case). A transformer must be safe, reliable, not overheat, and have a life expectancy of 40 years. Life expectancy used to be 25 years, but older designs (done without modern computer algorithms) were quite conservative and give 40+ years with no degradation.

(A developer of a large building left to his own devices may fit a cheap, small, lossy transformer, leaving the tenant to pay for the electricity it wastes and deal with the heat it creates.)

Open wire lines can put an extra requirement on the networks they feed. Where this is, say, a village with 40kVA load then two 20kVA transformers will be supplied. These should have similar losses so that they share the load, but also have a Continuous Energy Rating of 40kVA in case one fails. At 40kVA the working transformer will run hot (140^{O}C with an outside temperature of 5^{O}C is permitted) and reduce its life expectancy – this is acceptable as not more than one or two such events are likely in its lifetime.

Mr Dyer showed two short films: in one a pole mounted transformer burst into flames – why? Two protection devices did not work – neither locally nor upstream - one was known about but awaiting parts for repair. If a transformer does fail and bursts, arcing can ignite the transformer oil.

In the other, American, film a large transformer did fail, burst and burning oil destroyed an entire substation – he commented that there was no fire wall around the transformer.

Power transformers are no longer made in the UK, with one exception for very large HVDC transformers. UK Power Networks now buy from: Slovenia, Portugal, Italy, India, Australia, Germany, Netherlands, Sweden, Ireland, Finland and Turkey.

Specifications follow IEC Standards (directly copied as British Standards but not bilingual in French), and a BS for reclaimed cooling oil. Schedules are prepared for specific designs. With many of these suppliers they find it necessary to send a representative to check out the test equipment and witness the factory testing. One of the more stringent tests is to apply a short circuit to the output for one second. Mr Dyer told the story of one such test where the transformer blew up, though it had not been made for the UK.

Cooling oil works well, but is not environmentally friendly, so special precautions are taken to drain / refill it during maintenance. As it is costly drained oil is reclaimed. A new oil based on esters is being developed.

In London planning permission is not needed for substations less than 3m square by 2.8m deep. They have to contain the transformer, monitoring and protection equipment – the latest transformers with thin steel core laminations have grown - exemptions for replacement transformers have to be sought.

In rural areas a similar sized 11kV substation is often housed in a glass resin bonded plastic box. The equipment still has to be earthed – by aluminium rods, copper being too attractive to thieves!