SOME NOTES ON THE LIVERPOOL ELECTRIC SUPPLY UNDERTAKING.

As it is impossible in a short paper to deal fully with all matters connected with the Liverpool Electric Supply Undertaking, the Author proposes to give a brief survey describing the evolution of the Undertaking to the present day, and will endeavour to explain some of the principal changes made, and the effect these changes have had on the Undertaking. He will endeavour also to deal with some of the main factors which govern the costs of production.

In the early part of the year 1883 a Company called the Liverpool Electric Supply Co.Ltd, was formed to supply electrical energy in a central portion of the City, but the supply was not available until the July of that year.

The supply was commenced with a small gas engine driving a dynamo in Eberle Street, but in the same year a Station was erected in Rose Street, which had a capacity of 1,000 - 60 Watt lamps and ran regularly until 1890, when the load was transferred to a newer Stationin Harrington Street built in 1888.

The system of supply was direct current at a pressure of 110 volts.

Previous to the autumn of 1888 the supply mains were all run overhead, and at first pressure was only put on each day at dusk.

With the advent of the Station in Harrington Street, the hours of supply were lengthened until a 24 hours supply was maintained in 1891.

In 1887 another Station was built in Tithebarn Street, and in the year 1888 the Company with the consent of the Corporation obtained a license from the Board of Trade to supply electrical energy in a portion of the City, and use underground mains.

In 1889 a Provisional Order was obtained and in this year the Tithebarn Street Station was extended, and adjacent premises in Highfield Street were acquired.

In 1890 the Oldham Place Station was constructed.

In 1892 a Provisional Order was obtained for a larger portion of the City, and also the district of Toxteth Park, which was outside the City Boundary at that time. A station to serve this district was built at Lark Lane.

The Plant at the earlier Stations was of various types, but gradually Willans and Robinson High Speed engines became the standard, each generator being 150 K.W. capacity and arranged to supply direct current at a pressure of 110 volts.

With the object of using the copper in the mains to the best advantage, and at the same time to enable the existing stations to supply over as large an area as possible, a beginning was made in 1890 to change to the three wire system, with a pressure of 220 volts across the outers, and in 1897 a further change to 460 volts across the outers was decided upon. These changes involved a great amount of work, and took many years to complete.

Batteries were used at a number of the Stations, but as they became too small for the increasing load they were gradually displaced.

In 1895 a larger Station was built at Paradise Street, and the earlier Station at Harrington Street was closed.

In the year 1896 the Corporation took over the Undertaking from the Company, and the whole of the energy was then supplied from the four Generating Stations, Highfield Street, Paradise Street, Oldham Place and Lark Lane, the total capacity of plant being 4,000 Kilowatts.

When in 1897 the Tramway Undertaking was taken over by the Corporation it was necessary to make further provision for the increasing demand. Two new Stations were laid down. Pumpfields in 1899 and Lister Drive in 1900.

These two stations were similar in design and were very much larger than anything then in existence in Liverpool.

In the Pumpfields Station there were 12 sets of Willans engines coupled direct to direct current generators of 700 K.W. capacity each.

Each set of plant could work either on the lighting or traction loads. The sets were arranged in the engine room in two rows of six. The crankshafts running parallel with the length of the engine room.

A boiler house containing fourteen 30'0" x 8'6" Lancashire boilers and two economisers with a chimney in the centre was placed at each side of the engine room. Each boiler house was run as an independent unit, there being no steam connection between the two boiler houses. The coal was stored in bins overhead and was carried from the canal bank by means of an endless canvas belt. The water from the Leeds and Liverpool Canal was used for condensing purposes.

Lister Drive Station was similar to the Pumpfields Station as regards design and the type of plant used, but as there was no canal at at Pumpfields, cooling towers were installed for cooling the circulating water, and the method of handling the coal was varied.

It is interesting to note that the last three generating sets originally installed in this station were Willans engines coupled to three phase alternators each of 700 K.W. capacity, generating alternating current at 6,000 volts at a periodicity of 50 per second.

The alternating current was taken to some of the older generating stations where motor generators of 500 Kilowatts and 200 Kilowatt capacity were installed. The high tension current being delivered direct to the motor, the dynamo supplying direct current suitable for either lighting or traction.

In 1903 - 1904 a second station was erected at Lister Drive.

This station saw the commencement of the use of turbines in connection with the public supply of electrical energy in the City.

The turbines ten in number are arranged on each side of the engine house and are of 2,000 K.W. capacity each.

There is a boiler house on each side of the turbine house, each fitted with eight water tube boilers capable of a normal evaporation of 22,000 lbs of steam per hour.

The completed stations No.1 and No.2 comprised, therefore, 2 engine rooms and four boiler houses. Each boiler house being run as at Pumpfields as an independent unit.

As this plant was installed the steam plant in the older stations was gradually displaced, and further converting plant added to replace it, and as the area covered by the supply extended new substations were added.

During the last three years the only stations containing steam generating plant with the exception of the Destructor Stations were Lister Drive and Pumpfields.

In 1911 it was decided to displace the Willans and Robinson sets in Lister Drive No.1 station and replace them with turbine sets.

Two 2,000 K.W. turbo-generators each driving 2 - 1,000 K.W. direct current generators arranged in tandem and 2 - 3,500 K.W. and 2 - 6,000 K.W. turbo alternators have been installed.

In order to provide steam for this increased capacity it was necessary to replace the Lancashire boilers with water tube boilers, and in order to get the greatest capacity of steam, the boiler house has been reconstructed with a strong floor above the boilers upon which are placed the economisers, one to each boiler.

At present six water tube boilers and economisers have been installed in the place of seven Lancashire boilers.

A start has been made towards the reconstruction of a second section of seven Lancashire boilers.

It is interesting to note that the steaming capacity of each section as reconstructed is approximately three times what it was before. This increase has enabled very much larger generating units to be installed, with the result that when the scheme is completed the capacity of No.1 Station will be 35,000 Kilowatts as compared with a capacity of 8,400 Kilowatts as originally laid down.

In order to improve the efficiency and minimise the number of standby boilers, a steam pipe has recently been connected between the reconstructed boiler house in No.1 station and the adjacent boiler house in No.2 Station. This alteration has proved extremely useful and very considerable economy has resulted.

An extension of this principle will be carried out in the near future, by connecting the two steam ranges at the opposite end ~~of~~ to the present connection thus forming a complete ring. It is intended also to connect the two steam ranges in No.2 Station.

Advantage has been taken in the reconstruction of providing overhead coal bunkers and complete coal handling plant.

The reconstruction of the boiler house necessitated taking down the foundations of the old building 14'0" and lifting the roof 17'0".

The coal is brought to the Works by rail, and the wagons conveying the coal for the reconstructed portion are run over two hydraulic rams, which have heavy yokes fitted to the end of the rams. The wagon is lifted bodily, and as one ram has double the vertical movement of the other the truck is lifted endwise, and the coal is dumped into a hopper below the rails from whence it gravitates to a coal conveyor which transfers it to the overhead bunkers.

The conveying plant can deal with the coal at the rate of one ton per minute, and the overhead coal bunkers have a storage capacity of 650 tons.

The cooling towers are arranged at the end of the turbine houses, and recently a system of pipes has been laid which enables the whole of the towers connected with the No.1 and No.2 stations to be coupled together.

These towers are of different makes, the latest type being made in cylindrical form of iron plates. The ground space occupied for the work done being less than with other types in use.

As more modern and efficient plant has been installed at Lister Drive, the older plant at Pumpfields has been used less and less.

The output from the Pumpfields station had reduced from 9,780,000 units in 1907 to 2,300,000 in 1913.

With the reduced output the costs of production per unit had risen very materially. The station could not be shut down entirely as the electrical pressure could not be maintained without it.

In order to enable the steam plant to be shut down for a great portion of the year, three rotary converters have been installed of 1,500 K.W. capacity each, and four of the engine sets have been displaced to make room for them.

The energy for the rotaries is supplied from Lister Drive.

Since this alteration has been completed no steam plant has been used at Pumpfields, but the steam plant is always available, and it is intended as occasion arises to use this station to help at times of peak load in the winter.

The rotary converters are more economical than the motor generators fitted in the other substations, and consequently the losses in distribution will be less.

DESTRUCTOR STATIONS.

The Health Committee of the Corporation possess a number of Refuse Destructors, and at five of these centres advantage has been taken of the steam available to generate electricity.

The Boilers and Buildings are provided by the Health Committee and steam is supplied to the Tramways and Electric Power & Lighting Committee, who find the generating plant which consists of high speed engines connected to direct current dynamos.

In all cases except Charters Street motor generators are provided as a standby in case there should be a lack of steam when the load would have to be provided for from Lister Drive.

About 6,000,000 units were generated last year from these five Stations.

MAINS.

The low tensions mains both for lighting and traction supply are single bitite insulated cables with the exception of the mains system at Garston and Gateacre, where the mains are mostly triple concentric paper insulated. The majority of the mains are laid in bitumen in iron troughs, but more recently earthenware troughs are being used in place of the iron troughs.

The high tensions mains are all three core paper insulated lead covered and armoured laid in iron or earthenware troughs filled in with bitumen or pitch. The low tension mains are divided into districts, each district being supplied independently of one another, but provision is made for coupling up one district with another in case of necessity.

It is interesting to note that some of these bitumen mains have been laid 26 years, and are today quite sound and good.

The effect of the alterations and improvements described may be gauged by a reference to the costs per unit shown in table No.1 which gives the costs for various items for the year 1896 when the Corporation purchased the Undertaking, and also for the year 1914.

	1896. Cost per unit. D.	1914. Cost per unit. D.
Coal.	.51	.223
Oil, Waste, Water etc.	.09	.016
Wages.	.34	.076
Repairs.	.35	.055
Works Costs.	1.29	.370
Rents Rates & Taxes.	.33	.159
Management.	.70	.082
Special Charges & Insurance.	.30	.025
Total Costs.	2.62	.636
Interest & Sinking Fund.	1.82	.607

TABLE No. 1.

The coal has reduced during the period from .51d. per unit to .22d per unit in spite of the fact that during the same period coal has advanced about 4/0d. per ton.

The Works Costs have reduced from 1.29d per unit to .37d. per unit, and the total costs including capital charges from 4.44d to 1.24d per unit.

It is interesting to note the proportion each item of cost bears to the whole, and also that the Capital Charges are nearly as much as all the other items put together.

The table No.2 shows a comparison of the maximum load exclusive of Tramways, the average price obtained per unit, the load factor, and the number of 60 Watt lamps connected to the supply in the years 1896 and 1914. The Power load for the sake of comparison has been converted to the equivalent in 60 Watt Lamps.

	1896.	1914.
Maximum load in Kilowatts.	2018	15,000
Average price obtained per unit.	6.64d	1.566d
Load Factor.	4.8%	25%
Equivalent in 60 Watt lamps connected.	52,490	640,800

TABLE No. 2.

Each Kilowatt of maximum load in 1896 provided for 26 - 60 W. lamps installed, whereas in 1914 each Kilowatt of maximum lighting and power load provided for the equivalent of 43 - 60 Watt lamps installed. At the same time the average Capital cost per Kilowatt of plant installed fell from £150 per Kilowatt in 1896 to £57 per Kilowatt in 1914.

The great improvement shown in the statistics given has been brought about mainly;

1. By centralising the generation of electricity, and installing more modern and efficient plant, and plant which costs less per K.W. than the plant originally purchased.
2. The use of larger generating units, and boilers of larger steaming capacity.
3. The better load factor.

It is very interesting to consider the tendency there has been towards higher speed of running of the generating sets since the earlier electric supply stations were installed, and to note how the higher speed has affected the costs of production.

In the earlier stations dynamos were driven by slow speed engines by means of ropes or belts, but when high speed engines became feasible, the dynamo was coupled direct to the engine, with a ~~consequent~~ result that a considerable economy in floor space, was obtained.

The high speed engine due to its reciprocating action had limitations in regard to speed which were soon reached.

At first only comparatively small engines were used, which were run at speeds up to 500 or 600 revolutions per minute. As the necessity for larger sizes arose generating sets of 600 K.W. were run at about 300 revolutions per minute, and for sizes of 1,400 K.W. capacity the highest speed attained for central station use was about 200 revolutions per minute.

High speed engines for driving dynamos have not been made in larger sizes than the last named, as any further increase in the size involves a reduction in speed, consequently the so called high speed engine becomes little better than the slow speed engine.

With the advent of the steam turbine with its purely rotary motion very much higher speeds could be attained than was possible with the reciprocating engine.

This increased speed of running brought in new considerations for the designers of the electrical portion of the generating sets, but gradually many of the difficulties have been surmounted, and the tendency today is still towards higher speeds. It is quite customary now in order to enable the higher speeds to be utilised and to enable the material in the electrical portion of the plant to be used to the best advantage to force air under pressure through the dynamo to carry off the heat generated.

In these high speed generators very great care is taken in the design to provide for adequate ventilation. Ducts are provided through the iron stampings both of the rotor and stator for the passage of air. It is very desirable that these passage ways should be kept clean in order that the efficiency of the ventilation may not be impaired, or the temperature of the machine would rise, and the safe output of the plant would decrease.

It is customary to clean the air either by passing it through screens made of cloth or through a very finely divided spray of water. The latter system tends not only to clean the air, but also to reduce its temperature, which is an advantage, as this cooling effect tends to increase the safe capacity of the machine.

In the early days £15 per Kilowatt was considered a reasonable price to pay for generating sets. At the present time turbo generators with condensing plant can be bought under £3 per K.W. for fairly large sizes.

When Capital charges bear such a large share of the whole cost of production it is easy to see what a great effect the turbine has had in helping to reduce costs.

The steam turbine has also enormously facilitated the use of large generating units. The reciprocating engine for a 3,000 to 5,000 K.W. plant became very bulky requiring a very large amount of floor space, a large amount of labour to look after it, and in case of repair liable to be out of commission for a lengthy period.

Turbo generators are now being made in sizes up to 30,000 K.W. capacity.

The tendency in connection with the Liverpool supply it will be noticed is all in the direction of centralisation.

In the early days when only low pressure current was generated it was necessary to place generating stations at different points to deal with the demand in the particular district on account of the very heavy cost of the mains required to transmit low pressure current over a long distance. As the load on each of these stations was comparatively small only small sized generators could be used.

When Lister Drive was equipped with alternating current machines it became possible to do away with the smaller [redacted] stations, and owing to the centralisation of the [redacted] plant larger generating units were used which were cheaper in first cost and of greater efficiency, and much more economical in floor space.

In addition to this the question of the delivery of coal to the small stations was a difficulty. By the adoption of a centralised scheme, economy was obtained in the delivery, handling and storage of coal.

At Lister Drive a Railway siding enables the coal to be brought direct from the colliery and delivered right into the bunkers. In the case of the latest installation of boiler house plant already described the coal is not handled from the time it leaves the Colliery until the residue in the form of ashes is dumped from the end of the chain grate stoker.

To deal with the ashes it is intended to instal a suction ash plant. The ashes are conveyed through pipes laid for the purpose from the ash cellar to the ash hopper, and the conveyance of the ashes is caused by drawing a large volume of air through the suction pipes.

This plant consists of an air pump capable of dealing with a large volume of air coupled to the 10" suction pipes which are laid under the boilers. The ashes first pass through a crusher which breaks them to a suitable size, after which they pass through an opening into the 10" pipe. The volume of air passing is sufficient to carry them to a receiving hopper above the roof where they are stored, until they can be conveniently discharged into railway trucks. At the head of the receiving hopper there is a series of jets which discharge water in the form of a very fine spray, which acts both as a screen to prevent dust passing to the air pump, and also as a means of cooling the ashes.

A plant of this description is very convenient as it can be used also to remove the flue dust from the boilers and economisers. The ease with which this material can be removed should enable the boilers and economisers to be kept much cleaner than under the older system, and consequently improved efficiency should be obtained.

The Liverpool Undertaking was initiated primarily in common with other of the earlier stations to develop a lighting load, and no one imagined in those early days that it would be possible to supply energy so cheaply as it can be obtained today.

The reconstruction and alterations tothe plant have been responsible to a very large extent for the reduction in the costs of production and the general improvement in the Undertaking.

There is, however, another item which has very materially affected the results, viz; the improvement in the load factor.

The load factor may be stated as the relation of actual units produced with any given maximum load, to the possible number of units that could be produced, if the plant ran at this maximum load continuously throughout the year.

$$\text{Load factor.} = \frac{\text{units} \times 100}{\text{maximum load observed during year in Kilowatts} \times 8760 \text{(hours in year of 365 days)}}$$

The Author will endeavour to show with the aid of some curves how the load factor affects the costs of production.

Figure 1. shows a typical daily curve for private residence lighting and a typical daily curve for office lighting for a day in summer and a day in winter.

It is well to remember that in the early days of the Undertaking the whole of the supply was taken by consumers having a demand such as is shown in figure 1. The load factor for a supply of this nature would be about 5 per cent, whereas the load factor of the system today is about 25 per cent.

The improvement has been brought about by the use of the energy for purposes necessitating longer hours of use such as arc lamps for street lighting, motors in factories, tramways, radiators etc.

The great difference between [redacted] summer and winter [redacted] is very marked both in the case of the private residence and of the office lighting curves but it will be noticed that the maximum load for the private residence comes on at a later hour and that the load remains on longer than in the case of the office.

It will be appreciated that the two sets of curves shown are typical, and also that in a large supply Undertaking, there are many lighting consumers whose demand would vary materially from those shown. Take for instance the case of an underground basement where the light would be required most of the day, and possibly late in the evening, and the case of a Railway Goods Yard where there would be a moderate demand during the day, but where a large portion of the lights would be required throughout the night.

The general tendency of the varied requirements of individual consumers is to improve the load factor, and it is an advantage therefore to have connected to the supply as large a variety of user as possible.

In certain cases the maximum demands of individual consumers coincide, but there are very many cases where the maximum loads do not coincide. If it were possible to obtain load curves of each consumer connected to the mains at any one time, it would be found that the actual maximum load registered at the station would be very considerably less than the aggregate of each consumers maximum. In confirmation of this it may be stated that the actual number of Kilowatts connected to the mains in the form of lighting or power is 38,500 Kilowatts, whereas the actual load on the station at any one time due to this connected capacity is only 15,000 Kilowatts. This relation of the actual maximum load to the sum of the consumers maxima is called the diversity factor.

The ideal condition of supply would be that the maximum load should be continuous throughout the year which would give 100 per cent. load factor, and under these conditions the lowest costs of production would be attained. Unfortunately such conditions are not obtainable although individual consumers might attain as high a load factor as 80 per cent. For ordinary Supply Undertakings the load factor would vary from about 12 per cent. to 30 per cent. but some of the Power Companies might exceed the higher figure.

It will readily be seen how great an effect the load factor has upon the costs when it is appreciated that plant to provide for the maximum load has to be purchased and Interest and Sinking Fund charges have to be paid upon the Capital sum expended independent of the quantity of units produced.

The Capital charges per unit, therefore, vary directly in proportion to the load factor.

It is, therefore, the aim of everyone in control of Supply Undertakings to improve the load factor on the Station, and with this object in view the power load has been cultivated.

Curves shown in figure II represent daily load curves of two power users at present coupled to the Liverpool supply mains. It will be noticed that in both instances the supply is fairly continuous, both day and night, with breaks for meal hours. The load factor in these cases would be between 50% and 60% as allowance must be made for the supply being discontinued for a portion of each Saturday and the whole of Sunday, and also for holidays.

Figure III shows a comparison between a power load and a lighting load; the lighting load being mainly office lighting.

It will be noticed that in the case of the power load the variation between summer and winter demand is very small, but in the case of the lighting load the variation is very marked.

These curves show clearly why energy can be produced cheaper for the power load than for the lighting load, owing to the load factor being so much greater in the case of the power user than is the case with the lighting user.

There is an additional reason which affects the production of power favourably as compared with a lighting load. Lighting is affected by dark weather, fogs, thundershowers etc. which may entail a sudden demand on the supply. Consequently boilers have always to be maintained under steam, and men have to be in attendance to meet any sudden emergency which adds very much to the costs of production. Power on the other hand is not affected in the same way. In order to show the effect of the improved load factor a curve (Figure lV) has been made to compare the character of the load curve in 1895 with the present load curve. It will be observed that the peak load in 1895 was 1850 Kilowatts and the morning load at 11 a.m. was 450 K.W. The peak load, therefore, was four times the load at 11 a.m.

Similarly for the 1914 curve the peak load ~~mf~~ was 24,000 K.W. and the morning load at 11 a.m. 13,000 Kilowatts. In this case the peak load is less than double the morning load. This shows that the character of the load curve on the system has changed very materially and that the plant was used to much better advantage in 1914 than in 1895.

Another item of interest in connection with these curves is a comparison of the output represented by the area of the summer curve relatively to the output represented by the area of the winter curve for each year.

The area of each curve has been taken out and the result shows that the area of the winter curve for 1895 is five times the area of the summer curve for the same year, whereas the area of the winter curve for 1914 is only 1.7 times greater than the area of the summer curve in 1914.

This result shows that the plant necessary to provide for the winter load is used much more during the summer months under existing conditions than it was during the earlier period.

In other words whereas in 1895 four-fifths of the plant was not earning revenue during the summer months this proportion has been reduced to less than half at the present time.

If the character of the load curve in 1914 had remained the same as in 1895, and if the day load at 11.o'clock in the morning had risento the present figure, viz; 13,000 K.W. in 1914 the maximum load instead of being 24,000 Kilowatts would have been approximately 52,000 K.W. It would have been necessary to purchase plant to provide for the extra 28,000 K.W. and the Capital expemditure would be considerably over one million pounds higher than it is today. It is certain, however, that had the character of the load curve remained as in 1895 the output would have been very much less than it is today as the prices charged for the energy would of necessity have been very much higher than they are, and consequently many consumers who have availed themselves of the supply would have been unable to do so at the higher prices per unit.

It will be seen, therefore, from the foregoing how important it is to improve the load factor.

During the last two years over 8,000 H.P. in motors has been added to the system, and it is quite certain that this large increase in the power load will have a marked effect on the costs in the future.

The following results were achieved in another town mainly owing to the large accession of power load and a consequent improvement in the load factor.

The total costs including Capital Charges in 10 years decreased from 3.5d per unit to 1.3d per unit, while the units for power purposes increased from about half a million per annum to 12 millions per annum whereas the lighting units only increased during the period to the extent of three millions per annum.

During the period the average price obtained per unit decreased from 4.2d per unit to 1.7d per unit. In spite of this large reduction the profits increased very materially.

Such results are very encouraging, and when it is appreciated that this process of reduction of costs is still progressing at a very rapid rate one is forced to think of the electrical possibilities before us in the future.

Electricity is being used today for so many purposes and will in time be used for many other purposes. Cooking by electricity is making progress, and so soon as the price of the energy is capable of being reduced a little more, there is little doubt that cooking by electricity will be used very extensively. When this time comes there will be a very large increase in the demand, and it is anticipated that this type of load will tend to still further improve the load factor.

A vigorous effort is being made to secure a good power load, and in a number of cases an alternating current supply has been given, instead of a direct current supply. In such cases the high tension mains at 6,000 volts are run into consumers premises and the supply is transformed down on the Consumers premises to the pressure required for the motors, usually 400 volts between phases.

The problem of supplying low tension direct current to large power users situated at a considerable distance from substations becomes difficult on account of the very large amount of copper necessary in the mains. The supply from the high tension mains simplifies things very materially, and as the high tension mains are in duplicate additional security is provided to the Consumer.

The Author considers that many of the Power users in Liverpool are not sufficiently alive to the great advantages of electric driving, although it is gratifying to know that the demand for power purposes is increasing rapidly. The advantages claimed for electric driving are not based alone on theory, but are proved from actual experience to be facts.

In the large Manufacturing towns in the Country the Central Electric Supply is being used more and more, and the output from the stations is growing by leaps and bounds.

Liverpool cannot be considered to be a manufacturing town where towns such as Newcastle, Glasgow Manchester, Sheffield, Leeds and Bradford are considered, but yet there is a very considerable amount of power used in this City, and it is gratifying to think that some of the larger power users are appreciating the many advantages of electric driving, and are continually increasing their demand.

The reason why Manufacturers throughout the Country are adopting the Central Supply as their source of power so rapidly, is in the Author's opinion, mainly due to convenience.

When one considers that the cost of power in most Works is such a very small item in the total cost of production of the article produced, it is easily appreciated that convenience may easily become a more important factor than cost.

Electric driving enables any of the machines in a factory to be run overtime without incurring heavy additional expense such as would occur where the manufacturer produces his own power. It is an advantage to be able so readily to speed up any process in the factory, and it is easily conceivable that by this means a very material increase of the output from the factory may be made.

It is a great advantage to be able to augment the power for any machine or group of machines without disorganising the factory. A larger motor can be put in at the week end without any loss in working hours on the particular machine.

Consider what a difficulty arises when it becomes necessary to put in a larger engine in a factory. The whole Works may have to be shut down for a week or two during the change.

Owing to the facilities obtained by electric driving manufacturers are enabled to take orders for quick delivery that they could not otherwise undertake.

Again where a manufacturer has his own engine and boiler there is a certain amount of his time and attention taken up in looking after the plant, but with electric driving this trouble is avoided altogether.

These are some of the reasons that have been proved from actual experience during the last few years to be real advantages and which in the Author's opinion are the main reasons why the Central Electric Supply is being used to such a large extent today.

The table below gives the horse power of motors coupled to the supply mains in the districts named.

In Newcastle	260,000 H.P. is	coupled to	the mains.
" Glasgow.	67,000	Do.	Do.
" Manchester.	80,000	Do.	Do.
" Birmingham.	74,000	Do.	Do.
" Sheffield.	40,000	Do.	Do.
" Leeds.	34,000	Do.	Do.

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James P
Britsmith