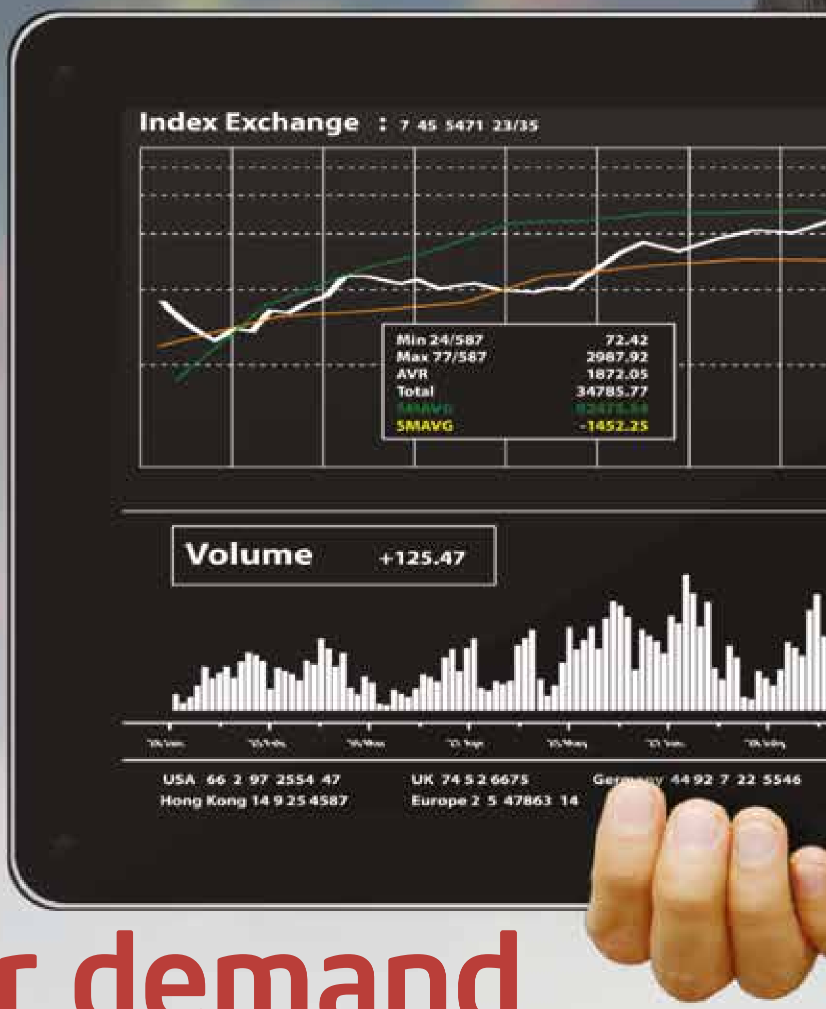
> Over the last thirty years, the global installed generating capacities have increased at a CAGR of 3.41 %, which means it has doubled over that time, and the rate has been growing further



Transformer demand 2018 to 2028, and beyond

GSU Transformers - Part 1

Background

Over the last thirty years, the global installed generating capacities have increased at a compound annual growth rate (CAGR) of 3.41 %, which means it has doubled over that time. Furthermore, the rate has been growing.

Back in 1988, the global generating capacity was growing at about 65,000 MW per annum (p.a.), and indeed during the decade 1988 to 1998, the average annual demand was a shade over 65,000 MW. However, it increased to an average of 124,000 MW p.a. in the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If the average generator has a working life of 30 years, then the implied replacement rate is 3.3 % per year, which means that the replacement rate in any single year is equal to 3.3 % of the total installed capacity 30 years ago

following decade and to 224,000 MW p.a. during the period 2008 to 2018, Table I.

The installed capacities at each of those milestone years is displayed in Table II.

The resulting newly added capacities installed during each decade are displayed in Table III.

For the manufacturers of Generator Step Up (GSU) transformers, this is the basic ten-year production planning model. Or, to be a little more accurate, the apparent power in GVA of GSU required to meet the active power in GW demands needs to be multiplied by a factor of approximately 1.1 on the basis that the GSU transformer is usually oversized by 10 %. It is a small factor, but it increases the average annual apparent power demand up to 71.7 GVA, 136.7 GVA, and 246.7 GVA, respectively. This is the starting point for any estimates for future transformer demand. As far as any statistics can be termed as fact, these are internationally recorded and verified factually correct demand figures.

There is, however, another element that should be added to the total global demand. Those are the capacities which should replace the old generating plants which are retired every year. That is not easy to calculate, and it may require complex mathematical models for an accurate estimate. However, it can be estimated to a reasonable level of accuracy much more simply under some assumptions as follows. If the average generator (across all types in every country) has a working life of 30 years, then the implied replacement rate is 3.3 % per year, which means that the replacement rate in any single year is equal to 3.3 % of the total installed capacity 30 years ago. On this basis, the replacement of generator units in GW per decade is shown in Table IV.

This results in a total apparent power in GVA of GSU transformer demand over the period to be as shown in Table V, which takes into account an additional 10 % increase in GSU rating due to usual oversizing.

Clearly from a GSU transformer manufacturer's point of view, the global market has performed very well over the last 30 years. With demand, and hence with production capacity increasing from 96 GVA p.a. in the first decade to 172 GVA p.a. in the second decade, and finally, to 280 GVA p.a. Thus recording increases in orders of 79 % and 63 % respectively over the period.

Trends over this time

As noted at the start of this article, the CAGR rates of global installed capacity have increased steadily from 2.26 % through to 4.34 % over the 30 years.

Table I. The global installed capacity growth rate

Decade	Growth rate
1988 to 1998	2.26 %
1998 to 2008	3.64 %
2008 to 2018	4.34 %

Table II. The global installed capacities – 10-year intervals

Year	Global installed generating capacities in GW
1988	2,528.2
1998	3,161.1
2008	4,518.8
2018	6,909.5

Table III. Newly added capacities installed each decade, globally

Decade	New capacities installed in GW	Average new capacities p.a. in GW
1988 to 1998	652.4	65.2
1998 to 2008	1,242.8	124.3
2008 to 2018	2,243.1	224.3

The type of generating capacity that has been added globally has, however, changed dramatically. Fossil fuelled generating capacity has dominated the industry with between 60 % and 70 % of the total across the time series, hydro is the next largest sector but is declining in importance, as has nuclear, which is

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Table IV. Estimation of the new capacities due to the replacement of the old units per decade, globally

Decade	Replacement capacities installed in GW	Average replacement capacities p.a. in GW
1988 to 1998	222.7	22.2
1998 to 2008	322.0	32.2
2008 to 2018	310.2	31.0

Table V. Total GSU transformer demands

Decade	Newly installed and replaced transformer capacities in GVA	Average replacement capacities in % of the total capacity
1988 to 1998	962.6	25.4 %
1998 to 2008	1,721.3	20.6 %
2008 to 2018	2,808.6	12.2 %

Renewable energy generation capacities are the only type that is increasing in the importance of the global mix, from negligible up to 16.7 % share; nuclear has halved, fossil fuel has decreased by 2 %, and hydro is reduced by 8 %

the third-largest. On the other hand, renewable sources have shown the most significant increase from negligible amounts, increasing to nearly 17 % of the total capacity by 2018 at the global level.

The full picture is shown in Table VI.

The clear conclusion is that renewable energy generation capacities are the only type that is increasing in the importance of the global mix, from negligible up to 16.7 % share. Nuclear has halved, fossil fuel has decreased by 2 %, and hydro is reduced by 8 %.

This does not, however, mean that there is less nuclear, fossil, and hydro generating plant installed, in fact, quite the opposite is true.

Although nuclear is decreasing in importance because the overall total capacities were growing, there has still

Table VI. Installed global capacities by type in % of the total capacity

Type	1988	1998	2008	2018
Nuclear	12.1 %	11.1 %	8.3 %	5.2 %
Fossil	63.7 %	67.8 %	69.1 %	61.8 %
Hydro	24.2 %	21.1 %	18.6 %	16.3 %
Renewable	negligible	<1.0 %	4.0 %	16.7 %
Total GW	**2,062.4**	**3,109.5**	**4,483.3**	**6,889.8**

Table VII. Installed global capacities by type in GW

Type/ GW	1988	1998	2008	2018	Total net increase
Nuclear	248.7	346.2	371.6	360.4	111.7
Fossil	1,313.8	2,107.5	3,100.2	4,258.9	2,945.1
Hydro	499.9	655.8	832.8	1,123.2	623.4
Renewable	negligible	negligible	178.7	1,147.3	1,147.3
Total GW	**2,062.4**	**3,109.5**	**4,483.3**	**6,889.8**	**4,827.4**

been a net increase of 111.7 GW of nuclear plants, with the peak year was 2010 when a total of 375.2 GW was declared. However, since then, decommissioning has exceeded commissioning levels. In addition, it must be pointed out that these figures are NET additions and take no account of plant retirements. When this factor is taken into account, there will be a minimal amount of enewable retirements and much more possible retirements in the nuclear sector.

The change in the global generator fleet profile in terms of prime mover type has a significant effect on the supplier base for the GSU transformers. Large base load stations fuelled by coal or nuclear reactors are several magnitudes larger than those used for most renewable sources. A typical nuclear unit can be up to 1,000 MW requiring transformers of 1,000 MVA

China is the global leader in the installation of the new capacities, accounting for 50 % of all power station development worldwide, what simply cannot be ignored or surpassed

and larger while the coal-fired units are commonly sized at 500 MVA, and gas turbines are usually over 25 MVA. On the other hand, wind turbines are the largest single units in the renewable sector with the maximum power of 10 MW per unit while the majority of the units are in the range of 2 to 5 MW. This means that for every 1,000 MW nuclear power plant generator installed, a single 1,100 MVA GSU transformer should be installed. For the same capacity between, 200 and 300 new wind turbines should be installed with the same number of GSU transformers. Those are two very different scenarios from the GSU transformer production point of view.

The impact on the higher voltage grid system is also different for large centralized units compared to smaller decentralized units. The large centralized units such as nuclear or fossil-fuelled power plants are usually connected directly to the higher grid voltages with no interim step up stages. On the other hand, smaller decentralized wind farms and parks are often in isolated areas requiring not only multiple step-up stages but also the additional equipment such as powerline conditioning reactors and capacitors. Neither scenario can be considered better nor worse, but they are considerably different. This is the topic for another complete discussion, which is, however, out of the scope of this article.

Geographical trends

So far, the development of the global capacity network has been illustrated, covering the last 30 years, and future development will be covered in the next section. It should be noted that there has also been a very dramatic shift in the geographical layout of global development. If we focus on only one year – 1990, we can see that in many aspects that was a very notable year. The first web server was set into the operation, Germany was reunited, the Hubble telescope was launched, the USSR and many Eastern European countries began to restructure, etc. The global economy was still in good shape before the sharp recession that followed (1991 to 1993). Despite the recession, the global generating capacity continued to increase. In 1990 a total of 55,096 MW was installed worldwide. A little lower than average, but nothing extraordinary or particularly notable. It should be noted, however, that this year was the first when China and America installed practically the same amount of generating capacities. Each country was responsible for 20 % of the increase, each adding about 11,000 MW. This was a turning point in the change in the global balance of power plant building. There have been occasional years when the positions have reversed, but not since 2003 has the USA installed more capacities compared to China. China has never dropped below 37.7 % (2012) share of the total new installed capacities and, in six years, has reached above the 50 % level.

In 2004 China added 51,000 MW of the new capacities. Installation of the new capacities increased to 2013 when 100 GW level was exceeded with the 112.4 GW of the new capacities installed. That level has been pushed upwards over the 120 GW p.a. threshold for the last five years.

In the last five years China has added the net amounts to the installed capacity as shown in table VIII.

Table VIII. Power of the capacity additions in China by type in GW

Capacity type	5-year addition in MW
Nuclear	21,654
Fossil	290,320
Hydro	86,140
Renewable	236,200
Of which:	
Wind	102,580
Solar	127,010
Biomass	6,610
Total additional capacities	**634,314**

Other geographical trends could also be highlighted here, but China is a single most significant example over the last 30 years. A single country that has developed from adding 9,000 MW in 1988 up to accounting for 50 % of all power station development worldwide with the installation of the new capacities each year, which equals to the total installed capacity of Australia or Indonesia, for the last five years it simply cannot be ignored or surpassed.

Table IX. Power forecast of the global capacity totals from 2018 to 2028 by type in GW

Capacity type	**2018**	**2028**	**Increase in capacity GW**	**2028 % of total**	**CAGR %**
Nuclear	360.4	395.4	35.0	4.1 %	0.93 %
Fossil	4,258.9	5,323.0	1,064.1	54.9 %	2.26 %
Hydro	1,123.2	1,383.5	260.3	14.3 %	2.11 %
Renewable	1,147.3	2,593.9	1,446.7	26.8 %	8.50 %
Of which:					
Wind	505.3	1,064.5	559.2	11.0 %	7.7 %
Solar	466.2	1,294.2	828.0	13.3 %	10.8 %
Biomass	131.8	214.8	83.0	2.2 %	5.0 %
Total additional capacity	**6,889.8**	**9,695.9**	**2,806.1**	**100.0 %**	**3.48 %**

Future market development

Over the period of ten year (2018-2028) it is expected that the rise in renewable generating resources will continue, especially in the USA and Europe. In the parts of the developing world, the need for a supply of electricity will outweigh the concerns about the environment and renewable technologies will have less impact on the overall installation of the new capacities.

Despite predictions of the high growth rates of the renewable capacities over the period from 2018 to 2028 with the overall 8.50 % CAGR which includes the growth rate of the wind of 7.7 %, the solar of 10.8 %, and the overall growth rate of 3.48 % of all capacities types indicate that the market for GSU transformers will continue to be exciting over the next decade.

Despite lower individual CAGR rates, increases in capacity in both fossil-fuelled and nuclear units show that nearly 1,100 GW will be added to the total capacities by the year 2028, which means that the market for the huge GSU units will be buoyant. Once again, these figures are NET capacity increases, and to translate them into apparent power in GVA the factor of 1.1 must be applied. Furthermore, this analysis does not take into account the need for replacing old and retired plants.

Therefore, (2,806.1 x 1.1) = 3,086.7 GVA is the total new demand.

And replacement capacities can be estimated as 1988 capacity x 3.3 % (3.3 % is the replacement rate), which gives:

3,109.5 GW x 3.3 % = 102.6 GW.

The replacements in 10 years to cover the upcoming decade is then

102.6 GW x 10 = 1026.1 GW.

And to calculate apparent power factor 1.1 is used, hence

1,026.1 GW x 1.1 GSU rating = 1,129 GVA.

This gives the total demand for GSU transformers over the next ten years in the order of 4,238 GVA.

> **Considering the demands for new capacities and the replacement of the old units, it is estimated that in the next ten years, the demand for the GSU transformers will be in the order of 4,238 GVA on the global level**

Author

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