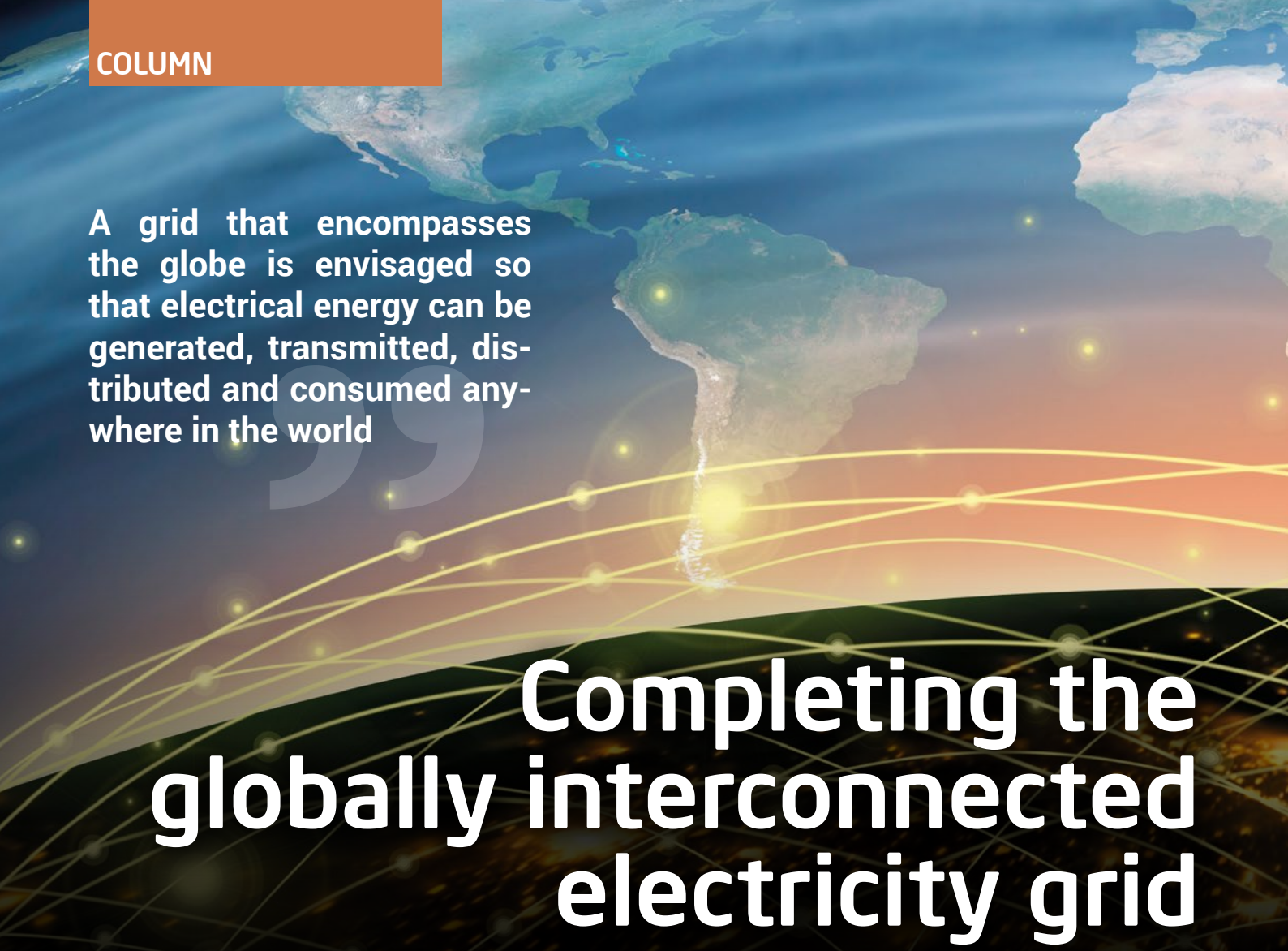

A grid that encompasses the globe is envisaged so that electrical energy can be generated, transmitted, distributed and consumed anywhere in the world

Completing the globally interconnected electricity grid

ABSTRACT

The total global load at the present moment in time is between 23,000 GWh to 24,000 GWh and this will probably increase by a factor of three by 2050. The Global Energy Interconnection Development and Cooperation Organisation – GEIDCO is promoting "Global Energy Interconnection which is "Smart Grid + UHV Grid + Clean Energy"; it is an infrastructure platform on which clean energy can be developed, transmitted and used massively worldwide. The total bill is estimated by GEIDCO at US$ 50,000,000,000,000 over the rollout programme of up to 30 years, which equates to nearly US$ 1.7 trillion each year at today's prices – a figure equal to the combined GDP of the top 10 countries in 2016, or nearly 70 % of the global total.

KEYWORDS

Global Energy Interconnection, GEI, capacity, world

1. Introduction

At a recent meeting in London, a seminar was held and a memorandum of understanding was signed between the Royal academy of Engineering and The Global Energy Interconnection Development and Cooperation Organisation – GEIDCO. This was the latest in a series of such cooperation agreements that have been agreed during the last two years.

The Royal Academy is a chartered body comprising some 1,600 elected fellows comprising the UK's national academy for engineering, bringing together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering.

GEIDCO with its permanent office domiciled in Beijing, China, is a international organization among willing firms, associations, institutions and individuals who are dedicated to promoting the sustainable development of energy worldwide.

In itself, this was not a particularly earth shattering event, but the objects and aims of GEIDCO certainly are. The organisation is promoting "Global Energy Interconnection (GEI) which is "Smart Grid + UHV Grid + Clean Energy"; it is an infrastructure platform on which clean energy can be developed, transmitted and used massively worldwide. It is also a comprehensive energy system that is cleanliness-dominant, electricity-centred, globally allocated and featuring co-construction and sharing."

In essence, the GEI envisages a grid system that encompasses the globe so that electrical energy can be generated, transmitted, distributed and consumed anywhere in the world; for example, solar energy can be generated in the Sahara desert and contribute to the energy mix in Europe Asia, South America or even Australasia.

The concept is technically feasible mainly because of the advances that have been made in UHV transmission technology, which leaves only two other main questions: political desire to achieve

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completion and finally, and probably most importantly, the finance to pay for the installation.

2. Technical feasibility

Is the project technically feasible? The answer seems to be yes, it is, and the technology will undoubtedly be improved during the implementation programme. As transmission voltages have increased, so has the power carrying capacity and, more importantly, so has the distance over which that power can be delivered. The ability to deliver power over distance is summarised in Table 1.

These levels of transfer capacity will be sufficient to enable meaningful quantities of energy to be transmitted on an intercontinental basis.

The total global load at the present moment in time is between 23,000 GWh to 24,000 GWh and this will probably increase by a factor of three by 2050. Currently, up to 60 % is provided by thermal generation and the installed thermal capacity is 4,300 GW; on a like for like basis it follows that this figure would increase to 12,900 GW by 2050. Therefore, it follows that to radically change or replace the installed thermal generating base, this will require up to 17,200 GW of non-thermal capacity over the period – on average 570 GW per year. Currently, the total annual demand for generating capacity (new and replacement combined) is in the order of 300 GW, of which 200 GW is thermal capacity. Therefore, to achieve the target, the rate of installing generating capacity will require double the current level of installation each year for the next 30 years. Additional to this, the grid to transmit this additional energy on an intercontinental basis must also be installed.

Table 1. Power delivery parameters

Transmission capabilities by voltage and technology					
	AC Transmission		HVDC Transmission		
Power and distance per voltage	500 kV	1,000 kV	±500 kV	±800 kV	±1,100 kV
Transfer capacity	1 GW	4 to 5 GW	3 GW	≥9 GW	≥15 GW
Distance	≤500 km	≥1,500 km	≥1,000 km	≥3,000 km	≥6,000 km

The upside for each participant is that it will stimulate economic growth; it will contribute to reducing global warming and will be promoted as a globally green initiative

3. Political will

This is the great unanswerable issue, and it is not intended that any answers will be proposed here. It will need an overarching international drive and some inspired diplomacy to keep the necessary players all pointing in the same direction to complete the system. Ultimately, all participating states will need to envisage a clear gain, either financial, environmental, industrial or political – or any mix of those motivating factors.

The upside for each participant is that it will stimulate economic growth; it will contribute to reducing global warming and will be promoted as a globally green initiative. The downside for each participant is the threat to national security and the reduction in energy self-sufficiency. Dependency on electricity being imported from or through regions that are viewed as not stable or potentially not friendly is a huge political risk. It therefore follows that most countries will restrict the percentage of their energy mix that is derived from this source. This is not necessarily a problem for a country with ample indigenous energy sources but it is a problem for a country that would be left exposed if the plug were pulled on their supplies.

One mitigating factor in favour of the GEI is that it can be subdivided into several mini-projects which may make it easier to develop the political consensus to complete the whole. Indeed, there are many examples of cross border power exchanges that have been developed over the last 30 or 40 years that operate very successfully for all parties and this is particularly evident across Europe.

It is, however, a very different proposition building a link that allows energy exchange between country A and country B to one which allows energy exchange between country A and country C – using country B as effectively a very convenient bus-bar. The question arises of who will pay for the necessary infrastructure upgrades that will allow large energy exchanges that have little or no benefit for the intermediary countries? All of this opens the door on the next discussion item – finance.

4. Finance

The total bill is estimated by GEIDCO at US$ 50 trillion over the rollout programme of up to 30 years, which equates to nearly US$ 1.7 trillion each year at today's prices – a figure equal to the combined GDP of the top 10 countries in 2016, or nearly 70 % of the global total; Table 2.

Our current estimates of the total global market for transmission and distribution equipment and systems is shown in Table 3. The value of transformers within this market is approximately 16 % of the total, and the other wound components needed is an additional 2 %, which together equate to some US$ 38.6 billion.

Conclusion

To summarise, the impact of implementing the GEI is such that the current level of T&D expenditure globally, which

Table 2. Top 10 country GDP and global total

Country and global GDP in US$ billions				
Country	**2015**	**2016**	**2017**	**% of total 2016**
United States	18,036.7	18,569.1	19,417.1	24.7 %
China	11,226.2	11,218.3	11,795.3	14.9 %
Japan	4,382.4	4,938.6	4,841.2	6.6 %
Germany	3,365.3	3,466.6	3,423.3	4.6 %
United Kingdom	2,863.3	2,629.2	2,496.8	3.5 %
France	2,420.2	2,463.2	2,420.4	3.3 %
India	2,088.2	2,256.4	2,454.5	3.0 %
Italy	1,825.8	1,850.7	1,807.4	2.5 %
Brazil	1,801.5	1,798.6	2,140.9	2.4 %
Canada	1,552.8	1,529.2	1,600.3	2.0 %
Subtotal	**49,562.3**	**50,720.1**	**52,397.2**	67.4 %
Others	24,634.6	24,558.0	25,045.2	32.6 %
Global total	**74,196.8**	**75,278.0**	**77,442.4**	100.0 %

Source: IMF WEO Statistics

Table 3. Global T&D market by type of system

T&D by type: 2016 values in US$ millions					
Region	**Traditional AC**	**FACTS**	**SMART**	**DC**	**Total**
Western Europe	18,198	1,395	7,632	1,873	29,097
Eeastern Europe	4,171	256	651	25	5,102
Federal Soviet Union	8,320	87	1,560	548	10,515
Africa	9,794	79	616	34	10,523
Middle East	9,671	108	943	88	10,810
Indian Subcontinent	8,914	168	1,501	169	10,753
Asia	65,013	3,386	18,784	7,968	95,151
South America	9,367	162	1,765	429	11,724
Central America & Carribean	1,154	1	60	0	1,215
North America	16,869	798	7,166	2,251	27,085
Australasia	1,740	42	521	44	2,346
Total	153,345	6,455	41,154	13,368	214,322

stands at US$ 214.3 billion per year (at today's prices), will need to be increased to a figure in the order of US$ 1,700 billion per year for the next 30 years. This equates to an increase by a factor of eight times.

It is not clear if the US$ 50 trillion budget is just for the T&D expenditure or if it includes the associated generating capacity needed to replace the thermal plant with renewable green sources. As stated earlier, the generating capacity additions will be in the order of 570,000 MW per year, which at a ball park figure of US$ 1 million per MW totals US$ 570 billion. This, together with the existing T&D spend of US$ 214 billion, totals US$ 784 billion.

It therefore follows that even at a most conservative analysis, implementing the GEI will require an additional spend of up to US$ 916 billion p.a. on average over and above existing levels; an increase by a factor of four times. No matter how the final figures stack up, this proposal clearly will need a step change in investment levels. Investment levels equalling to the total GDP of Italy, Brazil or Canada for a period of 30 years is a very large investment. It is never easy to attract finance for schemes such as this with a pay-back period so long into the future. Power Purchase Contracts may be one solution but the bottom line remains: who will pull together the consortiums to fund the development and what will be the increased price of electricity that the end consumer will have to pay? The proposed US$ 1,700 billion equates to US$ 227 per person per year for every person alive today, but the good news is that it will reduce to US$ 173 per person if, as predicted, the world population reaches 9.8 billion by 2050.

The total bill estimated by GEIDCO over the rollout programme of up to 30 years is a figure equal to nearly 70 % of the current global GDP

The plan is exceedingly good news for the contracting companies building the system and specifically to transformer manufacturers who will be looking at planned expenditure levels increasing by a factor of eight times or at least four times the current annual investment rate every year for the next 30 years. However, it is a long way from discussing the project to implementing it, and the discussion will roll on. There is a tutorial session planned for the 28th August at the CIGRE Session in Paris, to be held from 26th to 31st August 2018. The title is "Feasibility Study of a Global Electricity Network". Perhaps this will add to the discussion.

Author

Steve Aubertin is the Managing Director of Goulden Reports and following a first career in electrical engineering has spent the last 30 years researching and reporting on the global market for electrical products in both published and in the form of tailored research for specific clients.