**Our future electricity supply – love thy neighbour?**

Previously I discussed the impact of new technology, and more specifically: battery technology, on our future electricity supply. That article illustrated a conundrum that government finds itself in: do we wait for this new technology, do we ignore it, or is there something in between? One way to resolve this conundrum is through the following question: is there any other way through which we can enjoy solar electricity as a stable source (as opposed to an intermittent source) and which would not rely on extensive storage mechanisms? The answer to this question is: yes there actually is. That is the topic I would like to discuss in this article and through this discussion I will actually touch on some further issues in the Integrated Resource Plan for Electricity ("IRP").

Let's get back to the answer to the question above. Firstly, let me restate that solar energy is an intermittent source: we can only harvest it while the sun is shining. The same applies to solar electricity. The problem is we need electricity for extensive periods while the sun is not shining. A stable electricity source that provides electricity 24/7 as and when it is needed is what all of us need. Coal-fired, nuclear, oil – or gas-fired power stations are all examples of such sources. From this perspective, a stable electricity source is certainly worth more than an intermittent source.

How can we turn solar electricity into a stable source without extensive storage? To answer this question, imagine a city located in the centre of a geographical region. Some distance to the east of this city is a large solar electricity installation. The distance between the city and this solar electricity installation is such that the sun rises three to four hours earlier above the solar installation – thus while it is still dark over the city, this solar installation is already generating electricity. That means that the early morning electricity requirements of the city as it starts to awaken and gets ready for the day ahead can be fully supplied from this solar power installation. In fact, this solar power installation can supply all the electricity requirements of the city up till just after noon when the sun starts setting over the solar installation and its electricity output starts to dwindle. But this is not a problem since another solar installation located close to the city have started producing electricity and will now be in full production until the sun starts setting over the city and that solar installation's output is starting to dwindle. What we now need is a third solar electricity installation located some distance to the west of the city. The distance between the city and this third solar electricity installation is such that by the time the sun has fully set over the city, this third solar installation is at its peak output. Thus, this third installation can supply the early evening electricity demand of the city and even its late night demand as its own output starts to dwindle.

For this situation to work we clearly need two critical prerequisites. Firstly, we need a transmission line that can transport the electricity from the two outer solar installations to the city and secondly we need a landmass that stretches a few thousand kilometres to the east and west of the city.

Areas in the world where this *Geographical Dispersion Model* clearly could work include North America and Eurasia – especially since the transmission lines already (mostly) exist. It may seem that cities located along the coast (east or west) may have a problem – you can't have a solar installation a few thousand kilometres to the west of San Francisco? But this is not so, as long as you can go far enough to the east and vice versa. The Geographical Dispersion Model is the very reason why a country such as Germany can for certain (limited) periods operate on a high percentage of its own electricity requirements from renewable sources as we often read in the press.

The fact that under this model one would need a number of similarly sized solar electricity installations to supply the city allows me to introduce another key concept that is used to compare different electricity sources: the *capacity factor*. The capacity factor is simply the actual electricity produced by a power station over a period of time divided by the electricity that would have been produced by the power station if it operated continuously over the same period of time. Coal-fired and nuclear power stations typically operate at relatively high capacity factors (80% plus). Photovoltaic solar power installations typically run at capacity factors between 10% and 25% and wind turbines in the range 25% to 45% - both depends critically on the location. The capacity factor is a measure of the capital efficiency of an investment – just how hard is the money that was put into the ground working to produce electricity?

Why is the typical capacity factor of a solar installation so low? A solar installation only reaches its maximum capacity output as the sun reaches its apex – and that maximum output on any given day is less than its rated capacity unless it is orientated precisely at the correct angles towards the sun. One can take the actual output of such a solar installation on any day and restate it as the *equivalent hours* running at full capacity. In the Northern Cape, this number of equivalent hours will average around 5½ hours per day whereas in Cape Town it will only average around 4½ hours per day. By dividing this equivalent hours by 24 we get the capacity factor – this is another way to illustrate why photovoltaic, solar installations have such a low capacity factor.

What is the impact of the capacity factor on supplying our city in the example above with electricity? Firstly, let us assume the electricity consumption rate of this city is 100 MW and let us further assume that this is consumed constantly over the 24 hours (not a realistic assumption but it makes the numbers easier) – thus the daily consumption is 2 400 MW hours. A coal-fired power station (running at a capacity factor of 80%) supplying this city will require a design capacity of 125 MW. A solar installation (running at a capacity factor of 20%) supplying this city will require a design capacity of 500 MW. In addition to this, it will require the ability to store 1 920 MW hours of electricity (ignoring losses in the storage system). This example clearly illustrates how dangerous it is to simply compare the capital and running costs of two systems with different capacity factors, on a like for like basis.

In the Geographical Dispersion Model discussed above, the storage system of 1 920 MW hours is replaced by a transmission line and the single installation of 500 MW is replaced by (say) four installations of 125 MW each. The question is: which is cheaper? The answer to this question depends on so many variables that I am not even going to attempt to answer it. But let me say this: in future as new storage technology/(ies) emerges and matures the *Storage Model* will become decidedly cheaper. But is cheaper necessarily better? If we compare the Geographical Dispersion - and the Storage Models it is clear that the Storage Model is much more susceptible to power interruptions due to bad weather than the Geographical Dispersion Model. So, for risk management purposes, it will take a long-long time before we operate without any form of transmission line connecting different regions.

How does all of this apply to South Africa and our strategy for future electricity supply as outlined in the IRP? In the very first article of this series, I stated that in strategizing the future electricity supply one does not start with a clean slate as there is significant existing infrastructure. One critical piece of this infrastructure is the national grid. In our case, one of the prerequisites to use the Geographical Dispersion Model to convert solar electricity from an intermittent to a stable source without extensive storage mechanisms: the transmission line, is in place. The key question then is: do we have the landmass that stretches far enough from east to west to make this model feasible?

The maximum distance in South Africa along an east-west alignment is around 1 500 km. That is unfortunately not nearly long enough – the time difference between sunrise at the one end and sunrise at the other end is less than an hour. But, we can extend this line over our neighbouring countries Mozambique and Namibia. Even more critical is the fact that there do exist transmission lines to the Cahora Bassa dam in north-eastern Mozambique and to Walvis Bay in the western extreme of Namibia. Thus our first prerequisite is still in place and the extended line between these two extreme points is nearly 2 600 km. This is still not near the vast distances spanning North America or Eurasia but it might be enough to render a hybrid of the Geographical Dispersion model feasible.

What do I mean by a hybrid of the model? The distance between Gauteng and north-eastern Mozambique is too short for a solar electricity plant in Mozambique to supply the morning peak of Gauteng, but it is probably far enough to supply the morning peaks of the western most cities of our region – Cape Town, Walvis Bay/Swakopmund and even Windhoek and Port Elizabeth. Similarly, the distance between Gauteng and Walvis Bay is too short for a solar electricity plant located in Walvis Bay to supply the evening peak of Gauteng, but it is probably far enough to supply (part of) the evening peaks of the eastern most cities of our region – Durban, Richards Bay and Maputo. Solar electricity installations installed at these two extreme points together with any number of installations in South Africa can readily (at this point in time) supply a much greater portion of our daily demand, including the peaks, than what can be achieved by solar electricity installations in South Africa alone.

I believe this is a regional model that can hold great benefits for all three countries. The IRP envisages cross-border supplies from Botswana (coal-fired) and the Congo (hydro power) but no mention is made of cross-border supply with regard to solar electricity. To my mind, the paradigm underlying the IRP when it comes to solar electricity is one of solar electricity as an intermittent source. As stated previously, I believe we need a change of paradigm and strategize for solar electricity as a stable source. We can start moving towards that today with a suitable regional approach.