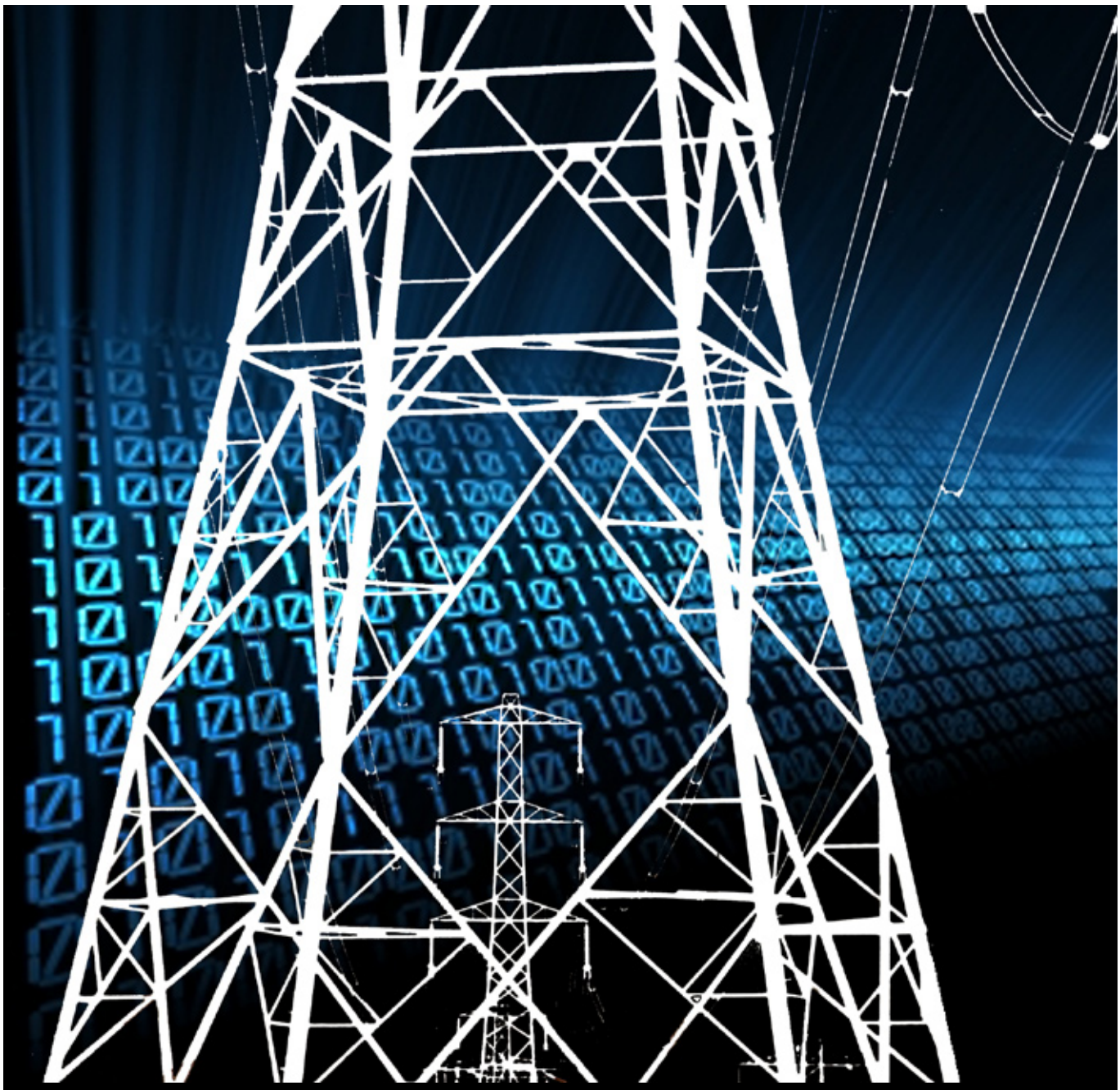

Smart Grids Rely On Relays

A White Paper exploring the requirement for Smart Grid technology and how new two way distribution might be achieved starting with the adoption of intelligent relays

By Keith Hamilton
Group Managing Director PBSI Group Ltd

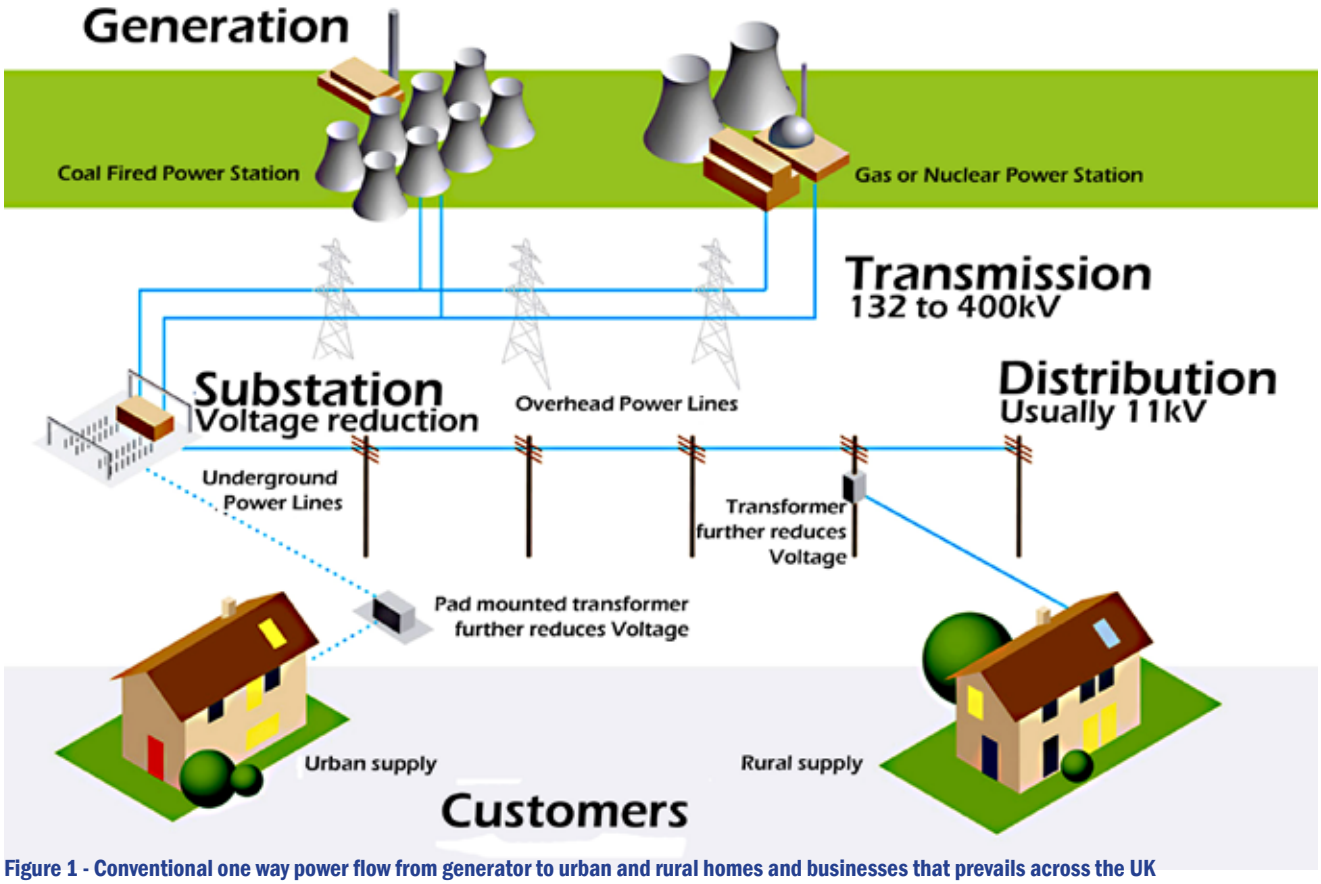

Figure 1 - Conventional one way power flow from generator to urban and rural homes and businesses that prevails across the UK

Smart Grids rely on relays

The quest for intelligent, so called Smart Grid technology is seen by many as the key to future exploitation of renewable energy sources and the inclusion on the Grid of home grown generation from micro CHP systems. But, as Keith Hamilton, Group Managing Director of PBSI Group Limited explains, the prerequisite for the establishment of Smart Grids relies on a significant investment in equipment as humble as protection relays.

The introduction in recent years by OFGEN of targets for CML (Customer Minutes Lost) and CI (Customer Interruptions) has led Distribution Network Operators (DNOs) to investigate ways of improving these two different performance indicators. Indeed, Improvements in operating performance have been achieved by adding additional protection grading at distribution level mid line points where possible. In other cases, control devices have been added to assist dead line switching as an aid to fault localisation on urban networks. The addition of Pole Mounted Reclosure (PMR) equipment as a replacement for fuses has markedly improved CI and CML figures on rural networks where they are fitted.

To make electricity systems smarter, a key consideration is the proliferation of alternative energy generators – notably wind farms. The introduction of these into the transmission mix must be carefully managed. Reinforcement of some transmission lines together with the building of new ones will need to be undertaken to get the new power to customers up, and particularly down, the country. Various DC link interconnections from Norway and France, for example, will help. A Super Grid connecting offshore wind farms from various European Countries may also prove beneficial, perhaps essential, to allow for two-way power flow from places where the wind is blowing to where it is not.

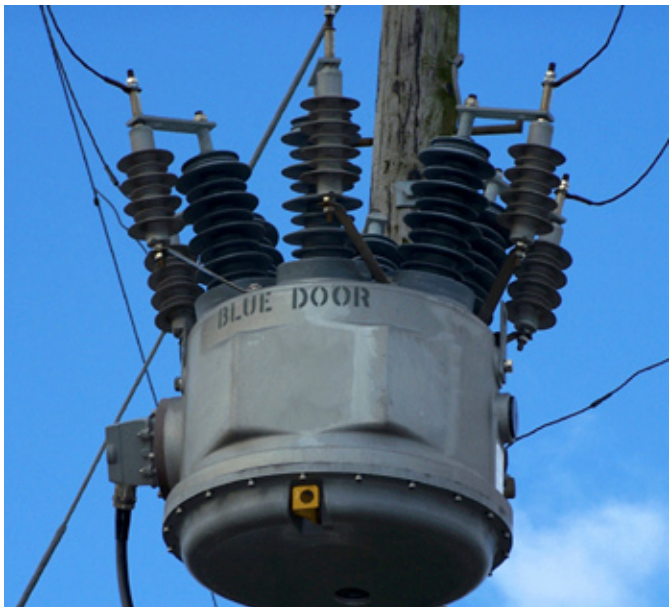

Figure 2 - Pole molunted recloser

Provided the National Grid and its transmission system can be engineered to cope with all this change, then security of supply even when the wind doesn't blow should be possible. Unless a Super Grid is installed and working, the only real guarantee of security of supply will be from one of two ways as described next.

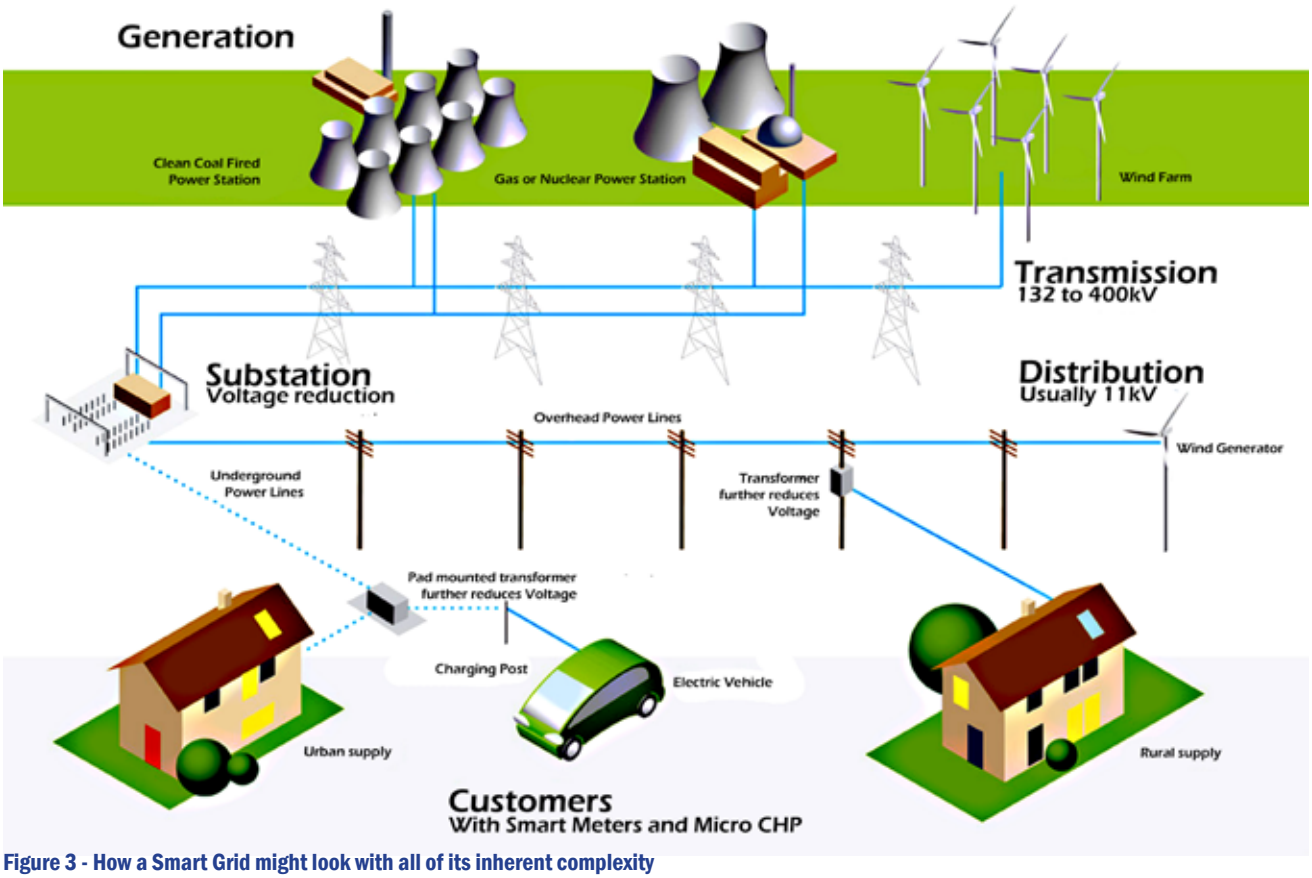

Figure 3 - How a Smart Grid might look with all of its inherent complexity

There will either have to be several new gas fired power stations constructed and commissioned before older Coal and Nuclear Stations are shut down. This is contradictory with the UK's overall aim to move away from fossil fuels and it comes at a time when Gas prices are unpredictable and currently high. Also, in some cases supply security is an issue when the UK's gas reserves are in rapid decline.

The only viable alternative to another dash for gas over the next decade, is to lengthen the life of existing coal and nuclear power stations. These will then be available to provide power when the wind does not blow or blows too hard. This option is expensive and, in theory, would create a significant over capacity. It also contravenes the UK's green targets.

Failure to implement one or the other (or a mixture of both) however, surely means the lights may start going out in the middle part of this decade - perhaps just before the next election!

The UK is undoubtedly moving towards greater on and offshore wind farm generation to meet its 2020 and 2030 targets of 20 and 30% from renewable energy sources. While this is currently happening principally within electrical transmission, the country must also make changes at the distribution level. Increasingly, factories, hotels, recreation facilities and so forth will be encouraged to implement local distributed generation (DG). Frequently, this might focus on a combined heat and power (CHP) scheme or a wind turbine generator. The latter could feed back into the distribution mix - most likely at 11,000 Volts.

As these moves take place the electricity distributors will likely be rolling out smart electricity meters to 24 million homes.

Homeowners will be encouraged to replace old gas or oil Boilers by fitting Micro CHP systems. This can then take advantage of flexible two-way tariffs that will become available from the introduction of smart meters and to improve security and efficiency of supplies.

Challenges will face both the Transmission operators and DNOs alike. Both will have to cope with a multitude of different power sources flowing from more than one direction.

There are a number of problems that will need to be resolved to manage this multiplicity of power sources. There is, for example, a standard (G59) that dictates what a distributed generator should do under certain fault conditions. DNOs insist on ROCOF (Rate of Change of Frequency or Vector Surge) protection being installed to isolate the generator from the DNO supply in the event the latter is lost.

Some would say that it's undesirable to have a standard that isolates a source of local generation that might be capable of feeding the local load. If local generation can be used as a local power zone then that is something the Regulator has expressed to be advantageous. G59 must be reviewed if it means some consumers can continue to have power in the event that they lose the DNO supply. The cost of having to install ROCOF relays for Micro CHP systems is likely to be a major stumbling block if the G59 rules are applied to home based systems.

The reason DNOs require loss of mains protection is to be sure that the Generator doesn't try to feed the exterior load (the term is "islanding") if capable of doing so. The Generator is now potentially out of synchronism with the DNO supply if it comes back on line. In such a circumstance, damage to the plant would be likely. Modern relays can sometimes offer alternative ways of ensuring this does not happen, without always needing to immediately isolate the local generation.

The potential for network reinforcement may also be an issue. Sceptics suggest DNOs sometimes use this to discourage potential distributed generator users because the cost of reinforcement falls on the end user. To be fair to the DNOs, adding distributed generation to medium voltage distribution lines can require such reinforcement. It may also affect fault levels requirements at the primary substation level. Hence, reinforcement is a technical requirement that must be investigated by end users carefully.

The problems do not just apply to the switchgear rating or fault level, for there are issues surrounding the protection relay settings also. If generating supplies come from two ends of the line - from the home, from factories and general office buildings as well as from the power stations through the National Grid - then some protection settings will need to be more flexible than they are today. The majority of existing distribution systems have electromechanical over current and earth fault relays fitted at the primary substation feeders. These 50 year old protection devices have fixed plug settings. They cannot, by their very nature and design, cope with the multi direction, DG and variable load requirements of what we regard as being necessary to deliver the Smart Grids of tomorrow.

A first step towards Smart Grids is smart protection!

Smart protection and control capable of handling the changing load and flow patterns of today and those more challenging ones that will be needed when DG, wind power and micro CHP have been added to the mix.

In some instances, following proper assessment of all the operating and load flow alternatives, this could require the switchgear to be changed. This could be achieved through retrofit or, in the worst case scenario, replacement. This is not simply because of the age of the switchgear, albeit some will probably be 50 or 60 years old, but because of probable increases in fault levels – caused as various two way power generation sources are added to existing one way distribution networks.

At low Voltage rapid power flow fluctuations, surges and two way power flow can be expected, because customers will wish to export excess generated output from their micro CHP at times. They will also expect to top up their own resources at peak times – such as when they plug in their new electric cars and use domestic appliances from, say, 6.00 pm onwards.

Modern protection devices, particularly those incorporating the IEC 61850 communication and control protocol, are now able to enable or block trips and facilitate intelligent control. Condition monitoring features can be programmed in to offer predictive rather than reactive fault maintenance options.

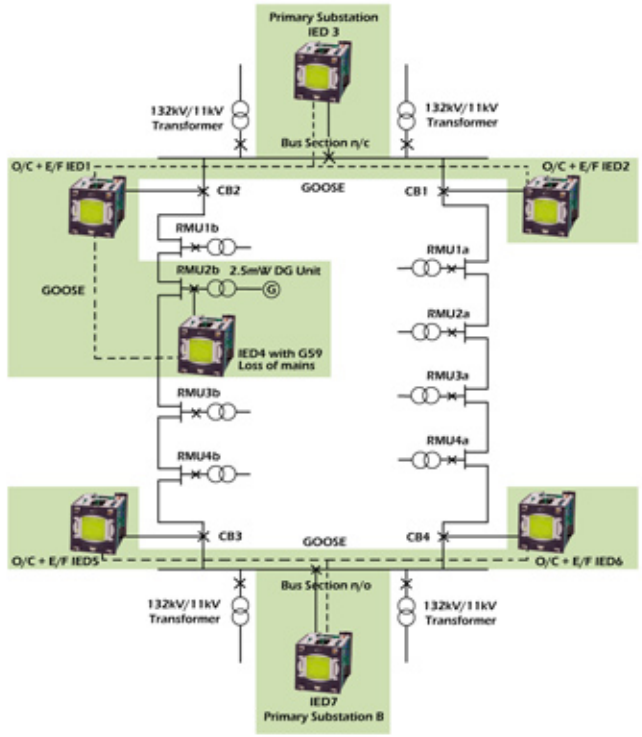

Figure 4 - What a future Distribution Voltage Smart Grid might look like

These same devices can offer metering values, blocking and acceleration schemes, automatic change over schemes, communications to control systems as well as peer to peer communication options. They also offer multi-setting options, directional if required, to suit variable load changes and cope with multidirectional power flow from various generating sources.

To facilitate Smart Grids DNOs will unquestionably need to retrofit or replace some switchgear and also replace most of the old electromechanical protection with modern protection and control relays. This will involve considerable time, organisation and investment, but it is essential if the UK is serious about having flexible Smart Grids in place when we find we need them.

All of the above begs the question do we really need to do this? The short answer is yes. By allowing increasing amounts of embedded generation into the UK's distribution network means that a complete re-evaluation of how the network operates is necessary. Power flows around the network will be bidirectional and less predictable. Therefore the primary plant will have to be surveyed to establish if it can cope with the changes. On each protection point additional equipment such as voltage transformers will have to be installed if newly fitted "Intelligent" protection devices are to function to their full potential. A complete new and secure communications infrastructure, such as, for example, IEC61850 will need to be provided to support the 'smart' new devices. A district power management process using data from the new devices will then need to be installed to monitor loading on the system to ensure network stability.

The UK currently has no effective initiatives in place to encourage any of this to happen.

For the UK to remain a nation with an ample electricity supply, then the implementation of Smart Grids must be completed very carefully. This will require a circuit by circuit evaluation, after a thorough assessment of all the supply options; loading; protection settings; and fault levels that could apply. Failure to address these facets in good time will mean supply security will be put at risk - and increasingly eroded as more and more renewable power comes on line.

One impression of what a future distribution voltage level Smart Grid might look like will have relays able to accelerate or block tripping depending on the circumstances occurring at the time. This will be enabled through communication with each other through IEC61850 Goose Messaging. This in turn is effected through direct links between the relays within the same substation. Where different locations are involved, as in the case of IED1 and IED4, relays will require fibre, power line carrier or radio links to be provided. This will also supply information to the overall district power management system.

The new intelligent relays will be able to cope with multiple generating sources, different load patterns and alternative power flow directions. They can increase both the effectiveness and life expectancy of aged switchgear as well as monitoring its condition and proactively maximising its availability. Much needs to be done and some things will assist the process more than others.

Rather as smart meters in the home empower the end user and allow energy management, the incorporation of smart relays' at distribution voltage levels lie at the heart of moves to implement and install Smart Grids.

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