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New Transformer Procurement Concepts in Times of High Uncertainty and Market Instability

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Summary **— New and proactive strategies are required in utilities and other transformer purchasers to ensure delivery of transformer capital investment plans in the current times of market saturation and various supply chain issues. Close collaboration with suppliers and adaptative and flexible engineering and commercial initiatives need to be implemented from as early stage in the project lifecycle as definition of requirements and tendering. This paper presents the strategy adopted by SP Energy Networks, and one of their main suppliers of power transformers, Kolektor Etra, in this regard.**

Keywords **— Transformer, Procurement, Standardisation, CPA, supply chain**

I. Introduction

Traditional procurement strategies in the area of power transformers have been proven to be no longer adequate to facilitate delivery of capital investment plans in the current climate of market saturation and various supply chain issues. Increasing demand worldwide in order to facilitate the green energy transition plans defined by the different national governments or institutions compounded by the multiple and unique market disruptive events that have been experienced in the recent years (i.e. COVID-19, Ukraine/Russia conflict, expansion of other related manufacturing industries…) have placed the power transformer industry supply chain under significant strain. Unit costs and lead times for power transformers have been seen to more than double in the shorter space of less than a year. These significant changes in the market environment need to be acknowledged by purchasers and manufacturers equally and adaptative and flexible approaches put in place in order to mitigate commercial and project delivery risks whilst maintaining quality standards and resilience of the equipment to be installed in the electricity networks. All the different areas associated with the procurement of new power transformers (i.e. technical specifications, supplier qualification, commercial requirements, project planning…) need to be included within this review and modification of current practices.

This paper provides an overview of the strategy adopted by SP Energy Networks, distribution and transmission network operator in the United Kingdom, and one of their main power transformer suppliers in the current period, Kolektor Etra from Slovenia.

II. Adaptative Strategies on Technical Areas

Review of transformer fleet and associated technical parameters

One of the main aspects influencing the efficiency of the power transformers procurement process is the degree of standardization achieved in the purchaser's network. Situations where transformers are purchased on a one-off basis with individual technical specifications and ad-hoc requirements to suit specific network conditions, substation locations and/or installation environments require significant engineering efforts. This additionally multiplies the number of tender events required and variety of transformers included within, which translates into a higher workload for both purchaser and manufacturer during each individual tender event and slow down the overall process.

In order to minimise this type of situations, it is important that the purchaser carry out an upfront holistic review of its network requirements with the aim of optimizing the number of asset types required while still ensuring network performance and license obligations are fulfilled. This not only assists in tendering processes but on the overall fleet management (i.e. monitoring and cross-reference of sister units, business strategy on strategic spares…). Certain transformer design parameters are dictated by the historical network construction (i.e. voltage class, insulation levels, etc.) with not much possibility to deviate from. However, others offer a greater degree of flexibility and can be defined with an overall view of present and future needs in order to identify the most optimum set of requirements, not for each individual substation, but for the network as a whole. Example of these could be impedance, rated power, tapping range, sound power level, etc. Although it is possible to define these on a site-specific basis, it is also possible to undertake a commonality analysis with the aim of identifying a suitable set of requirements to encompass a larger number of possible applications, or at least, establish a limited number of set of requirements. Caution shall be applied not to select worst case scenario type characteristics as otherwise a large number of new transformers can end up being significantly overspecified with the associated commercial implications. Figure 1 shows a real example where the different impedance envelopes required for two different transformers were overlapped and a common compliance area identified across the more relevant tap positions. The two transformers could be specified with a single more restrictive impedance envelope, obtaining a one design fit both type of solution. This design could also be adopted in subsequent projects requiring this type of transformer. This has the associated commercial benefits of only one design cost, only one type test costs, only one civil and P&C design cost... Although this exercise seems simple, the technical feasibility of a more restrictive impedance envelope should

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be discussed with the potential manufacturers, specially if allowable tolerances are narrower than those allowed by the applicable international standard. Similar case could be discussed in terms of specifying rated power. A selection of rated power requirements with adequate step increases (i.e. 60MVA, 90MVA, 120MVA, etc.) would be more efficient for a network operator than individually specifying based on current or forecasted site load (i.e. 52MVA, 57MVA, 62MVA instead of 60MVA for all). Any cost premium derived from specifying a slightly higher rated power than required will be most likely offset by the efficiencies gain in design standardization unless the step change is very significant. A cost-benefit analysis can be conducted to confirm that is the case.

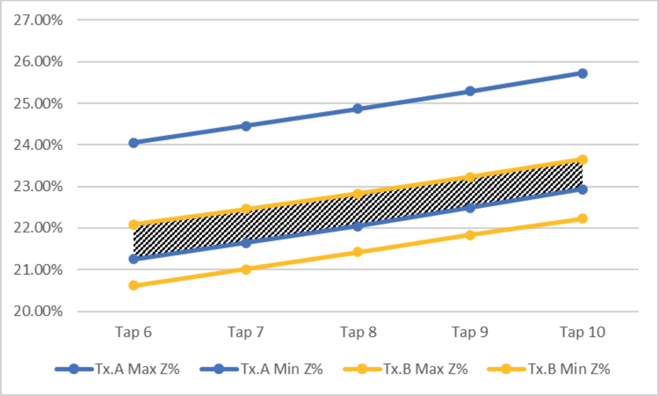


Fig. 1. Example of overlapping impedance envelopes and common compliance area for the original 275/33kV 120MVA transformer replacement requirements at East Kilbride and Dewar Place substations

The purchaser may be tempted to follow a like-for-like approach on transformer replacement projects on the assumption that the existing transformer type is the best possible solution for the site in question. However, this may not necessarily be correct as network operating conditions and requirements may have changed during the lifetime of the asset now being replaced, meaning that a different selection may be more adequate. This is especially relevant where the purchaser faces the replacement of legacy transformer types, with only a small number installed in the network and that are no longer purchased for new substations. In these cases, it is even more advisable to carry out the previously mentioned holistic review to try to progressively remove these legacy types of transformers from the network. However, in certain situations this may require a complete re-design of the network in the specific area where these legacy types can be found, including network voltage upgrades/downgrades, circuit reconfiguration, substation removal and relocation, etc. As an example, in SP Energy Networks the 132/33kV 45MVA legacy transformer type (6 units in total) is planned to be replaced, once end of life conditions reached, with a standard 132/33kV 60MVA transformer type as purchase cost differential in this case is considered to be offset by the standardisation related savings.

In the particular case of SP Energy Networks, as outcome of this holistic network review exercise and standardisation strategy, a standard list of transmission class transformer types was produced, and all key associated electrical parameters specified (i.e. voltage class, insulation levels, rated power, impedance envelope, tapping range, etc.). This list comprises 5 off types of 400kV and 275kV autotransformers and 11 off types of 275kV and 132kV double-wound transformers. It shall be mentioned this list is not rigid, and there may be situations where special requirements for a particular site may arise, and the associated transformers have to be facilitated. However, the simple fact of deviating from the standard transformer types imposes the need for adequate technical justification to be presented and agreed with all relevant stakeholders within the business.

It is appreciated that the standardization strategy explained above may be more applicable to network operators than other potential type of purchasers (i.e. industrial customers, renewable sector, etc.) due to the larger volume of assets in ownership. However, the same principles and logic can be still applied with the required adjustment to the scale of the fleet and the specific business operating environment.

A. Standard Transformer Concept

This standardisation exercise, defining the main types of transformers required, is the first stage to minimize the number of tender events required to meet business needs. However, within each individual transformer type, there may be multiple variants associated to accommodate the transformers into the different substations they have been ordered for. On green field type substation projects or substation extension projects, the flexibility at substation design phase is such that alignment with modern design practices and use of the most optimum, both technically and commercially, transformer design is possible. However, on existing substations with in-situ transformer replacements projects, or where extension of the substation platform is not possible, the available layout is already given, and additional site-specific requirements need to be considered into the project specification. This may translate into a single transformer type having different constructional variants to suit project specific requirements. There may be situations where these additional requirements drive a fundamental change of the transformer electrical design (i.e. very restrictive footprint dimensions which require re-design of the active part, use of alternative insulating fluids due to fire risk or environmental reasons, very restrictive sound power levels due to site sensitivity, etc.). However, in the majority of cases, the changes required are either mainly related to the external layout and disposition of elements (i.e. separate cooler bank vs. tank-attached radiators, cable or open air/oil bushings connection, requirement of additional online monitoring devices, etc.) or associated with the protection schemes (i.e. CT specifications).

In this second group of site-specific requirements, the electrical design of the transformer remain the same and as such the overall design of the transformer remains fundamentally the same. In the past, the Procurement strategy followed in SP Energy Networks required the transformers to be individually specified for each individual substation project for tendering, so that all details and requirements were defined before issuing the tender enquiry to the market. This represents an issue in the current climate where the strain on the power transformer supply chain requires all orders to be placed well in advance of the actual delivery dates. As an illustrative figure, lead times for 132kV voltage class power transformers have on average increased from 8 months to 20+ months. Unfortunately, in many cases it is not possible to finalise the full substation design process, which will identify all site-specific requirements for the transformer, that far in advance.

In order to overcome this situation, and with the aim to de-couple, to an extent, the substation design process from the transformer ordering process, the standard transformer design concept was adopted in SP Energy Networks. For each transformer type, a set of requirements, which would normally be site specific, are defined assuming modern substation design practices can be applied and considering the lowest cost option for each of the requirements. For each transformer type, these requirements are as follows: tank-attached radiators; oil/air HV and LV bushings, no support brackets for tank-mounted surge arresters, standard CT specification, single gas online DGA monitoring device, and no winding hot-spot fibre optics monitoring device. A transformer type with these characteristics will be considered a standard transformer design for a generic SP Energy Networks substation and is what asked to price against in a tender event. This would represent the minimum cost option for a transformer compliant with SP Energy Networks specifications and requirements.

This alone represents a significant reduction in tender timescales as no longer is necessary to finalise the full substation design before going out to the market. Depending on internal governance processes of each purchaser, this can translate into almost a full year reduction in tendering timescales, which in turn allows suppliers to secure manufacturing slots far earlier to compensate for extended lead times.

B. *Flexibility Mechanisms*

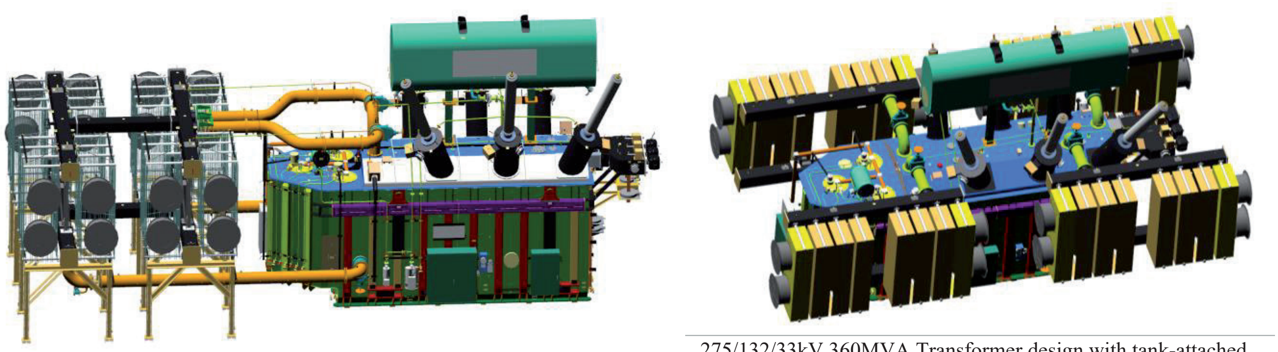
However, as previously explained, the standard design concept may not be suitable for all sites in real life. This can be managed by the use of optional elements. All requirements that would normally be site specific, but that have been defined as part of the standard design concept, will be listed separately and tenderers advised that other possible options may be selected at the time of order. For example, three off the same transformer type are required to be ordered for three different substations, all defined as a standard design at the time of tender, but after finalization of the full substation design, it is determined two of them require a separate cooler bank rather than tank-attached radiators, and the pipework orientation and distance between main tank and cooler bank are different for each one. This information is not critical to be known at the time of tender as the fundamental transformer design remains the same, and can be provided at a later stage, after contract award and prior to commencement of the detailed design activities at the manufacturer side. As a separate cooler bank represents an additional cost compared to the requirement of the standard design concept, this would need to be managed and controlled. Firstly, by requesting prices for the optional items at time of tender, so that these are presented in advance, and secondly, by engaging and making the situation clear to the relevant project managers of the involved projects so that contract variations can be agreed to manage the commercial side. Figure 2 shows as an example the design proposal from Kolektor Etra for the case above, where the same 275kV voltage class transformer design, including main tank mechanical design, could be employed with either tank-attached radiators or separate cooler bank arrangements.

This type of strategy also assists in achieving design efficiencies, not only at the manufacturer side, but also at the purchaser side (i.e. standardization of civil and P&C arrangements, optimization of equipment assessment activities in terms of design reviews and type testing, etc.) and also facilitate a higher degree of interchangeability. For example, there may be situations where multiple transformers of the same type are on order with the same manufacturer. If the only differences across these relate to the optional items listed above, these would be easily interchangeable between projects which allows a more efficient use of the manufacturing capacity by swapping manufacturing slots where project delays are communicated, which in turn also reduces potential storage costs for the purchaser.

Another element of the standard design concept is the use of a generic substation location for pricing purposes. At the time of tender, especially on green field type substation projects, the substation location may not have been defined yet, and even if it has, the access route to it may not have been built. This makes pricing for transport and delivery especially complicated and time consuming for the manufacturer that will quite likely need to make assumptions and increase their risks provisions for any potential eventuality that may be faced. This eventually translates into an increased price for the purchaser, that may or may not materialize in real terms, but whose costs will be incurred regardless. In order to mitigate these transport related risks for both parties, a generic substation location can be defined which will be representative of a typical location and will be the basis of the commercial offer. In order for this approach to be satisfactory, a good and close working relationship between manufacturer and purchaser is required so that final actual costs are as transparent as possible and are truly reflective of the costs incurred by the transformer manufacturer. This approach has the disadvantage of leaving an open-ended cost that in certain situations can be quite significant, particularly for remote locations or locations where there is not an already existing suitable route. It may not be possible to anticipate these costs in advance without detailed route surveys, which may represent a risk for project budget and programme and should be considered on an individual basis.

C. *De-Coupling Technical and Commercial Tender Phases*

The standard design concept approach can also have long-term advantages in case of multiple tender events. As both transformer types and standard requirements are defined and fixed, the technical offers and design proposals submitted by the manufacturers can be re-utilised at multiple tender events. Assuming there are no fundamental changes in the purchaser technical specifications, and/or in the applicable international standards and regulations, and that there has not been any critical update in the manufacturer design policies or manufacturing techniques, the tender technical proposals would continue remaining valid from one tender event



275/132/33kV 240MVA Transformer design with separate cooler bank

275/132/33kV 360MVA Transformer design with tank-attached radiators

Fig. 2. Illustration of the flexibility achieved by the standard design concept to accommodate different cooling arrangements

to the following. This has resource saving advantages for both parties, i.e. the manufacturer do not need to prepare a design proposal in each tender event, and the purchase do not need to assess compliance of the same in each tender event. This allows the purchaser to build a catalogue of technically compliant proposals on the very first tender event that can be referred to in future enquiries so that the actual tender exercise is limited to a commercial phase. Depending on internal governance processes of each purchaser, this can translate into 4-6 months reduction in tendering timescales although a significant effort is required on the very first tender event to build the mentioned catalogue. Where there are significant changes in purchaser technical specification or manufacturer design practices, the whole process would need to be repeated. Figure 3 illustrates the basic stages of a standard transformer design concept-based procurement process. This approach is also very effective in urgent purchases type scenarios to replace faulted transformers where strategic spare units are not available. Manufacturer

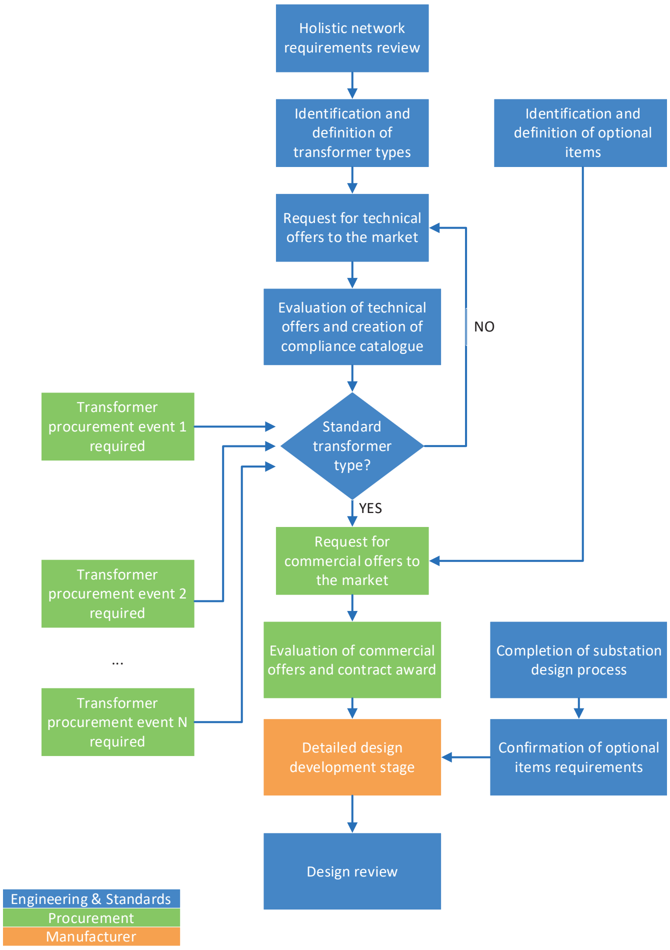


Fig. 3. Simplified flowchart of a standard transformer design concept based procurement process

III. ADAPTATIVE STRATEGIES ON COMMERCIAL AREAS

A. CONTRACTING MODEL

The standardisation exercise described in the previous sections, alongside establishing a closer relationship with other key stakeholders in the business, in order to understand longer-term requirements, and the de-coupling of technical and commercial tender phases, have all assisted in developing SP Energy Networks contracting model and tendering processes to adjust to the current market conditions.

Competition is an underlying principle in procurement policy, and widely acknowledged to be a key enabler of value for money. It helps the purchaser to secure the goods and services it requires at the right price and quality and is the best way of demonstrating probity in the award. The practice of acting ethically and fairly to all suppliers and stakeholders, allows the purchaser to comply to the procurement processes according to the tender requirements, set criteria, standards, or principles and to ensure adherence with purchaser's policies and rules.

The tendering process is a structured process, which is fair and transparent and includes a defined selection process with clear award criteria. By de-coupling technical and commercial tender phases, it is possible to simplify the award criteria to purchase price, or other defined lifetime cost calculation mechanisms, i.e. total cost of ownership (TCO) which accounts for losses capitalisation during the lifetime of the asset. This is achievable as technical evaluation of the offers would have been already performed in the previous phase of the process and reduces the formal tender event to a commercial phase only.

This contracting model makes the process repetitive, and consequently provides the purchaser with a current and up to date view of market conditions in price, lead-times, and capacity. The purchasers may have limited influence on market conditions for this type of equipment, but it is extremely important for the manufacturers to understand the purchasers and have the flexibility to adapt accordingly. This repetitive process also makes possible to tender multiple times in short periods of time and have a high percentage of comparability to previous prices paid. This provides an important regular insight to market changes in price, lead-times, and capacity, which can lead to changes in tendering strategies i.e., tendering earlier or later and budget forecasting.

In the current market conditions, it is extremely difficult to contract on fixed price basis as used to be the traditional approach within SP Energy Networks. This is primarily due to volatility of raw materials prices and other associated costs to the manufacturing process, further compounded by extended lead times and earlier placements of orders. Through negotiation with manufacturers, the implementation of price adjustment formulas (CPA), incorporating not only traditional raw materials in transformer manufacturing (magnetic steel, conductor material, etc.), but also some other volatile costs (insulating liquid, transport, etc.), resulted in a better distribution of uncertainties, and optimization of risk provisions, with the overall outcome of a more reasonable unit price for the purchaser and a lowest financial risk to the manufacturer. However, as it may be difficult to predict the point in time at which all these factors stabilise, it may be advisable to allow manufacturers to offer multiple pricing (i.e. fixed vs. CPA) with their associated conditions for the purchaser to evaluate.

Flexible contracting model makes possible to spread purchasing decisions over time and aligned to an agreed strategy to take advantage of movements in the market. This involves adapting to changing requirements, collaborating with manufacturers and stakeholders based on feedback and learning.

In conjunction with the tendering process, the purchaser should consistently monitor and asses the bidders on aspects such as financial risk, audit & insurance, management systems, accident rates, human rights, equality, diversity, sustainability, ethics and governance.

Additionally, a number of aspects following award decision shall be also considered as key enablers to facilitate an efficient and agile contract award process. A stable supplier base together with consistent set of legal and commercial requirements make possible to pre-agree a number of elements that, despite requiring final confirmation on each individual award, will fast-track these last stages of the procurement process. This typically includes: total cost of ownership calculator; terms & conditions; security provisions; and escalation formulas (CPA) and indices. This also represents a key part of the process to stay ahead of the supply curve and deal with short proposal validity periods.

All the factors detailed in this section assist in completing the commercial aspect of a tendering process in a period of 4 - 6 weeks, with notification and award taking a further 4 - 6 weeks. This significantly reduces the historical tendering time within SP Energy Networks and enables the business to commit to the manufacturers quickly securing the required manufacturing slots and, in instances, the benefit of fixed pricing against variable pricing. As illustration, with this process already set up, in early 2023 SP Energy Networks managed to purchase eleven large power transformers (132kV and above) on a full competitive tender process in 8 weeks from issuing the enquiry to the market to obtaining internal authorization for award. In the past, with a traditional approach, this would have taken 6- 8 months assuming all substation design processes were completed to allow the tender to be initiated.

This significant reduction in time is also an advantage to manufacturers, as it closes tendering events very quickly with feedback offered on their proposal if unsuccessful for preparation in advance of the next tendering process.

IV. Conclusions

Procurement strategies in the area of power transformers should be flexible enough to acknowledge and adapt to varying market conditions and ensure the most optimum solution, from technical, commercial and project delivery perspectives, is reached in each individual tender event. In the current environment of market saturation and various supply chain issues, it is particularly important to simplify and streamline procurement processes and improve engagement with key stakeholders within the purchaser business to clearly define long-term purchasing plans.

In achieving the above, decisions and strategies on the technical area play a key part as standardisation of transformer types, decoupling of substation design development and power transformer procurement, and simplification of design variants and site-specific requirements contributes significantly to reduce tender timescales which assists to offset the increasing lead times currently offered by the market. To mitigate against the possible rigidity of this approach, mechanisms can be built into the process to account for the particularities associated with each individual substation layout and/or installation considerations.

The standard transformer design concept defined in this paper has been proven to be a successful strategy within SP Energy Networks to be able to place power transformer orders early enough to ensure the business capital investment plans can be delivered as per agreed programmes; and pricing uncertainties and associated commercial risks are reasonably shared between manufacturer and purchaser. This approach and its repeatability, together with a stable supplier base, further assists to shorten tender timescales in multiple tender event situations and reduce resource dedication requirements, not only at tender stage, but potentially at subsequent equipment assessment and substation development following contract award.

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