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COMBINING INNOVATION WITH STANDARDISATION

Work Group
B3.11

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Combining Innovation with Standardisation

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1 EXECUTIVE SUMMARY

In recent years there has been a significant move to introduce innovation into substation design. This has been largely driven by Manufacturers and Solution Providers in response to technical developments and commercial pressures. New innovative products have been introduced to the Utilities, which can offer many benefits such as reduction of maintenance cost, ease of operation and simplifying the substation design.

Utilities, however, tend to be more conservative, for very good reasons, as they have to consider the whole of life aspects of the plant including the management of ongoing maintenance activities and consequently their approach tends to favour proven familiar designs that are often rooted in “standardisation”. Utilities believe that standardisation has many benefits such as lower substation cost, proven operating procedures, proven equipment, and simpler spares requirements. The application of new concepts and innovations in substation design is frequently considered as introducing risk.

The objective of this brochure, produced by Working Group B3.11, is to investigate the benefits and drawbacks of both approaches and to provide guidelines by which these two apparently contradictory philosophies could be coordinated in the design of future substations with minimal risk.

Based on a carefully structured questionnaire, the Working Group identified the reasons why Utilities would wish to standardise and also the reasons why Utilities, Solution Providers and Consultants would wish to introduce innovation. The detail of the Questionnaire and the analysis of the results are presented in Section 3 of this brochure. The major conclusions from the questionnaire for Utilities are that the most important benefits of both standardisation and innovation are perceived to be the same and these reasons are the same as those identified by Solution Providers and Consultants from innovation, The most significant eight reasons were:-

Reduce plant and equipment costs

Reduce maintenance costs

Reduce engineering costs

Improve operation (Function and flexibility)

Health, safety and environment issues

Reduce project duration

Reduce installation costs

Existing equipment obsolescence

Similarly, the same main constraints and difficulties were identified for both approaches by Utilities and also for innovation by Solution Providers and Consultants. The most significant constraints were time, costs, staff resistance, system operation practices, operator interface, training, environmental, company organisation, health and safety and legislation.

The brochure then looks at the top eight reasons and tries to indicate generic techniques by which the benefits may be obtained and the difficulties overcome.

From this analysis certain themes emerged. It became clear that using innovation on each individual substation is not a viable way forward. This would lead to unrealistic use of engineering resource and a system which was uneconomic to operate as different spare parts would be required for each location. Furthermore, it would have a very high risk of human error as the operators would need to know many different styles of substation. It appears that the most effective use of innovation is in developing new designs and techniques which can be fully developed and established as standards for a fixed duration. These standards will need to be reviewed regularly to ensure that they comply with the latest developments in Health and Safety policies and legislation. The standards should make use of the latest and most innovative equipment and techniques including intelligent use of condition monitoring designed to provide real value to the operation of the power system.

As the introduction of each new stage of standard designs will require some change to the way in which the system is run and have an impact upon the daily life of the staff involved, it is essential that the staff concerned with each phase of the operation are fully involved and consulted before the new standards are introduced. Ideally they will be fully involved in the whole process to ensure the maximum success. Feedback should always be provided from the operation and maintenance staff to the designers so that those aspects which cause problems are resolved in the next generation design.

Additionally, if the full benefit of introducing innovation into future standards is to be achieved then commercial innovation may also be required and a better system of co-operative working between the Utility and their Solution Providers may be required to deliver the projects of the future more quickly and efficiently with less risk.

The brochure then provides some guidelines for the controlled introduction of innovation. These outline the importance of having the correct structure within the company, having a clear strategy to ensure that innovations are introduced based upon the real value they bring to the company, having a clear plan for the introduction of the innovation and finally strong project management to manage the implementation phase to ensure that the forecast advantages are delivered.

In order to reap the maximum benefits from the innovations these need to be converted into the standards for the future. The brochure provides some guidelines on how this stage can be implemented in a disciplined well structured way to allow a smooth transition from today's innovation to the standards of tomorrow.

Finally, the conclusions of the team on combining innovation with standardisation are summarised in the following bullet points:-

- The reasons for standardisation and innovation tend to be the same
- Constraints and difficulties against standardisation and innovation tend to be the same
- Innovation may be in procedure, system or equipment
- The key drivers for standardisation and innovation are:
    - The reduction of true total cost
    - Reducing system operational risk
- Identification of innovation opportunities and the subsequent development into a standard require dedicated teams, resource and budget allocation
- A structured approach to innovation is essential and needs to be value-driven
- Involvement of all levels and functions within the business is essential; senior management must accept and drive the innovation

- Standardisation maximises the value of innovation
- Development of the innovation to an application standard also requires a structured, value-driven process
- Today's innovations are the standards of tomorrow

2 INTRODUCTION

In recent years there has been a significant move to introduce innovation into substation equipment. This has been largely driven by Manufacturers and Solution Providers in response to technical developments and commercial pressures. New innovative products have been introduced to the Utilities, which can offer many benefits such as reduction of maintenance cost, ease of operation and simplifying the substation design. In order to really benefit from these innovative products, the Utilities may be required to revise their design philosophy and application standards.

Utilities, however, tend to be more conservative, for very good reasons, as they have to consider the whole of life aspects of the plant including the management of ongoing maintenance activities and consequently their approach tends to favour proven familiar designs that are often rooted in “standardisation”. Utilities believe that standardisation has many benefits such as lower substation cost, proven operating procedures, proven equipment, and simpler spares requirements. The application of new concepts and innovations in substation design is frequently considered as introducing risk.

Substation standardisation has many advantages and benefits. At the same time new technology and innovations can add great value and could also bring many benefits to substation design, construction, operation and maintenance. It all depends on how relevant and valuable these are to the utility and whether the risk is worth the gain.

Utility application standards need to be regularly updated to reflect the new equipment and the design changes associated with the new equipment. Failure to update the utility application standards can result in outdated installations which therefore become obsolete with little benefit to engineers and designers.

The objective of Working Group B3.11 was to investigate the benefits and drawbacks of both approaches and to recommend methods in which these two apparently contradictory philosophies can be coordinated in the design of future substations.

Based on a carefully structured questionnaire, the working group aimed to identify the benefits to be obtained from innovation and from standardization. It was hoped that through analysis of this data, the areas of commonality and conflict between the two philosophies could be identified and methods for integration or balancing of both approaches identified.

This Technical Brochure is designed to assist both Utilities and Manufacturers to understand the implications of adopting innovative equipment designs in accordance with conventional design and the issues affecting future innovation projects, so that they can smoothly make the transition from today’s innovation to the standards of tomorrow, thus combining innovation with standardization.

3 DEFINITIONS

The title of this report employs two words "Standardisation" and "Innovation" which it would be useful to put in context for our work.

3.1 Standardisation:

3.1.1 Product Standard

"Product Standard" is most often used to mean international or nationally published documents that define the characteristics of equipment or sub-systems used as components of installations. Examples of this usage are IEC standards such as 62271-100 or 61850 or IEEE Standards such as 1525, C37.2.

3.1.2 Application Standard

There are more local documents written by utilities, manufacturers or others to set out in some detail how the components or systems designed to a "Product Standard" are applied together to achieve the required performance. These Utility standards often quote the equipment "Standards" and may be referred to as "Application standards"

Utilities develop application standards for a number of reasons; typically these include National legislation regarding health, safety, environment and security. These standards can also extend to incorporating good practice to help reduce construction errors, outage time, reduce cost, improve safety, ensure knowledge transmission and simplify operating and maintenance procedures.

Utilities normally select substation configurations that are applied for each voltage level by using certain equipment for each substation layout together with the method of protection and control for each arrangement. Other material such as substation hardware, substation cables and other material are predetermined. These arrangements are normally pre-engineered and are defined as substation standards. This is an example of application standards.

3.2 Innovation

Innovation results from the examination and implementation of scientific and technical developments, the integration of those developments to create "better" products or systems in terms of their cost, efficiency and/or performance. They can be classified into "Product Innovation" and "System Innovation". Some concepts of both innovations are explained,

3.2.1 Product Innovation

(1) Product Innovation can be regarded as the process that improves equipment beyond the range of the conventional standards and changes the performance, design and size of the equipment. Gas Insulated Switchgear, Digital Relays, Non-Conventional Instrument Transformers are examples.

(2) Another type of Product Innovation creates new category of products. It is invented by modularization or combination of equipment that is either conventional type or new concept type. This type of Product Innovation redesigns the layout of substations without changing their circuit structure and it can reduce the footprint of air-insulated substations. Two examples are shown below to illustrate how innovation can be used to optimize equipment layout and improve reliability.

Example1:

Fig 3.1 illustrates the use of mixed-technology switchgear (hybrid) in a single busbar configuration instead of conventional AIS. The innovative product is the hybrid module, which incorporates two disconnectors, a circuit breaker and associated CTs within a single GIS module. From the design stand point, this equipment has several advantages over the AIS equipment. The physical size of the substation in both length and width has been reduced compared to conventional AIS equipment. In addition this equipment is considered more reliable since the disconnectors are sheltered from the environment within the GIS enclosures, simpler civil works are required as foundations are smaller and steel requirements are reduced.

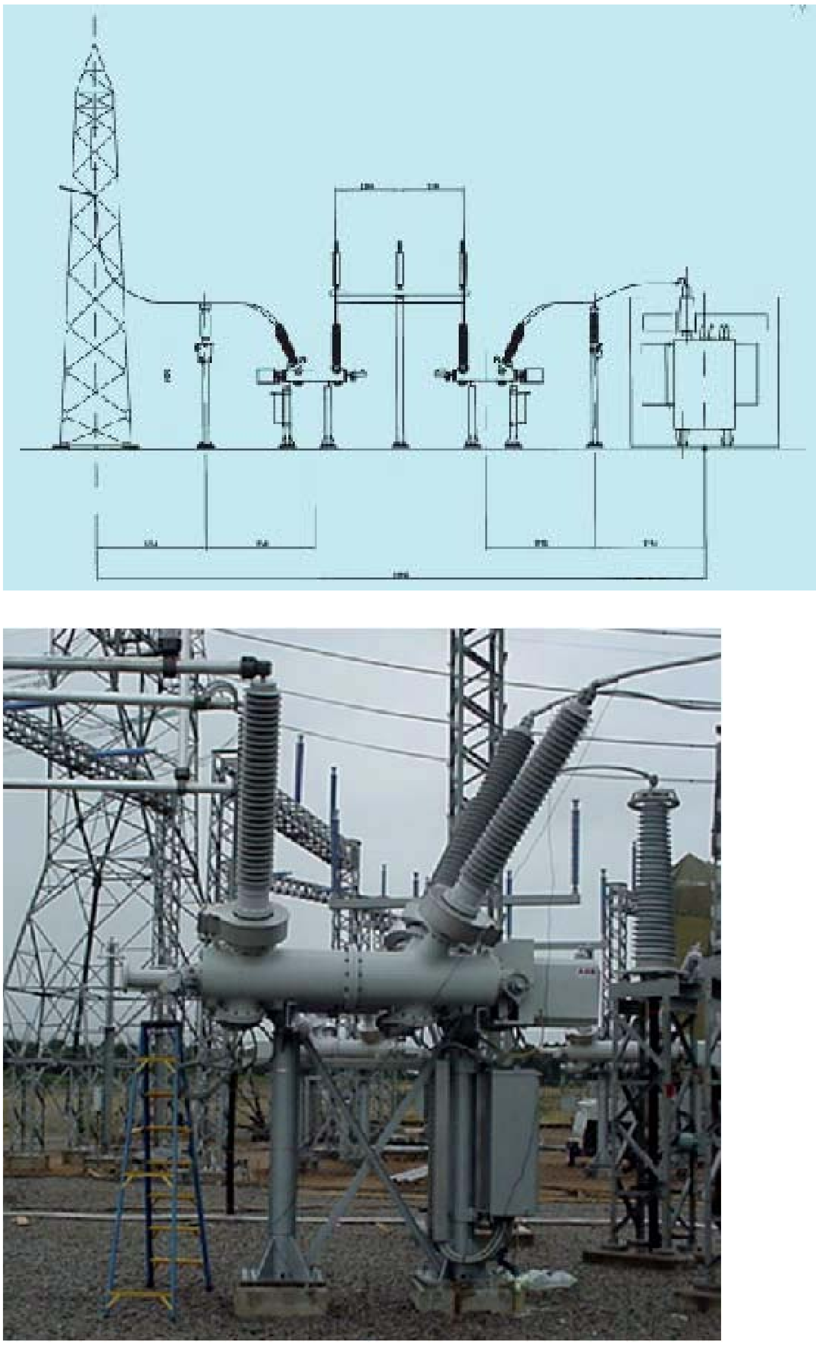


Fig. 3.1 Example – Hybrid modules used in a single busbar substation

Example 2:
Fig. 3.2 illustrates the use of the rotating Circuit Breaker (CB)/disconnector in an H station design. The innovative product is the combined CB/disconnectors. The single device incorporates the busbar disconnector, circuit breaker and the line side disconnector. (Note that the location of the CT is actually changed as it is now on the line side of the circuit disconnector compared to the original design) The advantage of this approach is that the site area for the station is significantly reduced as shown by the two diagrams, foundation requirements are also much less. The CB rotates such that the top connection disconnects from the busbar and the bottom connection disconnects from the CT.

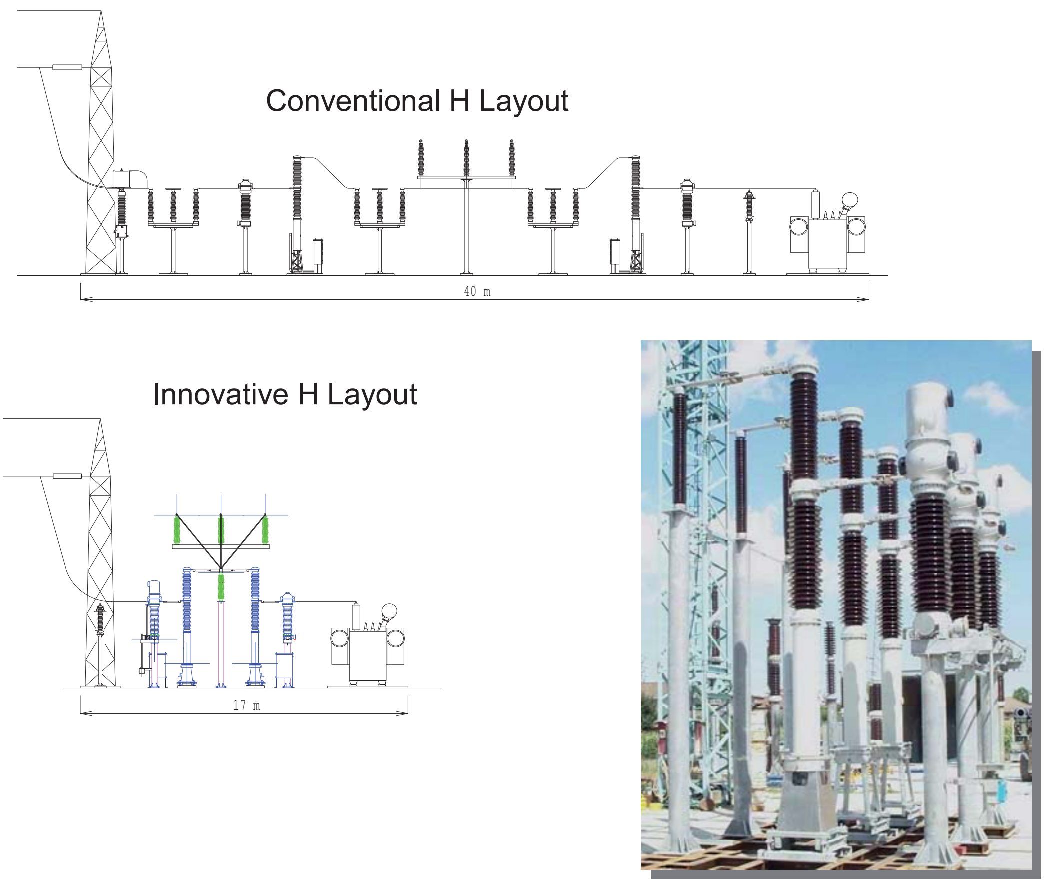


Fig. 3.2 Example of Innovative Solution to save space in 'H' Station Layout

3.2.2 Systems Innovation

Innovation can also be considered in the context of the power system where the improved performance of a product can result in a different architecture or procedure being introduced to take maximum advantage of the product. The development of microprocessor-based equipment to replace the electro- mechanical type relays can be considered, one of the major innovations resulting in a major improvement in the power system protection, metering and control. Another major innovation is the development of fibre optics which made a great improvement in terms of security, speed and reliability to communications between substation equipment and remote control centre or in the communication between protective relays located in different substations.

4 INDUSTRY FEEDBACK

4.1 Common elements

4.1.1 Introduction

In Electra No.228 the work of WG B3-11 "Combining innovation with standardisation" was introduced and the intention to gather data by means of a carefully structured questionnaire explained. It was explained that standardisation in this context refers to the application standards of the utilities and does not relate to the use of international standards such as IEC.

The WG has provided feedback based on initial examination of the responses in Electra 237, giving an indication of the level and quality of feedback, together with a short summary of information obtained from the initial review of responses

4.1.2 The questionnaire

The questionnaire was designed to gather the data required whilst imposing the minimum of effort on the respondents and allow for the majority of the analysis to be carried out numerically, thus providing an opportunity to provide quantitative results.

The questionnaire also asked for opinions and descriptive text in response to some questions, in particular to gather opinion from respondents who had issues outside those covered in the specific questions or options.

4.1.3 Distribution of the questionnaire

The questionnaire was issued from the WG Convenor to the B3 Study Committee Members in each country with a request to distribute as widely as possible. The intention was to seek feedback from four major functional groups, Utilities, Consultants, Solution Providers and Developers.

4.1.4 Response

The number of responses received, thirty-eight useable, was well below the number hoped for and the distribution of responses did not give as balanced a view as was anticipated, either geographically or functionally. In order to track responses without identifying the particular respondent each completed questionnaire was identified by a sequential reference, typically "**R1" through to "R43"**. During compilation of the results a number of duplications and discrepancies were identified which meant that some responses were invalid and hence the respondents R26, R27, R34, R40 and R41 were discounted in the analysis leaving the total of 38 valid responses.

The responses received were collated to a single representative response, which in many cases allowed the relative importance of the factors concerned with "objectives" and "difficulties" included in the questionnaire, to be assessed from each functional group. The respondents also had the opportunity to add other factors that the WG members had not specifically included in the questionnaire.

The areas concerned with "what was done" to meet the identified objectives were more difficult to analyse as the range of responses was very broad and essentially "free text". These responses have been collated and are published in the Appendices. It was particularly noticeable that some actions identified by respondents as "Innovation" were already other respondents "Standards" and that some "Innovations" were introduced as long ago as the 1970s. In particular one respondent identified the introduction of Air Blast circuit breakers as an "Innovation" which led the team to consider if a time limit of **"within the last 10 years"** should have qualified the questions. A good example of this was the introduction of numerical protection relays, which are just being introduced in some organisations but identified as “Standard” by many other respondents for some considerable time.

This further demonstrates that technologies move from being Innovative to Standards with time but at different speeds depending on the actual “innovation”, the growth profile of the utility and the attitude of the end user.

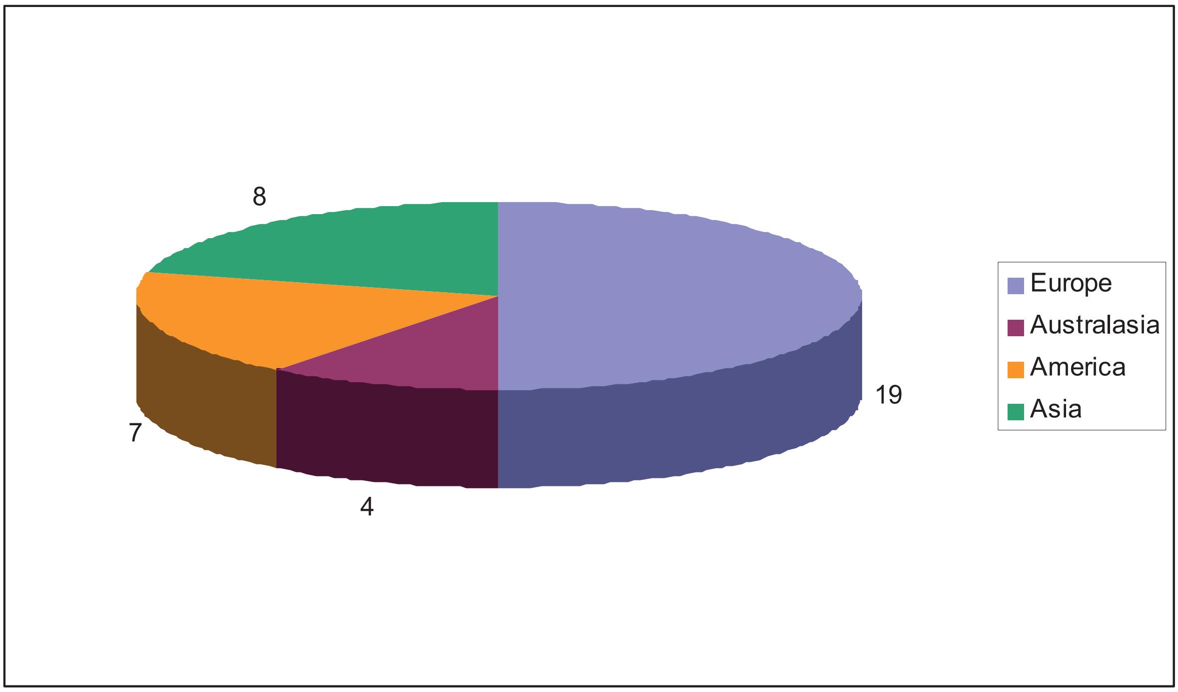
By analysing the responses, one of the objectives of the WG is to provide guidelines to assist utilities in the introduction of “Innovations” and where appropriate for the benefit of the utilities and their customers, to achieve a smooth and efficient transition of these “Innovations” to become the “Standards” of the future.

4.1.5 Results – Section 2 - Respondent profiles

This section provides a short summary of the information collated and analysed . Further information is included in Appendices “A” (Utilities), “B” (Consultants) and “C” (Solution Providers) of this brochure.

The geographical and functional distribution of the respondents is shown below in Figures 1 and 2.

Figure 4.1 Respondents By Geographical Area



The absence of responses from Africa and South America is a particular concern, as the impact is to under represent systems with long distance transmission and developing systems in the survey.

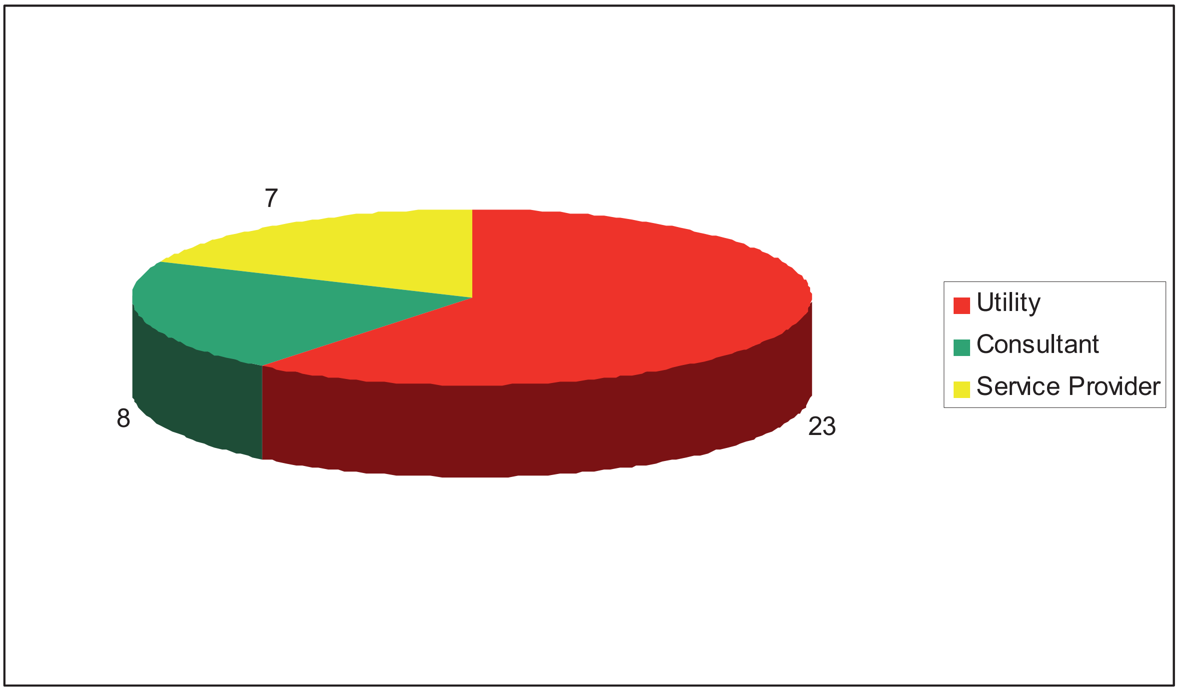


Figure 4.2 Respondents By Functional Group

The responses from utilities were dominant as shown but it was disappointing that there was no input from Independent Power Producers or Large Power users.

4.2 Additional data

4.2.1 Utilities

Appendix "A" provides more information about the Utilities who responded to the questionnaire.

In order to determine the characteristics of Utilities, Section 2 asked for some system information to determine the range of voltages, the size of the system and the intensity as illustrated in the following paragraph.

For example a respondent with only the lowest voltage levels and a high proportion of GIS with mainly cable connections could be classified as compact sub-transmission; respondents with mainly AIS extra high voltage equipment, and long overhead lines would be considered a sparse transmission network.

A summary of the network information received is included in Appendix "A" of the brochure.

The questionnaire also asked for other information relating to circuit lengths and the responses may be seen in the "Summary questionnaires" included in Appendix "A". However, on examination of the data it is clear that respondents interpreted this particular question in a number of different ways, making analysis difficult without further questions being raised.

Appendix "A" also provides more detail on the aspects of their business which were "standardised" and also on "innovations" in technology, operation or management which have been introduced to improve their performance.

4.2.2 Consultants

Appendix “B” is included at the end of this brochure and contains additional information about the geographical coverage, business characteristics and the “Innovations” which have been investigated and promoted by the Consultants who responded.

The table indicates a range of Consultant business from very small, specialised consultants to international companies who provide support and advice across the complete spectrum of T&D activity.

4.2.3 Service Providers

Appendix “C” is included at the end of this brochure and contains additional information about the geographical coverage, business characteristics and the “Innovations” which have been developed and promoted by the Solution Providers who responded.

The range of responses was similar to the Consultants, with Solution Providers ranging from major multi-national organisations with worldwide presence to small specialist manufacturers who support niche markets in particular fields of technology.

4.3 Analysis - Utilities

4.3.1 Results – Section 3 – Substation standardisation experience

The questionnaire asked the following questions specifically to utilities:

3.1 - Have you ever applied an application standardisation process? The majority confirmed that they had applied a standardisation process with only one of the respondents stating they had not standardised.
3.2 - What did you decide to standardise? For results see Appendix “A”
3.3 - Why did you decide to standardise? For results see 4.3
3.4 - What were the main difficulties in applying standardisation? For results see 4.4
3.5 – Do you have any additional comments? Free form For results see Appendix “A”
3.6 – Would you do things differently, if so what? For results see Appendix ”A”

4.3.2 Results – Section 4.1 – Substation innovation experience

The questionnaire asked the following questions specifically to utilities:

4.1.1 - Have you ever applied an application innovation process? The majority confirmed that they had applied an application innovation process with only two of the respondents stating they had not applied some form of innovation. However, this result may not be as conclusive as it first appears due to the wide range of activities that have been presented as innovation. This can be easily seen from an analysis of Table A-2 in Appendix “A”.

4.1.2 - What did you innovate? For results see Appendix “A” Table A-2
4.1.3 - Why did you decide to innovate and was it effective? For results see 4.3
4.1.4 - What were the main difficulties in applying innovation? For results see 4.4
4.1.5 – Do you have any additional comments? Free form For results see Appendix “A” Section 9.2
4.1.6 – Would you do things differently, if so what? For results see Appendix “A” Section 9.2

4.4 Analysis - Utilities

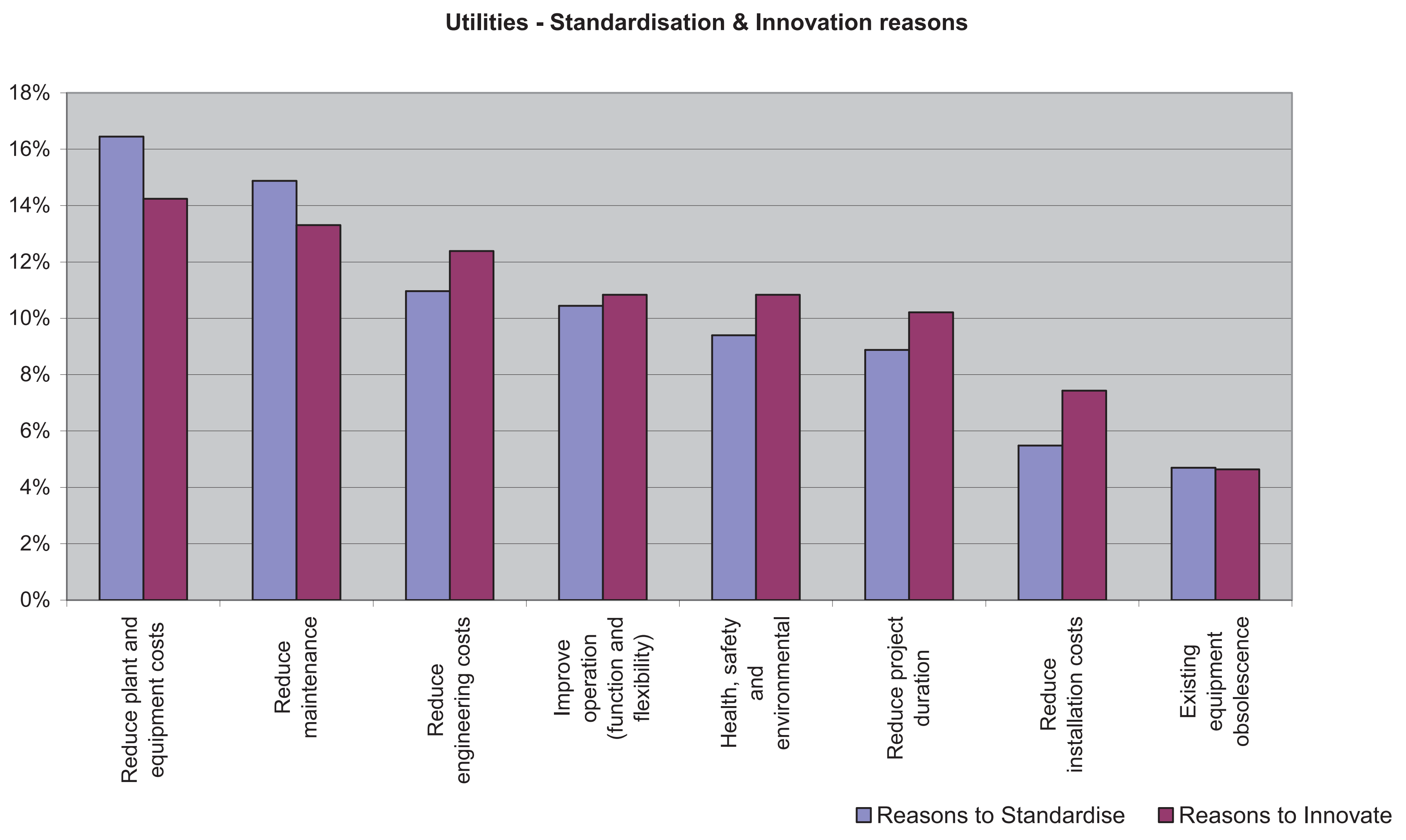
The analysis uses the responses in each category, weighted by the factors used in the questionnaire and summated for all respondents in the “function” being considered to reflect their importance. The figure shown on the “Y” axis is the percentage of the summated score for all categories. For an explanation of this process refer to Appendix “D”.

The questionnaire asked Utilities about their attitudes to standardisation and innovation, what were the objectives and which obstacles had been encountered in pursuing either strategy.

Analysis of responses from the “Utilities” are shown on the following charts which present the objectives of both standardisation and innovation in **Figure 4.3 (Reasons)** and the difficulties encountered in **Figure 4.4 (Difficulties).** The most important benefit of standardisation was to “reduce plant and equipment costs” whilst the most significant difficulty was the “time” required.

The remaining categories were similarly closely matched. This might lead one to conclude that close integration of a standardisation approach which is regularly reviewed to take advantage of innovation ought to give the optimum method of achieving the objectives.

Figure 4.3 - Reasons



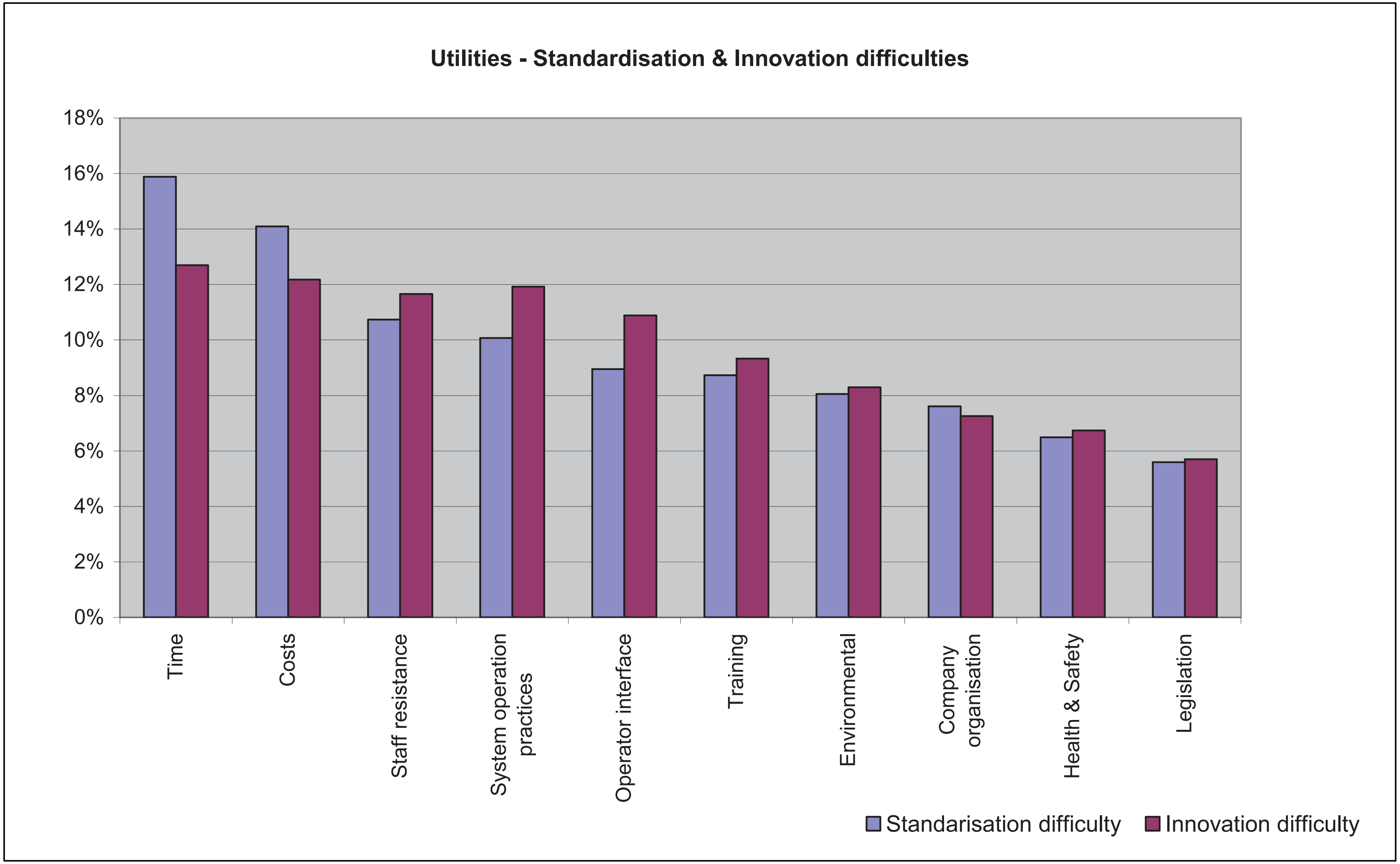
Other standardisation reasons rated less than 4% of total raised by Utilities

Legislation /regulatory	Legislation	3.92%
Facilitate technical and operational training	Operational	3.66%
System Security	Operational	2.35%
Reduce land costs	Cost	2.09%
Shortage of resource	Operational	2.09%
Increase availability	Operational	2.09%
Quality Control	Cost	1.31%
Quality Control	Cost	1.04%
Reduce Manpower	Cost	0.26%

Other innovation reasons rated less than 4% of total raised by Utilities

Reduce land costs	Cost	3.72%
Legislation /regulatory	Legislation	3.41%
Electric supply reliability	Operational	3.10%
Facilitate technical and operational training	Operational	2.79%
Shortage of resource	Operational	1.86%
Reliability (Equipments)	Operational	1.24%

Figure 4.4 - Difficulties



Other standardisation difficulties rated less than 4% of total raised by Utilities

Outage time reduction	1.12%
Knowledge transmission	0.89%
Staff availability	0.67%
Resources	0.67%
Not specified	0.45%

As with the objectives the difficulties encountered with both approaches were remarkably consistent with those categories that required acceptance of change such as "staff resistance" and "system operational practices" being slightly more prominent in respect of innovation.

Unsurprisingly, there is close correlation between the objectives and difficulties encountered with both strategies.

4.5 Consultants and Solution providers - introduction

The Consultants and Solution Providers were asked different questions from the Utilities only relating to their attitudes to innovation. The analysis of responses from the two functions are shown on the following charts which present the objectives of innovation in **Figure 4.5 (Reasons)** and the difficulties encountered in **Figure 4.6 (Difficulties).**

The Consultants and Solution Providers responded that the most important benefit of Innovation was "reduced plant and equipment costs" closely followed by "reduced installation costs", reduced project duration as important drivers. As with the Utility responses "staff resistance" and "system operation practices" were identified as the major difficulties by Consultants.

The solution providers responded that the second most important benefit of Innovation was "reduced engineering costs" and "reduced project duration" as the prime drivers, closely followed by "reduced installation costs". The major difficulties were identified as the "costs" and "time" with several other factors rated equally important.

4.6 Consultants questions

The questionnaire asked the following questions specifically to Consultants:

4.2.1 - Have you ever applied an application innovation process?

4.2.2 - What did you innovate?
For results see Appendix "B" Table B-1

4.2.3 - Why did you decide to innovate and was it effective?
For results see 4.5

4.2.4 - What were the main difficulties in applying innovation?
For results see 4.6

4.2.5 – Do you have any additional comments? Free form
For results see Appendix "B" Section 10.3

4.2.6 – Would you do things differently, if so what?

For results see Appendix “B” Section 10.3
For results see Appendix “B”

4.7 Solution providers questions

The questionnaire asked the following questions specifically to Solution Providers:

4.3.1 - Have you ever applied an application innovation process?

4.3.2 - What did you innovate?
For results see Appendix “C” Table C-1

4.3.3 - Why did you decide to innovate and was it effective?
For results see 4.5

4.3.4 - What were the main difficulties in applying innovation?
For results see 4.6

4.3.5 – Do you have any additional comments? Free form
For results see Appendix “C” Section 11.3

4.3.6 – Would you do things differently, if so what?
For results see Appendix “C” Section 11.3

4.8 Analysis – Solution Provider and Consultant

The analysis uses the responses in each category, weighted by the factors used in the questionnaire and summated for all respondents in the “function” being considered to reflect their importance. The figure shown on the “Y” axis is the percentage of the summated score for all categories.

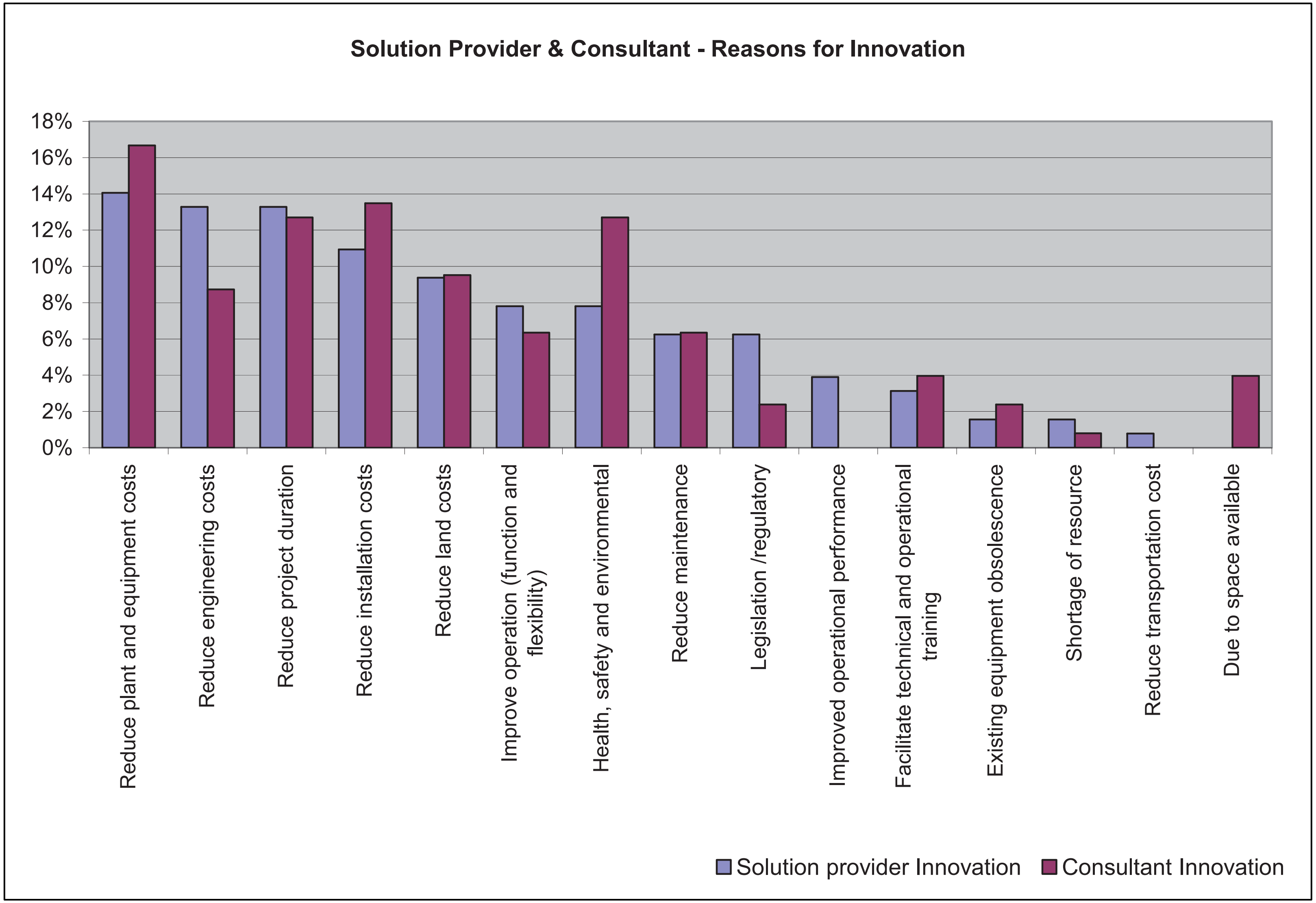
The questionnaire asked Solution Providers about their attitude to innovation, what were the objectives and which obstacles had been encountered in pursuing either strategy.

Analysis of responses from the “Solution Providers and Consultants ” are shown on the following charts which present the innovation reasons of both sets of respondents in **Figure 4.5 (Reasons)** and the difficulties encountered in **Figure 4.6 (Difficulties).** The most important reason given for innovation was to “reduce plant and equipment costs” whilst the most significant difficulty was the “cost” of the innovation task. This supports the view expressed in the commentary that convincing management to invest in innovation “up front” on the basis of longer term cost benefits is a significant issue.

The graphical presentation sequence is based on the importance assigned by the Solution Providers with the Consultant view shown alongside for comparison.

Whilst there are differences in some cases, for example “Health, safety and environmental” as a reason for innovation and “System operation practices” as a difficulty, there is generally close agreement between the Solution Providers and the Consultants.

Figure 4.5 - Reasons



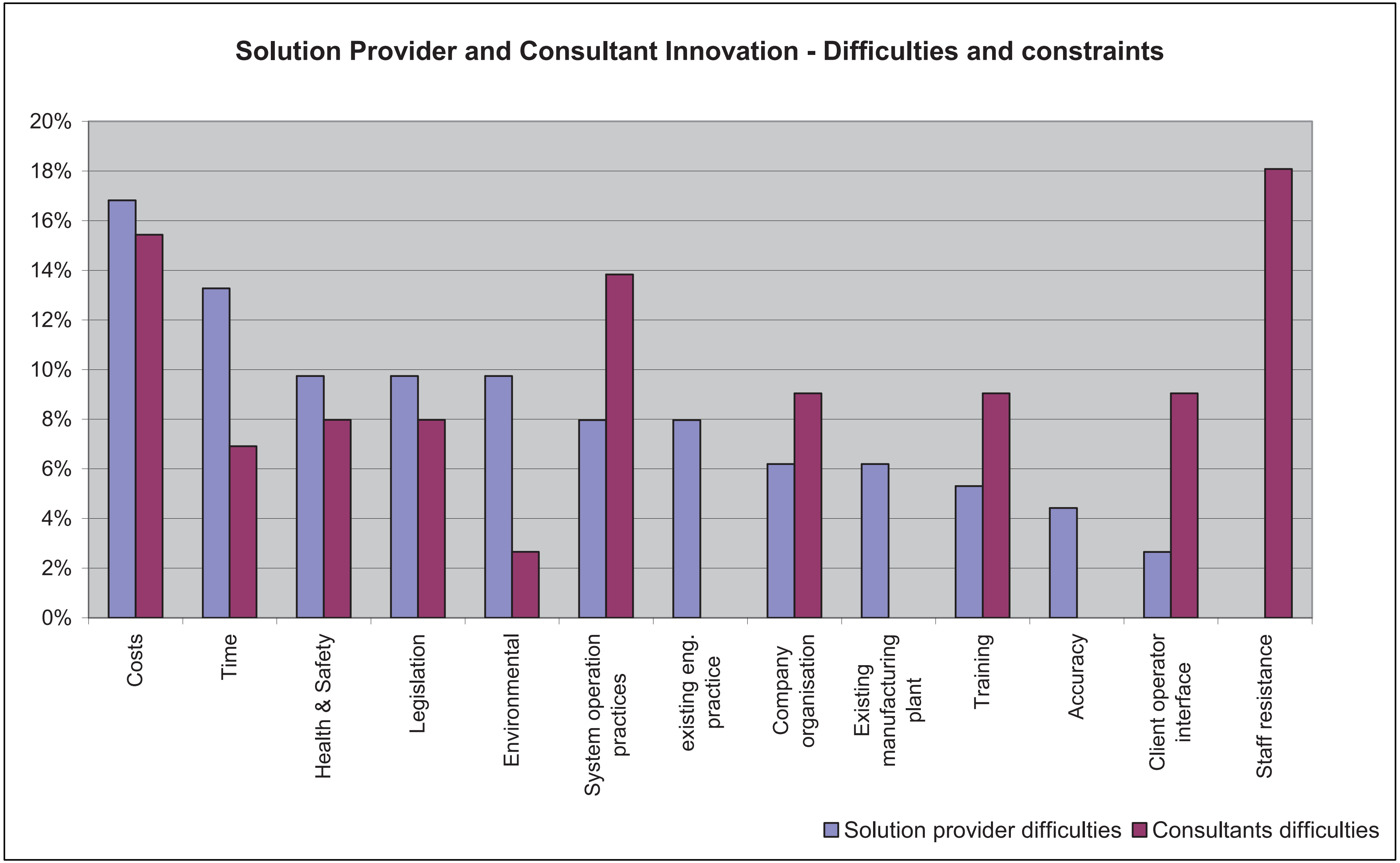
Other innovation issues rated less than 4% of total raised by Consultants

Legislation /regulatory	2.38%
Facilitate technical and operational training	3.97%
Existing equipment obsolescence	2.38%
Shortage of resource	0.79%
Due to space available	3.97%

Other innovation issues rated less than 4% of total raised by Solution Providers

Improved operational performance	3.91%
Facilitate technical and operational training	3.13%
Existing equipment obsolescence	1.56%
Shortage of resource	1.56%
Reduce transportation cost	0.78%

Figure 4.6 - Difficulties



Other difficulties rated less than 4% of total raised by Solution Providers

Accuracy	4.42%
Client operator interface	2.65%
Staff resistance	0.00%

The questionnaire also asked for an indication of the innovations measures actually introduced under a number of technology areas including protection, substation automation and control, primary plant civil works together with process areas such as engineering and commissioning. In the responses there was strong emphasis on the increased use of integrated systems for protection, control and system monitoring and the use of primary equipment that reduces land use, including Compact AIS, GIS and Hybrid arrangements.

4.9 Developers/IPP/Bulk users

Unfortunately there were no questionnaires returned from this group which is unfortunate as on occasion this group are more adventurous in their acceptance of new technology or innovative systems to gain commercial or operational advantage than the operators of major utility system to which they connect.

5 TECHNIQUES TO ACHIEVE THE OBJECTIVES

In the previous chapter an extensive survey was carried out to find out from Utilities what were the main reasons that they would wish to use standardisation and also their reasons for using innovation. Additionally, the reasons why Solution Providers and Consultants wished to pursue innovation were also explored.

The results showed that the reasons for standardising were virtually the same as those for innovation. In this chapter we look at the top eight reasons for wishing to standardise or innovate and then compare what we believe is the thinking and techniques behind them. These are then presented in a tabular form comparing standardisation and innovation and then a right hand column is added to make comments on how the benefits of these two approaches may both be achieved.

Also the results of the survey showed what the respondents considered to be the most common difficulties encountered in implementing either a standardised approach or an innovative approach. The top ten difficulties are presented for each reason again in tabular form with a column for standardisation and one for innovation and the final column suggests how these difficulties may be overcome.

5.1 Reduce Plant and Equipment Costs

5.1.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Standardise specifications Utilities can reduce the cost of equipment by using standard specifications. This can also lead to establishing period contracts for plant and materials which enable them to negotiate better pricing for the required equipment.	Customised design By using a design specifically produced to meet the functional needs of a particular substation then the amount of equipment required can be reduced compared to using a common standardised design.	The Utility can look at new innovations they wish to introduce. These can be developed with the Solution Providers and then standardised for a period of time
Solution Provider	Minimise production By using standardised designs the manufacturer is able to organise his production planning which means that his production line can operate more efficiently. Furthermore repetition means faster and more economical production by enabling the lines to be geared up for mass production. These advantages can be realised right through the supply chain and mean that component suppliers can also mass produce the required components efficiently. Limit component range By having standardised designs the manufacturer can reduce the number of different components which he needs to source and/or stock.	Use of innovative manufacturing techniques The Solution Provider can use innovation in the way in which he manufactures his equipment in order to achieve the lowest selling price. Offering innovative solutions The Solution Provider can offer solutions specifically designed to meet the customer's specific functional requirements. These solutions will usually result in a lower equipment cost compared to conventional solutions.	Solution Providers are usually looking for ways to differentiate themselves from their competitors. One way is to be the lowest price but another way is to offer innovative solutions. By ensuring that the innovative solutions can then be standardised for ease of production they can gain the benefits of both approaches

5.1 Reduce Plant and Equipment Costs

5.1.2 Difficulties

	Standardisation	Innovation	Ways to overcome the difficulties
Time	Using out of date standardised techniques for standard products may cause delays.	Production of an innovative design may take longer to produce. Design time may be longer due to familiarisation requirements for designers.	The innovation needs to be done offline rather than on an actual project. This way the teething problems can be resolved.
Costs	The use of standardised designs may result in using more equipment than is needed for the particular substation.	The production of specific innovative designs may increase the cost.	The innovative solutions need to be developed so that they can be rolled out as standards in the future to keep the costs low overall
Staff resistance	The continual production of the same standard arrangements and equipment can lead to the staff not obtaining any job satisfaction.	Utility staff may well object to the introduction of new equipment which they are not familiar with. Solution Provider's staff may object to the introduction of new manufacturing techniques which use more automation.	Staff need to be involved in the development of standard and innovative ideas, so that they feel that they have some ownership of the process.
System operation practices	With the increasing emphasis on new Health and Safety legislation and hence the revised practices necessary to implement it the standard equipment designed before the introduction of the new legislation may no longer be acceptable/compliant.	The introduction of innovative solutions may require some changes in operational practice (e.g disconnecting circuit breaker) This needs to be taken into account by the utility	It is essential to engage the operational staff into the process of either introducing a standardised design or an innovative approach. This consultation should ensure that the benefit of their experience is gained and that they are fully happy with the solution which they will have to operate.
Operator interface	Equipment suppliers have their own standards and complying with customer requirements often adds cost.	Operators usually prefer to have equipment which they are familiar with as this leads to a reduction in operator error.	How the operator interfaces with the equipment is very important so consultation is required at an early stage.

	Standardisation	Innovation	Ways to overcome the difficulties
Training	Introducing change is difficult for individuals to accept and although training on a new standard approach can be given doing the old way often prevails.	Much more training is likely to be required to introduce new innovative solutions	When introducing new systems or plant it is important that the staff are properly trained. It is a false economy to skimp on the training budget.
Environmental	Some equipment designed in the past will not meet the recent environmental requirements.	Some innovative solutions may not meet the environmental requirements in some countries.	Before introducing an innovative solution the environmental aspects must be fully considered. For standard solutions they must be regularly reviewed against changing environmental requirements.
Company organisation	Changes required in the Company organisation may be required because of takeovers etc. Streamlining of production facilities or outsourcing could trigger job concerns.	Some innovative solutions may require a change in the organisation of the Company particularly for manufacturing changes. This could also affect maintenance and operational staff.	Before trying to implement any new equipment it is important that it is compatible with the existing Company Organisation or if a change is required this must be addressed at an early stage.
Health & Safety (H&S)	Some equipment designed in the past will not meet the recent health and safety requirements.	Some innovative solutions may not meet the Health and Safety requirements in some countries	All items of plant whether new or existing standards need to be regularly reviewed against continuously changing H&S policies and specifically against the local requirements.
Legislation	Some equipment designed in the past will not meet the recent legislation.	Some innovative solutions may not meet the legislative requirements in some countries	All items of plant whether new or existing standards need to be regularly reviewed against continuously changing legislation.

5.2 Reduce Maintenance Costs

5.2.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Standardise specifications The use of standardised specifications enables utilities to develop standard maintenance procedures and hence to reduce the costs of maintenance. Furthermore, the amount of training can be reduced and this can be concentrated on an overall substation level rather than needing to focus on individual components.	Less equipment Innovative solutions may result in less equipment to be maintained thus reducing the maintenance costs. The use of condition monitoring may assist in innovative maintenance techniques which can reduce costs.	Use needs to be made of new maintenance methods coupled with the effective use of condition monitoring. A standardised way of dealing with maintenance needs to be developed but this does not imply standardised time based maintenance.
Solution Provider	Standardised O&M manuals The standardisation of equipment can lead to O&M manuals which have benefited from experience with lots of this type of equipment. Also more time can be spent on optimising the maintenance regime for equipment which sells in large quantities.	Better design The equipment may have been designed to allow longer intervals between maintenance or to make the access for maintenance to be achieved more efficiently e.g. modular designs.	The maintenance aspects of the equipment and the total design need to be considered at the early stage of design. This is particularly important if the design is to be adopted as a standard.

5.2 Reduce Maintenance Costs

5.2.2 *Difficulties*

	Standardisation	Innovation	Ways to overcome the difficulties
Time	Standardised designs may lead to having more equipment to maintain than would otherwise be necessary thus taking longer for maintenance.	Some innovative designs may require more time to carry out the maintenance.	The time required for maintenance needs careful consideration in any design. Time falls into two categories; man-time and outage time and both aspects need to be addressed.
Costs	Once the standard design has been in place for some time the equipment may require more maintenance than more modern equipment thus costing more.	Some innovative solutions may require more sophisticated tools to carry out the maintenance.	The cost of maintenance needs careful consideration in any design. The cost falls into two categories, direct cost for carrying out the maintenance and the consequential cost of the plant outage and outage time.
Staff resistance	Changes in work practices to achieve standardisation may be resisted, common tools and spares centrally held may generate more travel and longer overall maintenance time.	Staff may object to carrying out maintenance on new unfamiliar innovative solutions.	The maintenance staff need to be involved in any new plant or design standard or otherwise. This is not always easy to achieve but the benefits of doing this can outweigh the difficulties.
System operation practices	New maintenance techniques and practices may be introduced by a company which may not be compatible with the standard design.	The innovative solutions may not fit in with the maintenance practices of the utility.	New and standardised designs need to consider the operational practices involved in commissioning and switching procedures for normal operation.
Operator interface	The design to be selected as the standard may not have all the features necessary to comply with the Utilities operating and maintenance procedures.	The operator interface of the new innovative solution may not have all the features necessary to comply with the Utilities operating and maintenance procedures.	Before standardising on a particular interface or introducing a new one the operator requirements must be considered.

	Standardisation	Innovation	Ways to overcome the difficulties
Training	Training maintenance staff on standard techniques may be seen as unnecessary and wasteful	Innovative solutions will require additional training. Training everyone for a specific installation may be wasteful but may be necessary for flexible staff availability.	When introducing new systems or plant it is important that all staff are properly trained. This is particularly important for the maintenance staff.
Environmental	The existing standard designs, equipment and maintenance methods may not be compatible with modern environmental practices and legislation.	The innovative designs and maintenance requirements which are acceptable in some countries may not be acceptable from an environmental point of view in others.	Before introducing an innovative solution the environmental aspects must be fully considered. For standard solutions they must be regularly reviewed against changing environmental requirements.
Company organisation	Revised company organisation may not fit with the established maintenance practices used on the standard designs	Innovative designs by their nature may often require new ways of thinking and operating. The required change to established company structure may be strongly resisted.	Before trying to implement any new equipment or design it is important that it is compatible with the existing Company Organisation for maintenance. It may be that a change is required in the Company maintenance organisation and this needs to be properly addressed.
H&S	Changes in H&S practice may mean that standard designs developed under previous H&S practice are no longer acceptable.	Some innovative solutions may not allow the maintenance to be carried out in accordance with the local H&S requirements	How maintenance can be carried out safely needs to be carefully considered in the standard or new design and also it needs to be regularly reviewed to ensure that changes required from new H&S policies are quickly identified.
Legislation	Changes in legislation may mean that the standard design does not meet the requirements of the new legislation.	Some innovative solutions may not allow the maintenance to be carried out in accordance with the local legislative requirements.	A regular check of the standard or innovative solutions against current legislation is essential.

5.3 Reduce Engineering Costs

5.3.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Standardise specifications Utilities can reduce the cost of engineering significantly by using standard specifications. This enables them to issue tender enquiries quickly and also makes evaluation of the returned bids simpler.	Innovative ways of working with Solution Providers In order to avoid the costs of producing tender designs, the receiving and evaluating tenders and then checking again the final contract design innovative ways of partnering with key suppliers may be employed to enable them to work together to reduce the amount of engineering effort required in the procurement process. Care has to be taken to ensure that the implementation of this process is carefully planned and executed to obtain the best result.	Engineering resource in power engineering is particularly scarce worldwide. It is essential that innovative ways of producing cost effective standard designs are found. This will probably involve new commercial ways of working as well as purely technical innovations.
Solution Provider	Standardised Equipment and Layout Designs. The Solution Provider can reduce his engineering costs significantly if he is able to produce standard equipment for a particular client and also if standard substation layouts can be employed. This also has the benefit that the number of errors is reduced and the drawings can be approved more quickly with less rework. This is a very important feature in the present engineering climate where skilled resource is particularly scarce.	Making use of new techniques Engineering costs may be reduced by using new form of innovative software to assist with the engineering. This may be true for using software which automatically produces wiring and cabling diagrams from the schematics.	Engineering resource in power engineering is particularly scarce worldwide. It is essential that innovative ways of producing cost effective standard designs are found. This will probably involve new commercial ways of working as well as purely technical innovations.

5.3 Reduce Engineering Costs

5.3.2 Difficulties

	Standardisation	Innovation	Ways to overcome the difficulties
Time	Using standardised designs will tend to mean using older techniques. Implementing standard solutions and processes requires the time of key individuals who are generally occupied executing projects.	Some innovative designs may require significantly more time to produce and the introduction of new software systems needs a lot of time to get the system up and running and to enter all the menus required. The time of the whole implementation team will be extended due to the new designs or solution.	More co-operation is required between Utilities and Solution Providers to ensure that the most effective use is made of the time.
Costs	To create a set of standard solutions, designs, specifications, processes, procedures, etc. requires additional time, therefore cost, to create. Regular maintenance of all these requires time and cost.	The cost of the extra design effort required for custom designed innovative solutions can be high.	Custom designed solutions will not provide a cost effective way forward and also will utilise too much of the scarce resource of engineers. Cost effective design methods need to be developed and then applied in a standardised way.
Staff resistance	The repetition of completely standardised designs can be a little demoralising for the engineering staff who may feel that they do not obtain much job satisfaction from such an approach. Reduction of engineering by making processes more efficient can be a threat to employment.	When new techniques are introduced, which are designed to make processes more efficient, then there is often resistance from the staff as they see this as a threat to their jobs. In the present climate with such severe skills shortages this should not really be a problem but the staff may need to be convinced.	Engineers need to be valued and the importance of their contribution recognised and rewarded. They need to be fully engaged in ways in which their skills can be most effectively used. Standardisation leaves engineers time to concentrate on the non-standard real issues to ensure these are resolved and eliminate rework.

	Standardisation	Innovation	Ways to overcome the difficulties
System operation practices	Introducing standard solutions may introduce unsatisfactory connection arrangements resulting in overstressing old/existing plant and networks.	When introducing innovative techniques into engineering it is important to keep the system operators involved in the process particularly if the format of the design output is changed.	There needs to be closer contact between the design engineers and the system operators. This can be improved by ensuring that the design engineers visit sites after each design is commissioned and discuss with the operational staff the good and bad aspects of the design.
Operator interface	Moving from bespoke to standard operator interfaces to reduce engineering time and cost may economise on some aspects previously included. Change is often difficult for individuals to accept.	When introducing innovative techniques into engineering it is important to keep the system operators involved in the process particularly if the format of the design output is changed.	See comment above.
Training	Optimised (project specific) solutions are traditionally seen as cheapest. Training staff to deliver standard repeatable solutions often meets with resistance.	Innovative solutions will require additional training of the engineering staff.	It is essential that engineers are fully trained in new design techniques. Also training in the capabilities of new plant designs is important so that the plant can be used to achieve its full potential. Training to include the overall company strategy and the detail behind the standardisation.
Environmental	Environmental aspects are site specific where standard solutions may not be possible and will require more time and cost to resolve.	Local objections to the innovative solution. The new innovation may be less environmentally friendly than the previous solution which could result in more time and cost to resolve.	Design reviews to ensure that the designs are environmentally acceptable need to be regularly carried out.
Company organisation	If not implemented correctly, with full company support, then more resource may be needed to administer the standard solution.	When introducing innovative engineering techniques this may require some re-organisation within the Company.	The status of engineers needs to be improved in most Company organisations.

	Standardisation	Innovation	Ways to overcome the difficulties
H&S	Changes may be required to meet the updated H&S requirements so that the standard designs have to be modified.	Significant effort may be required in order to get the new designs compliant with existing legislation and accepted by H&S	Engineers are being forced to fully consider the implications on H&S of their designs. This has been a well established practice in the Electricity Supply industry but there is still room for improvement. Good communication between designers and customers will assist in overcoming difficulties.
Legislation	Changes may be required to meet the updated legislation so that the standard designs have to be modified.	New innovative designs acceptable in some countries may not meet the legislative requirements in other countries.	Engineers need to be trained in the impact of new legislation (often to do with H&S) on their designs.

5.4 Improve Operation (Function And Flexibility)

5.4.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	**Familiarity with Standard designs** The use of standardised designs yields significant advantages in the operation of substations. The operators can become familiar with the switching configuration and associated layout. This is particularly useful where staff may be required to cover switching operations in a number of different substations, often on a call out basis when the action required may be in the middle of the night and under difficult weather conditions. This can contribute to the reduction in human error faults which are often caused by unfamiliarity with the particular arrangement at a specific substation.	Designed to meet specific operational requirements The innovative design can be specifically tailored to meet specific unusual operational requirements. This could be a special switching configuration for example. Furthermore, if the new design is built in modules it may be possible to reduce outage times by replacing a module and carrying out the maintenance offline.	It is important that there is good communication between the Utilities and the Solution Providers to ensure that the effort is concentrated on finding solutions to real problems rather than producing solutions which are looking for problems. The Utilities need to look at the bigger picture rather than trying to bring each job in at the lowest possible capital cost. A careful look should be taken at the operational functionality and flexibility required and then co-operative working employed with the Solution Providers to ensure that this can be delivered.
Solution Provider	More detailed O&M manuals The Solution Provider can ensure that fully detailed O&M manuals are produced for the standard designs to assist the operators to get the maximum out of the plant.	Custom design to meet special operating conditions The Solution Provider can design in any special operating requirements which the customer wants.	See above

5.4 Improve Operation (Function And Flexibility)

5.4.2 Difficulties

	Standardisation	Innovation	Ways to overcome the difficulties
Time	The use of standardised designs may not give the operators the most effective operating conditions	Lack of familiarity with certain innovative designs may mean that the operator needs more time to be able to carry out operational requirements.	Better co-operation between Utility and Solution Provider should enable designs which minimise man-time and outage time.
Costs	Operating in an inefficient way in order to remain with standard equipment may lead to higher operational costs	The costs of training of staff in the innovative designs may lead to higher costs	Any new or standard design needs to consider the operating costs, this should include losses as well as personnel costs.
Staff resistance	Usually staff resistance will be experienced when it is decided to make a design standard rather than when it is established as a standard design. Staff are usually very conservative in their outlook.	The new innovative design may require that equipment is operated in a different way from that which the operators are familiar with.	The operational staff need to be involved in the introduction of any standard or innovative design at an early stage. They need to understand fully the implications on their daily work which will result from the implemented design.
System operation practices	If there are changes in the system operation practices then the standard equipment may no longer be suitable or the proposed standardisation may not cover all operational requirements.	The innovative solutions may not fit in with established operational practices.	The operational staff need to be involved in the introduction of any standard or innovative design at an early stage to ensure that their requirements are built in to the design.
Operator interface	If there are changes in the operator interface then the standard equipment may no longer be suitable. Or the proposed standardisation may not cover all	The innovative solutions may not fit in with the way in which the operator wishes to interface with the plant.	See the two comments above.

	Standardisation	Innovation	Ways to overcome the difficulties
	operational requirements.		
Training	No effect.	Innovative solutions will require additional training.	Operational staff will need to be fully trained in the requirements of the designs to ensure that they can get the maximum functionality and flexibility from the equipment
Environmental	The existing plant may no longer meet the environmental constraints now being required. For example the use of air blast circuit breakers may not meet modern noise limitations.	The innovative solutions which are suitable in one area may not be suitable elsewhere because of differing environmental requirements.	Operational staff these days are very aware of their obligations to the environment. Early consultation between the designers and the operational staff will help to avoid environmental problems being encountered later on.
Company organisation	Changes in the Company organisation or even ownership may make the standard solutions untenable.	The proposed innovative solutions may not satisfy the existing Company organisation.	The designers need to fully understand the Company's organisation for operational staff. Generally their designs should fit with the existing organisation but if the organisation is stifling efficient new designs then this issue must be addressed at an early stage.
H&S	Changes in H&S requirements may mean that existing standard designs are no longer acceptable. An example is the way in which safety clearances are defined.	Some innovative solutions may not allow operation in accordance with the local H&S requirements	How normal operation can be carried out safely needs to be carefully considered in the standard or new design and also it needs to be regularly reviewed to ensure that changes required from new H&S policies are quickly identified.

	Standardisation	Innovation	Ways to overcome the difficulties
Legislation	Changes in legislation may mean that the revised operational requirements cannot be fulfilled by the standard design.	Some innovative solutions may not allow the plant to be operated in accordance with the local legislative requirements.	A regular check of the standard or innovative solutions against current legislation applicable to operation is essential.

5.5 Health, Safety and Environment

5.5.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Use of Standard Designs By producing a standard design then more time can be spent in ensuring that the design is thoroughly checked to ensure that it complies with all relevant H&S requirements. Repeating this design will ensure a safe and effective design provided that the H&S requirements do not change.	Use of removable modules Innovative designs may provide an effective way of complying with H&S requirements, for example by ensuring that maintenance is not carried out with the plant in situ.	The incorporation of innovative techniques, such as modular designs, needs to be incorporated into future standard designs to ensure that H&S requirements can be met in a cost effective way without jeopardising safety.
Solution Provider	Co-operation between Utility and Solution Provider If a standard design is to be produced close cooperation can be established between the Solution Providers and the Utility to ensure that all of the required H&S issues are fully dealt with in the design.	Specific H&S design for compact or other special circumstances In special circumstances the Solution Provider may be able to develop innovative designs which provide a new and simpler way of meeting H&S requirements.	See above

5.5 Health, Safety and Environment

5.5.2 *Difficulties*

	Standardisation	Innovation	Ways to overcome the difficulties
Time	Where a standardised design is used for a special operational requirement then the H&S aspects may not be ideal and this may result in more switching operations and time required for operation of the plant.	Some innovative designs may require more time to perform operational requirements to meet the H&S requirements.	Standard or innovative designs need to ensure that operation and maintenance can be carried out in a time effective way both in terms of man-time and outage time. The use of removable modules may contribute effectively in this respect.
Costs	If new H&S requirements are introduced in certain substations then having one design for all may not give the lowest cost solution.	The measures necessary to make some innovative designs suitable to meet the local H&S requirements may not be economically justifiable.	Standard or innovative designs need to ensure that operation and maintenance can be carried out in a cost effective way both in terms of direct cost and consequential cost associated with outages.
Staff resistance	The staff responsible for the safe operation of the plant may not feel that the standard design can meet the requirements in all conditions.	Staff who have responsibility for the safe operation of the plant may not wish to have new designs with new problems to be dealt with.	Consultation with the staff responsible for implementing H&S measures is required to ensure that they are happy with the standard or innovative design.
System operation practices	New installation techniques and practices may be introduced by a company which may not be compatible with the standard design	The innovative solutions may not fit in with the H&S policies of the Utility.	See above
Operator interface	Manufacturer's standard interface may not be suitable for the Utility's requirements and operating regime.	Innovative interfaces may not include Utility requirements if produced by manufacturers based on least cost.	Important for manufacturers, Solution Providers and Utilities to work closely together, not just designers but H,S&E experts also.

	Standardisation	Innovation	Ways to overcome the difficulties
Training	Training Utility staff on a Manufacturer's standard equipment and interfaces may not align with the Utility's expectations.	Innovative solutions will require additional training.	Training in the H&S aspects of the new or standard designs is required.
Environmental	Each installation has to be considered specifically due to its unique environment.	Unique environmental requirements for each installation have to be considered and innovative solutions may not comply.	Standard building blocks or innovative solution packages which consider environmental issues may be used to produce overall compliance.
Company organisation	Changes in the Company's organisation with regard to H&S may invalidate some older standard designs	The Company's H&S policies may not allow certain innovative designs.	The Company's H&S organisation need to be involved at an early stage in introducing a standard or innovative solution.
H&S	This is the subject of this section.	This is the subject of this section.	This is the subject of this section.
Legislation	Changes in legislation may invalidate existing standard solutions,	Some innovative solutions may not comply with particular local legislation with regard to H&S.	A regular check of the standard or innovative solutions against current legislation applicable to operation is essential.

5.6 Reduce Project Duration

5.6.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Standardise specifications The use of standard specifications will significantly reduce the lead time at the front end of a project. This will also enable the civil input data to be generated more quickly thus enabling work to start on site more quickly. Furthermore the reduced amount of engineering and interfacing should enable the project to be implemented in a shorter timescale and with lower risk.	More compact solutions In some cases a more compact solution may be achievable which may avoid the need for additional land purchase and associated planning consents. In such cases innovative solutions may reduce the duration of projects. Innovative Contracting conditions By working closer with Solution Providers at an earlier stage of the project significant time can be taken off the front end of a project.	Closer co-operation between the Utility and the Solution Provider has the greatest potential for reducing project durations. The use of a smaller number of standard configurations by the Utility and the application of the most innovative solutions for these will tend to produce the most time effective solutions.
Solution Provider	Standard products and designs By using standard products, layout and protection designs the engineering time for a project can be drastically reduced. Also the manufacturing time for standard products can be reduced and the lead time for the supply of components reduced.	Innovative working with Customer By working closely with the customer at an earlier stage in the project the Solution Provider can avoid starting with unbuildable designs which can happen at the tendering stage in conventional contracts. The closer working at an earlier stage reduces time lost in handover from tendering to contract stages.	See above

5.6 Reduce Project Duration

5.6.2 Difficulties

	Standardisation	Innovation	Ways to overcome the difficulties
Time	This is the subject of this section.	This is the subject of this section.	This is the subject of this section.
Costs	Reduction in project timescales will generally result in reduced costs unless the reduction has been achieved by special acceleration measures.	Reduction in project timescales will generally result in reduced costs unless the reduction has been achieved by special acceleration measures.	In general reduction of time will generally bring a reduction in cost. Methods to reduce time which incur additional cost should generally be avoided.
Staff resistance	If the reason for the reduced time means that less work is now required then staff may resist these changes as they see them as a threat to their employment.	Staff may object to the innovative way of working as this may put different demands on them.	Staff engagement in new ways of working is essential if the most effective results are to be achieved.
System operation practices	Projects being delivered more quickly may put additional pressure on the operational staff to deliver the required outages and permit documentation.	New methods to reduce the time of projects may not fit in with the normal operational practices.	Attention needs to be paid to the opinions of the operational staff when trying to reduce outage and site installation and maintenance times.
Operator interface	No effect	New solutions may change the required operator interfaces.	See above
Training	No effect	Changes in the approach to enable the delivery of projects in a shorter timescale will require additional training of staff.	Training of all staff in new ways of working is extremely important if the best results are to be achieved.

	Standardisation	Innovation	Ways to overcome the difficulties
Environmental	Shorter timescales may not allow sufficient time for environmental consultations and studies.	Shorter timescales may not allow sufficient time for environmental consultations and studies.	By smarter working the parties can jointly address the environmental issues.
Company organisation	In order to deliver projects in shorter timescales a change may be required in the way in which the Company is structured.	In order to deliver projects in shorter timescales a change may be required in the way in which the Company is structured.	In general to make significant reduction in the timescale of projects will require a change to Company organisation and this needs to be recognised and implemented.
H&S	When projects are being delivered in shorter timescales then more attention is required to ensure that the proper time is allowed for safety issues, e.g. design review of hazards, method statements and risk assessments, etc.	When projects are being delivered in shorter timescales then more attention is required to ensure that the proper time is allowed for safety issues, e.g. design review of hazards, method statements and risk assessments, etc.	The process used to achieve shorter project timescales needs to incorporate adequate time for safety of the design, installation, operation, maintenance and demolition.
Legislation	Achieving the optimum project duration reduction may not be possible due to the time limitations in complying with specific legislation. This is particularly relevant to issues such as planning consents.	Achieving the optimum project duration reduction may not be possible due to the time limitations in complying with specific legislation. This is particularly relevant to issues such as planning consents.	Earlier consultation is required and the designers need to be sensitive to the need of producing designs which are aesthetically pleasing and do not generate excessive noise.

5.7 Reduce Installation Costs

5.7.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Use of standard equipment and designs By using standardised equipment and layouts the installation methods can be optimised by experience and method statements and risk assessments being well established. This can lead to faster and lower risk installation of the equipment. This approach may also yield significant savings in secondary equipment installation by using modular cabling techniques.	Innovative design customised to ease installation The innovative design may be specifically designed to enable rapid and hence lower cost installation for example by accepting the use of modules which enable installation to be a smaller number of larger parts.	The Utilities and Solution Providers need to work closely together and establish designs which can reduce installation costs whilst still working in a safe and risk free way.
Solution Provider	Standard maintenance techniques When standard designs are being used the Solution Provider can ensure that the equipment is designed for ease of installation. Standard procedures benefiting from the experience of earlier stations can be fed back into the standard design to ensure low cost installation.	Modular design The use of modular designs can enable more rapid installation. This can be particularly beneficial for the secondary equipment where the number of connections to be made on site can be reduced and these could also be effected by the use of plugs and sockets.	See above

5.7 Reduce Installation Costs

5.7.2 *Difficulties*

	Standardisation	Innovation	Ways to overcome the difficulties
Time	Standardised designs may lead to having more equipment to install than would otherwise be necessary thus taking longer.	Some innovative designs may require special installation techniques or plant thus causing delays.	In general reduction of installation cost will generally bring a reduction in time. Methods to reduce cost which incur additional time should generally be avoided.
Costs	This is the subject of this section	This is the subject of this section	This is the subject of this section
Staff resistance	If by the use of standardisation it is possible to reduce the number of men required then staff will resist as they will fear for their jobs.	Staff may object to new methods of installation. If the methods are designed to reduce the number of men required then staff will resist as they will fear for their jobs.	Staff engagement in new ways of working is essential if the most effective results are to be achieved.
System operation practices	Introduction of new installation practices may not be possible with the established standard design.	The innovative solutions may not fit in with the established installation practices of the utility.	Attention needs to be paid to the opinions of the operational staff when trying to reduce installation costs.
Operator interface	If focus is on standardisation to reduce installation costs then operator interface may be overlooked or ignored	The innovative designs may change the way in which the operator interacts with the equipment. New designs may encounter unforeseen difficulties.	See above. To avoid installation difficulties the installation needs to be well thought through and techniques trialled ahead of time in order to overcome any possible difficulty.
Training	Installation of different equipment though standard from each Solution Provider or Manufacturer may generate huge Utility training budgets.	Innovative solutions will require additional training.	Training of all staff in new ways of working is extremely important if the best results are to be achieved.

	Standardisation	Innovation	Ways to overcome the difficulties
Environmental	The design which optimises installation costs may not meet environmental requirements.	The design which optimises installation costs may not meet environmental requirements.	By smarter working the parties can jointly address the environmental issues.
Company organisation	In order to reduce the installation costs a change may be required in the way in which the Company is structured.	In order to reduce the installation costs a change may be required in the way in which the Company is structured.	If the current organisation is hampering the reduction of installation costs then this issue needs to be addressed and dealt with.
H&S	Changes in H&S practices may mean that older standard designs no longer comply with the new H&S requirements.	Some innovative solutions may not allow the installation to be carried out in accordance with the local H&S requirements	The process used to achieve lower installation costs needs to incorporate adequate safety procedures.
Legislation	Changes in legislation may mean that the standard design does not meet the requirements of the new legislation.	Some innovative solutions may not allow the installation to be carried out in accordance with the local legislative requirements.	A regular check of the standard or innovative solutions against current legislation applicable to operation is essential.

5.8 Existing Equipment Obsolescence

5.8.1 *Techniques*

	Standardisation	Innovation	Comments
Utility	Use of standard interfaces By using standardised interfaces between the items of plant this makes it much easier to replace an obsolete item of plant with another item or later design. These standard interfaces should be applied both on the primary interfaces and also on the secondary interfaces.	Innovative design to adapt new plant to old layout Innovative ways may be produced to enable newer designs to be fitted into the space vacated by obsolete equipment Retrofit or Refurbishment. In some cases obsolete equipment may have its life extended by retrofitting part of the plant with newer design equipment e.g. replacing some bulk oil distribution switchgear interrupters with vacuum interrupters. Another solution may be refurbishment of the obsolete equipment to extend its life.	The Utilities and Solution Providers need to work closely together in order to find the best ways both to cater for future obsolescence of the plant and also to assist in dealing with obsolescence of existing plant either by innovative solutions to adapt equipment to meet the needs or by retrofit or refurbishment.
Solution Provider	Use of standard interfaces The Solution Provider may standardise his primary and secondary interfaces which will make replacement when the plant becomes obsolete much easier.	Retrofit or Refurbishment. Manufacturers may offer to refurbish older items of plant as a way to maintain a good relationship with their customer. Another alternative is to retrofit parts of the obsolete plant with newer technical developments. This can be very useful when the removal of the complete plant may cause the customer difficulties.	See above

5.8 Existing Equipment Obsolescence

5.8.2 Techniques Difficulties

	Standardisation	Innovation	Ways to overcome the difficulties
Time	If integrated into the initial design this should not be an issue.	Some innovative solutions may take more time to develop.	When developing the standards of today allowance should be made for how the plant will be replaced at the end of its useful life.
Costs	If integrated into the initial design this should not be an issue.	A cost analysis should be made of retrofit or refurbishment solutions compared to complete renewal to avoid excessive costs.	When developing the standards of today allowance should be made for how the plant will be replaced at the end of its useful life in a simple and cost effective way.
Staff resistance	This should not be a problem.	Staff may object to innovative designs to replace well proven familiar equipment.	Staff engagement in producing solutions to the problems of obsolescent plant is essential if the most effective results are to be achieved.
System operation practices	Provided that in introducing standardised interfaces it does not affect the operation of the plant this should not be a problem.	Care needs to be taken when introducing innovative solutions or retrofit that full consideration on the system operational aspects is considered.	When the proposal for dealing with the obsolescent plant is produced it is important that all relevant staff are included in the decision making process.

	Standardisation	Innovation	Ways to overcome the difficulties
Operator interface	This should not be a problem	When introducing innovative, refurbished or retrofit solutions care need to be taken to ensure that the established operator interface is maintained.	See above
Training	This should not be a problem.	Training will be required both for operation and maintenance of retrofit, refurbished or innovative plant.	If retrofit or similar is to be used then training of all relevant staff is important to the success of the process.
Environmental	Provided that there are no changes to environmental requirements then standard interfaces should present no problems.	The replacement equipment, retrofit or refurbished equipment must meet the latest environmental requirements.	The proposed solutions need to be checked against the environmental needs.
Company organisation	This should not be a problem.	This should not be a problem.	This should not be a problem.
H&S	Provided that there are no changes to H&S requirements then standard interfaces should present no problems..	The replacement equipment, retrofit or refurbished equipment must meet the latest H&S requirements	The proposed solutions need to be checked against the H&S needs.
Legislation	Provided that there are no changes to legislation then standard interfaces should present no problems.	The replacement equipment, retrofit or refurbished equipment must meet the latest legislation.	The proposed solutions need to be checked against the legislation.

5.9 Observations

From the tables above the following themes emerge. Firstly, it is clear that using innovation on each individual substation is not a viable way forward. This would lead to unrealistic use of engineering resource and a system which was uneconomic to operate as different spare parts would be required for each location. Furthermore, it would have a very high risk of human error as the operators would need to know many different styles of substation. It appears that the most effective use of innovation is in developing new designs and techniques which can be fully developed and established as standards for a fixed duration. These standards will need to be reviewed regularly to ensure that they comply with the latest developments in Health and Safety policies and legislation. The standards should make use of the latest and most innovative equipment and techniques including intelligent use of condition monitoring designed to provide real value to the operation of the power system.

As the introduction of each new stage of standard designs will require some change to the way in which the system is run and have an impact upon the daily life of the staff involved, it is essential that the staff concerned with each phase of the operation are fully involved and consulted before the new standards are introduced. Ideally they will be fully involved in the whole process to ensure the maximum success. Feedback should always be provided from the operation and maintenance staff to the designers so that those aspects which cause problems are resolved in the next generation design.

Finally, if the full benefit of introducing innovation into future standards is to be achieved then commercial innovation will also be required and a better system of co-operative working between the Utility and their Solution Providers may be required to deliver the projects of the future more quickly and efficiently with less risk.

6 GUIDELINES FOR CONTROLLED INTRODUCTION OF INNOVATION

In this section, some guidelines are given for those companies looking for the introduction of innovation in a controlled way.

In the first stage of the process special attention should be paid to the different innovation proposals that will face the organization, because not all of the 'strange' or new projects are innovations. Therefore, it is important to define, what exactly innovation is. It could be technological innovation or simply the adoption of a new process or way of working in the organization.

Suggested definitions for innovation, research and development may be as follows:

Innovation is the activity that leads to the release of new products, processes, or considerable improvements over the existing ones.

This could be translated into improvements, the creation of new products through the implementation of advanced technologies or the adaptation of other sector's technologies, the acquisition of advanced know-how (patents) and its implementation.

Research is the basic and planned investigation to discover new knowledge and a better understanding in the scope of the science and technology.

The research is materialized in original research, new knowledge, experimental studies and feasibility studies.

Development is the application of the research results or other scientific knowledge, in order to produce new materials, equipments or systems.

The result of the development could be new products, prototypes, pilot projects or conceptual formulas.

In the following figure, a roadmap summary for the innovation concept is shown, as well as the necessary stages from the identification of the new requirement until the final product or service (or opportunity):

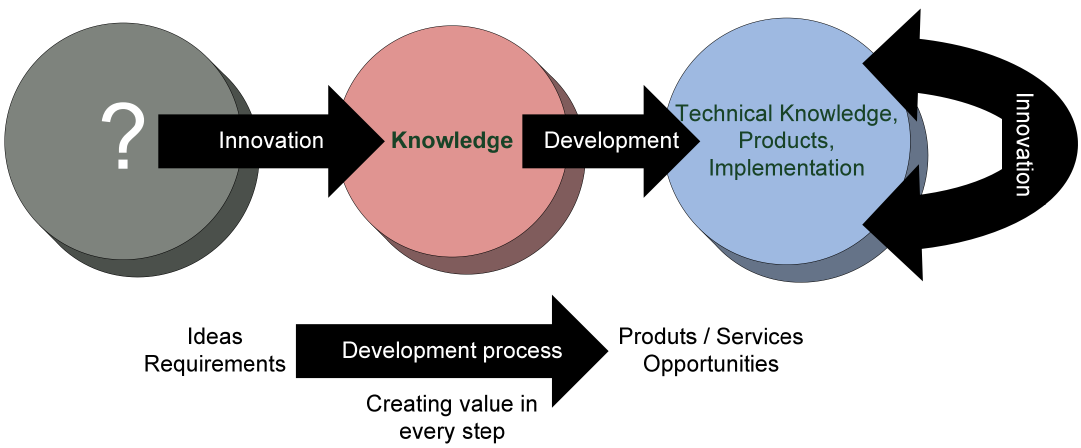


Figure 6.1: Creating value

Considering all the information from the previous sections, and the experience of different companies (Utilities and Solution Providers) in introducing innovation in a controlled way we would suggest that the following guidelines may be taken into account.

These guidelines may be grouped as follows:

1.- Future development Structure.

2.- Future development Strategy.

3.- Future development Planning. Roadmaps.

4.- Future development Projects. Execution.

6.1 Future Development Structure:

When an organization is considering the development of innovation projects, the first step that needs to be taken into account is setting up a dedicated development unit or structure which leads everything related with innovation inside the company or which is responsible for the introduction of a particular innovation.

For the success of the innovation introduction process, it is really important that the senior management of the company is involved in this structure and committed to achieving the change required, providing material support and direction to implementation.

The development group should completely control the introduction of innovation and will be in charge of the management of the different development processes in the company.

They should define and review the innovation Company's strategy and control the fulfilling of the different future development objectives through for instance innovation and project portfolios.

When defining a future development management model or structure, there are a number of options that can be taken into account:

From the resources point of view, the future development structure could be external or internal:

External future development structure

A company may choose this kind of structure because the internal resources (human resources) are limited. However, a small internal group should supervise this external help by defining the main objectives (specifications) and validating the results. Also, the senior management of the company has to be involved to define strategies and a project leading group has to manage projects.

Although the company can get the desired results, one of the major disadvantages of this model is the loss of knowledge within the company.

Internal future development structure

All the structure belongs to the organization, therefore, this option consumes more of the companies resources.

In contrast to the previous option, all the innovation knowledge will remain within the organization.

Finally, both structures may be united through open innovation where external and internal resources work in a same team.

From the organization point of view, it can be distributed or centralized:

Distributed future development team:

In this model, there is a group which manages the support of the different business units; cross-functional teams are then in complete interaction.

Technicians belong to the different departments of the company and help on a part time basis in the innovation projects. As a consequence, although the innovation resources are limited, the resultant structure is in deep contact with the core business.

This kind of organization is suitable, but not limited to, for the external structures explained previously.

Centralized future development team

There is one or more dedicated units with their own human resources. This way of working will provide faster answers and solutions. However, this group could easily lose contact with the real needs of the company.

It is suitable for the internal structures explained above.

After having chosen the most suitable structure from these options, the resultant structure needs to focus on the following objectives:

6.1.1 Company's innovation necessities definition

This Future development Plan provides a business' long term global vision which will be developed in different short and medium term projects. In order to achieve this global challenge the defined structure must be aware of:

- The various needs of the Company (considering the different business units).
- The State of the Art of the different processes or products in which the company is involved or interested in.
- Opportunities offered by the surrounding environment: new technologies (Technological watch).
- Identification of the barriers to fulfil specific milestones.

6.1.2 Future Development Culture

The company's senior management team which participates in this group, should also promote every business unit's participation, with innovative ideas and suggestions, in order to set up the desired culture. For the success of this promotion and participation, specific innovation training programs should be developed showing:

- What exactly is innovation?
- Benefits and advantages for the organization.
- How can they face innovation?
  - - How to manage it?
  - - Future development plan and strategy definitions.

Each of the business units should participate in the future developments plan definition as it is shown in the next picture:

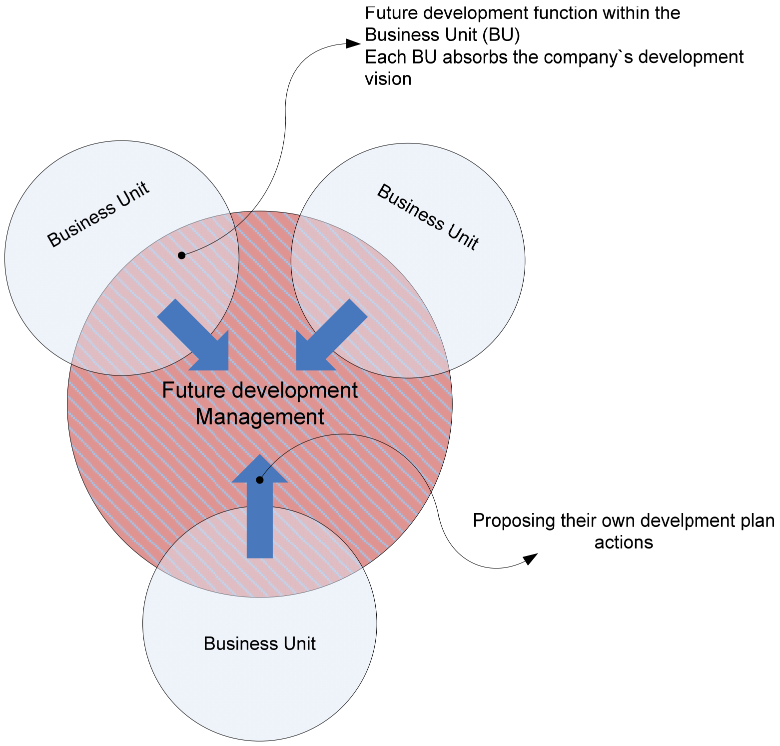


Figure 6.2: Future Development Culture

6.1.3 *Future developments plan evaluation*

Once the innovation structure has been developed and the different budgets have been defined, this development group should evaluate all the innovation processes. For instance, the following processes may be put forward:

- Managing the innovation portfolio
- Using stage-gates to manage innovation projects
- Industrialization/commercialisation

Therefore, innovation process indicators will be set up, identifying possible improvements in the overall innovation process and suggesting the corresponding solutions.

6.1.4 *Knowledge management*

The Future Development Structure will manage the company's technological knowledge. Special attention should be paid to specific training processes that show within the company all the future development efforts (projects) and the results obtained within the company.

6.2 Future Development Strategy

Once the Future Development structure has been established, an appropriate innovation strategy should be defined. In order to find the most effective one, the strategy has to be developed in accordance with the overall Company's strategy (i.e. the objectives of the company).

Therefore, the future development team should focus its efforts and decisions on maximizing the value to the company. Otherwise, they will never get the required resources to develop the final strategy. In summary, if no value is obtained, innovation will never be worthwhile.

Once this step has been taken, it is suggested that the management group define the required resources (man-hours and budget) in order to fulfil the pre-defined strategy and objectives. As a consequence, it is very important that the Senior Management of the company is involved in the definition of this new development strategy.

The defined innovation strategy will involve every part of the company. In order to achieve the ultimate company's objectives, every business unit within the company will face their own innovation challenges and objectives.

In the next picture, an overview of the different factors that may influence in the strategy elaboration is shown.

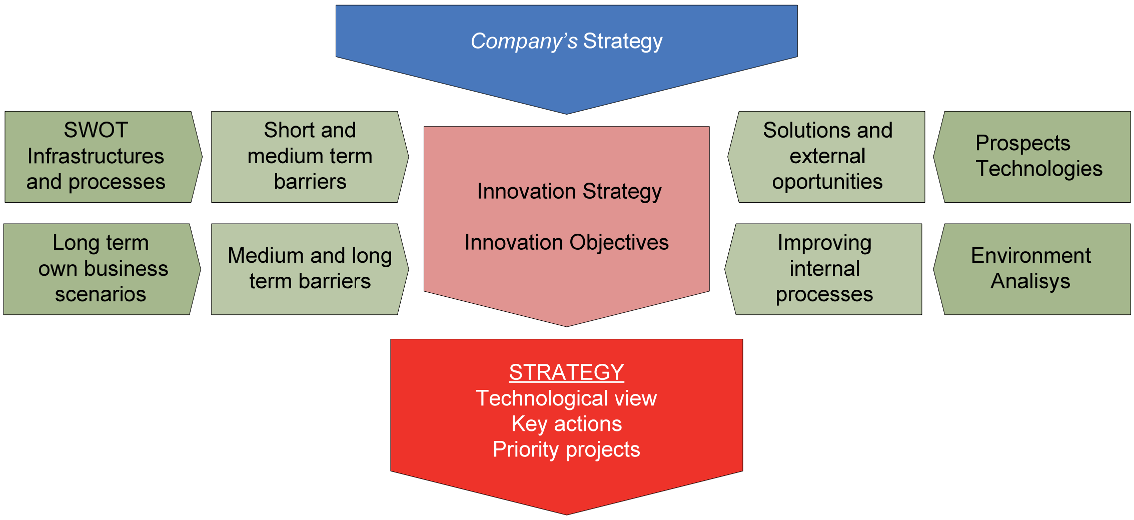


Figure 6.3: Strategy influence factors

This Future Development Strategy should be defined on a medium/long term basis, considering all the possible benefits and risks when developing the different innovation proposals. The Strategy and the associated innovation ideas should also integrate both requirement and technology evolutions on a short/medium/long term basis.

For the success of the strategy, it is very important to communicate it properly within the company, at all levels. Every unit should participate in the objective definition and should also be informed about the different objectives and principles behind each process (setting up the desired future development culture); as well as the proposed planning in order to participate actively in the related projects. This communication function, as a task of the future development team, is fundamental to create the desired future development culture.

The strategy, and the consequent objectives should be reviewed frequently.

6.3 Future Development Roadmaps (Implementation Plan)

The strategy will be deployed around a few priority innovation ideas. Each of them will have assigned a roadmap (covering the short, medium and long term) that will allow the future development team to identify the gaps and barriers. These will trigger some of the projects.

There are two different approaches for the roadmaps development:

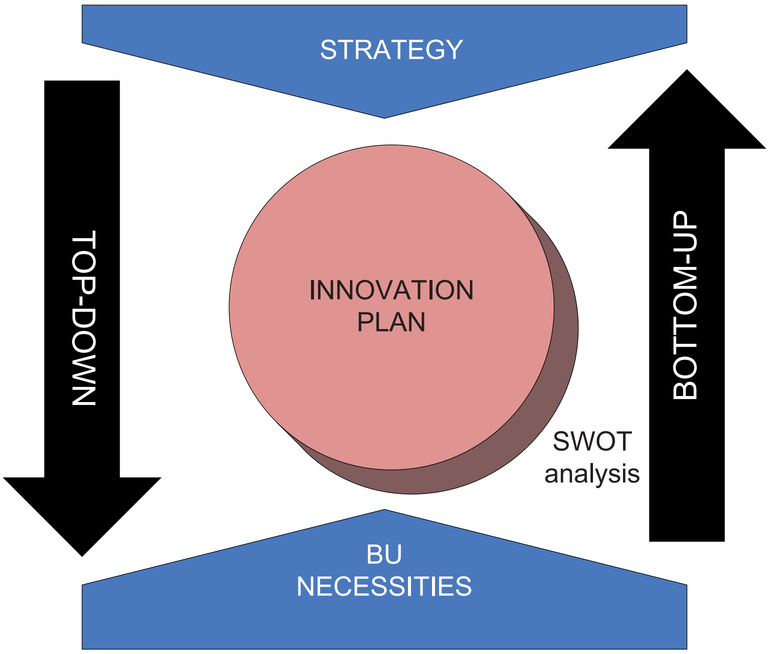


Figure 6.4: Roadmap approaches

1.- TOP-DOWN: The plan is defined from the organization's global strategy.

2.- BOTTOM-UP: the different business units propose their own actions in order to fulfil their short term necessities. The defined future development plan will cover the different gaps identified when comparing all those BU necessities with the company's strategy (SWOT (Strengths, Weaknesses, Opportunities, Threats), analysis, etc). The resultant actions will be gathered in a global plan to accomplish with the defined strategy.

The different steps that an innovation implementation plan should consider can be summarised as follows:

- Setting up the project portfolio.
- Portfolio management process.

These two stages are normally carried out during the strategy definition by the future development team. During the project portfolio definition the following points could be taken into account :

- Identify clearly the objectives, to have a clear vision and develop key parameter indicators:

  What do you want? Normally a new requirement to be covered or an existing procedure or application to be improved.

- Innovation introduction is often difficult due to various reasons:

Utilities are rather conservative companies; people normally are not fond of changes. If it works at present, why should I change it?

Initially, companies do not want to be the first ones to apply an innovative solution. Therefore, a deep justification is needed.

In order to get the required resources, innovation projects must add value to the company and the following have to be measured for all projects:

Reduction in costs and time (for example, by reducing maintenance, facilitating operation, etc)

Social, environmental reasons.

Technical reasons.

In addition, the justification should include a risk management analysis, both for the global innovation portfolio and for the associated projects. The resultant proposals have to be balanced:

Risk balanced, including low, medium and high technical risk projects.

Balanced by the timing of innovation (long, medium and short term)

So, for project basis, it is necessary to study not only the advantages but also the difficulties and challenges involved when introducing innovation:

External benchmarking is always useful, learning from others that may have faced similar problems.

Where and when are you going to innovate?

How much does it cost? Investment return rates have to be calculated from the beginning of each project.

Possibilities of the final product, are there new opportunities?

6.4 Future Development Projects (Execution stage)

This last stage normally includes:

- Project management, including the definition of deliverables (for example: partnership, needs of business units, technology, project value, etc.), at each project stage.
- Execution or application.

These two last stages belong to the implementation project plan. A strong implementation team (project team) will be in charge of this part.

In summary, after having developed and clarified the necessary future development structure and strategy during the innovation project stages, the following steps are normally considered:

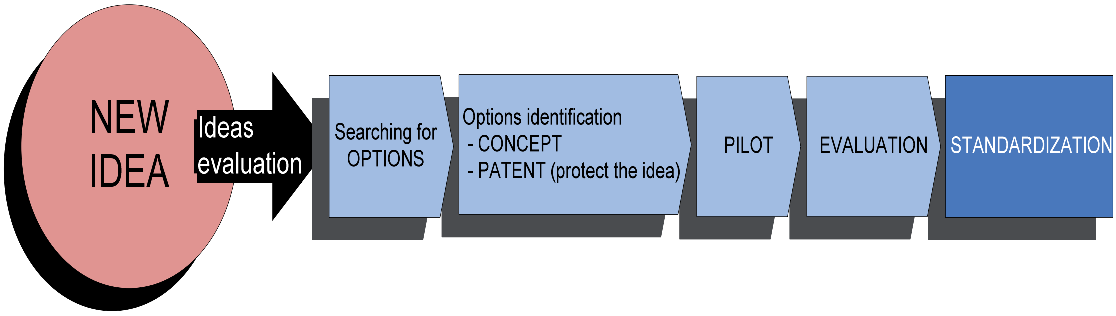


Figure 6.5: Innovation project steps (stage gate)

- Innovation procedures or processes must be introduced gradually, *STEP by STEP*:
    - Identify options that fulfil the requirements
    - Concept proof and design a pilot project.

- Collaboration: During this implementations stage, coordination and communication between the affected areas are very important
    - The different business units involved in the project should participate from the beginning (not only during the design stage, but also during the application and final evaluation); this is a major issue and a key to the future success of development projects.
    - A close collaboration between the different companies in the electrical sector (utilities, consultants and solution providers) is vital during the whole lifecycle of the application, including post-delivery support.

- Communication: In order to publicise the results and the new products or processes, *communication and training programmes* should be developed within the company. All the involved business areas should be informed regularly about the progress made.

- Evaluation or testing plan:

Once each project step has been finished, an evaluation must be done to ensure that the defined objectives have been achieved and the final viability (through the defined key parameter indicators).

In order to decide whether the final products or process is acceptable for the company, all the conclusions from the future development team must be discussed, *Have the initial objectives been achieved?*

- Certification and standardization:

If the future development team, including the senior managers of the company, consider that the application of innovation adds value to the company, its treatment should be extended as a company standard.

In conclusion, companies should implement an innovation process, and only once that process succeeds, should it be standardised and introduced to the rest of the company.

7 INTEGRATING INNOVATIVE SOLUTIONS INTO THE NEW GENERATION OF STANDARDS

7.1 Introduction

As described in chapter 6 the process of integrating innovation into a new company application standard begins with the specification for the innovation i.e. introduction of the innovation should be considered from the beginning as the first step in the creation of a new standard

The specification for the innovation should include, taking care to avoid being too prescriptive or limiting, any relevant interface or operational requirements which will facilitate its introduction into existing operational & construction environments

The maximum benefit will be gained from a new standard where there is a sizable ongoing construction programme. If the foreseen work programme over the next number of years (say 3 to 5 years) is small then the effort involved in creating a new standard may not be worthwhile.

Introduction of a particular standard may impact on any or all of the following areas:

- Design/engineering
- Procurement
- Construction
- Commissioning
- Operation
- Maintenance

Therefore the decision to create a standard needs to be a considered one.

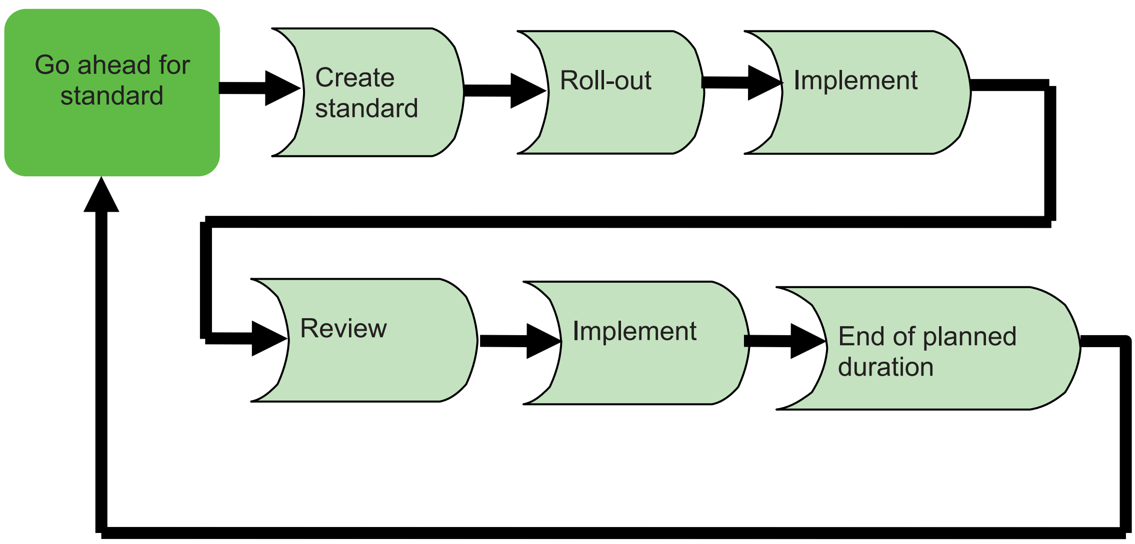


Fig. 7.1 Standardisation Process

7.2 Review of Initial Pilot project

The innovation is likely to have been deemed worthwhile trying based on the results of a feasibility study which itself is likely to have been based on a number of assumptions e.g. budget costs.

Therefore the results of the innovative solution pilot project must be reviewed against the planned objectives e.g.

- Reduction in procurement cost
- Reduction in installation cost
- Reduction in engineering cost
- Reduction in project cycle time

In considering the installation and engineering costs the one-off development costs associated with the first implementation must be excluded.

There is likely to be pressure from the Asset Management function to get the new standard into service as quickly as possible to get the earliest use of the planned benefits.

A careful assessment is required as to whether or not the pilot project has produced an outcome which is to an adequate standard across all of the required areas to allow this. Premature introduction of a new standard is likely to result in a period where ongoing changes are required to the “standard”. Too much of this will lead to disillusionment with the whole standardisation process.

Since actual product is now available it is now possible (and essential) to get either a sign-off or a list of specific issues which need to be considered from the Construction, Commissioning, Operation and Maintenance functions.

Depending on the level of outstanding issues a further iteration of the pilot process with an improved design may be required before considering standardisation, i.e. avoid premature lock-down of the design.

7.3 Scoping

The scope of the new standard must be clearly defined so that all parties are clear what is included in the standard and also what is not included, to prevent subsequent misunderstandings over any changes. This scope may not necessarily include all parts of the pilot project.

The physical interfaces of the new standard design with other standards or with variable parts of the standard must be clearly defined.

7.4 Implementation Process and Issues

Formal agreement to the new standard must be obtained from all relevant parties, in particular asset managers, commissioning staff, operating staff.

The situations in which the standard is to be applied should also be agreed. The pilot project is likely to have been set up around the most common situation .e.g. the use of MTS (Mixed Technology Switchgear) in new Greenfield single busbar stations.

Once the standard has been created it should be agreed how widely the standard is to be used in related situations e.g. for extensions to existing stations, for refurbishment in existing stations, use in double busbar stations etc.

If this decision is not made at the beginning there should be an understanding that use of the new standard must be considered first in any new situation. Any decision not to use it must be reserved to senior management

The approved list, which should be as short as possible, of variants to the standard design must also be defined. With HV equipment standards for example a small number of options in current transformer rating may be required to allow the standard to be applied successfully in all parts of the network. A certain element of overprovision may be required as standard to reduce or remove the need for expensive customisation.

An example is the provision of test facilities where a single standard test socket, sized for the most complicated protection scheme could be used for all protection relays and the functions allocated to individual pins on the test socket are also standardised as far as possible.

A1 I_R	B1 I_S	C1 I_T	D1 I_N
A2 V'_R	B2 V'_S	C2 V'_T	D2 V'_N
A3 V_R	B3 V_S	C3 V_T	D3 V_N
A4 I_{REF}	B4 I_{REFN}	C4 V_{do}	D4 V_{dn}
A5 Trip TC1	B5 Trip TC2	C5 Start CBF	D5 AR Close
A6 Uy1-	B6 Block Dupl. AR	C6 CB Status	D6 CB Ready
A7 PTT Tx	B7 PTT Rx	C7 PTT Ch. Fail	D7 Carrier Start
A8 DCEF Tx	B8 DCEF Rx	C8 DCEF Ch. Fail	D8 AR Block
A9 Ux1+	B9 U11+	C9 VT MCB	D9 Manual Close
A10 U11-	B10 U21-	C10 Us+	D10 Signals

Test socket for distance relay

A1 I_R	B1 I_S	C1 I_T	D1 I_N
A2 V'_R	B2 V'_S	C2 V'_T	D2 V'_N
A3 V_R	B3 V_S	C3 V_T	D3 V_N
A4	B4	C4	D4 I_y
A5 Trip TC1	B5 Trip TC2	C5 Start xCBF	D5 AR Close
A6 Dupl. Relay- (Uy1-)	B6 Block Dupl. AR	C6 CB Status	D6 CB Ready
A7	B7	C7	D7
A8	B8	C8	D8 AR Block
A9 Relay + (Ux1+)	B9	C9 VT MCB	D9 Diff. Prot. Block
A10 U11-	B10 U21-	C10 Us+	D10 Signals

Test socket for differential relay

A1	B1	C1 I_N	D1 I_{NE}
A2	B2	C2	D2
A3	B3	C3	D3
A4	B4	C4	D4
A5 Trip HV TC1	B5 Trip HV TC2	C5 Start HV CBF	D5
A6 Trip LV TC	B6	C6	D6
A7	B7	C7	D7 Block SEF
A8	B8	C8	D8
A9 U11+	B9	C9	D9
A10 U11-	B10 U21-	C10 Us+	D10 Signals

Test socket for overcurrent relay

The new standard must be fully documented e.g., drawings, material lists, order details, configuration details, test procedures, etc. with this information made easily available to all who may need to use it.

The planned duration for the new standard must be agreed. This must be as long as possible, at least 3-5 years, for any real benefit to be gained from the effort put into the standardisation process.

Procurement positions must be set in place to ensure that, as far as possible, all of the required material will be available for the planned duration of the standard. This may be particularly necessary for digital protection or control equipment and may require a certain element of advance purchase towards the end of the required period. In addition to the obvious situations due to hardware change this should also be considered in cases of software version change.

The final point is to ensure that a formal approval process, which should be biased to say no, is in place to deal with any proposals for revisions before this review date e.g. on safety or performance grounds. The approval level for this process must be at a senior enough level to ensure that a refusal to modify the standard is enforceable.

As mentioned earlier a standardised design will not always be the optimum solution for a particular project. Strong management control is therefore essential to stop individual efforts to “improve” or “optimise” the standard.

7.5 Roll Out

A new standard cannot be successfully rolled out by stealth. A formal planned roll out process of briefings, demonstrations, training etc. will be needed to provide adequate visibility of the new standard.
These need to cover the justification for and expected benefits from the standard as well as details of the standard itself.

Visible management support will be needed during this process to promote take up of the standard by the various affected parts of the company. This support is also required to encourage users to keep the larger picture in mind when faced with some of the compromises associated with adoption of standards. This support is likely to have to be maintained for a considerable period to encourage the development of an open-mind approach towards any problems which may arise during standard implementation.

The roll out process must also be actively planned so that all necessary designs, materials, procurement documentation, special tools etc. are in place before staff need to use them to apply the new standard.

All of the above are even more important if a standardisation process is being introduced for the first time.

7.6 Review Process

As mentioned above the new standard should be put into place for a long enough period to get a return from the standardisation effort, of the order of 3-5 years. However it would be counterproductive to insist that absolutely no changes can be permitted for this period.

A reasonable method of dealing with this issue is to also agree a planned review date, perhaps halfway into the planned duration of the new standard.

A process should be introduced whereby proposed changes or improvements to the standard are submitted to a review group which either rejects them or accepts them as providing a tangible benefit. However it is important that any resulting change is then parked until the review date when a single composite revision of accepted changes can be introduced.

An exception to this process will be required to deal with any safety-related issues which may need immediate implementation. However strong management control and a robust review process is essential to ensure that genuine safety issues are involved rather than a “safety” flag being used to push a change proposal which in reality should be handled through the change control review process described above.

8 CONCLUSIONS

During our investigations into ways in which standardisation and innovation may be combined, as described and explained in the previous sections, certain conclusions became apparent. This section attempts to detail these conclusions.

8.1 The reasons for standardisation and innovation tend to be the same

The results of the survey which we carried out showed that the eight most important reasons why a Utility would want to standardise are exactly the same reasons why they would wish to introduce innovation. This should not really be a surprise because Utilities will strive to achieve the best results whether it be from Standardisation or Innovation.

8.2 Constraints and difficulties against standardisation and innovation tend to be the same

The survey also showed that the difficulties which Companies face are also basically the same whether they are trying to introduce a standardised approach or an innovative solution. In fact the introduction of a standardised approach may be an opportunity for major innovation and step change for a utility.

8.3 Innovation may be in procedure, system or equipment

Innovation does not need to be limited to new plant or even new layouts, it can also be innovation in procedure or processes which can improve the efficiency or effectiveness of a Company.

8.4 The key drivers for standardisation and innovation are:

8.4.1 The reduction of true total cost

In a world which continues to become more and more competitive it is natural that Companies will continue to strive to minimise costs. The most obvious and easily identified are costs are those associated with the procurement of new capital plant. However, the operational costs, including maintenance, outage costs and their associated consequential costs must also be considered when choosing the right system and plant to be applied.

8.4.2 Reducing system operational risk

Another very important consideration is the reduction of risk. It is therefore very important that before a standardised approach is taken it is well proven to ensure that the operational risks are minimised. The use of sensitivity analyses when selecting between different solutions may be applied to minimise the risks.

8.5 Identification of innovation opportunities and the subsequent development into a standard require dedicated teams, resource and budget allocation

The development of innovative solutions requires a dedicated team involving all parts of the Company in the process for it to be successful. Trying to introduce innovation as part of a normal project to avoid the extra development costs is a false economy and will usually fail to deliver the hoped for benefits. It is therefore important that the required resource is identified and allocated to the process and the appropriate budget allocated.

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8.6 A structured approach to innovation is essential and needs to be value driven

When selecting and implementing an innovative solution it is important that a well structured approach is taken. Innovation should not be introduced because it is available but should be in response to a real need and its introduction will bring real value to the business. Consequently, the introduction of innovation needs to be developed as a business case

8.7 Involvement of all levels and functions within the business is essential; senior management must accept and drive the innovation

When introducing any new system into an organisation it is essential that all of those affected by the scheme are party to its development. This is particularly important for the people who will need to install, commission, operate and maintain the equipment. If the innovation is to yield real benefit the introduction process needs to be driven by Senior Management within the Company but in a structured way that enables the opinions and concerns of all involved to be taken into account.

8.8 Standardisation maximises the value of innovation

Individual custom-designed innovative solutions will rarely bring significant benefit to a Company. For the real benefits to be obtained in the longer run the new more efficient solutions need to be rolled out as a standard. In this way the value of the innovation will be maximised.

8.9 Development of the innovation to an application standard also requires a structured, value driven process

The process of converting an innovative solution into a standard is also not a trivial task and needs a similar structured and value-driven process to that used for the original introduction of the innovation..

8.10 Today’s innovations are the standards of tomorrow

As an industry we cannot afford to stand still and live with standard designs that are many years out of date. It is essential that innovation continues such that the latest, most cost efficient technology may be exploited. However to maximise the benefits to be derived from this technology the application of carefully developed standards is essential, such that the innovation of today becomes the standard of tomorrow.

9 APPENDIX A – UTILITY RESPONSES

9.1 Network characteristics – Utilities

In order to determine the characteristics of Utilities responding to the questionnaire Section 2 asked for some system information to determine the range of voltages, the size of the system and the intensity.

For example a respondent with only the lowest voltage levels and a high proportion of GIS with mainly cable connections could be classified as compact sub-transmission; respondents with mainly AIS extra high voltage equipment, and long overhead lines would be considered a sparse transmission network.

R1						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
90-170	30	1	170	3	44	2

R3						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
90-170	1	1		11	1	15

R4						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
171-300	5		12		5	
90-170	28		63		61	

R5						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
171-300	4	3	38	16	15	8
90-170	3	0	14	0	6	0

R6						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	13	1	99	7	39	0
171-300	29	3	248	21	98	6
90-170	27	1	181	6	83	0

R8						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	17	3	150	20	50	5
171-300	11	1	90	15	20	5
90-170	8	10	70	80		

R9						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
90-170	80		800		200	

R12						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
90-170	19	1	189	10		

R13						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	14	0	95		16	
171-300	35	2	107	4	41	5
69-170*	434		1200		many	many

R15						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	113	17	893		232	
171-300	100	6	854		321	
90-170	56	20	2267		1397	

R17						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
171-300	0	8	0	63	10	33
90-170	12	9	74	100	40	91

R19						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	4	9	81	201	54	0
171-300	18	15	311	73	79	18
90-170	13	31	238	52	112	75

R21						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	4	19	84	149	80	2
171-300	23	26	189	493	119	75
90-170	62	31	490	501	509	301

R22						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
171-300		15		150		30
90-170						

R23						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	158	15	741	161	800	20
171-300	177	10	604	52	600	50
90-170	0	0	780	21		100

R24						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
>550	1				2	
301-550	32	1		3x6	60	
171-300	45				89	
90-170					7	

R25						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	7	12	44	77	41	2
171-300	39	7	270	48	133	12
90-170	32	5	317	50	74	7

R31						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	3	1	13	7	3	3
171-300	26	6	175	35	50	33
90-170	127	14	725	82	213	152

R35						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	8	4	351	139	43	0
171-300	111	2	623	18	228	2
90-170	105	1	208	8	307	5

R36						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	27	3	125	15	38	2
171-300	65	5	321	24	75	39
90-170	45	0	222	0	80	4

R39						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	142	15	793	88		
171-300	408	53	1641	224		
90-170	0	0	0	0		

R42						
Network voltage	No. of substations		Number of CBs		Number of	
kV	AIS	GIS	AIS	GIS	OHL ccts	Cable ccts
301-550	3	6	72	51	19	0
171-300	17	15	252	131	112	22
90-170	84	10	442	78	240	17

Table A-1 - Responses to Question 3.2 - What did Utilities standardise?

The following tables summarise the responses of utilities to a request for information about their **“standardisation”** activities. The column headed “No. adopting” is the total number of respondents who indicated that they had standardised in a defined area. The two rows labelled **“E”** earliest, **“L”** latest, **“Mi”** minimum and **“Ma”** maximum indicate the range of dates or durations taken by respondents. The data is not co-ordinated across columns; e.g. the respondent who initiated standardisation in 1962 did not necessarily take three months to create the standard or spend 6 Man-months of effort

Indicate the areas where you follow a standard			When did you initiate standardisation?		How long did it take to create the standard (months)?		How long did it take to create the standard (man months)?		How often do you review?	Was a training program necessary?	
	A		B		C		D		E	F	
Technology standardisation:	**No. adopting**		**Year**		**Months**		**Man-months**		**Months**	**Yes**	**No**
Protection systems	20	**E**	1962	**Mi**	3	**Mi**	6	**Mi**	12	9	9
		L	2006	**Ma**	60	**Ma**	24	**Ma**	60		
Substation automation and control	19	**E**	1962	**Mi**	6	**Mi**	6	**Mi**	12	10	8
		L	2005	**Ma**	36	**Ma**	60	**Ma**	72		
Primary switchgear	17	**E**	1962	**Mi**	2	**Mi**	4	**Mi**	12	3	13
		L	2001	**Ma**	24	**Ma**	24	**Ma**	60		
Civil works	12	**E**	1962	**Mi**	2	**Mi**	2	**Mi**	36	3	8
		L	2005	**Ma**	12	**Ma**	12	**Ma**	60		
Substation Auxiliary systems	17	**E**	1962	**Mi**	2	**Mi**	2	**Mi**	12	2	13
		L	2001	**Ma**	12	**Ma**	20	**Ma**	96		

Indicate the areas where you follow a standard Process standardisation:	A No. adopting		When did you initiate standardisation? B Year		How long did it take to create the standard (months)? C Months		How long did it take to create the standard (man months)? D Man-months		How often do you review? E Months	Was a training program necessary? F Yes	No
Engineering	17	E	1990	Mi	1	Mi	2	Mi	12	4	13
		L	2005	Ma	24	Ma	48	Ma	36		
Commissioning	13	E	1990	Mi	1	Mi	2	Mi	12	6	7
		L	2006	Ma	12	Ma	24	Ma	36		
Management	12	E	1990	Mi	5	Mi	10	Mi	12	4	7
		L	2005	Ma	12	Ma	30	Ma	36		
Maintenance	15	E	1990	Mi	6	Mi	2	Mi	12	8	7
		L	2006	Ma	24	Ma	60	Ma	36		
Operation	8	E	1991	Mi	1	Mi	10	Mi	12	3	4
		L	2005	Ma	12	Ma	24	Ma	24		

Table A-2 - Responses to Question 4.1.2 - What did Utilities innovate?

The following tables summarise the responses of utilities to a request for information about their **"Innovation"** activities.

Respondent	Indicate the areas where you have introduced innovation	When did you initiate innovation ?	How long did it take to select an innovation (months)?	How long did it take to define your requirements (man months)?	How often do you review?	Was a training program necessary?	
Protection systems	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R3	Standardization on relays that are IEC 61850 compliant	2004	6	6	as required	1	0
R3	Incorporation of Arc Detection devices on AIS switchboards	2006	3	3	as required	0	1
R3	Remote Voltage indication for cable isolation.	2006	3	3	as required	0	1
R4	Digital protection	1999	6	3	on going	1	0
R5	Digital protection	1996	3	3	as required	1	0
R6	Digital protection	1999	4	0	as required	1	0
R8	Digital relays	1995	6	12	0	1	0
R8	Current diff. Prot.	1995	12	6	120	1	0
R13	Eleminate Lock out relays	2006	2	1	being installed	1	0
R21	Digital protection	2006	2	1	being installed	1	0
R31	Digital protection relays	1995	3	6	60	1	0
R31	Circuit protection relays with	2005	12	1	60	0	1
R39		2005	12	48	12	1	0
R43	Digital relays	No data					
R43	Multi-function relays	No data					

Substation automation and control	Description of the innovation	Year	Months	Man-months	Months	Yes	No
R3	Software interlocking on Switchgear	2004	6	6	as required	0	1
R4	Software voltage regulating	2000	6	3	on going	1	0
R4	Plant monitoring	2003	3	2	on going	1	0
R6	Interlocking software system	1995	4	12	as required	1	0
R6	Automatic operator soft system	1997	6	24	as required	1	0
R8	Digital control	1990	6	6	0	1	0
R21	Automatic restoration system	1982	84	0	as required	1	0
R31	Substation control system	2000	6	6	60	1	0
R31	Event recorders	1990	3	3	60	0	0
R36	Single-pole reclosing on 230kv lines	2006	12	3	0	0	1
R39	Protection&control&Auxiliary Services integration	2004	24	48	12	1	1
R39	61850 communications infrastructure	2006	12	72	12	1	0
R43	Programmable logic controllers	1990	0	0	0	0	0
R43	Human-machine interface	1990	0	0	0	0	0
							0

Primary switchgear	Description of the innovation	Year	Months	Man-months	Months	Yes	No
R1	Disconnecting CB	2006/2007	12	12	as required	0	1
R3	Non-withdrawable CB's, low maintenance, non-oil equipment	2005	3	6	as required	0	1
R4	Gis	2006	2	2	on going	1	1
R5	AIS compact designs	2005	12	6	60	1	0
R6	HIS compact designs	2006	6	18	as required	0	0
R15	Hybrid switchgear	2005	12	4	as required	0	1
R21	One point switch 500kV CB	1997	6	15	as required	0	1
R31	Gis	1975	3	6	60	1	
R31	Hybrid/compact switchgear	2003	6	6	60	1	0
R35	Install 36 & 52 kv GIS instead of air insulated switchyard	2000	2	12	48	1	0
R36	Elimination of closing resistors on 500kv breakers, use of SA's and POW controllers	2003	1	2	0	0	0

R39	NSR substations (new HIS configuration)	2004	12	60	24	1	1
R43	Air blast CB	1950	0	0	0	0	0
R43	Minimum oil CB	1970	0	0	0	0	0
R43	SF6 CB	1990	0	0	0	0	0
							0
Civil works	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R4	Modular control buildings	2005	3	3	on going	1	0
R31	Surface control ducts	1979	1	1	60	0	0
R31	Multi-phase foundations	2000	1	1	60	0	1
R36	Re-use of existing foundations when replacing old breakers	2003	1	2	0	0	1
							1
R3	Power quality meters on new switchboard installations	2006	3	3	as required	0	1
R6	Automation system	1999	3	9	as required	1	1
R8	Digital generator Control	1995	1	1	0	0	0
R13	Dual DC system	2005	1	1	as required	1	1
R39	Auxiliary Services devices reduction	2006	12	12	12	1	0
							0
Engineer	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R3	Define scope of works early, engage project managers and outside consultants when required.	2004	3	6	as required	0	1
R5	Involve contractors early	2004	6	6	36	1	1
R8	Cad	1990	6	12	0	1	0
R31	Intelligent schematic software	2001	2	2	0	1	0
R31	Software	0	0	0	0	0	0
R36	5-year blanket orders for all major equipment, with type approval of drawings/type of equipment	2003	4	3	0	1	0
R39	Substation Engineering Tool (61850 and non 61850 systems)	2007	24	72	6	1	0
R43	Company standards	0	0	0	0	0	0
Commission	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R6	To execute the FAT Tests	2003	6	12	0	1	0
R35	Inspection, testing & acceptance process	2004	36	72	60	1	0

R36	Elimination of Doble testing on most SF6 equipment	2002	1	0	0	0	0
R39	Automatic Commissioning protocol generator	2006	12	36	12	1	1
							0

Manage	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**

Maintain	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R3	Condition based maintenance on most aparatus	2004	3	6	as required	0	1
R4	Transformer monitoring	2001	on going	on going	on going	1	1
R5	Condition based maint.	2002	12	24	36	1	0
R21	External diagnosis(AE)	2001	12	10	as required	1	0
R21	Operation time monitoring device	1998	22	120	as required	1	0
R3	Condition based maintenance on most apparatus	2004	3	6	as required	0	0
R36	Streamlined maintenance on 500kv series cap banks	2002	6	3	0	1	1
R39	Amigo' Project (Maintenance managing system)	2006	24	48	?	1	0
R43	Computer-aided	1985	0	0	0	0	0
							0

Operate	Description of the innovation	Year	Months	Man-months	Months	Yes	0
R8	Gis	2005	12	12	0	1	0
R21	Automatic sequential operation program	1985	84	0	as required	1	0
							0

9.2 Descriptive feedback - Utilities

The following table summarises the responses of utilities to a request for additional comments in respect of successes or failures of **Standardisation** activities in Question 3.5.

Respondent	Group	Comment
R39	Business	Due to the increase in the number of projects a more efficient way of working was needed: Standardization of all the engineering, construction & commissioning procedures was adopted. The new Power System quality and safety requirements also lead to the stand
R39	Legacy	The standards referred are usually Application Standards
R39	External	Standardization help a lot to our suppliers and colleagues: Usually these standards are published allowing our suppliers to know exactly what we need

The same respondent R39 also indicated that it would continue with application standardisation but would make the following changes:

- Normally standardization processes are established in a short period of time
- More time is needed to assume the new processes, to show the benefits.
- All the affected areas should participate in the standardization process.

The following table summarises the responses of utilities to a request for additional comments in respect of successes or failures of **Innovation** activities in Question 4.1.5.

Respondent	Group	Comment
R13	Business	Management involvement in the discussion was the most important factor in approving the changes.
R19	Business	Installation of Knowledge database makes the performance more efficiency such as data-management, maintenance, planning etc. However, it takes a lot of time from installation to fixation.
R21	Business	Installation of Knowledge database makes the performance more efficient. For example, we reduce approximately 975 working hours per one branch.
R23	Business	resource constraints to manage the pilot and move to implementation. Lack of priority given to pilot schemes in advance of a impending project need.
R36	Business	The elimination of closing resistors and use of high-energy SA's and POW controllers on switching 500kV circuit breakers brought multiple benefits: lower equipment costs, improved reliability, lower maintenance costs. Similarly, re-using existing foundations and control wiring when replacing circuit breakers has reduced overall costs. On processes - by introducing 5-year blanket orders, Engineering and Procurement costs were reduced significantly, as specification time and drawing approval processes have been simplified.
R39	Business	For the innovation introduction, time and money are needed in the beginning of the process. Sometimes getting them is difficult because results appear some months / years later. Innovation is always difficult in these kind of companies (conservative)

R19	Legacy	Automation and Automatic restoration system improve operation performance and shorten the outage time. However, Fault locating system is too expensive to install everywhere, so it is installed to important substation.
R23	Legacy	The interoperability of new protection with existing infrastructure. On protection systems the managing remote end protection modifications. Substation wide protection/control mods are very difficult e.g interlocking, busbar protection - getting outages is the key problem. Work that affects more than one substation bay. Ongoing impacts to substation auxiliary loads.
R36	Legacy	The old Engineering organisation has initially resisted to the innovation process, but the changes allowed it to overcome severe manpower shortages.
R19	External	Installation of VCB cuts down the usage of SF6 gas. The building cost of environment continous substation is high.
R23	External	Considering the application of pilots up to a national level and avoiding regional variations emerging. For information and software based systems the risk associated with security of remote and third party access. Issues like this significantly limits the uptake of new working methods
R39	External	Usually, the decision must be taken by different agents i.e. solution providers, manufacturers etc.

The following table summarises the responses of utilities to a request for additional comments on different approaches or solutions that would be taken after Innovation experience.

R12	Business	Talk to the top management business persons, instead of engineering and operations.
R23	Business	More resource dedicated to pilot projects. Keep any projects at a circuit or bay level and not substation wide until the problems have been resolved. The issues of IT access and remote access need to be addressed at the beginning and signed onto before the project commences. Managing change control of software systems. Life-cycle management costs need tobe established when considering an innovative product, particularly maintenance resources and training. ensure site is involved in any FAT.
R24	Business	Talk to the top management business persons, instead of engineering and operations.

10 APPENDIX B – CONSULTANT RESPONSES

10.1 Geographical coverage - Consultants

8 of the consultants who responded provided geographical information about the area in which they work and the coverage is shown in the table below:

Geographical area	No. of responding consultants active
Australia	1
Central America.	1
China	1
Denmark	1
Europe	1
Far East	2
Fiji	1
Georgia	2
Germany	1
Greenland	1
India	1
Indonesia	1
Iraq	1

Geographical area	No. of responding consultants active
Ireland	2
Kosovo	2
Middle East	4
North America	4
Northern and Central Africa	1
Norway	3
Bangladesh	1
Papua New Guinea	1
Portugal	1
South Africa	2
South America	3
Spain	4
Sweden	1

10.2 Business Characteristics – Consultants

There were eight consultants who responded with information about the characteristics of their business

Reference	No. of T&D clients	No. of T&D employees	Comments
R7	310	15	
R14	200	40	
R16	102	15	
R20	150	15	
R29	2	4	
R30	300	20	
R37	40	10	
R38	160	30	

The table indicates a range of Consultant business from very small, specialised consultants to international companies who provide support and advice across the complete spectrum of T&D activity.

Table B-1 - Responses to Question 4.2.2 - What did Consultants innovate?

The following tables summarise the responses of Consultants to a request for information about their **"Innovation"** activities.

Respondent	Indicate the areas where you have introduced innovation	When did you initiate innovation?	How long did it take to select an innovation (months)?	How long did it take to define your requirements (man months)?	How often do you review?	Was a training program necessary?	
Protection systems	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R14	Combined protection and control	2001	3	3	12	0	1
R29	Add automation functions	2003	6	3	1	1	0
R30	Integrate control & protection	1998	12	24	12	1	0
Substation automation and control	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R7	System control & measurement	1996	2	2	6	0	1
R20	Windfarm control via internet	2005	3	2	as required	0	0
R29	Integrate automation and SCADA control	2004	12	8	3	1	0
R30	Numerical control 220kv	2000	8	8	60	1	0
R37	Protection and Control Integration	2004	4	4	0	1	0
Primary switchgear	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R14	Compact switchgear	2006	3	3	1	0	1
R20	Partial discharge dectector	1995	36	12	6	1	0
R20	Busbar upgrading	**2001**	**0**	**1**	**as required**	0	0
R30	MTS single bay extension 110kv	2003	4	4	60	0	1
Civil works	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R7	Equipment supporting	1991	2	2	12	0	1

R30	Driven by move to MTS	0	0	0	0	0	0
Substation Auxiliary systems	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R37	New Auxiliary Services rack integrating AC and DC	2004	4	4	0	0	1
Engineer	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R14	Specification	2006	3	3	3	0	1
R14	Specification and configuration	2001	3	3	12	0	1
R16	Fluid filled cable removal	2001	12	12	6	1	0
R16	Cable fault locator (Gas sniffer)	2003	36	12	12	1	0
R30	CAE tools (EPLAN)	2002	18	6	0	1	0
R37	Imputation procedures	2005	2	2	12	1	0
Commission	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R30	Relay test equiptment	2002	6	2	0	1	0
Manage	Description of the innovation	Year	Months	Man-months	Months	Yes	No
Maintain	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R16	Condition based risk management	2000	24	24	2	1	0
Operate	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
Others	**Description of the innovation**	**Year**	**Months**	**Man-months**	**Months**	**Yes**	**No**
R16	Cable rating software package	1998	48	12	6	1	0

10.3 Descriptive feedback - Consultants

The following table summarises the responses of Consultants to a request for additional comments in respect of successes or failures of **Innovation** activities in Question 4.2.5.

Respondent	Group	Comment
R7	Business	Usually innovations introduced have contributed for better solutions, and were accepted and have produced the intended benefits, without further problems.
R16	Business	Certain customers are very reluctant to invest in the solutions offered until prooven by other clients.
R38	Business	Management concern with costs have not included consideration of widely accepted financing alternatives, e.g. including the cost of underground distribution in a 30 year home mortgage. Innovators, in every sector - manufacturers, consultants, etc., should consider financing alternatives to Utility Commission approval of a tariff increase. As an example, a GIS in a retail area with surrounding business paying the added costs over an extended period of time (10 years?)than one department are involved for the technical decision.
R7	Legacy	A very important concern is to maintain acceptability of proposed solutions, compatible as possible with prior trends.
R38	Legacy	The legacy problem of engineering and operating staff resistance to ANY change was corrected with replacement of utility management with aggressive business people who instituted forced retirement of a engineering/operation who insisted on clinging to outmoded practices.
R7	External	Always maintain compatibility with applicable legislation.
R16	External	Government targets are of main concern to our clients, so we try and provide solutions to help resolve the various network problems.
R38	External	Environmental legislation will FORCE change, and legislation will not go away. Innovation will be required to meet the legislative requirements, e.g. de-regulation, renewable energy sources

The following table summarises the responses of Consultants to a request for additional comments on different approaches or solutions which would be taken after **Innovation** experience in Question 4.2.6.

R38	Business	Talk to the top management business persons, instead of engineering and operations.

11 APPENDIX C – SOLUTION PROVIDER RESPONSES

11.1 Geographical coverage – Service Providers

7 of the Service providers who responded provided geographical information about the area in which they work and the coverage is shown in the table below:

Geographical area	No. of responding Service Providers active
Afghanistan	1
Asia	1
Australia	3
Canada	1
Central America	2
China	2
CIS-countries	1
Cyprus	1
East Asia	2
Eastern Europe	1
Germany	1
Iraq	1
Ireland	1

Geographical area	No. of responding Service Providers active
Japan	3
Middle East	3
Nepal	1
Nigeria	1
North America	3
Pakistan	1
South Africa	2
South America	4
South East Asia	2
Sri Lanka	1
UK	1
USA	3
various in Central Africa	1

11.2 Business characteristics – Solution providers by product range

Solution provider ref.	Range of products and services
R2	Turn-key substations up to 800 kV including all primary and secondary equipment
R10	132kV to 400kV turnkey AIS and GIS substations, Extensions to existing and rehabilitation of existing (replacement of circuit breaker only, protection only, etc). Medium voltage solutions offered when part of higher voltage package. Wind farm connections

R11	Complete turnkey projects for High Voltage Direct Current (HVDC) Specialised equipment (thyristor valves and controls) Flexible AC Transmission Systems (FACTS) installations.
R18	Gas insulated switchgear Gas circuit breaker Transformer Vacuum circuit breaker C-GIS IPB GMCB
R28	Real-time Information System software (SCADA, Substation master stations)
R32	Turn-key substation up to 550kv including all primary and secondary equipment GIS from 72 to 550kV GCB from 72 to 800kV Transformer up to 765kV Arrester Protection Systems Substation automation and control

Table C-1 - Responses to Question 4.3.2 - What did Service Providers innovate?

The following tables summarise the responses of Solution Providers to a request for information about their **"Innovation"** activities.

Respondent	Indicate the areas where you have introduced innovation	How long did it take to identify the market for the innovation or to generate interest in the innovation (months)?	When did you make it available to the market?	When did you first supply the innovation ?	How often do you review the product or innovation against market needs to determine if requirements have changed?	Was application / product training of the client necessary?	
Protection systems	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
Substation automation and control	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R10	Co-Location of Systems and Automation	2	2002	2002	9	0	1
R10	Common drawing platform	6	2003	2003	9	0	1
R28	Distributed software structure	12	1999	2004	4	1	0
Primary switchgear	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R18	Integrated GIS	12	2001	2001	6	0	1
R18	C-GIS	12	2001	2001	6	0	1
R32	Hybrid GIS	18	2001	2003	24	0	1
R33	Compact GIS	12	1998	2001	6	0	1
Civil works	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R10	Precast walls into floor	3	2002	2002	9	1	0
R10	Standard drawings	12	2005	2005	9	1	0

R10	Standard calculation methods	6	2005	2005	9	1	0

Substation Auxiliary systems	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R10	Standard drawings and documents	6	2005	2005	9	0	1
R33	Synchronous switching controller	24	2006	2007	6	0	1

Engineer	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R2	Reducing no. of interfaces by changing/developing eng. Tools	6	2001	2001	24	0	1
R10	Standard supplier drawings and agreements	6	2006	2006	36	1	0
R10	Standard structures	12	2005	2005	24	0	1
R10	MRP for projects	24	2003	2003	6	0	1

Commission	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R28	Spreadsheet definition of database & views	6	2005	2005	4	1	0

Manage	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**

Maintain	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R18	PDM for GIS	24	2001	2002	6	1	0

Operate	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**

Others	**Description of the innovation**	**Months**	**Year**	**Year**	**Months**	**Yes**	**No**
R11	Statcom	12	2002	2003	0	1	0

11.3 Descriptive feedback - Solution Providers

The following table summarises the responses of Consultants to a request for additional comments in respect of successes or failures of **Innovation** activities in Question 4.3.5.

Respondent	Group	Comment
R18	Business	Customer's own specification, application standard. Customer's organization that more than one department are involved for the technical decision.

12 APPENDIX D – COMMON INFORMATION FROM RESPONSES

12.1 Example of response weighting

The following spreadsheet shows how the responses to Question 3.4 were summated and weighted to derive an indicator of the relative significance of the identified difficulties and constraints. In the chart summaries published in Electra those scoring below 4% were omitted.

3.4	Main difficulties/constraints when applying it:		Weighted Value		Degree of difficulty					Changes?		Significance
	Factors				**1**	**2**	**3**	**4**	**5**	**Yes**	**No**	
		Time	71	Operational	5	6	5	3	1	10	9	15.88%
	Business	Costs	63	Cost	6	3	3	5	2	6	12	14.09%
		Staff resistance	48	Operational	1	4	5	2	8	8	11	10.74%
		System operation practices	45	Operational	3	2	1	7	5	8	9	10.07%
		Operator interface	40	Operational	1	3	4	3	5	7	7	8.95%
		Training	39	Operational	1	4	2	5	2	7	6	8.72%
		Environmental	36	Legislation	1	3	5	1	2	4	7	8.05%
	Legacy	Company organisation	34	Operational	1	1	5	1	8	5	10	7.61%
		Health & Safety	29	Legislation	1	2	1	3	7	4	9	6.49%
	External	Legislation	25	Legislation	3	1	0	1	4	1	8	5.59%
R39		outage time reduction	5		1	0	0	0	0	1	0	1.12%
R39		knowledge transmission	4		0	1	0	0	0	0	1	0.89%
R35		staff availability	3		0	0	1	0	0	0	1	0.67%
R36		resources	3		0	0	1	0	0	0	1	0.67%
R19		Not specified	2		0	0	0	1	0	0	1	0.45%
			447									

As an example, the weighted value for “Time” being considered the most significant reason for difficulty in applying standard solutions was made up as follows:

Value in column 4 is derived by taking the number who considered the particular difficulty to be level 1 difficulty and multiplying by 5, then the number who consider it to be a level 2 difficulty and multiply by 4 and so on to the level 5 difficulty which is multiplied by one.

and with the values substituted =

- (5*5) + (6*4) + (5*3) + (3*2) + (1*1) = **71**

The total weighted value of all responses to the Question 3.4 was 447. To derive a significance value the weighted score for each “Difficulty was divided by the total weighted value and expressed as a percentage

- (71/447)*100 = **15.88%**

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