CONFIGURING CONTROL CENTRES FOR COST EFFECTIVENESS AND RESILIENCE

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The paper briefly examines the various technological factors which enable a utility to introduce significant reconfigurations of its Power System Control scheme. The human and organisation factors which influence the maintenance of the status quo are also examined.

The trends which have led to a restructuring of power system control in a number of utilities are examined. In most cases economic forces lie behind the changes which can be identified. Issues which arise as a consequence of restructuring are discussed.

A number of examples of possible configurations relevant to the power utility in Croatia are discussed; budgetary prices for typical configurations are presented. One configuration is presented which ensures a very high level of reliability in the event that the National Dispatch Centre is unavailable for operation.

Key words: Control centre, SCADA, EMS, resilience, restructuring.

1. INTRODUCTION

Many countries in the Eastern Europe are engaged in a process of upgrading and enhancing their power systems. The age and condition of much of the transmission and generation plant dictates that significant investment is required to refurbish the existing systems. The systems and equipment used to centrally monitor and control the power system have become obsolete at a faster rate than the high voltage equipment. In particular there is a pressing need to completely upgrade many utility's SCADA and Energy Management Systems.

The demands from all sections of utilities for telecommunications facilities has been growing at a very high rate, largely driven by new business methods which are based on significant Information Technology projects. The extent of information needed by the System Control function has also grown at a remarkable rate.

Those utilities that, for a variety of reasons, are considering refurbishing or upgrading their Power System Control Centres (PSCC) are offered a much wider choice of computer system configurations than was available in the past. This paper examines the 'enabling factors' and the 'inhibiting factors' that influence the choice of PSCC configurations.

2. POWER SYSTEM CONTROL DEVELOPMENTS

The roles, functions and arrangements adopted to provide Power System Control have evolved dramatically over the last decade. These changes have been caused by a wide variety of factors, prominent among them are the following:

1. Opening up of a competitive electricity market in Europe,
2. A recognition that commercially available software and systems can enable a PSCC to considerably improve its performance,
3. An acknowledgement that the PSCC structures conceived some decades ago may not be relevant to today's organisational requirements.

The next sections discuss the factors which enable changes in the configurations of PSCCs to take place and those factors which tend to oppose such changes.

3. ENABLING FACTORS

The factors which make a significant reconfiguration of PSCCs possible are very largely based on the extraordinary growth in the capabilities and improvements in the price performance ratios now available in hardware and software. The main factors are summarised below.

3.1. Processing Power of Modern Hardware

The continuing growth in the processing power and improvement in the price performance ratios of computers has acquired the status of a natural law - Moore's Law - which states that processing power of computers doubles every 18 months. For a small fraction of the

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price of a mini-computer of the 1970s, one can now buy a Pentium processor, with a clock speed of 400 MH and a processing power equivalent to many powerful mini-computers.

The availability of very kennly priced hardware has effectively made almost unlimited processing power available to the PSCC.

Thus the most complex algorithms and processor intensive applications can be executed at a rate which meets all of the performance and response requirements of very large utilities - and at a modest price for the necessary hardware.

3.2. Large Capacity Databases

The older generation 16 bit hardware had a fundamental limitation in the size of files and databases that could be realistically handled in real-time. This led to a frequently encountered upper limit on the number of data-points which could be dealt with. The introduction of 32 bit hardware - and more recently 64 bit hardware - has increased the manageable size of databases enormously. Effectively there is no upper limit on the number of data-points that a SCADA system can now handle.

Coupled with the larger capacity data-base is the ability of fast processors to search, retrieve and manipulate data from such large files. This ability is in turn built on the very large capacity disk storage devices with their short data access times.

All these factors have made it possible for modern SCADA systems to deal with models of very large power networks in a highly responsive manner - in a way that earlier computer systems could never emulate.

3.3. Powerful and Standardised Applications Software

The algorithms needed to support State Estimation, fast decoupled load-flows etc. were largely well developed many years ago. However the processing power necessary to execute such programs in an acceptably short period of time were not available when older generations of SCADA systems were being developed. The low price of high performance processors means that it is now economical to run computationally intensive applications, in a manner which was unthinkable a decade ago. Thus a PSCC can now install and operate virtually any application that it chooses. The cost benefit ratio has made the expenditure on advanced applications - such as Contingency Analysis, constrained Economic Dispatch or Operator Load flow - easier to justify.

Another important fact is that the price of all applications software is falling! This good news stems from 2 asppects - firstly there is a larger customer base over which the development costs can be spread; secondly an improvement in the quality of software and a greater degree of standardisation has mental that customisation costs have reduced. The PSCC has benefited from these changes in that manufacturers now offter complex software packages at prices below that which applied some years ago. Again the PSCC can now afford and more easily justify the installation of software which may not have been affordable some years ago.

3.4. Powerful Remote Consoles

A Remote Console is a full functionality console which is located remotely from the main dispatch room. It enables a utility to geographical disperse its dispatchers. Provided a high capacity telecommunications link is provided between the Remote Console and the main PSCC hardware complex, the remote dispatcher has exactly the same facilities as a dispatcher located next to the computer system. Marginally slower responses may be obtained on the VDUs.

The benefit of employing Remote Consoles is that it enables dispatchers to be located in the same region as the network they are controlling. It gives the utility the opportunity to position a dispatcher, or scheduler of operations and maintenance activities, close to the personnel and systems for which he is responsible. Thus a Remote Console can be seen as a menas of giving back authority and responsibility to local staff, while simultaneously concentrating most hardware and software in a selected location.

3.5. Bandwidth and Capacity of Telecommunications Networks

A generation ago many links supporting SCADA applications relied on Power Line Carrier equipment, or on analogue voice channels on pilot cables. The effective available bandwidth was probable under 2,400 bauds. At the same time much effort was devoted to sharing channels or to designing a communications network with low capacity on all links.

The rapid installation of high capacity digital radio links and the increasing deployment of fibre optic facilities are 2 examples of how a modern utility is now moving, into a situation where a basic building block for any application is a 64 k bit/s link. Compare this data rate with a tyical RTU data communications speed of 1200 baud. The ready availability of such high speed links, and of very high capacity backbone networks, makes the design and implementation of links from a PSCC to remote substations or to other control centres easy to achieve.

4. INHIBITING FACTORS

The previous section has described the factors which enable change in the structure and scope of PSCCs to take place. There are a number of factors which have a

diammetrically opposite effect and these inhibit change from taking place. These are described in this section.

4.1. Reluctance to Accept Change

Some people welcome variety and change - most do not. Most organisations have an in-built resistance to change and it is one of management's main challenges to create the climate to allow change to take place and to motivate employees to 'take ownership' of the change. It would be wrong to assume that opposition to change is rooted in less experienced or less senior personnel. Managers themselves may have a fear of the future and a lack of confidence in their ability to make their mark in new organisations. But it is the responsibility of management to promote the future and to motivate staff to participate in the development of their organisation. Middle management may need to be led and motivated by senior management! In their turn middle management must motivate their staff to accept change and to take ownership of the future of the organisation.

4.2. Perceived Necessity for Local Knowledge and Involvement

In essence the development of large modern PSCCs involves the centralistation of activities. This is often seen as the removal of local knowledge and the disenfranchisement of local expertise. But as local networks grow more complex and spread across larger geographical regions is it really true to imagine that local knowledge is vital?

There is a distinction to be made between centralising where processing of information takes place, on one hand, and where resonsibility for decisions and actions is designated on the other hand. Centralisation of processing power can bring significant economic benefits and these should not be overlooked. There may be benefits obtainable from delegating responsibilites for local networks to local staff, this advantage can be exploited by using the capacity of modern telecommunications networks to transport information to Remote Consoles. But the question that must be asked and answered honestly is 'when all significant information upon which decisions can be made is available to an operator - because standard designs and data acquistion policies are in place - what does it matter where the operator is located?

4.3. Personal Comfort Zones

Society and industry was a more comfortable place to live and work in in the past. Work-loads and levels of responsibilities were lower. In general industry requires a greater commitment from its employees nowadays. Staff are now more frequently stretched - in terms of experitise reqired and work-loads - and are expected to be more committed to their jobs. Why should utility employees be exempt from such pressures - unless they and their employer jointly agree that lower standards and expectations are acceptable?

In terms of PSCC operations older work regimes placed the responsibility for the operations of perhaps 25 - 35 substations on each dispatcher. Now the norm is closer to 50 - 75 substations per dispatcher. This change moves employees out of a comfort zone into a regime where greater commitment is expected. In return for this commitment, industry generally rewards its employees with higher salaries and a participation in an industry and society which benefits from higher standards of living.

4.4. Lack of a Vision of the Future

Few power systems are operated in isolation. Few utilities can ignore trends in work practices or unit costs that are developing in neighbouring utilities. The global economy is clearly visible within the electrical system of western Europe. Failure to acknowledge this inescapable fact is to fail to have simple vision of the future and to ignore forces that are shaping the economic environmental in which PSCCs operate.

The large scale interconnection of the power networks of western Europe, and the introduction of competitive markets, means that lowest price units will displace high price units. There will be a diminishing space for cost producers - they will be displace by low cost producers. If transmission networks charge a high transit price, or if they have severe transmission line constraints, alternative bypass paths will be found. If a transmission network is poorly managed its revenues will be less than their potential, or quality of supply to customers will be poor. Economic 'hidey holes' are always short-lived and the more efficient operator will prevail.

Absence of a clear vision of the future can lead to attempting to deny what next year's developments will bring along.

5. MARKET TRENDS

A brief analysis of the electrical market and work practices reveals a number interesting tredns. The most noticeable are summarised below.

5.1. Economic Forces

An examination of the price of electrical energy in Europe shows that it has fallen over the last number of years, especially in those regions where competition has been introduced. This is an inexorable trend and one that will be felt in all countries in the EU. Croatia cannot escape the effect of this trend. Every participant in the electricity market will be under pressure to improve business performance.

5.2. Power of Electricity Regulators

Implementation of the EU Directive 92/96 requires the establishment of the Office of a Regulator, whose mission includes protection of public interest in the operation of the electricity market. The Regulator is unlikely to permit any entity with an effective monopoly - e.g. the PSCC - to operate inefficiently and to recoup undue costs from other entities in the market place. Thus it can confidently be expected that the Regulator will ensure that the System Operator must achieve a unitised operating cost comparable to, at least, the industry average. Failure to reduce costs and to perform efficiently will most likely lead to caps on charges that can be levied on charges for Use of System or System Operations.

5.3. Reduction in Number of Control Centres

A clear trend has emerged in many countries for a consolidation in the number of Control Centres. Consolidation in the number of Control Centres has been made possible by the technological factors mentioned in an earlier section, coupled with economic forces pressing down on costs. For example at the outset of the deregulation of the market in the UK, there were 5 control centres, now there is effectively a single centre. Similar events have taken place in Italy and in the USA. If Ctoatia is to follow the same trend, a reduction in the number of regional control centres can be expected to occur.

5.4. Improved Productivity of Dispatchers

In older Control Centres, individual dispatchers were responsible for monitoring and controlling a relatively small number of stations. This was partly attributable to limitations in the capacity of equipment to monitor larger numbers of stations, and also due to a lack of standardisation in the manner in which equimpment in a station was monitored. Both of these limitations have been, or are in the course of being, removed so that an individual dispatcher can now monitor and control a significantly larger number of stations.

Another factor which has improved the efficiency of PSCCs has been the introduction of partly manned Branch Control Centres (or Remote Consoles). Such Branch Control Centres may be manned during busy periods, such as the prime day shift or during periods of disturbances. Outside such times the Branch Control Centres can be closed and monitoring and control performed from the main dispatch centre. This capability has been enabled by modern computer hardware and software and by the introduction of high capacity telecommunications links.

5.5. More Focused Organisations

All organisations are more or less continuously under review for improved effectiveness and economy. The electricity industry is no exception, with frequent reorganisations and restructurings. Such changes inevitably lead to an examination of what exactly are the business objectives of the organisation. This examination frequently leads to decisions to reduce staff numbers, to concentrate on newly articulated core activities, etc. Such re-engineering of businesses puts increasing pressure on established departments and usually leads to searches for savings, reductions in staff numbers, improved work practices, etc. The outcome is always the same - the old tasks must be carried out by a smaller number of personne!

6. ISSUES TO BE ADDRESSED

Arising from some of the changes and trends discussed above, a number of important issues can be identified. The more significant issues are discussed below.

6.1. Management of Change Process

When a business is undergoing a re-engineering process, all parts of the organisation are likely to be subject to review and to some degree of change. Top management and middle management will be expected in their turn to assist in the change process. Clearly some managers will themselves be the 'victims' of the change and they may loose responsibility or be re-assigned to other work. It is important that each organisational unit participates fully in the business analysis process. Difficult and searching questions have to be asked and then answered honestly. The PSCC organisation cannot expect to stand immune from such examinations and subsequent changes.

It is a responsibility of top management to ensure that all units in the business are participants in the change process, including the PSCC.

6.2. Number of Dispatchers Necessary to Manage System

The idea of increasing the number of stations that each dispatcher monitors and controls was introduced earlier. There is no easy answer to the question as to how many substations or data-points that a dispatcher can manage. The number depends on the utility's own philosophy of operations, its own switching and safety procedures; its own maintenance policies, etc. A careful analysis of the possible operating arrangements needs to be undertaken and conclusions drawn from this analysis. Of course an awareness of what has emerged as best international practice in other utilities will assist in arriving at appropriate answers.

The answers to the issue will assist arriving at conclusions as to how many dispatchers are actually needed and how they might be optimally grouped.

6.3. Resilience against Failure

Earlier discussions indicated that a distinguishable trend is evident to reduce the number of Control Cen-

tres. Such a reduction usually means that the failure of a Control Centre impacts on a larger number of stations and on a larger number of customers. The demand for a higher quality of supply is ever present and this means that careful thought has to be given as to how to guard against the loss of a Control Centre. If processing power has been concentrated at a higher level, means must be provided for the management of system operations to be undertaken from another Control Centre. The challenge is to reconcile the potential to reduce the number of Control Centres with the introduction of a means to safeguard against the failure of a now more powerful and influential Control Centre.

7. EXAMPLES

In this section some examples are provided of options that could be adopted in Croatia for dealing with the issues discussed above.

7.1. Reduction in Number of Control Centres

In figure 1, a schematic diagram is provided of the configuration of Control Centres that currently exists in Croatia. Figure 2 shows one possible configuration which exploits the capability of modern hardware and software and telecommunications links to concentrate all system control equipment and personnel in a single location. A restructuring of the nature outlines in the figure would have a significant impact on the operating practices, staff locations, dispatcher productivity levels, etc. The change management challenges implicit in such a restructuring require considerable attention.

7.2. Guaranteeing Resilience In PSCC

In figure 3 slight variation on the configuration shown in figure 2 is presented, which includes an Emergency Control Centre. The Emergency Control Centre may be a replica of the National Dispatch Centre, or it may have somewhat limited functionality to achieve savings. The Emergency Control Centre is linked to all RTUs, any switching that is required can be carried out by software within the Telecommunications Network Management System, or by special software installed in both the NDC and the Emergency Control Centre. In this example Remote Consoles are also included as an indication of how a degree of local autonomy call be achieved.

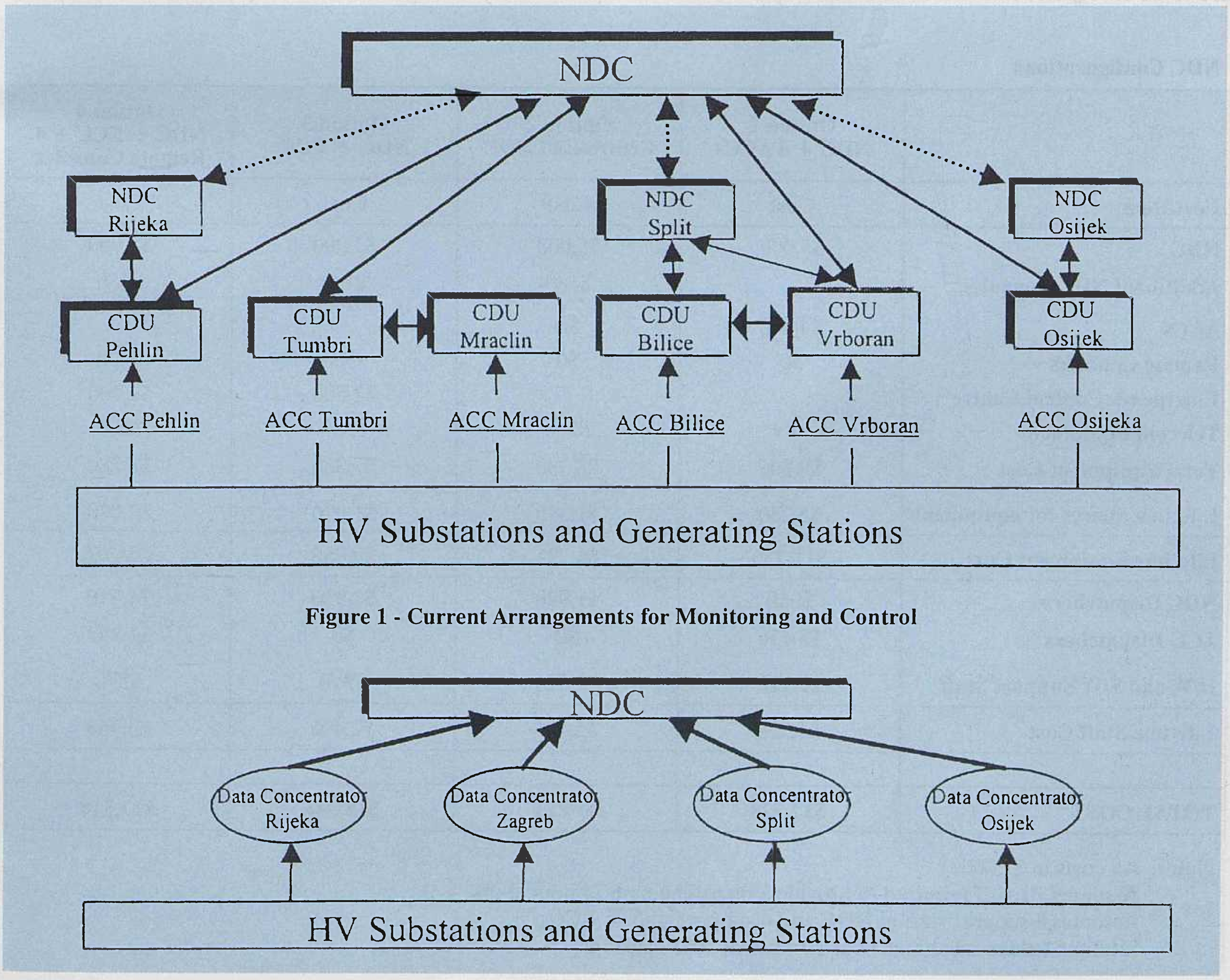

Figure 1 - Current Arrangements for Monitoring and Control

Figure 2 - Centralised National Dispatch Centre

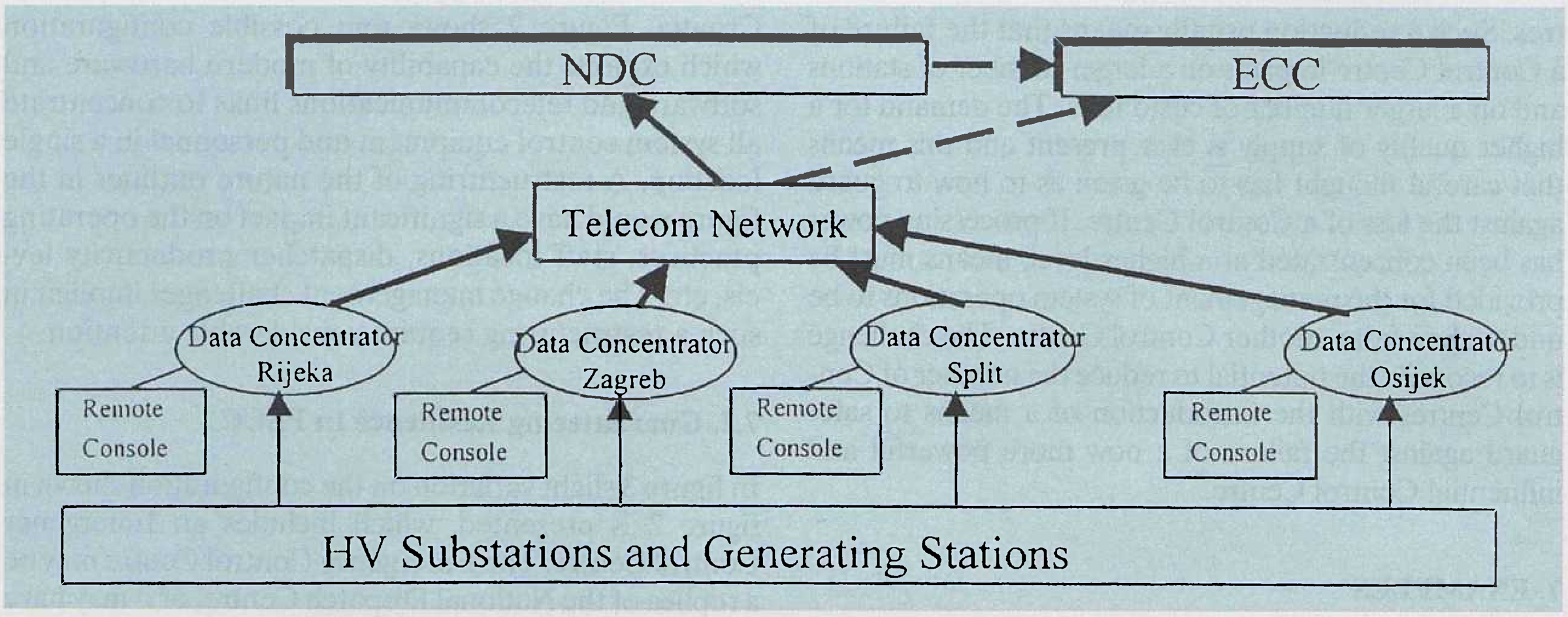

Figure 3 - NDC with Emergency Control Centre and Remote Consoles

7.3. Savings Achievable by Reconfiguring Control Centres

In figure 4 a summary table is provided for the estimated costs for the configurations shown in figures 1, 2 and 3. A large potential saving is achievable and if such savings are to be foregone, clear reasons must be provided.

8. CONCLUSIONS

The earlier sections have discussed the evolutionary changes in technology which make it possible to re-structure PSCCs; a later section has outlined the forces external to many utilities which make changes in older practices and organisations imperative. Some exam-

NDC Configurations

	Option 1 NDC + 4 ACCs	Option 2 Centralised NDC	Option 3 NDC + ECC	Option 4 NDC + ECC + 4 Remote Consoles
Cost Item	Cost	Cost	Cost	Cost
NDC	$5,000	$5,000	$5,000	$5,000
Additional NDC Consoles		$180	$180	$180
ACCs	$4,000	$0		
Remote Consoles	$0	$0	$0	$400
Emergency Control Centre			$2,500	$2,500
Telecom Equipment		$200	$200	$200
Total Equipment Cost	$9,000	$5,380	$7,880	$8,280
Lifetime Spares for equipment	$2,250	$1,345	$1,970	$2,070
Lifetime Equipment Cost	$11,250	$6,725	$9,850	$10,350
NDC Dispatchers	$960	$1,920	$1,920	$1,440
ACC Dispatchers	$3,456	$0	$0	$1,152
H/W and S/W Support Staff	$2,112	$576	$576	$576
Lifetime Staff Cost	$6,528	$2,496	$2,496	$3,168
TOTAL COST	**$17,778**	**$9,221**	**$12,346**	**$13,518**

Notes: All costs in $1,000
Assumes 10 staff required to provide 2 dispatchers on 24 hour shifts
Assumes 8 support staff in NDC and 4 support staff in ACCs
Lifetime values calculated over 10 years at 10% discount

Figure 4 - Cost Estimates of NDC Options

ples of a restructured hierarchical control system, with budgetary cost estimates, typify the life-time costs that are associated with different Control Centre arrangements.

In the short-term some utilities may be able to continue with approaches that evolved some time ago. But external economic forces will inevitably find weaknesses in poorly conceived organisational structures and in time oblige changes to be implemented.

It is the long-term interests of every utility that its senior management identifies strategic trends, formulates a coherent plan to deal with the vision of the future, motivates middle management and staff to accept the new corporate vision and to strucutre and equip the organisation for the benefit of the stake-holders in the utility.

OBLIKOVANJE TROŠKOVNO UČINKOVITIH I OPERATIVNO PRILAGODLJIVIH UPRAVLJAČKIH CENTARA

Rad ukratko razmatra različite tehnološke čimbenike, koji omogućavaju poduzeću da uvede značajne izmjene u shemi upravljanja sustavom. Također se razmatraju ljudski i organizacijski čimbenici, koji podržavaju postojeće stanje.

Analizirani su trendovi koji su doveli do restrukturiranja upravljanja sustavom u određenom broju poduzeća. U pozadini identificiranih promjena najčešće se nalaze gospodarski razlozi. Komentiraju se pitanja koja proizlaze iz restrukturiranja.

Analizirano je više primjera mogućih konfiguracija za Hrvatsku elektroprivredu, uz prikaz cijena tipičnih konfiguracija. Predočena je konfiguracija koja osigurava visok stupanj pouzdanosti u slučaju da Nacionalni dispečerski centar nije u funkciji.

WIRKSAMKEIT UND ANPASSUNGSFÄHIGKEIT ALS ZWECK DES GESTALTENS VON STEUERUNGSDIENSTSTELLEN

Diverse für die Umgestaltung der Stromversorgungssteuerung maßgebliche technische Einflussgrössen werden im Artikel in kurzer Fassung überprüft . menschliche und organisatorische die Beibehaltung vom Status quo beeinflussende Faktoren sind ebenfalls der überprüfung unterzogen.

Führende Tendenzen in der gestaltung von steuerungsdienststellen wurden an mehreren Anwendungsbeispielen untersucht. In den meisten Fällen konnte man hinter solchen Änderungen komerzielle Beeinflussungen entdecken. man setzt sich mit den daraus emporsteigenden Folgen auseinander.

Mehrere Beispiele möglicher sich an die Energieversorgung in Kroatien beziehender Gestaltungsvarianten sind in betracht gezogen und vorausgerechnete Preise für typische Varianten vorgezeigt. Dargestellt ist eine auch für das eventuelle Ausfallen des Hauptlastverteilers hohe Zuverlässigkeit gewährende Gestaltungsvariante.

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