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INNOVATION AND INTEGRATION OF NEW TRANSMISSION AND SUBSTATION TECHNOLOGIES IN THE AMERICAN UTILITY INDUSTRY

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Innovation and Integration
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Transmission and Substation Technologies
in the
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Innovation and Integration of New Transmission and Substation Technologies in the United States Utility Industry

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Introduction

The integration of new technology is always a challenge for the engineering manager, but I believe that nowhere is it more difficult than in the electric utility industry. Utilities are regulated monopolies without the normal competitive pressures that drive other industries to develop new technologies. The electric utility industry in the United States has been in a period of technological stagnation for almost 30 years. Along with regulatory attacks, financial crises, declining growth rate, political and environmental realities, the climate is not conducive to technological innovation.

However, the energy industry worldwide may experience major changes in the next few decades. It is important that the technologies to respond to these needs be developed.

This paper explores the causes for difficulties in innovation and integration of new technology in the utility industry and also explores a project approach to accelerate that integration in the area of substation technology.

Electric Utility Industry

The electric utility industry went through a period of rapid growth between 1935 and 1960. There were rivers to be harnessed, factories to be supplied, a war with its demands for electric power, and rural America to be electrified. Rapid technological growth occurred in thermal generation efficiency [8], machine sizes [9], and maximum transmission voltages in the USA (figures 1,2,3). Rapid growth also occurred in measures such as installed Northwest Federal hydro capacity [2](see figure 4). The classical growth curve, characterized by the "S" curve, is apparent in each of these measures of growth and technology. Maturity was reached in each case in the 1960s.

In his book Hirsh [9] states: "Instead of continued improvement, electric power technology appeared to have reached barriers that could not be breached." He also

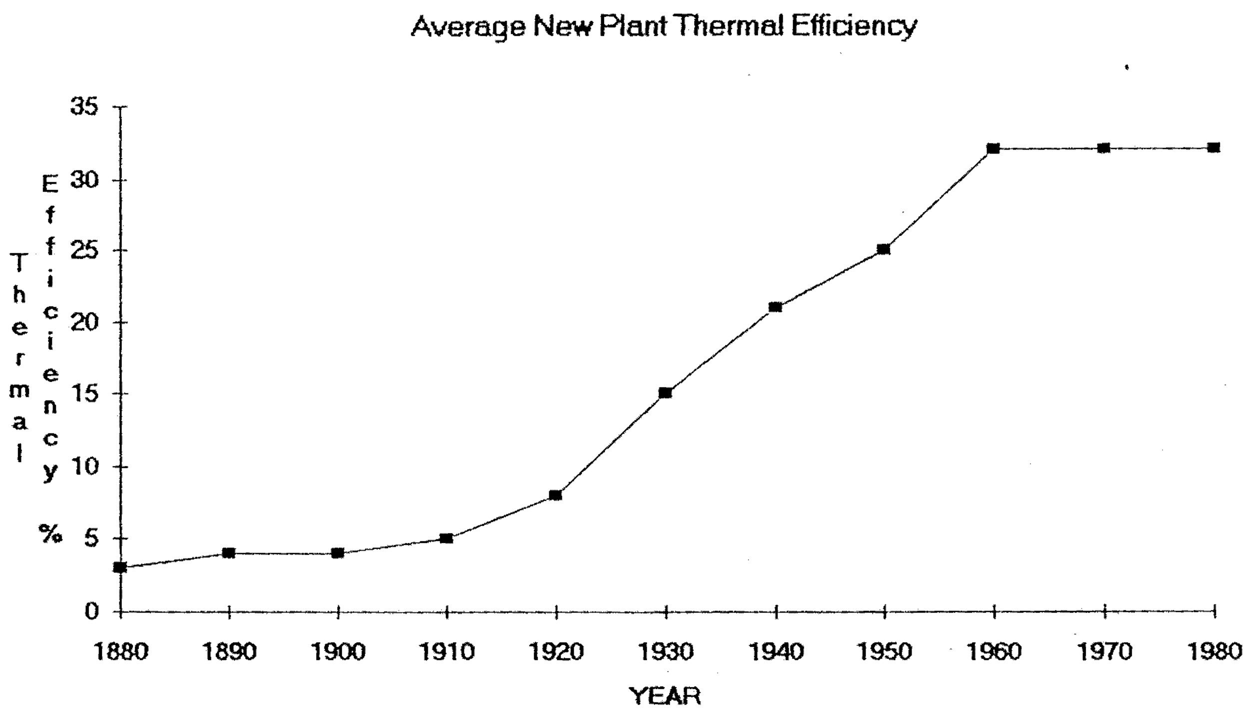


Figure 1. Average new thermal plant generation efficiency improvement from 1880 through 1980. The classic "S" growth curve is apparent [5]. Data from Hirsh [9].

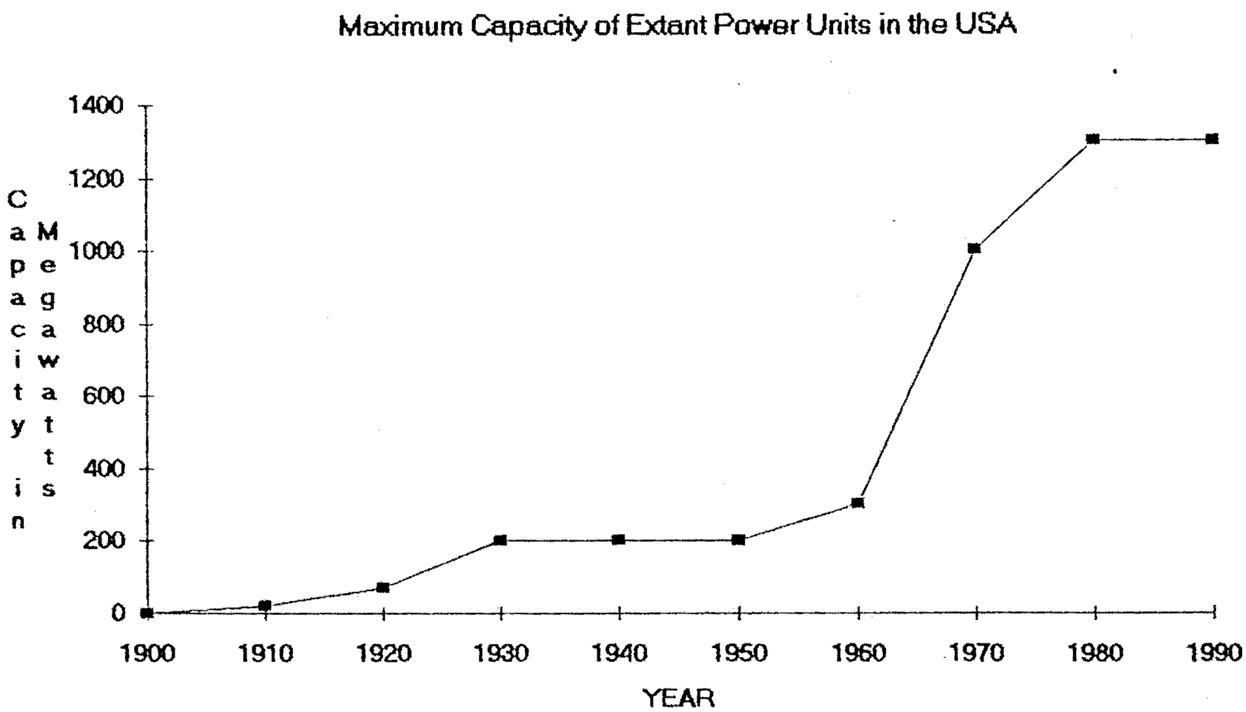


Figure 2. Maximum size of extant power units (generators) in the United States from 1900 through 1990. The classic "S" growth curve is apparent [5]. Data from Hirsh [9].

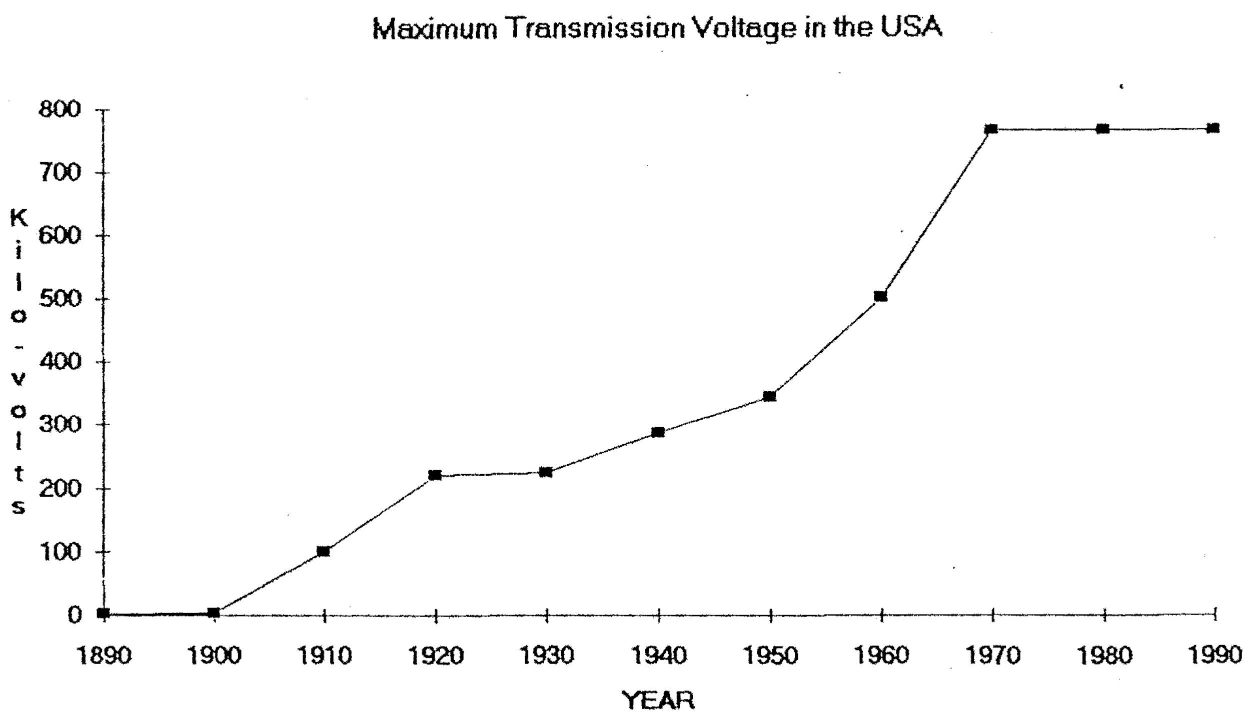


Figure 3. Maximum transmission voltage in the United States from 1890 through 1990. The classic "S" growth curve is again apparent [5]. Data from Stevenson [30].

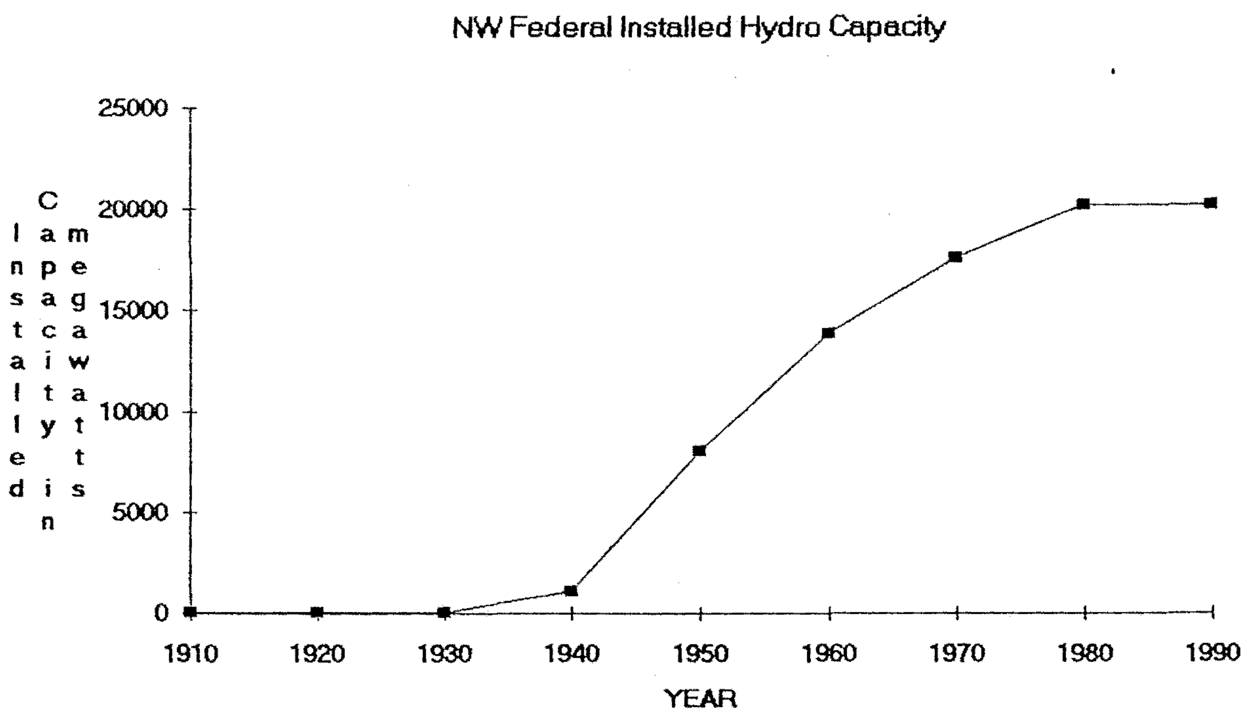


Figure 4. Installed Northwest Federal Hydro Capacity, 1910 to 1990. Again the "S" growth curve is apparent [5]. Data from BPA [2].

refers to the present situation in the industry as "technological stasis". It is important to understand this situation as it significantly contributes to the attitude within the industry today and effects innovation.

Competitive Pressures in the Utility Industry

Some portions of the utility industry are extremely competitive[21]. The sale of bulk and surplus power, intertie access, sales between power pools, non-utility generators, and sales to non-core customers are all very competitive. These competitions do not spawn technological innovation in transmission and substation technologies. The problem is that bulk transmission costs are not a significant portion of the delivered cost of power. Generation and distribution are the major factors. An analogy exists in most commercial products where transportation is not a significant portion of the cost to the consumer.

Economic Situation

The economic situation between 1970 and 1985 has had an effect on the utility situation. Load growth dropped and abandoned nuclear plants sunk costs alone were approximately 10 billion dollars by DOE estimate [21]. PUCs disallowed 6.5 billion of this from included in utility rate bases [16]. Many utilities found themselves with excess capacity during this period. Fossil fuel costs increased and environmental regulations caused construction delays. Inflation during this period was also very high. The increase in electrical rates nationwide went up in the same manner as the Bonneville Power Administration's (BPA) rates (shown in figure 5). There was a strong public/political reaction to these increased rates.

Utilities found themselves in a situation where the costs of "non-prudent" (high risk) investments which did not yield benefits were not recovered. Regulatory agencies determined that these losses from high risk ventures were not recoverable. This was a strong demotivator for any risk taking [21]. If a new innovation reduced the cost of the power to the consumer, the regulatory agency required a reduction in cost of that delivered product, electric power. If the new innovation was high risk and successful, political hindsight determined that it was not high risk. This offers little incentive for taking the risk of research or new technologies as there is little, if any, return even if successful.

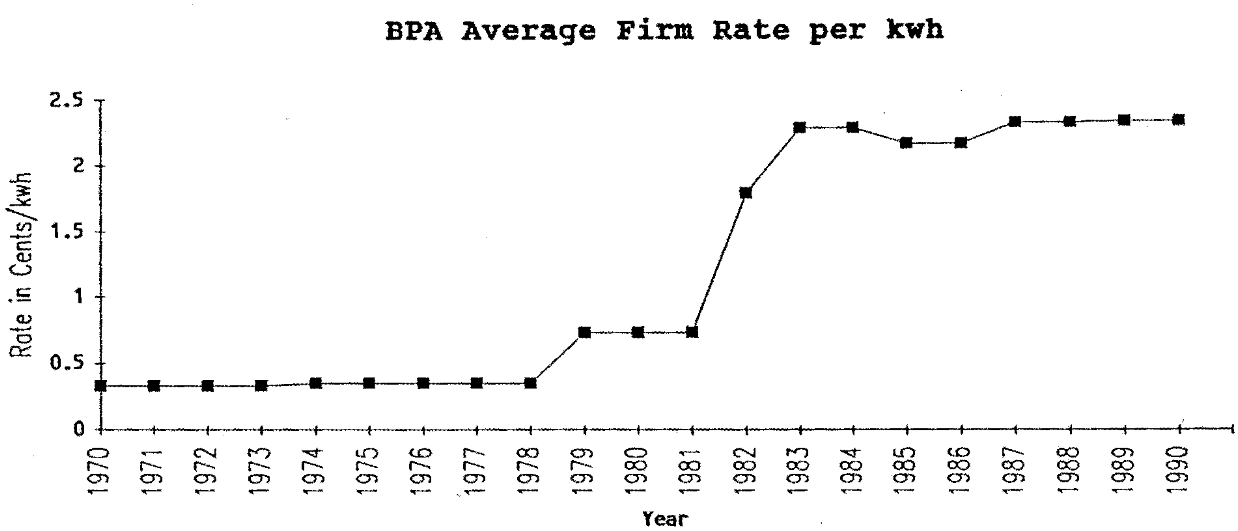


Figure 5. BPA average firm rate in cents per kilowatt-hour from 1970 to 1990. Rates had been stable from 1940 to 1970. The classic "S" growth curve is again apparent [5]. The rate increases caused social, political, and economic problems for BPA. Data from BPA [2].

Regulatory Effects on Competition

The electric utilities in the United States are either private companies, nonfederal government utilities, or branches of the federal government such as the power marketing agencies which are part of the Department of Energy. The industry falls under many regulatory laws and controls as they are generally considered natural monopolies and in a position to exert adverse effects if not controlled. A few of the key regulations and regulatory bodies include:

Public Utility Holding Company Act (PUHCA)

Public Utility Regulatory Policy Act (PURPA)

Public Utility Commissions

Federal Energy Regulatory Commission (FERC)

Although these regulations and regulatory bodies may be necessary, they have had an adverse effect on competition.

Other Measures of the US Utility Industry Situation

Another measure of creativity or innovation might be the number of technical papers written as proposed by Shockley [28]. The Institute of Electrical and Electronic Engineers (IEEE) Power Engineering Society is composed of both US and foreign members. The membership ratio is 75% US and 25% foreign. The ratio of papers written is 50% US and 50% foreign [7]. This means that foreign engineers publish twice as many papers as domestic engineers.

Participation in technical societies also reflect the interest that utilities place in technical activities. From 1975 to 1991 utility membership in the IEEE Switchgear Committee dropped from 39% of the committee to 31%. The number of utilities participating in the Electric Power Research Institute (EPRI, a cooperative utility research organization) also dropped with some major utilities withdrawing.

Summing Up the Utility Situation

A situation therefore exists in which the utility industry in the United States has reached technological maturity/stasis, the economic situation and regulations are dismotivators for innovation. Utilities are natural monopolies and regulations/regulatory bodies removed remaining external competition and incentives for innovation. Utilities are not competitive in terms of new technology development.

A term has been coined by economist Harvey Leibenstein; "X-inefficiencies"[13]. This term describes internal problems of companies which are not subjected to external competition. The primary problems include misallocations and weak motivation [21]. This term has been used to describe EPRI [21], but I believe that it applies also to utilities as well.

Utility Equipment Manufacturers

Despite the situation in the utilities, a separate but related industry exists which supplies the utility industry with equipment to generate and transmit power. Users traditionally account for more innovations that do producers [27]. This may or may not be true in the utility industry. Producers are pressured to meet the demands of their customers, however. Producers do have a unique opportunity to observe the utility industry as far as innovation and the integration of new technology, especially a view of the situation in different countries as the major equipment manufacturers are large multi-national/global corporations.

To obtain the benefit of the perception of innovation and acceptance of new technologies by the utility industry from the equipment manufacturers viewpoint I conducted informal interviews with high level engineering managers of the 6 largest utility equipment manufacturers in the world. From those interviews I obtained the following comments:

> New technologies must not cost more than traditional technologies despite higher performance/higher reliability or they are not initially accepted by utilities. Only first cost is considered.
>
> The situation in Europe is much like that in the US as far as the acceptance of new technology.
>
> The situation in Japan is not the same as in the US. When in my introduction to the interview I made the statement that utilities were not competitive as were other industries to develop new technologies, I was told that in Japan they are. The motivation is an inter-regional competition which has existed for hundreds of years.
>
> Manufacturers are typically interested in increased cooperative research efforts, but not always with US utilities.

I was especially interested in the response from the 4 Japanese managers who I interviewed as compared to the 2

Europeans. I toured a number of facilities and discovered a large number of research projects underway, especially in ultra-high voltage transmission. These discussions lead me to compare the situations in the two countries.

The Japanese utility system is composed of 10 utility companies, each serving a region from generation to distribution. It was interesting to note a portion of the main island is served at 50 hertz frequency and a portion at 60 hertz. These two regions are intensely competitive, one with the present capitol (Tokyo) and the other with the old capitol (Osaka). They are served by the two largest utilities. I also found cooperation between manufacturers, universities, and utilities much stronger than in the US.

This competitive situation has been noted by others such as Porter [22], "Japan, then, is characterized by some of the fiercest domestic rivalry of any nation...". He also notes:" Rivalries are intensely personal, Emotion and face saving seem to play a central role. Everyone in the organization focuses on besting the key competitors..."

The United States is served by over 3000 utilities (150 of them might be considered large utilities). With the present proliferation of independent non-utility generating companies this number will grow. There are few universities with any sort of power engineering program, and these do not strongly cooperate with utilities or the few still existing US manufacturers. There is little, if any, cultural competition between regions.

The present state of US manufacturers is also in decline. In the past 10 years the following has occurred:

> ITE-Gould (US) was bought out by Brown Boveri (Swiss).
>
> Brown Boveri merged with Asea (Swedish) and bought out Westinghouse(US).
>
> Allis Chalmers (US) was bought out by Siemens (German).
>
> General Electric, although still in the business did not develop modern circuit breaker technology and sells Hitachi (Japanese) circuit breakers under the joint venture name of High Voltage Breakers.
>
> Mitsubishi (Japanese) and Alsthom (French) now manufacturer high voltage equipment in this country.

Almost none of the developmental engineering work on high voltage equipment is done in this country.

Blocks to Innovation

The US electric power industry has both special and traditional blocks which can spawn resistance to innovation and acceptance of new technologies. These blocks are organizational/cultural, technical, and political.

Organizational and cultural blocks include:

1. Poor climate for innovation. The lack of competitive pressure or other factors which create a poor climate for innovation. Aged/static technical organization [27].

2. Perceived high risk investment with little potential for return due to regulatory control [9]

3. Organizational inertia. This is amplified in large organizations and the utilities which attempt any new technology integration tend to be large organizations. Note too that large companies reward successful "administrators" [5] and not innovators.

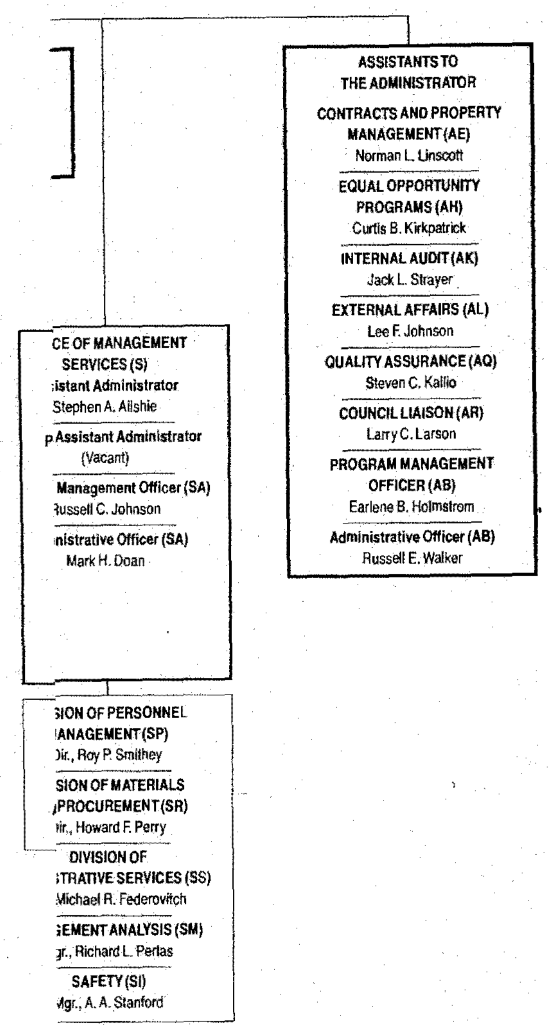
4. Poor organizational structure for innovation [3,5]. Utilities are structured in a manner which does not promote technical innovation. For example BPA is divided into 4 areas to administer its power system. The divisions of Operations and Maintenance are separate from these, as is Engineering (see figure 6). The motivations which drive the areas and operations are widely different from engineering. Engineering is placed in the role of selling a product (innovation) which the customer does not want. Changing technology causes the most difficulties for these groups. Even within engineering there is an organizational assumption that system protection equipment is separate from computer equipment.

Technical blocks include:

1. Technical inertia. The technologies which the organization (or individuals) have employed in the past are difficult to change [34]. The old tools are available to solve problems.

2. Uncertainty of new technologies, fear of the unknown [33]. This causes both individual and organizational stress.

3. Sunk cost [34]. Changing a technology may require a large investment, especially if the old technology is not compatible and must be salvaged.



Official Organizational Chart
U.S. Department of Energy
Bonneville Power Administration
September 30, 1991

Figure 6. BPA organization chart. Note the distance from Engineering to Operations, Maintenance and Construction. Also each area office has both engineering and operations/maintenance staff which are organizationally remote from Engineering or Maintenance/Operations headquarters. The organization is designed to move staff closer to our customers and not to assist in the integration of new technology or innovation.

4. Loss of technical resources. Cut backs in hiring, and early retirements have widely been employed to reduce engineering staff during the years of slow growth. The result is a loss of technical expertise and depth to reach the critical mass [34] for new technology integration in a large organization. This has been observed in other industries [1]. This is a consideration which is related to technical innovation; the necessity of a company to maintain the necessary technical competence to be able to respond to its business needs [18].

Political/social blocks include:

1. Threat to status, intellectual or emotional[5]. Engineers who have developed strong expertise in conventional technologies strongly resist loosing that power which their expertise provides. The decisions of the past may also be indicted by change.

2. Not invented here syndrome [5].

3. External political pressures

Model of the Organization

In many ways an organization is very similar to an individual. Organizational behavior parallels human behavior and has evolved as an entire field of study and has researched the social structure of organizations. Other research has analyzed organizational resistance to change in terms of human defense mechanisms [10]. The motivational model of an organization might also be developed in parallel with Maslows [15] model of human motivation (see figure 7).

The lowest level described by Maslow is the physiological level. This is based on the human bodies desire to maintain "homostasis", an interesting term when considering change in an organization and the parallel of technological or organizational stasis. It also parallels terms used by other authors such as "stability" [24] and "social equilibrium" [3] in regards to the desire to maintain sameness. For an organization this level reflects the ability to keep the body alive, make payroll, other payments, etc.

The second level is the safety or security level. This represents sufficient stability to operate effectively. It is interesting that Maslow [15] uses an example of a child's need for "an undisrupted routine", and "a predictable orderly world", and discusses these needs in terms of resistance to change. Also Kets de Vires [10] discusses "paranoid firms" and their fear that they will "overinnovate".

The third level is the social or love level. This seems at first glance to be difficult to apply to an organization, but love is a desire to be accepted and not be alone. Companies have that need and when exposed to constant public attacks, the company's image is destroyed and it is isolated.

The fourth level is esteem. This is where I found the Japanese utilities: in a competition for esteem. Companies can be moved by esteem if the lower levels are fulfilled.

The fifth level, self actualization can also be obtained by a company. This is when it can contribute to the culture which supports it. If is reflected in endowments and grants etc.

I am proposing that these factors also apply to the motivation of organizations, especially motivation for innovation, and that innovation is motivated in the lower two levels by survival. Technologically competitive industries compete at these levels. If innovation is not required as a means to achieve the first two levels, and I believe that innovation challenges the first two levels in most circumstances, it will not occur. The nature of these lower levels discourage innovation in non-technology driven companies. These levels cannot be achieved by innovation in utilities.

The third level of the hierarchy is social, and social pressures can achieve competition. It innovation is not perceived as a means to achieve this level, there is no reason to innovate.

If innovation is seen as a means to achieve ego or esteem, it will. The difficultly is that as with an individual, you must achieve the lower levels first before you can be driven by ego. The first three levels must be achieved by some other means.

Is Innovation and New Technology Needed?

One of the most common arguments for not adopting new technology is that it is not needed. The old technology is doing the job, is proven, and doesn't require risk or investment.

In the first part of this paper I made the claim that the electric utility industry is in stasis, it cannot continue to remain in stasis however.

The problems which the energy industry will face include:

Environmental - global warming and greenhouse gases, ozone, acid rain, electro-magnetic fields, right of ways, endangered species such as salmon, and nuclear waste to mention a few. Electric utilities in the US contribute two-thirds of all sulphur dioxide, one-third of all nitrogen oxides, and one third of the US and 11% of the global emissions of carbon dioxide [19].

Fossil fuel dependence - price, embargo, or depletion of reserves.

Regulatory pressures - national energy policy, proposed PUHCA and PURPA revisions

Economic pressures - inflation, recession, depression, and interest rates.

Competitive pressure - EC 92, re-negotiation of trade agreements, movement to international standards, etc.[4].

Unexpected load growth or change in load location.

Delays in acquiring resources - due to uncertainty waiting until last possible minute before construction.

Stressing electrical systems - This was expressed by Pearson et al[20]:"Electrical power systems face increasing demands to serve new and unusual loads, to integrate unconventional new resources, and to transmit power in unforeseen ways. These expanding demands will require utilities to operate existing facilities closer to their limits, thus increasing the performance requirements of operation and control systems."

Change in national energy policy or regulations [36].

Even as I sat typing this paper, the television was on and I heard Rick Meyers (KATU Portland 11/27/91) making an editorial comment on the critical need for growth in the electric power industry in the northwest.

As the electric energy industry goes through the changes which it must, it is important that the technology be available to respond to the changing scenarios. New control devices and strategies allow higher loading levels and lower stability margins. As the power system is stressed and margin are reduced, and pre-construction approval times increase due to long review processes, design and construction times must be shortened to allow response to system changes in time to meet needs. Increases in reliability will be required to meet system needs under higher stressed conditions. New devices will be required to control power flow and new sources of power will be developed. The impacts on society if the electric utility industry is unable to respond quickly are severe.

Changing the Organization

To understand the difficulty of innovation in any industry one must understand the organizational motivators. Short term survival issues have moved the US utility industry to a condition which parallel Maslows [15] lowest level. Motivation cannot happen when survival is an issue. Uncertainty of the future has made passing the parallel of Maslow [15] second level impossible. Political pressure and negative public reaction has made utility companies the popular villains; unloved (level 3).

Most organizations want to move to a stable secure position, without political and social stress. Some have proposed using frequent reorganizations [18,32] to assist in keeping organizations from becoming stagnate. This does not truly threaten the security of the organization however, or it would not be risked.

BPA has developed a company slogan/strategy which addresses issues in this hierarchy: "The best for the Northwest through teamwork: The most competitive and socially responsible utility in the Nation." The term "socially responsible" reflects BPA's public involvement program which has greatly enhanced BPAs public image. This has increased public acceptance (Maslow level 3).The word "competitive" is assumed by most to mean competitive in a business sense, as electric utilities are not generally considered a technology competitive/driven business. It could mean competitive in developing technologies to meet future opportunities and needs.

The competitiveness of the Japanese is obviously a major factor which drives their utility industry to be innovative. This competition is not driven by the same motivators as it is in other industries. It can be driven by a desire to be the best. Rivalry stimulates creativity in the individual [27] and in companies/industries.

Innovation is generally considered a requirement for any company to be competitive and will increase a firms competitiveness. Most companies are assumed to be in competition. Competitiveness is a driver of innovation. Organizations do not respond to innovative ideas unless they are driven to do so because innovation upsets stability. The risk of innovation and new technologies will not be accepted unless they must be (notice the parallel to Theory X [16]). If the business situation does not demand innovation, then the companies cultural values must if innovation is to occur. A company can be self motivated to achieve (notice the parallel to Theory Y [16]). It is up to the engineering management to create that character and culture [35].

Innovation and Technology Acceptance

In addition to moving the organization to a higher level of the Maslow Hierarchy [15] and developing organizational goals and support for the organization to be technologically competitive, it is important to obtain support for strategic plans and specific projects. Here organizational, technical, and individual resistance can be encountered. This is where the technology and project manager must obtain support for plans, innovations, and new technologies.

The following are proposed as methods to destroy blockages to innovation:

> Inertia, organizational and technical. Large masses can only be forced onto different courses quickly by apply large forces, or more slowly by smaller forces which are applied for longer time durations. The larger and more powerful the group desiring the change in direction, the quicker it will happen. Here the importance of high level and widespread support is obvious. To build this force the importance of synergism to multiply force, obtaining broad involvement to increase force, and strong leadership and a strategic plan to apply persistent and properly directed force can be seen. The keys to accomplishing this are envision the future (strategic plan) [11,26,29,34,35], enlist others [11], foster collaboration, strengthen others [11].
>
> Uncertainty. Uncertainty or fear of the future is really a fear of the unknown. If the future is well planned this fear is reduced. The answer of course is strategic planning or a vision of where the organization or technology will lead [5,11,26,29,34,35]. Economic concerns can also be addressed by analysis and planning.
>
> Threat to status/not invented here syndrome [5]. Here project approach and people skills are the key. The development/negotiation of a common vision and the enlistment of support[11,26,34,35]. The team must have prestige and people must want to be a part of it. The team must be enabled and strengthened[11]. Blocks to team success must be removed [33].

Project Approach and Organization

In order to increase innovation and make possible the integration of new technologies the project approach is critical.

Project Selection and Strategic Planning. When the project is first conceived it is necessary to determine if the project fits into the organizational goals and objectives and that the economics and risk are acceptable. Timing is also critical in the selection of a project [3]. The correct time to introduce a new technology may depend upon staff, other related technologies, and other factors.

It is crucial that a strategic plan be developed [3, 12, 18, 26]. Analysis of the expected resistances and impacts of an innovation, and a plan to deal with them is a necessity [3]. The strategy for how the technology will be presented to other groups, its advantages, how much emphasis is placed on its difference from existing technologies [3],

The Entrepreneur. It has been shown that established companies can become innovative by adapting an "entrepreneurial strategy" [24]. Every innovation needs an "idea champion or visionary"[14]. The characteristics of this individual and his credibility [3] or technical legitimacy is vital. The entrepreneur must enlist the support of both managers and others [11].

Project Team This is a critical element. The individual team members must be carefully selected and the team guided into a synergistic force. The members must each be strengthened, empowered, and enabled [11]. Differences in interests and priorities of team members must be reduced [32].

The team structure should be made up from a core group or "nucleus [13] of technical experts. The core then expands within the existing organization and the technical synergism "snowballs" [13] in this group. Multiple small design teams in existing organizations then form a "Hydra" [13]. The core team is the motivating force. The inclusion of the existing organization is necessary to obtain acceptance of the technology.

Conclusions

The electric utility industry in the United States has gone through a period of technological stasis for the last 20 years. Economic and regulatory assaults have threatened utilities at the organizational physiological, security, and social level as described by Maslow [15] in relation to individuals. For industries without normal competitive pressures to compete for survival, attaining the esteem levels is one motivator which can stimulate innovation.

Moving the organization to achieve this higher motivational level is achieved by developing the goals and corporate culture to do so. Organizations without pressures to be technically innovative must be moved beyond the lower levels of the hierarchy to be motivated to innovate.

Normal resistances to innovation occur in this industry as in any other. The size and structure of utility companies makes them resistant to change. Technological inertia, threats to individuals or organizations technical base or power base all are resistances. Understanding these problems is necessary to develop a strategic plan and the creation of a project structure which will reduce, but not eliminate, resistance to innovation or new technologies.

The the development of a shared vision, involvement in decisions and delegation of responsibility and rewards. The "what's is it for me" and threat questions must be answered in such a manner than individual and organizational resistances are overcome allowing innovation and new technology integration to occur.

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Appendix A

Advanced Substation Technology Project

The Start of a Strategic Plan

Introduction

This project envisioned is an effort to correct the lag in adoption of modern technologies in the substation environment. Many opportunities were being lost. The project could completely change the technology employed in BPA substations. It would result in making both organizations and technologies obsolete. The project was met with expected resistances from some groups.

The scope of the project is broad. The project will replace hardware with software. Presently substations are hard-wired and this project would widely distribute microcomputers on a fiberoptic local area network. It will also use new optical current and voltage sensing and new nonceramic high voltage bushing technology. In the long term the project would explore many different technology options.

Project Goals, Objectives and Strategy

It is essential that any R&D project fit into the company's goals, objectives, and strategy. The initial goals, objectives, and strategy of this project were established at its conception. At various points in the project these will be reviewed to determine progress towards meeting those goals, and reexamine the project goals and objectives to assure that they still are directed to meeting BPA goals and objectives for RD&D.

The initial objectives of this project are as follows:

> To demonstrate emerging technologies in substation equipment and design which offer potential benefits to BPA.
>
> To accelerate the development of new equipment and concepts for future BPA substations.
>
> To develop in house expertise to allow BPA to rapidly incorporate these technologies should our situation demand their use.
>
> To participate in the development of standards and to drive the development to provide benefits to the utility/user.

The goals of this project are as follows:

To develop a substation which is free from any possible hazard from fire and/or explosion.

To enhance the performance and reduce the cost of substation equipment by the incorporation of modern computer technology.

To reduce the manpower necessary to perform maintenance by incorporation of automatic diagnostics and monitoring.

To eliminate the use of wire for control and data communications within the substation through the use of fiberoptics. This will improve performance, reliability, and reduce cost.

To integrate the substation control and protection system, and other systems within the substation, to form a SYSTEM rather than stand alone components

The project strategy was developed also to meet BPA strategic policy for RD&D. Key points include:

Pilot project strategy, application on a trial basis.

Team project approach using primarily engineers from the Technical Career Program for Professional Engineers (TCPPE program, BPAs senior and principle engineers/ technology managers). If no TCPPE engineer is available from a division or group, a non TCPPE engineer may represent that group until a TCPPE engineer becomes available.

An approach to involve as many individuals, both from within and outside BPA, as possible.

Utilization of normal project work flow procedures so this project will involve more BPA personnel who are not normally involved in RD&D.

A loose project organization to allow as much freedom as possible for innovation.

Project managers will be assigned for each portion of the project and they shall form project teams as required to complete their portion of the project.

The project will look for cooperative opportunities and cofunding whenever that can be achieved without sacrificing project objectives.

BPA Goals, Objectives, and Strategy

This project is intended to meet the objectives set forth in the BPA Objectives, Strategies and Guidelines for Research, Development, and Demonstration. Specific RD&D objectives addressed by this program include:

> Reduce program costs consistent with prudent utility practice by such measures as: increasing the effectiveness and useful life of new and existing system equipment, reducing operating and maintenance cost, and reducing the cost of necessary capital investments and system replacements.
>
> Support BPA's objective to improve the BPA transmission system through orderly replacement and upgrade of deteriorating and obsolete facilities and equipment.
>
> Prepare BPA to take advantage of emerging technologies when they mature and show promise of benefits from application by electric utilities and their customers.

This project is also to follow guidelines in developed in the BPA RD&D Strategy. Those which apply most directly to this project are:

> Consider joint funding, coparticipation, and cooperative projects for large projects.
>
> Undertake pilot projects to gain early experience with state-of-the-art projects or processes. Application of new technology on a limited trial basis hastens its commercialization and transfer to the users.

Project Organization

The Project Steering Committee was created to monitor and direct the project. The initial structure proposed was to create a broad based core group and involve as many individuals from the organization as possible.

The initial core group structure :

- Engineering
  - System Engineering
  - Electrical Engineering - Control
  - Electrical Engineering - Protection

Laboratories

Maintenance

Construction

Area Engineering

The selection of the individuals from each organization is essential to project success.

The team structure will consist of a small core team of 5 to 7 members. A second level team will include all the project managers. Other second level team members will participate in the project during various phases of the project. Team members will support the project managers and offer assistance to help them succeed. The primary mission of the core team is to promote new technologies and use their status as TCPPE engineers to support the efforts of the project managers. This is an adopted Nucleus- Snowball-Hydra team concept[13].

It was determined that we would involve as many people as possible in the project. We would empower people to lead a portion of the project and get full credit for their efforts, and have full accountability. The core team will assist them, strengthen then, to help them succeed.

Selling the Technology

A series of presentations have been made to engineering staff and area staff to enlist support. Results were mixed. More presentations are planned. A panel session is planned at an internal engineering conference.

Sponsoring an Advanced Substation Technology Conference has been proposed. This will be planned for 1993.

Project Responsibilities

Project responsibilities were not assigned, but interested parties asked for responsibility for certain technologies or existing projects were coordinated with this project. The responsibilities are as follows:

Project administration	System Planning (EOHA)
Prototype circuit breaker	System Planning (EOHA)
Optical PT/CT	Laboratories (EL)
Prototype breaker controls	System Planning (EOHA)

Control and Protection	Electrical Eng. (EEPC)
Operator Interface	Electrical Eng (EE)
On-line diagnostics	Maintenance (MM)
Gas Density Measurement	Construction (MK)

Other projects are planned to be incorporated or new projects undertaken.

Future Actions as a Result of This Study

Based on the study of utility resistance the following changes in the project have been initiated:

The project team will be modelled after the "Nucleus-Snowball-Hydra" structure [13]. Some changes in team membership have been initiated.

A more detailed strategic plan will be developed.

A plan to sell the changes, address resistance directly is being developed.

Project engineers will be encouraged to travel to manufacturers and other utilities to exchange ideas.

A technical conference will be sponsored with the advanced substation technology as the only subject.

It has been proposed to management that the group be responsibility for strategic technology planning for BPA substation and transmission technology.

A more detailed analysis of the advantages and impacts of the proposed new technology will be requested from each project manager.

Publication of papers will be encouraged. Participation by a broad group of individuals in these papers will be encouraged.

Project management systems will be automated to reduce administrative overhead.

Appendix B

Project Documents

Project Diagram

Project Control Diagram

Metering and Relay Block Diagram

Current Transformer and Relay Monitor Block Diagram

Outdoor Equipment Monitor Expert System Block Diagram

Responsibility Interface Matrix

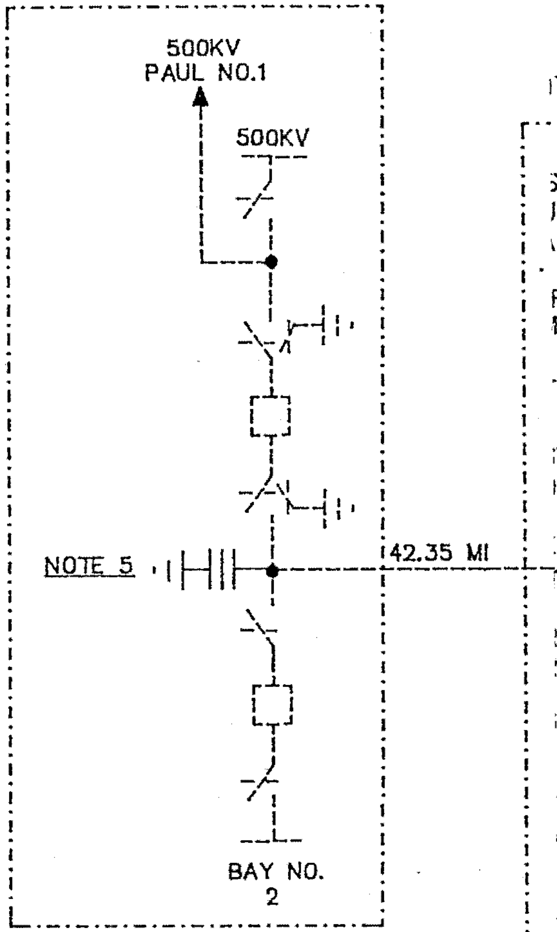
Project Schedule as of 12/9/91

Work Order Estimate

Project Cost Status as of 11/26/91 (2 pages)

ALLSTON SUBSTATION

LOWER COLUMBIA AREA



ITES:

; PROJECT WILL DEMONSTRATE ADVANCED SUBSTATION
JIPMENT AND CONTROLS INCLUDING SOLID
\TE CONTROLS, FIBEROPTICS, ETC.

RESISTOR, STAGGERED POLE, ADVANCED TECHNOLOGY
IONSTRATION BREAKER.

ICAL CURRENT TRANSFORMER.

TING CT'S REMAIN TO PROVIDE BACKUP TO
ITOTYPE EQUIPMENT.

: NEW BREAKER IS RESISTORLESS, THEREFORE,
TAL OXIDE SURGE ARRESTERS WILL BE ADDED
ALLSTON AND PEARL SUBSTATIONS. THE
:ESTERS WILL BE RATED 1.7 p.u. SWITCHING
:GE PROTECTIVE LEVEL.

EPARATE RELAY HOUSE WILL BE CONSTRUCTED
THIS BREAKERS' RELAYING.

EPARATE CONTROL PROJECT DIAGRAM WILL BE ISSUED.
AYS WILL USE LOW LEVEL SIGNALS OUTPUT FROM
ICAL EQUIPMENT.

)RDINATING ENGINEER: HOLLI KREBS – EOFA
)–3886 OR FTS 429–3886.

	COORD ENGR	OM&C	AREA	APPROVED

PROJECT DIAGRAM

UNITED STATES DEPARTMENT OF ENERGY
BONNEVILLE POWER ADMINISTRATION
HEADQUARTERS, PORTLAND, OREGON

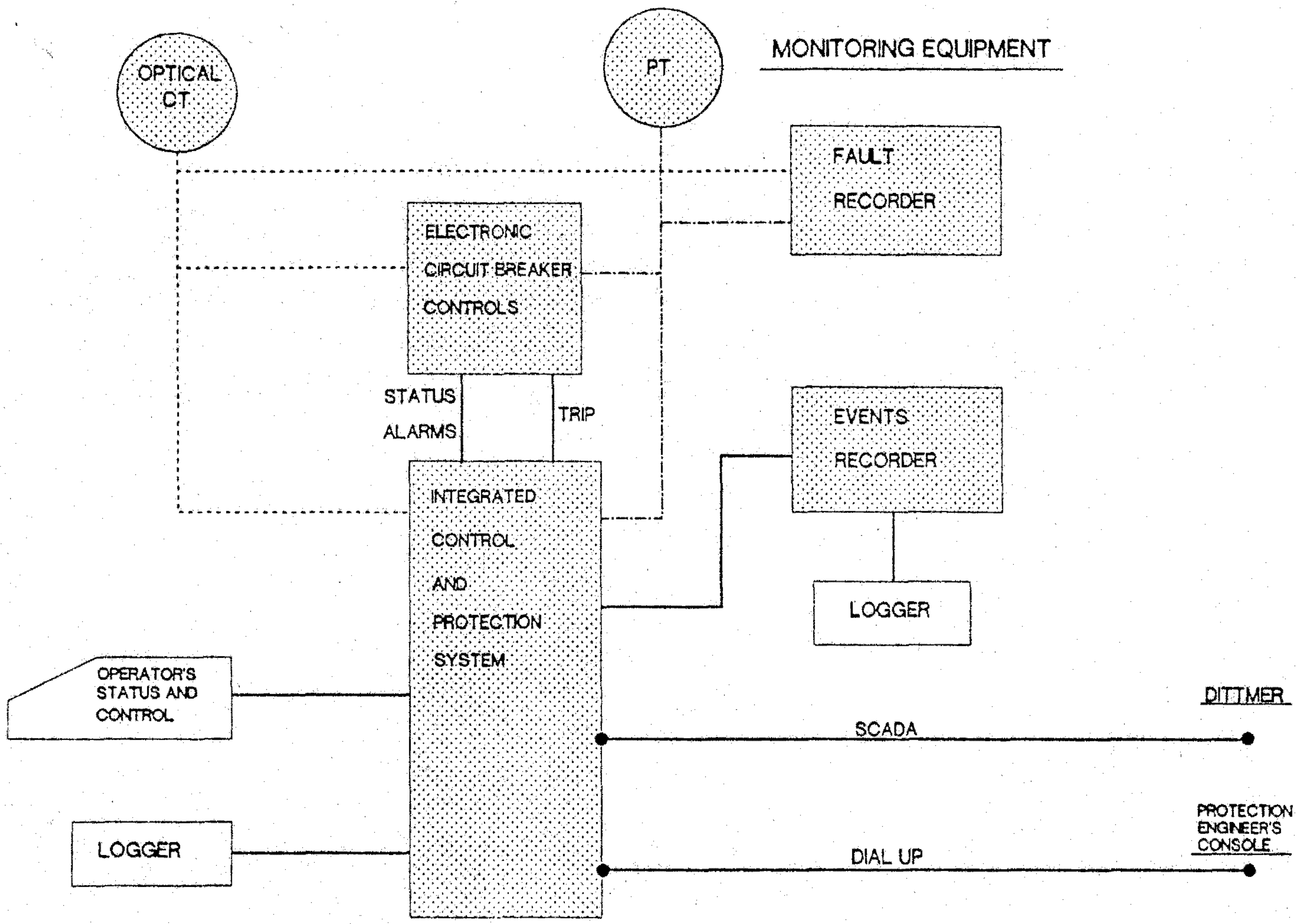
DIVISION OF SYSTEM PLANNING

KEELER SUBSTATION

500KV BREAKER ADDITION

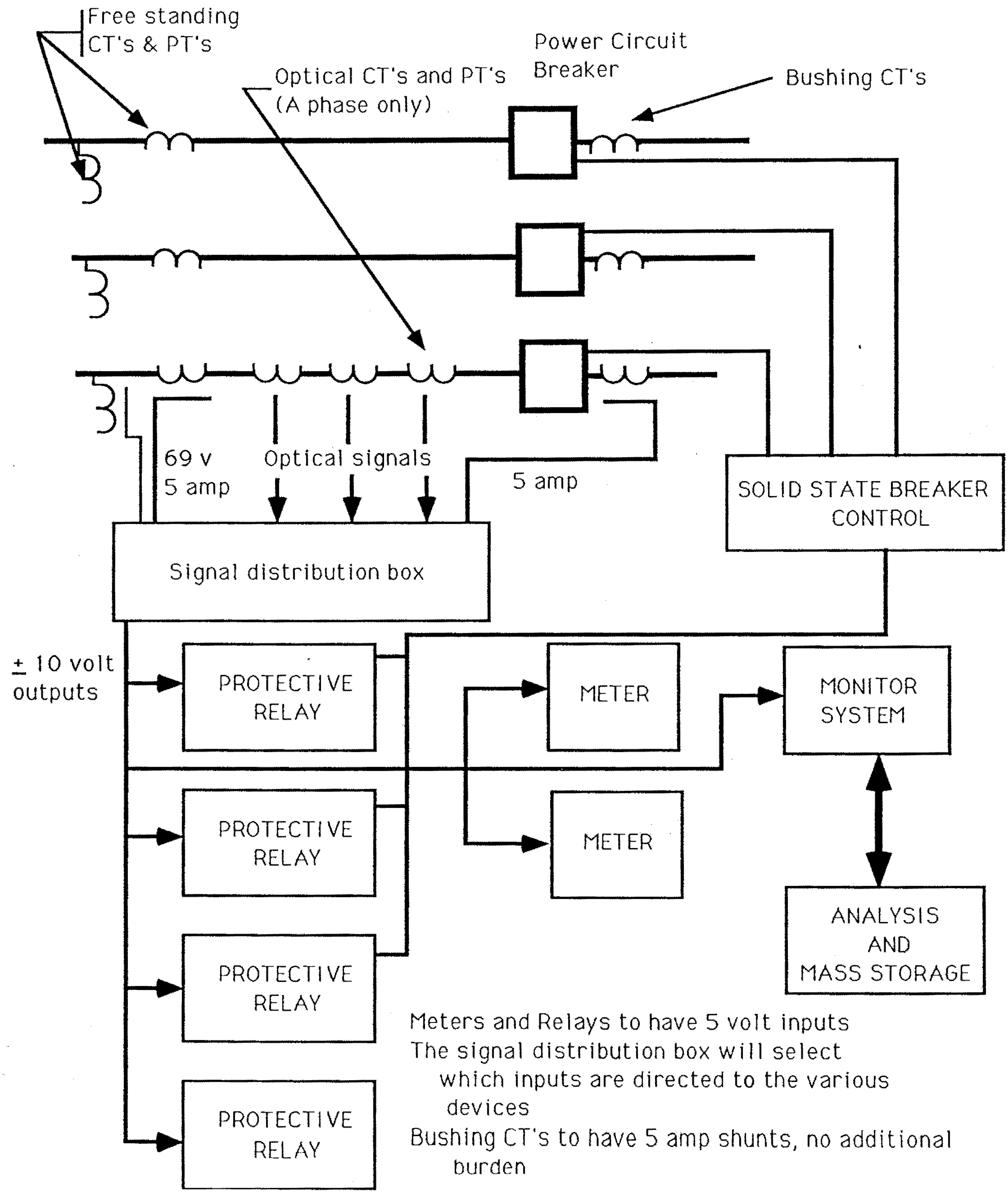
SERIAL	SOURCE	SIZE	SHEET	REVISION
196635	DSP	A3	1 OF 1	

KEELER SUBSTATION



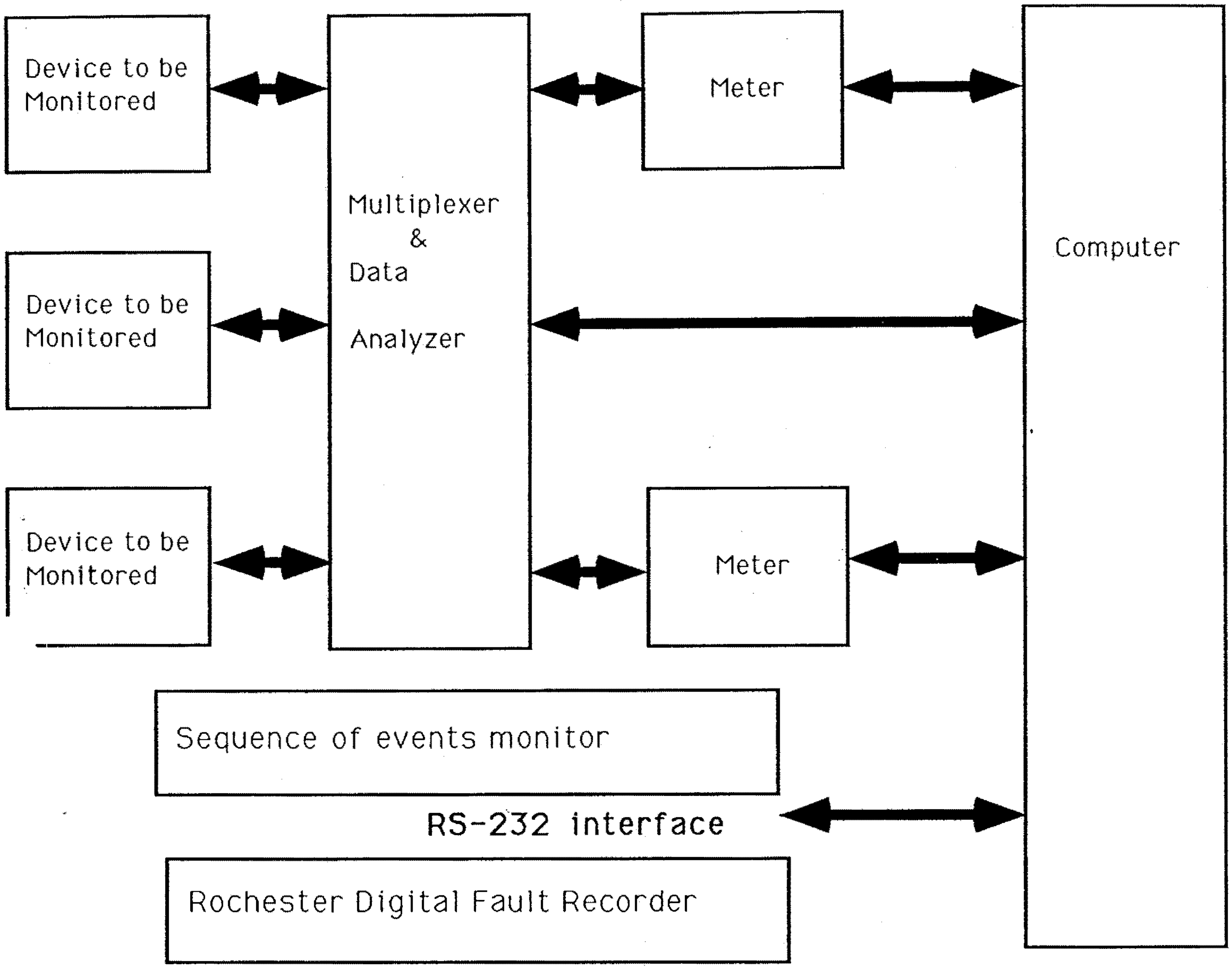
ADVANCED SUBSTATION TECHNOLOGY INTEGRATION PROJECT
CONTROL PROJECT DIAGRAM

Advanced Breaker Project
Metering and Relaying Block Diagram



Meters and Relays to have 5 volt inputs
The signal distribution box will select which inputs are directed to the various devices
Bushing CT's to have 5 amp shunts, no additional burden

Advanced Breaker Project
Current transformer and relay monitor



Monitor

Relay performance with SER and DFR and record data on RS-232

Optical CT's and PT's using digital volt meter and DFR

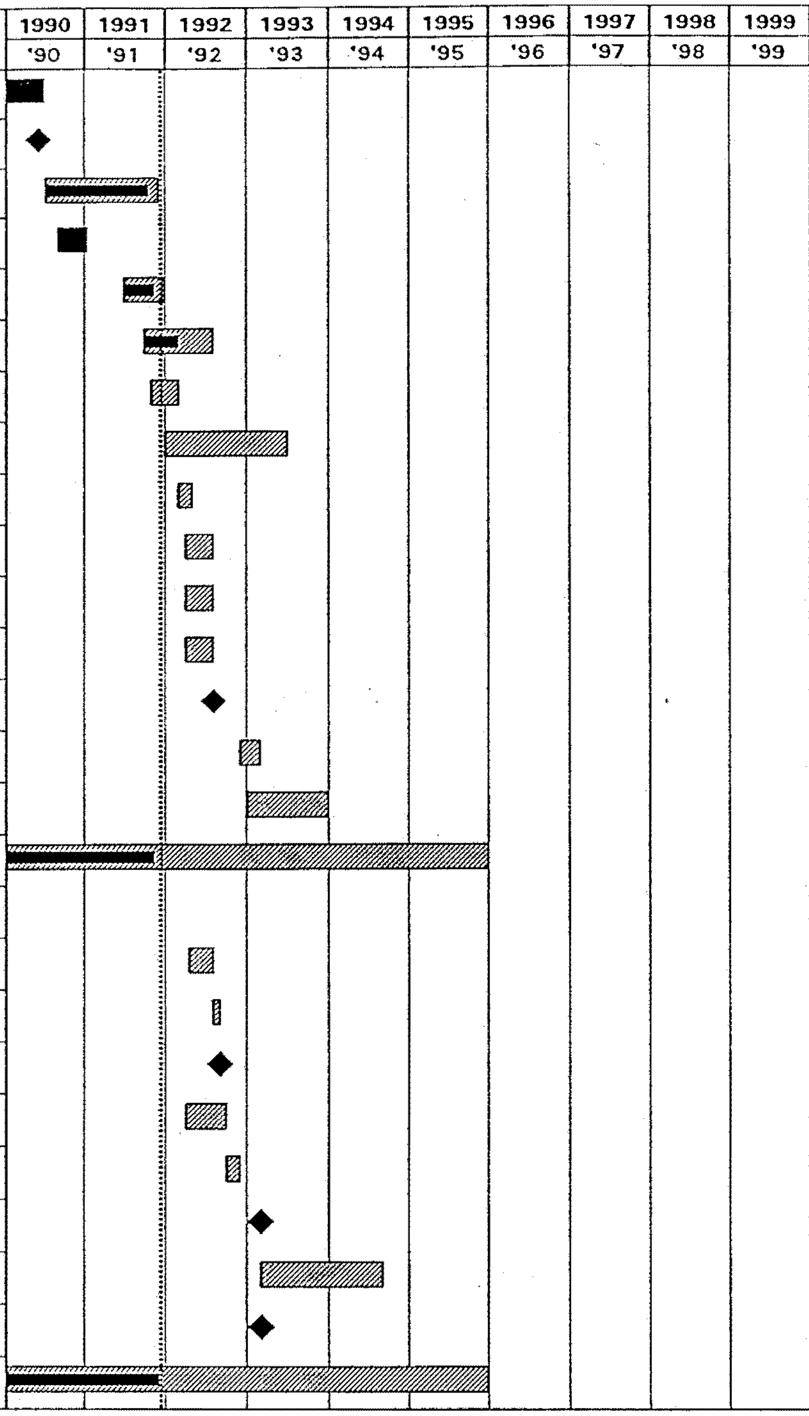
Temperature using digital thermometer

Other physical quantities as necessary

RIM.XLS

	EOH	EL	EEPC	EEP	EESB	MKTP	AREA	MMEB	Steering Comm
Proj Admin	P,A								R
Project Scope	P								A
Proj Review/RPT	P								A
Circuit Breaker	P		R		S			R	R
Current Xfmr		P	R	R	R				R
Control & Protect	R		P,A	S					R
Design	R		R	R	P,A	R	R		R
Monitoring Sys	S,R	R	R	R	R	R	R	P	R
Project Sched	S	R	R	R	P	S	R	R	R
Gas Density	S					P			R
Relay House					P		R		A
PRIMARY	P								
APPROVAL	A								
SECONDARY	S								
REVIEW	R								

ID	Name	Duration
3	Planning	6.38ed
4	Project Approval	0d
9	Contro and Protect Investigation	512.38ed
5	Circuit Breaker Purchase	135.38ed
7	PCB and Arrester Inst design	184.38ed
6	Optical CT Purchase	306.38ed
10	Control and Protection Spec	121.38ed
13	Circuit Breaker controls	547.38ed
11	Control and protection	61.38ed
8	Circuit Breaker Install	122.38ed
15	Arrester install-Allston	122.38ed
16	Arrester Install- Pearl	122.38ed
17	Circuit Breaker Energize	0d
12	Control and Protection Install	90.38ed
14	Circuit Breaker diagnostics	365.38ed
1	Project management	2191ed
2	Design - costs	1d
18	Optical CT Install Design	108.38ed
19	Optical CT Install	31.38ed
20	Optical CT Energize	0d
21	Relay House Design	183.38ed
22	Relay House Construction	61.38ed
23	Control and Protection Energize	0d
24	Evaluation	549.38ed
25	Staged Tests	0d
26	Project Team Innovation/Planning	2191.38ed



Project: Advanced Sub Tech
Date: 12/6/91

Critical | Progress | Summary
Noncritical | Milestone