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The Planning and Policy Implications of the Wide Spread Use of Decentralized Electric Generating Equipment.

By
Joachim F. Mayer

A Master's Degree Project

Submitted to the Faculty of Environmental Design in partial fulfilment of requirements for the degree

Master of Environmental Design (Planning)

May 1994

ISBN 0-315-99415-0

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Acknowledgements

I would first like to thank my parents for their support throughout my educational efforts. I would also like to thank my supervisory committee, Professor Elder, Dr. Olmsted and Mr. Blair for their advice and critical comments throughout this project. In particular, I appreciate Professor Elder's attitude of allowing me to 'muck it out myself'.

This document would never have been completed without the support of TransAlta Utilities and the numerous employees of the company who assisted me, in particular Malcolm McDonald, Bryan Holter, Diana Drysdale and Philip Lulman. I need to send an extra thanks to Bryan Holter who answered in an understandable manner my endless questions about technology and engineering.

I would also like to thank Mrs. Luxford and her family whose moral support throughout my education was greatly appreciated. Thanks must also go to Greg Klymchuk whose computer knowledge greatly assisted in completing the final document. Finally, I would like to thank my friends, class-mates and instructors who, during this educational experience, enriched my life in such a significant way.

ABSTRACT

The Planning and Policy Implications of the Wide Spread Use of Decentralized Electric Generating Equipment.

By
Joachim F. Mayer

May 1994

Submitted to the Faculty of Environmental Design in partial fulfilment of requirements for the degree Master of Environmental Design (Planning)

Supervisor: Professor P.S. Elder

This Master's Degree Project examines the organizational structure of the electric utility industry, the challenges facing the industry and the likely responses by the industry to these challenges.

The central thesis of this work is that the status quo of the electric utility industry and its dominant model of organization, the central station model, will respond to the challenges facing the industry by evolving towards a more decentralized model of electricity generation. The most significant feature of the central station model is its large generating facilities, 400 megawatts and larger. Decentralized generation typically refers to facilities that are 200 megawatts or smaller.

The implications to society of this evolution could be significant. Numerous smaller projects would more widely distribute the economic benefits associated with the construction and operation of such facilities. The regulator structure and monopoly ownership pattern in place today could be replaced by a market oriented system with multiple owners. This market orientation could decentralize decision making and give communities greater say in how their electricity is generated.

Key Words

central station model, franchised monopolies, regulation, mature market conditions, environmental concerns gaining economic expression, decentralized generating facilities, competitive market places, economic development, decentralized decision making and community integrated energy systems.

The University of Calgary
Faculty of Environmental Design

The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled

The Planning and Policy Implications of the Wide Spread Use of Decentralized Generating Equipment,

submitted by Joachim Mayer in partial fulfillment of the requirements for the degree of Master of Environmental Design.

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Dr. R. Page, EVDS

Date: June 28, 1994.

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CHAPTER 1 - INTRODUCTION

> Few societal decisions rival in complexity and difficulty the contemporary decisions on energy. Every decision to build or not build a major energy facility, to alter price relationships among competing energy sources, or to adopt a policy affecting energy demand or choice of energy form is a step toward the ultimate societal choice of what the shape of the final energy system shall be.[1]

This paper is an exercise in speculation. The topic being speculated on is the future evolution of the electric utility industry in the era of 'Sustainable Development'.

Electricity's effect on our culture is profound.

> (The) late 20th century has been shaped by technologies that require electricity: the FAX machine, computers, telephones and televisions all which determine our perceptions of what we do and what others have done.[2]

Every industry or economic sector has a structure. This structure is defined by both the way the component parts interact and interconnect and by the external environment the industry operates within. The external environment represents the constraints, pressures and opportunities that organizations within the structure face. These constraints include social, political and economic considerations. They may also include technology, competition, and access to strategic resources.

"There is a structure to the process that creates a phenomenon (and) structures do in fact determine behaviour."[3] To understand the behaviour of an industry requires that one moves beyond a reductionist view of focusing on the individual component parts in isolation. Instead, what is required is

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1 Richard C. Carlson, Willis W. Harman, Peter Schwartz and Associates of Stanford Research Institute International: Energy Futures, Human Values, and Lifestyles: A Look at the Energy Crisis. (Boulder, Colorado: Westview Press., 1982). p 5.

2 Dr. David Sanborn Scott: Exploiting Patterns in Energy Evolution. (University of Victoria, Institute for Integrated Energy Systems, Paper presented to National Hydrogen Association Annual Meeting; Washington DC, March 18-20, 1992) p 5.

3 Marc Roberts and Jeremy Bluhm: The Choices of Power - Utilities Face the Environmental Challenge. (Cambridge, Mass.: Harvard University Press, 1981) p 7.

that the interconnections and interactions of the various components be observed as to how they work within constraints.

An equilibrium or status quo usually develops if the external environment remains static for a period of time. But with a change in the external environment the original structure is challenged. Such is the case with the electric utility industry in the western industrial world today.

An amazingly consistent model or equilibrium has emerged across numerous jurisdictions for the organization of the 'Electric Utility Industry' (EUI). This consistency is largely due to the technologies that have dominated the industry for the century. The essential nature of these technologies has had a significant impact on the ownership pattern of assets and the regulatory model that has emerged to govern the industry. That essential nature has been one of monopolistic order. The external operating environment and the essential structures that represent the status quo today are the topics of chapter two.

Today that equilibrium is under challenge, the topic of chapter three. The first challenge is that the EUI has reached a stage of market maturity. For approximately 75 years the industry was in a 'growth phase' where the demand for electricity grew faster than 'Gross National Product' (GNP). One need only consider the experiences of the average Canadian household this century to gain insight into the situation. As households bought their first electric toasters, refrigerators and microwaves, their requirements for electricity grew. But once a household had these appliances its demand for electricity leveled off.

In the late 1970s, the growth phase ended for the EUI and a 'mature market' state was reached. The dominant characteristic of a mature market for a product is that demand begins to follow the increases and decreases in GNP. Since exponential growth in demand and revenues could no longer be anticipated, utility companies needed to develop strategies that reduced their financial risks and maximized their flexibility under changing market circumstances.

A second challenge to the equilibrium is due to technological innovation. Most electric generating facilities today are massive in size. The standard output of a facility today is in the range of 300 to 600 megawatts (MW). This tendency towards large generating facilities stemmed from years of experimentation where it was found that, when using original technologies, the larger the facility the greater the efficiency achieved. This pattern of technological development is often referred to as the 'central station' model.

In the 1960's, however, it was discovered that regardless of the size of a facility an efficiency ceiling of 33 percent could not be surpassed. With this ceiling established, these original technologies were now vulnerable to being displaced by technological innovation, for any alternative that could surpass the 33 percent ceiling would gain a competitive advantage.

And this is exactly what has occurred. Newer generating technologies have emerged which are more efficient than their predecessors. For example, a combined cycle turbine has an efficiency rating of approximately 50 percent. But in addition, where older technologies had to be of a large size to attain a 33 percent efficiency rating, these newer technologies can achieve a 50 percent rating in a variety of sizes. This means that essentially, a 100 MW unit is as efficient as a 300 MW unit.

This increased efficiency, plus additional flexibility in sizing, is just what the industry requires in a mature market condition. As stated earlier, utility companies need to develop strategies that reduced their financial risks and maximized their flexibility under changing market circumstances. Under mature market conditions, the failing of central station technologies is that they offer very little flexibility. They must be massive in size to gain their optimal efficiency. The sunken capital costs associated with these developments is typically measured in billions of dollars. The construction time-line for such projects could easily be ten years. These two characteristics do not allow for flexibility under changing market circumstances.

What is needed by electric utilities in a mature market atmosphere are smaller generating units, ones that have a lower capital cost and therefore allow their owners to carry less debt. As well, since exponential increase in demand is not anticipated, adding small increments of power reduces the risk that capacity will be build, but not absorbed by the market.

Culminating with the industry's desire for generating technologies that are smaller in scale is society's concern with the protection of the natural environment. These concerns are gaining expression through regulatory instruments. Examples of these instruments include direct intervention and the use of economic instruments such as pollution permit trading programs.

What will be argued here is that if policies continue to be introduced which impose an economic cost for activities that damage the natural environment, the optimal scale of operation for electric generation will be redefined towards smaller facilities.

The significance of these new technological options and the potential redefining of the optimal scale of operation will have significant impact on the structure of the EUI. The monopolistic structure that exists today was driven by the assumption that generating facilities had to be massive in size. If the optimal scale is redefined, the monopolistic ownership structure that dominates the industry today can also be questioned. Monopolies are constantly criticized in this society and market mechanisms have been perceived as preferable means of organizing an industry. These topics will be discussed in chapters four and five.

1.2 Conceptual Model of the Energy System

To gain a better understanding of the Electric Utility Industry, discussions will begin with the development of a conceptual model of the energy system. Fundamentals of Energy System's Architecture[4] presents the essential components that make up the causal relationships which represent the energy sector.

The entire system outlined is driven by the demand for Services. To quote Dr. Scott: "We often hear the claim that civilization has an insatiable demand

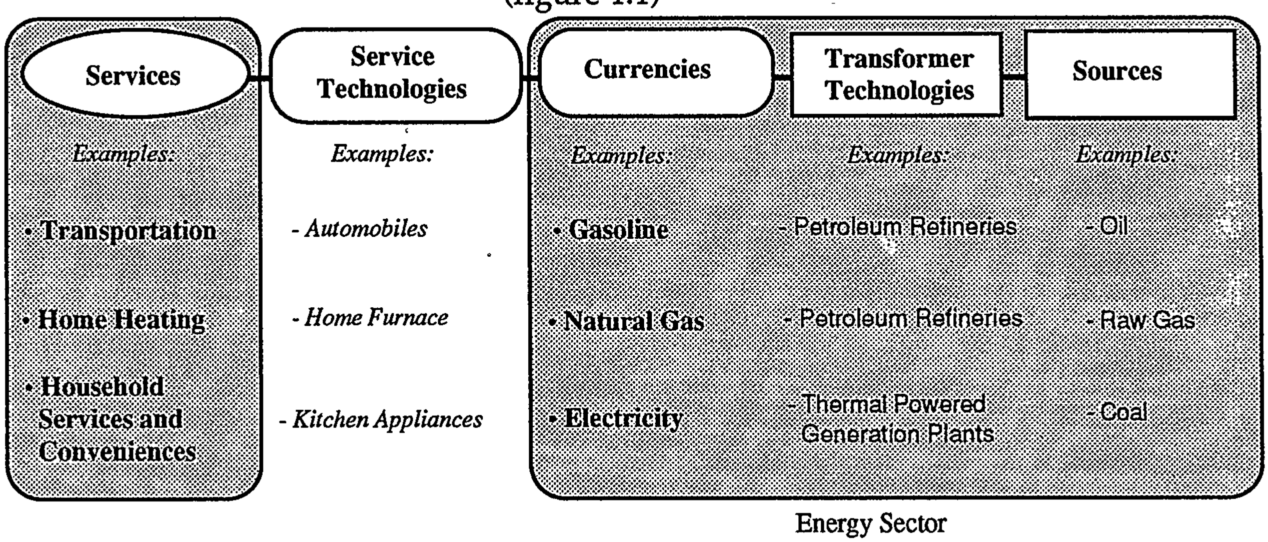
4 Scott, p 5.

for energy. I believe this is incorrect. Rather civilization has a insatiable demand for energy services."[5] Let us consider transportation as an example. Today, one way to deliver that service is with the automobile. A hundred years ago this service would have been delivered through the service technology of the horse and buggy. Admittedly a horse is not a technology as such, but the point is that the desire for the service has remained constant and it is the means of delivering that service that has changed over time.

Energy Currencies are similar in concept to financial currencies. A financial currency allows financial transactions to occur, but is not in itself a source of wealth. Service Technologies are devices that convert the potential of an energy currency into a service available to the end user. Thus, Energy currencies (gasoline) allow energy transactions to occur through service technologies (automobiles) to deliver the desired services.

Energy Systems Architecture.

(figure 1.1)



Within the category identified as the Energy Sector, '<u>Transformer Technologies</u>' and '<u>Sources</u>' are presented here along with 'Currencies'. Electricity is not a primary source of energy; some other form of energy must be used to produce it. Electric current is created when a wire with the

[5] Scott. p 4.

necessary properties is moved through a magnetic field. A modern generator has many turns of wire wrapped around a rotor that spins at high speed within a strong magnetic field. This creates a large amount of current, but the power to turn the generator must come from somewhere else.

Utilities currently rely on three main types of technology for the generation of electricity. They include hydroelectric, thermal and nuclear options.

> At hydroelectric plants the potential energy in water is backed up behind a dam and is stored in a reservoir. The water is then allowed to fall so that it passes through a turbine, turning a shaft with blades attached to it. The turbine, in turn, drives the generator. In fossil fuel or nuclear plants the energy released by burning fossil fuels or through the fission of uranium atoms in a nuclear reactor is used to boil water. The resulting steam drives the turbine, which in turn drives the generators.[6]

Returning to the diagram, in this causal relationship demand for services is listed on the left to accentuate its importance. The implied notion is that services and the individual end user are seen as synonymous. With this model, the actual energy flow is from right to left; from sources to services.

This conceptual model of the energy sector represents an ideal situation. The reality of the structure in place today is contrary to this ideal. EUI views itself as a fuel processor, with the actual customer being the regulatory system. The end-user is relegated to the position of a bystander. An elaboration of this perception will be developed in chapter five.

The methodology of this paper has two essential components. The first is the historical method which is used to review the evolution of the EUI to date and create an understanding of the challenges facing the industry. The second technique used is scenario development. Through this method different possible outcomes from these changing circumstances are discussed. Throughout this paper the language of the economist is used. This paper relies heavily on arguments that use capitalism's focus on efficiency to promote environmental ends.

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6 Marc Roberts and Jeremy Bluhm: p 46.

1.3 Ideological Disposition

The ideological disposition of the writer is best represented by Barry Commoner through his book, Making Peace with the Planet. Commoner develops the argument that people live in two worlds. The first realm is labeled the 'Technosphere' and is defined as the technological aspects that lie within human society. The second realm, the 'Ecosphere', is defined as the organic and inorganic processes of the natural environment.

Both spheres operate by different rules. The ecosphere is a closed or circular system. Components of this system have developed complex interrelationships over billions of years. In contrast, the relationships between the various components of the technosphere tend to be linear. Resources are mined and manipulated into finished goods, the consumer uses the goods and when the items no longer serve their purpose they are discarded. "In the technosphere, the end of the line is always waste, and an assault on the cyclical processes that sustain the ecosphere."[7]

A second difference between the realms is that the ecosphere tends to be conservative in character since the interrelationships have taken so long to evolve. The natural environment has a limited ability to change quickly. In contrast, the technosphere is composed of processes that reflect rapid change and variations and hence, is more amenable and capable of change than the ecosphere.

To quote Lester Brown;

> These contrasting views of the state of the world have their roots in economics and ecology - two disciplines with intellectual frameworks so different that their practitioners often have difficulty talking to each other. Economists interpret and analyze trends in terms of savings, investment, and growth. They are guided largely by economic theory and indicators, seeing the future more or less as an extrapolation of the recent past. From their vantage point, there is little reason to worry about natural constraints on human activity.

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7 Barry Commoner: Making Peace with the Planet. (New York: Pantheon Books, 1990) p 11.

In contrast, ecologists study the relationship of living things with each other and their environments. Ecologists think in terms of closed cycles - the hydrological cycle, and the nitrogen cycle, to name a few. From this perspective all growth processes are limited, confined within the natural parameters of the earth's ecosystem. These divergent views of the world are producing a certain global schizophrenia, a loss of contact with reality.[8]

In Commoner's opinion the solution to the recent heightened conflict between these realms is not to choose sides. Technospheric concern with economic growth is necessary to help the world's ever growing human population, and those in poverty, to meet their basic needs; and ecological considerations must become part of the decision making process if humans are to continue enjoying the quality of life a healthy environment can deliver.

The peace treaty between the two realms has been labeled 'Sustainable Development'.

The World Commission on Environment and Development, characterizes sustainable development as paths of social, economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their own needs while maintaining ecosystems and ecological processes essential for the functioning of the biosphere.[9]

With the technosphere more adaptable than the ecosphere and the most basic pattern of the ecosphere being cyclical, Commoner suggests that the future interplay between the two realms will require a change in the technologies used to deliver goods and services. Pollution is inherent in the very design of many production technologies. What is required is a change to production technologies that will have '0' emissions. A lofty goal indeed, but one that will ultimately deliver the peace between the two warring factions.

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8 Lester R. Brown: 'The New World Order', in Linda Starke (ed.) State of the World, 1991: A World Watch Institute Report on Progress Toward a Sustainable Society. (London: W.W. Norton & Comp., 1991) p 5/6.
9 World Commission on Environment and Development, quoted from William Clark, 'Managing Planet Earth'. in Scientific American. (New York: Scientific America Inc., Sept. 1989) p 48.

But a change in technologies may well serve the interests of both realms. As Clark states;

> Surprisingly often, the economic costs of the 'conserving technologies' also turns out to be lower: cost advantage - not environmental concerns - is responsible for halving the ratio of energy consumption to the gross national product in the U.S. since its peak in the early 1920's.[10]

To deliver the necessary peace, the industrial system needs to become self contained and work in harmony with natural cycles. Frosch and Gallopouos have proposed a sustainable model for industrial societies which they refer to as an 'Industrial-Ecosystem'. In this model, industries become more integrated so that

> the consumption of energy and materials is optimized, waste generation is minimized and the effluent of one process - whether spent catalysts from petroleum refining, fly and bottom ash from electric-power generation or discarded plastics - serves as the raw material for another process. The industrial ecosystem would function as an analogue of biological ecosystems.[11]

Thus, the desire to promote the goals of sustainable development, by advocating an industrial ecosystem model as it may apply to the electricity generation industry, will be an underlying goal throughout this paper.

1.4 Time Perspectives

In this section, a case will be made that industrialized western societies will be based on fossil fuel for at least another fifty years. This argument will be made to establish the time frame of this study which is between now and the time society has transcended to a more sustainable energy source than fossil fuels.

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10 Commoner, p 54.
11 Robert Frosch and Nicholas Gallopoulos: 'Strategies for Manufacturing'. in Scientific American. (New York: Scientific America Inc., Sept. 1989) p 48.

If the underlying goal of energy planners is the attainment of a more sustainable society, any new technologies or energy sources that may be proposed must be considered relative to the constraints they will undoubtedly meet. Although it is impossible to identify the specific hurdles an alternative energy 'currency' may face, a historically paralleled situation exists.

In the early part of the twentieth century, in the western world, liquid fossil fuels displaced coal as the primary energy currency . In brief, this situation will be reviewed and, in an attempt to simplify the analysis, the rail road industry in Canada and its experiences in changing its locomotive fleet from steam to diesel will be focused upon as a representative case. Although it is not to be presumed that future experiences will be similar to past experiences, some insights may be gained.

> In order to begin to penetrate a competitive market, a new large-scale technology (or energy currency) must pass the thresholds of scientific feasibility, of technical feasibility on an industrial scale, and of commercial feasibility. When all three thresholds are considered and it is realized that they precede actual market penetration, then fifty years may be on the short side. (In addition), fifty years is two human generations, and this is needed to accommodate changes in the social infrastructure that must parallel changes in the technical infrastructure.[12]

It will be assumed here that market principles are still a significant guiding force in the future. "An emerging energy currency, which is considered commercially viable, should be viewed in a similar manner to any other new good and service trying to create or penetrate a market."[13]

Because of the sheer immensity of a proposed energy system transition, two factors immediately arise. First, the new energy currency requires the development of a distribution system. Second, service technologies need to be in place to take advantage of the alternative energy currency. Hence, when discussing the displacement of coal, by oil, as the dominant energy currency it

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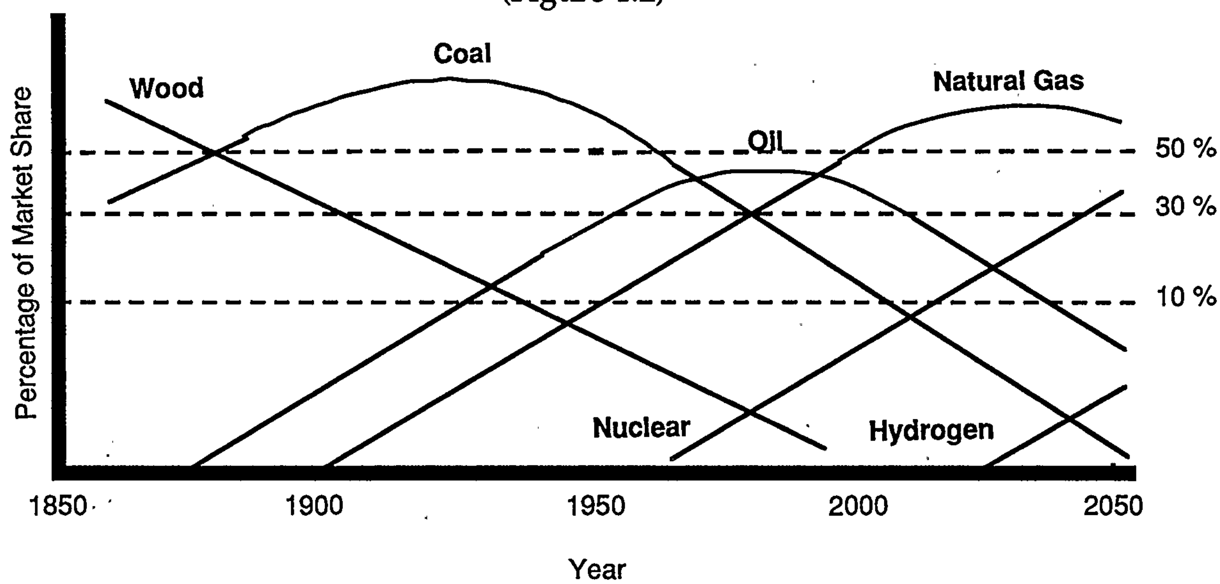
12 Wolf Hafele. Energy in a Finite World: A Global Systems Analysis. (Cambridge, Mass.: Ballinger Publishing Comp., 1981) p 9.

13 C. Marchetti And N. Nakicenovic. The Dynamics of Energy Systems and the Logistic Substitution Model. (Laxenburg, Austria: International Institute for Applied Systems Analysis, 1979) p 254.

is not just a discussion of the utilization characteristics of the coal versus oil, as will be illustrated by the rail road example.

<u>The Market Share of Various Energy Currencies as a Percentage of the Total Market for Energy, Past and Projected Future.</u>

(Figure 1.2)



As one will note from figure 1.2, it took approximately 75 years for oil and natural gas to capture 50 percent of the market. If oil is considered alone, it took approximately 100 years for this energy currency to approach 50 percent of world wide market share. (Modified version of a graph found in Hafele)

1.4.2 A Brief History of the Oil and Rail Road Industry

The origins of the oil industry began in the mid-nineteenth century when kerosene began to replace expensive whale oil as a fuel for illumination. The petroleum industry expanded greatly in the early twentieth century with the further development of 'service technologies' that used liquid fossil fuels as their energy source. Examples of this include the proliferation of the motorcar and the conversion program carried out by the world's largest navies from coal to oil. "The use of oil made it possible in every type of (naval) vessel to have more gun-power and more speed for less size and cost."[14]

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14 Daniel Yergin. <u>The Prize: The Epic Quest for Oil, Money, and Power.</u> (New York, Simon and Schuster, 1991) p 153

Throughout the early twentieth century, oil displaced coal as the primary fuel within the industrial and residential sectors of the economy. "Refined petroleum use (in the U.S.A.) rose from 21 million to 71 million gallons between 1899 and 1914, and crude production from 60 million barrels to 250 million."[15] As the century progressed, the only market sectors where coal use increased was in steel production and electricity generation.

Oil did not supersede coal because coal 'ran out'. Oil displaced coal because it was simpler and cheaper to handle and transport, and permitted new types of machinery. In other words, oil replaced coal because it cut costs. But even with these obvious advantages it took 100 years for liquid fossil fuels to capture fifty percent of the energy market.

To understand why this took so long, one must understand that existing equipment, knowledge, and organizational forms constitute real capital that cannot be replaced overnight without incurring heavy macro-economic losses.

> (There is) no reason to suppose that these lead times have become shorter with the years nor to expect that the pace of change is going to be substantially different in the future unless one feels compelled to go in for some sort of 'crash program'.[16]

To try to gain a greater degree of insight as to why this process might take so long, consider the rail road industry in Canada and their experience of converting from steam to diesel locomotives. The diesel engine was invented in 1892 by Dr. Rudolf Diesel of Germany. "The initial designs were very heavy ... . Its first tests for industrial feasibility were in ships and stationary applications. Designs developed and became light enough to power rail road locomotives (by the 1920s)."[17]

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[15] Nathan Mager. The Kondratieff Waves. (New York: Praeger 1987) p 103

[16] Mans Lonnroth, Peter Steen and Thomas Johansson. Energy in Transition: A Report on Energy Policy and Future Options. (Los Angeles: Univ. of California Press, 1980) p 23.

[17] C. Fred Bodsworth. 'The Growlers are Coming'. in Macleans Magazine, (Toronto: Maclean-Hunter Publishing Company, Oct. 15. 1948) p 24.

The advantages of the diesel motor and in particular the operating cost savings associated with the concept were well known by the rail road people. Because the diesel motors had a thermal efficiency of approximately 33%, versus the steam locomotive's 7%, fuel costs could be reduced significantly. The diesel engine could produce more horsepower than steam units. Steam units had to stop every 200 miles to dump their ash, re-fuel and take on water. After 100,000 miles an overhaul was required. In total steam engines were only available 35% of the time.

In contrast, diesels only required refueling every 500 miles and refueling was completed in a few minutes. Typically, after one million miles an overhaul was required. Diesel engines were available 94% of the time.

> The savings from diesel-electric extends even to road-beds, as the smooth, even power from the traction motor, and the use of the motor for dynamic braking eliminate the pounding from the great driving wheels and the frequent use of the air brake common with the steamer.[18]

Even though diesel products were available to the rail roads in the 1920s, and their operating advantages were well known, the majority of the locomotive in the Canadian fleets were not diesel powered until the mid-to-late 1950s. Why was there such a time lag in changing technologies? To quote Bodsworth:

> "Diesel locomotives cost roughly twice as much to build as their coal-burning (counterparts), although mass production and assembly-line construction methods are now beginning to bring diesels costs down. The price in 1948 for a diesel unit was $600,000, whereas the Canadian postwar price for a steam locomotive in the same horsepower class was $350,000.[19]

Also to be considered was the cost of setting up repair depots and fuel storage tanks, which normally run at 5-8 percent of the cost of the locomotive itself.

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[18] Victor Drury: 'Locomotive Industry's Forward Steps' in <u>Industrial Canada.</u> (Canadian Manufacturer's Association, Jan. 1950) p 75.
[19] C. Fred Bodsworth. p 24.

> But the main (inhibitor to the transition was) the railway's (unwillingness) to write off huge investments in steam locomotives that still have a good many years of useful life in them. As a result both the CNR and CPR have been scrapping their steam units only as they wear out.[20]

The steam engine was a well entrenched technology, its capital costs had steadily decreased over time with research and development costs paid for and mass production in place. As well, the infrastructure to support the technology was in place and in some cases unpaid for. Infrastructure installations then and now are typically designed and built to have a long life span. Since the smooth operation of an economy depends on costly installations such as transportation and communication networks, it is logical to have these assets be durable. As well, the cost of infrastructure installations are typically amortized over the estimated life time of the asset. This allows investors to make payments for the asset while income from the asset is being experienced. Because of this, owners of capital assets typically resist the replacement of infrastructure before it has been paid for.

A final consideration to justify the resistance to the change in equipment is unique to the rail road industry of the early twentieth century. It was called 'fuel reciprocity'. "This is a situation where, for example, in the U.S.A. in 1948, railroads spend $175 million a year for coal to burn, but they get back $500 million for the coal they haul."[21]

"Diesel engines first appeared around 1929 in Canadian rail road operations as Switchers. Switchers are small locomotives used in rail yards to move individual cars about."[22] After World War II, rail roads began planning for the mass replacement of capital equipment. Financing was readily available, and much of the equipment was in need of replacement. No major program of capital replacement had occurred during the war or during the 10 years of economic depression prior to the war. A total revamping of the system was

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20 Financial Post: How Diesels Are Paying Off for Rails. (Toronto: Maclean-Hunter Publishing Company, July 11, 1953) p B1.
21 C. Fred Bodsworth. p 26.
22 W.P Snead: 'Rail Road Revolution: Steam to Diesel' in Saturday Night. (Montreal: Consolidated Press Ltd., Sept. 12, 1953) p 27.

necessary and before the diesel engine had its opportunity to fully displace the steam engines.

When the first large diesel locomotives were purchased in the late 1940s and early 1950s, they were only used for large, long, intercontinental hauls where lower operating costs could offset the high capital costs. Eventually the number of manufacturers who mass produced diesels grew and the equipment became cheaper. By the sixties essentially all steam engines were out of operation.

It took forty years and the unique circumstances associated with the depression and the war for the diesel locomotives to totally displace the steam engine. One of the social consequences of this displacement is summarized by this 1956 Financial Post head line - "Alberta Coal Output Hits 40 year low, 60 Mines Close - Need for closing the mines was attributed to the declining market for coal because of the dieselization of railways."[23]

With the exception of the above quote, institutional and social resistance were not discussed, but they too can play a significant role in limiting the pace of technological displacement. The above discussion demonstrates that the displacement of one energy system and its associated service technologies, with another, can take many years. The factors that influenced the pace and progress of transition included a clear understanding on the part of the decision makers of the superiority of alternative currencies. The replacement costs of both the new delivery systems and the service technologies must also be known. Finally, if the infrastructure in place is not spent, or paid for, there typically will be resistance to its replacement. When a clear opportunity arises for the transition to occur, such as when the original assets are spent, this situation must be taken advantage of or it may not arise for another 20-30 years.

The only other way to hasten such a transition in infrastructural installations would be for governments to either allow owners of these networks to

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[23] Financial Post: Alberta Coal Output Hits 40 Year Low, 60 Mines Close. (Toronto: Maclean-Hunter Publishing Company, March 3, 1956) p 1.

depreciate assets at an accelerated pace, or through direct intervention to force replacement. In this paper, government's role will be assumed to be that of regulator, and policies involving the manipulation of the tax system or direct incentives are not discussed.

Thus, the rail road example, allowing for actions based on classical economic principles and the normal cycle of depreciation and replacement of assets, demonstrates what hurdles a new energy currency might face if it were to attempt to displace fossil fuels. To further investigate this notion of fossil fuels being displaced, a brief overview of one possible alternative fuel source will be discussed.

1.4.3 Future Alternatives: A Brief Overview of the Challenges for a Hydrogen Society.

In a more sustainable society the energy currencies available may include a combination of methanol, hydrogen and electricity. It is likely that more than one dominant currency will exist, since each fuel may serve a particular niche better than another and a choice of alternatives protects society from having its supply interrupted. Interruptions have occurred in the past during periods of uncertainty such a wars, cartels or strikes. In brief, let us review what would be involved in the transition from fossil fuels to hydrogen. Opinions vary greatly as to whether a hydrogen economy is possible. But it will be accepted here as feasible for the purpose of showing what might be involved in transforming a society away from fossil fuels.

"From an ecological point of view hydrogen is unequaled for environmental safety."[24] On combustion, water is the exhaust and thus hydrogen can be regarded as a clean, non-polluting fuel. In terms of abundance, hydrogen is the ninth most abundant chemical element on Earth.

For hydrogen to become a dominant energy currency, significant infrastructure development will be required. "The production of hydrogen

[24] Walter Peschka: Liquid Hydrogen: Fuel of the Future. (New York: Springer-Verlag, 1992) p vii.

from water requires the input of a considerable amount of electricity."[25] The likely sources of this electricity would be nuclear and solar. Large nuclear reactors could provide cheap electricity, but concerns related to waste by-products would persist. These large reactors would most likely be sited near large bodies of water and far from population centres. In the case of solar energy, the most efficient way to collect this form of energy is with massive facilities. Again these facilities would likely be sited away from major urban centres in such locations as North Africa, Saudi-Arabia and Australia. "Hence, the electricity (or liquid fuel) to which they would give rise is liable to have to travel at least 1000 miles and in some situations as much as 4,000 miles, to go from the site of production to the site of use."[26] Either a large electric transmission systems or a pipeline system would be required. Unfortunately existing natural gas pipelines cannot be used.

In terms of service technologies, it has been demonstrated in laboratories today that hydrogen can be used for both surface and air transportation vehicles, as well as in stationary uses such as fuel cells and modified combustion engines.

If the above described model were to come into existence, many billions of dollars would be involved. Major infrastructure development would be required. Service technologies which used hydrogen would have to become widely available. Plus, if hydrogen is in a position to become commercially viable, it will have to fit into the physical and social structure of the day. There also may be significant public and political resistance to more and larger nuclear facilities. If this model were to come to fruition, it will take at least fifty to one hundred years for it to occur.

"Today fossil fuels are available and abundant. At 1988 use rates, stores of coal, natural gas and oil could last 1,500, 120 and 60 years, although production from unconventional sources could double the time for gas and

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[25] K.C. Cox & K.D. Williamson Jr.: Hydrogen: Its Technology and Implications. (Boca Raton, Florida: CRC Press Inc., 1977) p i.

[26] J. O.L. Bockris: Energy: The Solar-Hydrogen Alternative. (London: The Architectural Press, 1975) p 12

oil."[27] The infrastructure to transform raw resources and deliver the refined currency is in place and in many cases not paid for. The service technologies which use the currency are well entrenched. An intellectual infrastructure is in place with vast knowledge on the use of fossil fuels. Alternatives to fossil fuels today are largely uneconomic or in the state of development. "Fossil fuels are still expected to be the main source of energy well into the next century."[28]

Of the fossil fuels options available, it will be assumed in this paper that natural gas will in the near future come to be western society's preferred fuel source. Because natural gas has a relatively low carbon content, it is seen to be the easiest way for the energy system to evolve so as to counter air pollution and 'greenhouse effect' concerns.

In summary, faced with the possibility of the fossil fuel based economy surviving for another fifty to one hundred years, the challenge of this early period in the era of sustainable development will be to maximize the utilization of petroleum and coal products. With this perspective, the time frame of this paper is between now and the emergence of alternative energies to displace fossil fuel products.[29]

1.5 Conclusion

In this chapter the direction of this essay was outlined. The more extended discussions will begin by outlining both the essential technologies and participants that make up the status quo of the electrical utility industry today (chapter 2). This will be followed by a discussion of the challenges that the status quo of the EUI is presently facing (chapter 3). Chapter 4 will outline the technical alternatives that might emerge in response to these challenges and

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[27] William Fulkerson, Roddie Judkins and Manoj Sanghvi: 'Energy from Fossil Fuels' in Scientific America. (New York: Scientific America Inc., September 1990) p 84.

[28] Stephan Schmidheiny with the Business Council for Sustainable Development: Changing Course: A Global Business Perspective on Development and the Environment. (Cambridge: MIT Press, 1992) p 47.

[29] Mr. R. Blair: Member of Supervisory Committee and past President of Nova Corporation of Alberta, Personal Communication, May 1994. Mr. Blair felt that the estimations offer in quote #27 on the future availability of fossil fuels were optimistic. Regardless of what estimate is accepted, the process predicted here of society moving towards alternative fuel sources after a period of continued use of fossil fuels will prevail, but perhaps with a shorter time frame than suggested by the author.

chapter 5 will discuss the impacts the changes outlined in chapter four might have on society.

A central theme of this paper is that the structure of the EUI has been, is and will continue to be, determined by the characteristics of the dominant technologies of the industry.

Also outlined in this chapter was a conceptual model of how the EUI should ideally be viewed. This model introduced terms such as 'services', 'service technologies' and 'energy currencies', which will be used throughout this paper. It was argued that the focus of the energy system should be on the delivery of services and not on the processing of fuel. But, as will be discussed in chapter 5, this is not the self-perception of today's utilities and regulators. They see themselves involved in an industry whose primary purpose is to be efficient fuel processors who deliver an energy currency.

A time perspective for the issues to be discussed in this paper was also offered. It was argued that western industrial society will remain fossil fuel based for as much as another fifty to one hundred years. If one accepts that society is not prepared to sacrifice services available today, the issue becomes one of replacing fossil fuels with a more sustainable fuel source. But finding an alternative fuel source is not the only issue, since alternatives are available today. As was demonstrated with the rail road industry's experience of converting from steam engines to diesel engines, what also becomes of issue is the building of the infrastructure required to produce/reform and deliver this new energy source.

The ideological disposition of the author was also presented. Commoner presents a point of view that suggests sensitivities of how technology and human activity (the 'technosphere') should be integrated with the natural environment (the 'ecosphere'). This sensitivity will influence discussions of how the EUI might evolve from its present state (chapter 4 and 5).

CHAPTER 2 - THE EXISTING SYSTEM

Every scenario effort begins by looking inward. Examine the mind-set which you consciously or unconsciously use to make judgements.[30]

This chapter will present an overview of the existing technical and organizational system in place for electricity generation and distribution in Alberta. This section will begin with an overview of the technical components of the 'centralized' system and a brief history of its evolution.

Three essential groups are involved in the organization of the electricity business. They include the electric utilities themselves, the governmental bodies responsible for the regulation of the industry and the suppliers of equipment. The utilities that operate within Alberta and their associated regulatory bodies will be used as a representative case of how most jurisdictions are organized. Minimal focus will be given to the suppliers of equipment.

2.1 Essential Components of the Electric Generation and Distribution Infrastructure.

The essential components of the electric system will be described here in a technically rudimentary fashion. Figure 2.1 outlines the three essential components of the 'centralized' model of electricity generation and distribution. These components include generation, high voltage transmission and local distribution.

The name centralized is derived from the model's dominant characteristic of having very large electric generating facilities. The standard generating technologies of this model are either hydroelectric, thermal (from coal, oil or natural gas) or nuclear. The size of these generating installations can vary, but typically they are between 400 megawatts (MW) and 1000 MW in size.[31]

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30 Peter Schwartz: The Art of the Long View. (NY, NY.: Doubleday Currency. 1990) p 53.

31 A watt is a measure of 'power', and power is the rate at which energy is made available. An analogous situation would be the measure of horsepower in an automobile engine. An engine may have 350 horsepower available to the user, just as a generator may have 100 megawatts of power available to the

"Two-thirds to three-quarters of the retail cost of electricity comes from the cost of generation."[32]

The second essential component of the system is the high voltage transmission system. The electric current produced by the generating equipment is put through a transformer which increases the current's voltage to a level that allows for easy transport over long distances with minimal losses.[33]

At a point close to the end users, the power from the high voltage transmission system is again directed through a transformer, or substation, and its voltage is altered to 69 KV. With the voltage altered, the electricity is then directed onto a local distribution system and from there to homes and buildings. Large industrial users of electricity may have a transformer on their site and take their power directly from the transmission system.

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user. The capital cost of electric generation equipment is often measured relative to its power rating in kilowatts (KW). Thus one may read of a 100 KW generating technology that costs $1,200 per installed kilowatt; which implies that the generator cost $120,000 to purchase and install. As a final point on the watt unit of measure, just as a automobile may have the potential of 350 horsepower, it is but on the rare occasion that all this potential power will be used. The same is true of electric generators.

The most common unit of measure when discussing the costs associated with generating technologies is the cost per watt/hours or kilowatt/hour. A W/hr, or KW/hr, is a measure of 'energy', and energy is 'power' multiplied by 'time'. When placing a dollar value on energy, the kw/hr measurement incorporates both operating and capital costs.

Operating costs are calculated by dividing the costs associated with running a generator for an hour (fuel, maintenance, etc.) by the power rating of the generator. For example, if $1,800 worth of fuel is required to operate a 100 KW unit for an hour, the operating portion of the costs would be ¢1.8 ($1,800/100,000 W).

The capital cost portion of this calculation will require two preliminary assumptions. First, an estimate is required as to the number of hours a unit will operate in a year. For this example it will be assumed that a unit will operate 80 percent of the time, or 7008 hours a year (80% * 8760 hours). The second assumption required will be the length of time desired as the pay-back-period. For this example it will be assumed the unit will be amortized over a 15 year period. If the capital cost of this unit is $120,000, $8,000 will be paid off per year ($120,000/15 years). To calculate the hourly charge, $8,000 is divided by 7008 hours, for a total of ¢1.1.

Thus, the final charge for this examples is operating costs plus capital costs (1.8+¢1.1) for a KW/hr charge of ¢2.9.

The watt/hour is also the common unit of measure for the billing of end-users. Thus, if a facility uses 3 Kilowatts in an hour, at ¢2.6 per KW/hr, they will be charged ¢7.8 for that service.

32 Martin Allday: 'Outlook for the Electric Industry', in Public Utility Fortnightly. May 15, 1991. (Arlington, Virginia; Public Utility Reports, Inc.) p 27.
33 Typical losses from transmission are 8 to 10 percent.

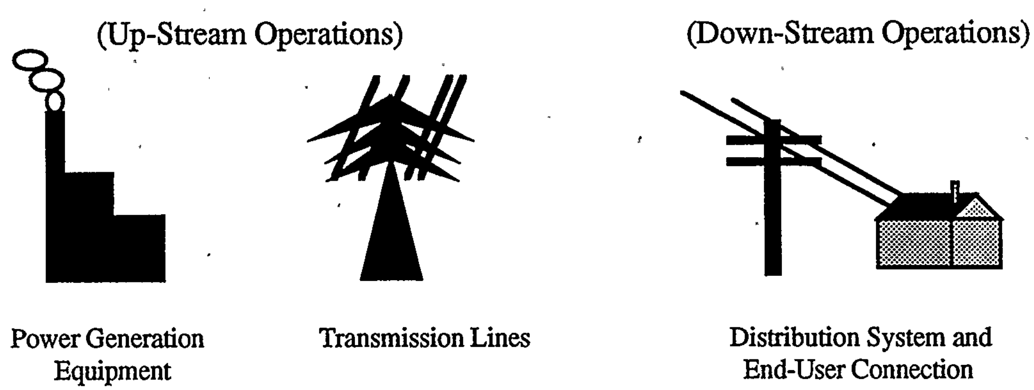
The electric generating facilities and the high voltage transmission system are referred to in the industry as the 'upstream' portion of the business. The local distribution system and the connection with the end-user is referred to as the 'downstream' portion of the business.

The size of the system is determined by considering three factors. The first is 'base load', which is the average, minimum, power demanded daily. The second is 'peak load' which is defined as the amount of electricity required during the hours, or days, of greatest demand.

The third consideration is 'gross margin' which is a margin of safety within the system over-and-above peak load. The purpose of the gross margin is to offer a margin of safety so that if any one generator breaks down or is required to be taken off line for maintenance, the system as a whole will not fail. This margin of safety is typically an additional 25 to 30 percent above anticipated peak loads.

<u>Conventional Infrastructure of the Electric Industry</u>

(Figure 2.1)



Since electricity cannot be conveniently stored on a mass scale; it must be produced as needed. Power plants can vary their rate of production on demand but the necessary capacity must be in place to meet peak demand. Daily peak demands occur typically in the early morning and the late afternoon. Annual peak demand occurs on cold winter days and during heat waves.

Although the maximum load demanded yearly may only occur for a few hours a year, the generation, transmission and distribution capacity must be in place to meet that demand. This means that for most of the year only part of a plant's capacity is in use. The average demand is approximately 65% of maximum capacity.

Another technical idiosyncrasy that must be appreciated is that the daily operation of the overall system requires a high degree of vertical coordination between the component parts. The transmission system can be viewed as a pool of energy which requires that the patterns of supply and demand are always in perfect balance. If that system wide balance is disrupted by increased demand or lack of supply, the system will black-out. Since electricity can not be stored, as the demand increases or decreases generating equipment is signaled by a central coordinating group to increase or decrease its output proportionately. This coordination game goes on 24 hours a day, 365 days a year.

Finally, it should be noted that an extensive network of transmission links exist which interconnect Alberta, British Columbia and numerous electric States in the western U.S.A.. to form the 'Western Systems Coordinating Council'. This interconnectedness allows for an additional level of reliability and cost effectiveness for all participating members. Reliability is increased because if any one generator in the system is knocked out, or taken off line for repairs, the other participating members can compensate for the loss and minimize or alleviate any inconvenience to end-users.

Without this option, utilities would be required to build enough additional capacity within their own system to compensate for routine repairs and the possibility of disaster. By distributing the risk over a great number of participants, the cost to any one participant is reduced.

Interconnectedness also allows utilities more flexibility in managing their generation system. For example, B.C. Hydro purchases power from Albertan utilities late at night to help supply their base load requirements. This interprovincial purchase of energy allows water levels in BC reservoirs to rise. Conversely, due to the different time zones each province is in, BC helps Alberta meet its peak load requirements.

2.2 A Brief History of the Electricity Industry in Canada.

The main purpose here is to create an understanding of why the system in existence today is centralized both in terms of equipment and ownership. "Throughout the history of electric power generation in North America, the growth and development of the industry have been characterized by increases in the size, scale and centralization of power generation."[34]

The first electric generator appeared in large urban centres in the 1880s. These original generators were typically small in size compared to today's units, generally coal fired and dispersed throughout the community so that they could be located close to the point of demand. This was necessary because transmission technology had not evolved to the point where a interconnected system was possible. The electricity created was primarily used for street lighting, industrial applications and urban transport. These arrangements would be defined as an example of a 'decentralized' model of electricity generation.

The ownership structure of the industry was defined by the characteristics of the dominant technologies. Just as the technology of the day was decentralized, so to was the ownership of the equipment. No regulation existed. The industry was populated by small promoters who worked in an atmosphere that was highly speculative since they were working with unproven technologies and in unstable markets.

The development of the transformer changed the nature of the electricity generation business significantly. "The transformer was probably the single most important invention in determining the organization of electricity and,

34 Marc Messing, H. Paul Friesema, David Morell: Centralized Power: The Politics of Scale in Electricity Generation. (Cambridge, Mass.: Oelgeschlager, Gunn & Hain Publishers, Inc., 1979) p 1.

indeed, the emergence of (large centralized) utilities."[35] With the development of the transformer, generation could occur at great distances from the point of demand. This additional flexibility in the siting of equipment allowed for opportunities which maximized the 'economics of scale' to be investigated.

Virtually simultaneous to the development of transmission technology was the development of large turbine technologies for both thermal and hydro applications. These two developments moved the technological model for electricity generation towards centralization.

> In Canada at the turn of the century, the major opportunity for cheap energy were in hydro-electric generation. The new transmission technologies brought hydroelectric resources within reach of virtually all of the major population centres in Canada, so that from the turn of the century until the 1960s hydroelectricity provided virtually all of Canada's generating requirements.[36]

The first of these mega-projects included the Niagara Falls, Ontario development (1896) , the St. Maurice River (1897) and Shawinigan Falls, Quebec (1903) developments, and the Seebe development (1909) on the Bow River in Alberta.

The economics of scale inherent in the hydroelectric facilities of the day (early twentieth century) were so massive that utilities were able to reduce prices for all classes of customers, while increasing their profits at the same time. Electricity rates in most major population centres in Canada had fallen from as much as 10 cents to about 3 cents per kilowatt-hour by the time of the depression of the 1930s.

> Prices would stay at that level in nominal terms until the late 1960s, when inflation and rising interest rates forced utilities to seek their first-ever rate increases. Real electricity prices, therefore, fell almost continuously from the 1920s until the energy price shock of the 1970s, and there is little doubt that this steady price decline contributed greatly

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35 Mans Lonnroth: The Coming Reformation of the Electric Utility Industry. (Los Angeles: Univ. of California Press, 1989) p 766.
36 K. Morgan MacRae: Critical Issues in Electric Power Planning in the 1990s, Volume II. (Calgary: Canadian Energy Research Institute, 1989) p 5.

> to the massive growth of electricity demand experienced during this period.[37]

Ownership followed the technological developments of the day towards centralization. The mega-projects of the early twentieth century required millions of dollars to finance, great amounts of construction and operational coordination and the careful planning of distribution systems to service huge geographic areas.

> The most efficient way of organizing all these complexities and minimizing the duplication of expensive installations was by granting the participants monopolistic status within certain operating areas. It is not surprising, then, that this new phase in electricity supply was accompanied by a period of rapid concentration of ownership in the electricity industry, as more successful small utilities combined themselves into larger and larger trusts.[38]

Electric utilities in Canada, for constitutional reasons, are under provincial jurisdiction. Due to the growing social importance of electricity, plus its natural monopolistic status, regulation of the industry was deemed necessity. Many provinces also assumed ownership of their regional electric utilities.

> The electric utilities grew up around the middle class in the big cities and the large industries of the late 1800s. The economic benefits of (large centralized generation plants and transformer technology) made utilities reach out for further users. Gradually, markets grew among poorer urban people, small towns, smaller businesses and eventually rural areas. (Electricity became) as much a social right as a means of production and, moreover, a symbol of progress, industrialization and even education.[39]

The nature of the business has largely remained unchanged since the beginning the of the century. The only real change in Canada after 1960 was the development of thermal and nuclear power generating systems when it became clear that hydro potential in some provinces could not meet the ever increasing demands for electricity. "In 1950, fully 95 percent of Canada's

37 K. Morgan MacRae. p 23/24.
38 Ibid. p 8.
39 Mans Lonnroth. p 768.

electricity was generated by hydroelectric facilities; by 1965 this share had fallen to 80 percent, and has continued to decline since then to its present share of 65 percent."[40]

But the essential paradigm of the central station model did not change. No real competition existed to either the model as a whole, or to the component technologies that made up this model. Based on the criteria of reliability and cost effectiveness as then defined, the model served the utilitarian interests of society well.

2.3 Monopoly Franchise Holders within the Alberta Electric Utility Industry

The experience of the electricity industry in Alberta differs in two way from most other provinces in Canada. First, the largest utilities in the province, TransAlta Utilities Ltd. and Alberta Power Ltd., are privately owned corporations. It should be noted that less than ten percent of the power generated in Canada is by privately owned utility companies. With private firms generating the majority of the power in the province, Alberta is unique within Canada.

"Second, the majority of electricity in Alberta is generated by coal burning thermal units, versus hydroelectric facilities, as is the case in most other provinces."[41] Alberta has great quantities of sub-bituminous coal with low sulfur content. Approximately 83 percent of the power generated in Alberta is by coal burning.

Three corporate identities are involved in electricity generation within the province of Alberta. They include Alberta Power, Edmonton Power and TransAlta Utilities. These companies also own the transmission systems within the geographical areas where they have franchised control. They also tend to own the majority of local distribution systems within their franchised area. The only exceptions to this are three municipalities which owned their

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40 Statistics Canada: Historical Statistics of Canada, Series Q85-91. (Ottawa: Minister of Supply and Services Canada, 1985) quoted in MacRae, p 12/13.
41 The other major exception within Canada is Ontario Hydro whose generating capacity is 48 percent nuclear and 26 percent fossil fuel burning thermal units.

distribution systems. Those municipalities include the Cities of Calgary, Lethbridge and Red Deer.

TransAlta is both the largest electric utility in the province and the largest privately owned utility in Canada. They own and operate three coal fired generators as well as 13 hydroelectric stations. Their operations account for 70 percent of the total electricity production in Alberta. TransAlta's transmission and distributions network services the majority of urban and rural areas in central and southern Alberta. They are also wholesale suppliers to the Cities of Calgary, Red Deer and Lethbridge.

Alberta Power is the second largest electric utility in Alberta, as well as the second largest privately owned electric utility in Canada. They co-own and operate a large coal-generating facility with TransAlta Utilities, as well as owning and operating other smaller coal burning and hydro units in Northern Alberta. Alberta Power's operations account for 20 percent of the power generated in Alberta and their primary service area is northern Alberta. Edmonton Power is the largest municipally owned utility in Canada and the third largest generator in the province. It operates one major coal burning plant and two smaller natural gas burning plants.

As a closing comment to this section, the suppliers of equipment to this industry have been labeled by Lonnroth the 'electrotechnical industry', "(Consisting) of a handful of very large multinational corporations: ASEA-BBC, General Electric, Westinghouse, Siemens, Hitachi, Mitsubishi, Toshiba, NEI, GEC, Alstrom and a few others."[42] These firm tend to have a very close relationship with electric utilities because the costs and potential profits involved with developments are very large, research and development costs are extremely expensive and there are a limited number of customers world wide for such technical and expensive products. The products these firms use are virtually the same and no one firm has any particular technical advantage over the others.

42 Lonnroth. p 767.

2.4 Why Regulation is Necessary.

The rationale of a market economy system dictates that price will mediate between the interests of the firm and the consumer. The firm is free to carry on its business in a manner that will maximize profit. The consumer, who can typically choose amongst competing products, can shop for the best price. Utility services, such as natural gas distribution, electric power generation, and water and sewer systems are not predisposed to competitive situations.

The prime reason why competition will not work for these products is that their provision necessarily entails a more or less permanent, and relatively costly, physical connection between the premises of the customer and those of the supplier. Under these circumstances, the consumer cannot switch from one supplier to another in order to secure a more favourable price or a better service. "Consumer and supplier are, in effect, 'married'."[43]

2.5 Regulatory Agencies within Alberta

This section will discuss the regulatory agencies that have a direct influence upon the electric utility industry (EUI) in Alberta. The first agency to be reviewed will be The Public Utility Board. Its primary role is to regulate the on-going operations of the utilities, and set the electricity rates that will be charged to end-users. It could be perceived as being the substitute for microeconomic forces that would exist in a freely operating market place.

The second agency that will be discussed is The Energy Resources Conservation Board. Its role is to promote the efficient and safe use of Alberta's energy resources. Its involvement with project development is typically through the review and issuing of building permits for new installations. It could be perceived as a substitute for the macroeconomic aspects of a freely operating market place. The parallel in this case is not prefect, for in a free market situation macroeconomics is primarily concerned with new entrants into a market. The implication is that new entrants will

43 G.L. Burton, W. Major, & W.J. MacFarland: Report of the Advisory Committee on the Regulation of the Electric Power Industry in Alberta. (Edmonton: Minister of Industry and Tourism, May 1970) p 23.

build new facilities. Since the structure of the EUI is monopolistic, the issues of concern for the ERCB are not typically new entrants, but new facilities.

The Albertan model of regulation is both typical and atypical of regulatory structures found in other jurisdictions. It is typical in terms of the aspects of the business regulated and the methods used. What is atypical is that these responsibilities are divided among two agencies. Most jurisdictions have one agency that handles all aspects of regulation. This will soon also be the case in Alberta. In February 1994, the Alberta government announced its intentions to merge these two organizations.

To gain an understanding of the focus of regulation and the self perception these organizations have of their responsibilities one needs to return to figure 1.1, in chapter 1. The essential components of the causal chain that regulation is focused upon are 'sources', 'transforming technologies' and 'currencies'. The underlying goal of regulation is to create a situation where there are efficient fuel processors who deliver an energy currency.

2.5.2 The Alberta Public Utility Board

The Public Utility Board of the Province of Alberta is a quasi-judicial tribunal with the same powers, rights, privileges and immunities as the Supreme Court of Alberta.[44] The PUB reports to the Lieutenant Governor In Council, through the Attorney General. In regard to its duties, the Board takes its direction from The Public Utilities Board Act and The Gas Utilities Act.

The Board is not subject to direction by individual ministers or members of the legislature and its decisions and orders cannot be reviewed or altered by Cabinet. Typically, the full contingent of Board members is ten, with approximately fifty supporting staff. "Generally, a division of three members

44 There are two circumstances in which decisions made by the Board can be appealed. The first is if an intervenor or applicant discover that the information used to make a decision was in error or misinterpreted. The second is if it is felt that there has been a mistake in law or the PUB has acted outside its jurisdiction. If either of these circumstances arise the initiating party can approach the Board, or the Supreme Court of Alberta, (and if necessary appeal the decision up to the Supreme Court of Canada) for a ruling. Other than the circumstances described above, PUB decisions are binding and to disobey the directives of the Board is an offence.

is appointed to deal with an application and that division has the full authority of the board to completely determine the matter."[45 &46]

"The objective of the Board in rate regulation is to approve just and reasonable rates so that neither the financial integrity of the utility nor the level of service to the customer is placed in jeopardy."[47] Although the bulk of the work carried out by the Board is in regard to the rates charged for utility services, the Board also has other duties. Those duties include the annual review of the utility companies' operations, and the accommodation of public participation.

The PUB sets the rates that end-users will pay for electricity. The procedure to decide what end-users will pay for services, or conversely, what utilities will be paid for supplying services, is called the 'cost of service' method. There is a two phase process to decide how much utilities will receive in revenue. Phase one determines the total revenue requirements of the utility to deliver service at cost. Once this amount is decided upon, phase two determines the rate of return utilities require to remain viable operations. This method of setting rates is a substitute for the spot market mechanism that would exist in a freely operating market place.

The discussion will proceed from here to outline in greater detail the rate making process.

> The objective of phase one is to establish a rate level which will result in the utility supplying service at cost. 'Cost' is defined as the average total cost per unit of output, includes operating expenditures, depreciation on plant and equipment, (and) working capital.[48]

The final dollar amount that the PUB decides upon in phase I, is referred to as the Total Revenue Requirement. Prior to the beginning of phase one, the

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45 W. R Horton & D.J. Sheridan: The Alberta Public Utilities Board: An Overview. (Edmonton: Government of Alberta, 1977) p 7.
46 On occasion a single Board member may be designated to deal with an issue. Under these circumstances, the member chosen must submit a report to the full Board, who then issue a decision. Also, for localized issues, PUB meetings may be held regional centres. For issues with macro-implications, like rate changes, hearing occur in either Calgary's or Edmonton's court house.
47 W. R Horton & D.J. Sheridan. p 50.
48 Burton, Major & MacFarland. p 29.

utility applying for a rate increase must distribute, to the Board and intervenors, documentation which outlines the evidence that will be used as justification for a rate increase.

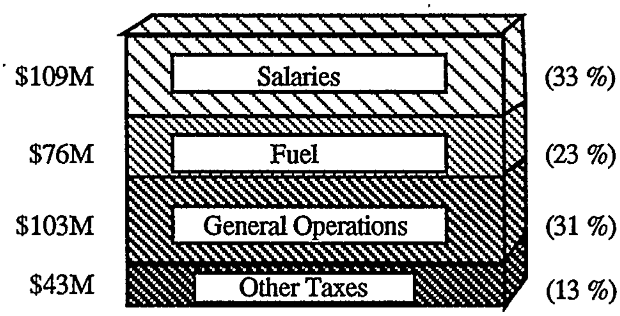
Numerous technical issues arise during a rate hearing including: accounting methods used to ascertain costs and depreciation, the impact of inflation on costs, converting the original costs of old plants into current dollars in order to achieve comparability, determining life expectancy of equipment, and the anticipated demand for electricity.

In its most basic form, the revenue requirements of a utility are broken down into two parts: The operating expenses and return on rate base. In other words:

Revenue Requirement = Operating Expenses + Return on Rate Base

Breakdown of Operating Expenses for TransAlta Utilities in 1991.

(Figure 2.2)[49]



Total Operating Expenses in 1991 were Approximately $332 Million

Operating expenses represent those expenditures that are necessary for the day-to-day operation of the business. Figure 2.2 is an example of the general categories of anticipated expenditures for TransAlta Utilities in 1991. Since operating expenses directly influence rates, the Board must scrutinize them to ensure that they are 'reasonable'.[50]

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49 Modification of Training Course Material, TransAlta Utilities, 1991.

50 In reviewing operating expenses the Board uses a prospective test, where utilities project revenues and expenses. This method is used rather than an historical analysis, which looks at previous expenditures and then adds a certain percentage to that amount. The aim of the prospective test year is to anticipate rapidly

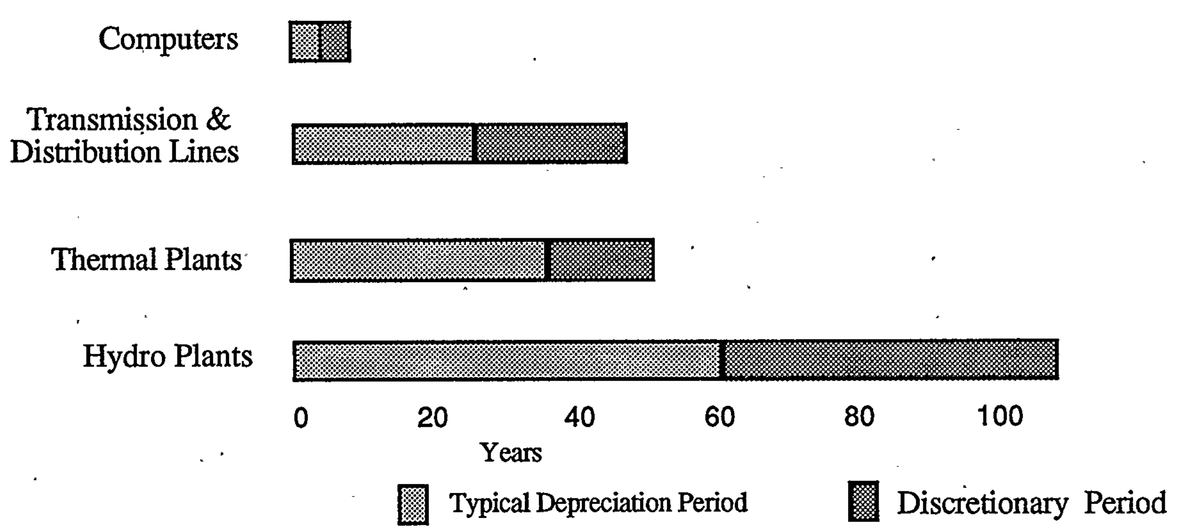
The second aspect of establishing revenue requirements is calculating the rate base. The 'Rate Base' is composed of three parts, as defined below:

Rate Base = Value of the Utility's Assets - Depreciation + Working Capital.

Assets are defined as the physical plant and equipment used and owned by the utility to supply electric services. Depreciation is the annual loss in value of an asset due to use. Figure 2.3 demonstrates the typical depreciation periods of various categories of equipment used in the electric utility business. Working capital is the money required to bridge the gap between the time expenditures are made for new facilities, and the subsequent periods of revenue generation.

<u>Depreciation Periods of Various Categories of Equipment</u>

(Figure 2.3)



Utilities companies want the rate base to be as large a dollar value as possible since their earnings are dependent on the value placed on assets; while

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changing conditions more effectively and to accommodate the rate-making objective of setting prospective rates that will adequately cover prospective costs. From, C. Hunt & A. Lucas (ed.). <u>Canada Energy Law Service</u>, Volume Four. (Calgary: Discontinued Series by, The Canadian Institute of Resource Law, 1990) p 30. Referred to here after as Hunt & Lucas, discontinued series.

conversely, they want to keep the depreciation dollar value as low as is attainable. Not surprisingly, the intervenor's position is the exact opposite.

The second phase of the 'cost of service' method is the establishment of the revenue requirement need by the utility. This is also referred to as Return on Rate Base. Return on rate base can be defined as "the profit that the company will be allowed to earn on its shareholders' investment."[51] The challenge for the Board is to balance the utility's need for a return that is adequate to maintain investor confidence, while keeping the price Albertans pay for electricity as competitive as possible.

Another important question the Board must also address is the capital structure of the firm. The necessity for this review stems from the PUB's desire to ensure that the utilities do not take actions that may threaten their long-term viability. Once the capital structure is approved, it cannot be changed without a Board hearing[52]. The Board reviews annually the capital structure of the firms under its jurisdiction.

The financial structure of a utility typically includes the following components:

1. Common Shares.
2. Preferred Shares.
3. Debt - which may include such items as bonds, debentures, or bank loans.
4. Other forms of financing - typically no or low cost loans from the government, or deferred income taxes.

Figure 2.4 is a breakdown of the capital structure for TransAlta Utilities in 1990.

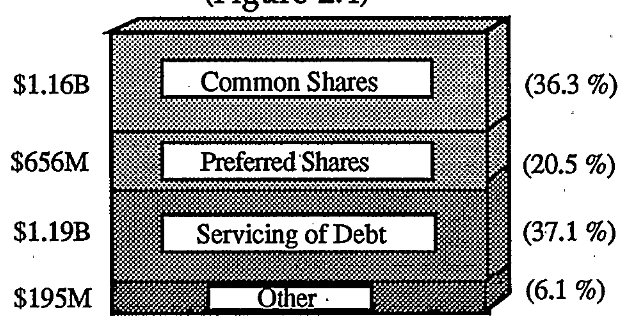
51 Janet Keeping. The Regulation of Utilities in Alberta. (Calgary: Unpublished Manuscript, 1990) p 15.
52 It should be noted that a hearing to consider the restructuring of the capital structure is a less formal procedure than a rate hearing and typically, according to Ms. T. Johnson, there are no intervenors.

"The issue of offering a sufficient rate of return is very important since the electric utility industry is very capital intensive relative to other industries."[53] Because of this, large sums of money are need up front to build facilities, while revenues from plant and equipment is generated over the life-span of the equipment. This money must be raised on the capital market or through bank loans.

Although the Board must always consider the needs of the consumer, the PUB can not risk allowing a utility to be badly managed or under-financed. If a utility is perceived in the marketplace as being financially weak, the cost of borrowing money will increase and the ability of the firm to sell stocks and bonds will be made more difficult. Expensive financing implies higher rates. Financially weak utilities may threaten the dependability of service in the long run.

<u>Capital Structure for TransAlta Utilities, 1990.</u>

(Figure 2.4)[54]



Rate Base in 1990, Deemed to be $3.2 Billion

As mentioned earlier, once the Board has accepted the revenue requirements proposed by the utility and established a rate of return, the two amounts are added together to give the final revenue requirement. Figure 2.5 reveals the revenue requirements for TransAlta Utilities in 1991..

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53 For example, it is estimated that 50% of Canadian Western Natural Gas's operating expenses stem from the purchase of natural gas. In the service industry, salaries may represent well over 50% on the firms operating costs.

54 Modification of Training Course Material, TransAlta Utilities, 1991.

Figure 2.5 also displays the charts related to operating expenses and capital structure. The complexity of TransAlta's revenue requirements is greater than the model described above. Added to the generic model are income taxes and transfer charges to the Electric Energy Marketing Agency (EEMA) . The EEMA program will be discussed at a later point.

Since the board attempts to balance the interests of the consumer and the utility firms, public hearings play an important role in the PUB's operations. Public hearing can be initiated by customer complaints or by the Board's when changes to electricity rates are to be considered.

Because of the PUB's quasi-judicial nature, rate hearings before the Board usually involve applicants and intervenors. Intervenors are either individual customers, organized customer groups or public interest groups that are deemed to have a legitimate interest in the matter-at-hand and who come forward to challenge the applicant's (for a rate increase) position.[55]

"Every intervenor possesses all the rights and privileges which are afforded in any legal proceeding to a party."[56] An intervening party may cross-examine the utility's witnesses, call evidence on their own, receive and examine documents filed, and submit arguments both as to the merits of the application and on the procedural aspects of the hearing. The practice to date has been for the utilities, at the Board's discretion, to pay for the intervenor's costs.

Although honourable in attempt, the nature of the regulatory process makes the accommodation of a spectrum of interests impossible. The decision making process is highly centralized and regulators are the designated representatives of the public interest. Once decisions are made, one uniform solution is applied to every enduser within the monopoly franchised area. Because of this structure, the real customer that the electric utilities must serve is the regulator. It is they who choose among options. Endusers are largely bystanders to the process.

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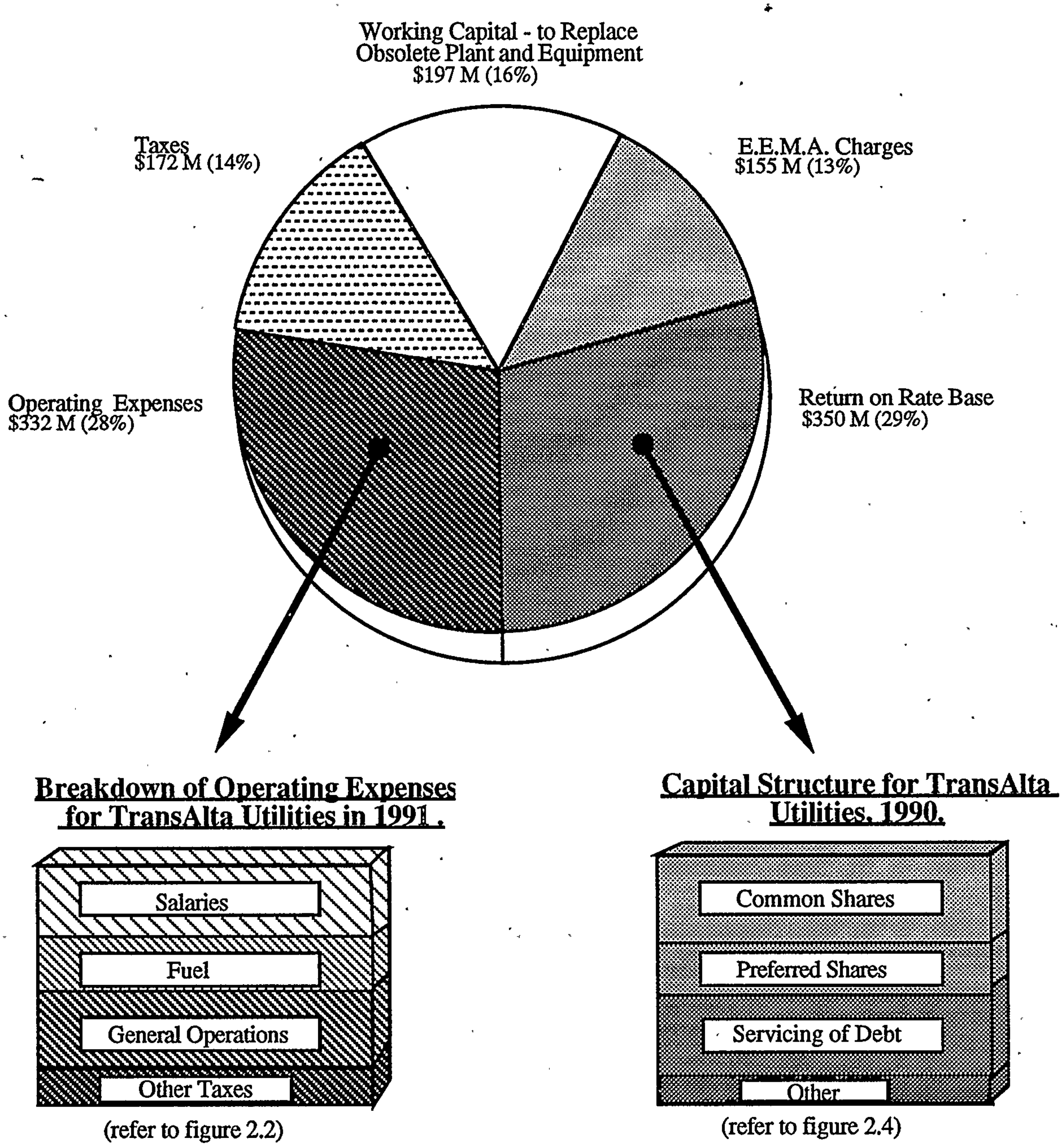
55 Intervening groups include: The Industrial Consumers Association of Alberta, The Municipalities of Calgary, Red Deer and Lethbridge, and The Alberta Union of Rural Electrification Associations.
56 Alberta Public Utilities Board Brochure: How to Intervene. (1990) p 2.

Breakdown of TransAlta Utilities Revenue Requirements for 1991.

(Figure 2.5)[57]



[57] Modification of Training Course Material, TransAlta Utilities, 1991.

As a final note on the operations of the PUB, the Electric Energy Marketing Agency (EEMA) will be introduced.[58]

> The agency was formed for the purpose of averaging the 'upstream' (that is generation and transmission) costs of electricity in the Province of Alberta. Prior to (the EEMA program), customers in northern Alberta paid approximately 2 cents per kw/hr more than residents of southern Alberta.[59]

EEMA is essentially an extension of the PUB process, since it is the PUB that sets the 'upstream' revenue requirements for generators in the province.

Although virtuous in conception, the EEMA program has become a source of discontent, especially for TransAlta Utilities. To quote Mr. Ken McCready, President of TransAlta, in his opening speech to the 1991 PUB rate hearings:

> (The program has) been in place nearly ten years now and presently is producing unanticipated and unintended results. This aging mechanism to accomplish the objective is now accomplishing the absurd result of reversing the rate disparity. Alberta Power customers enjoy, overall, bills that are 5 to 6 percent lower than TransAlta customers, who send the subsidy to them. And Edmonton Power customers are 7 to 10 percent lower. That subsidy translates into a TransAlta customer bill being some 14 percent higher than it would be if there was no EEMA.[60]

2.5.3 The Alberta Energy Resource Conservation Board

> (The general guide-lines for The Energy Resources Conservation Board include providing) for the economic, orderly and efficient development and operation in the public interest of electric energy in Alberta (and) to assist the government to control pollution and ensure environmental conservation.[61]

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58 EEMA originally had agency status, but in 1992 its status was changed to departmental, within Alberta Energy.

59 Hunt & Lucas, discontinued series. p 30-6028.

60 Ken McCready, Opening Comments to the 1991, PUB rate hearings for TransAlta Utilities. (Unpublished) p 2.

61 The Hydro and Electric Act, as quoted from Janet Keeping, p. 47.

As it affects the electric utility business, The Alberta Energy Resources Conservation Board's (ERCB) approval is required before any infrastructure facilities can be build, operated or altered. The ERCB is an independent administrative tribunal. It takes its direction from The Energy Resources Conservation Act and performs functions pursuant to some 20 statutes. The Conservation Board panel can be comprised of up to seven members, with representatives from other agencies if this is deemed necessary. There are approximately 750 staff members employed by the ERCB.

The ERCB's authority to intervene in the activities of the electric utility industry stems from the Hydro and Electric Energy Statute. Under this statute the Conservation Board's responsibilities include:

1. The appraisal of reserves and productive capacity in Alberta of hydro and electric energy.
2. The appraisal of requirements for electric energy in Alberta and markets outside Alberta for electric energy generated in Alberta.
3. Provide for economic, orderly and efficient development in the public interest of hydro energy and generation of electricity in Alberta.
4. Insure safe and efficient practices in the public interest in generation, transmission and distribution of electric energy.
5. Assist the Department of the Environment in the control of pollution to ensure environmental conservation in regard to above items.[62]

As with the PUB, ERCB has as its stated goal the protection of the 'public interest'. However, in contrast to the PUB, the ERCB is a far more political organization. More stakeholders are involved, the methodology used may vary from case to case, and more contextual issues receive attention in an ERCB decision. The Conservation Board may have to interact extensively with other agencies, as well as with cabinet (and possibly the legislature) before final decisions can be handed down.

The ERCB's involvement in a project is from 'cradle to grave'. Projects are typically assessed individually and on their own merits, using the forecast

62 J.I. Strong: The Role of the Energy Resources Conservation Board and its Relationship with the Electric Industry and the Energy Resources of Alberta. (Edmonton: Energy Resource Conservation Board. 1972) p 7.

information supplied by the proponent as the starting point of evaluation. The ERCB is not responsible for the strategic planning of resource use. Planning is left to the individual utilities and various groups such as the Electric Utility Planning Council.[63] To illustrate the numerous roles the ERCB plays, a hypothetical case will be developed in which a utility company is proposing to build a new coal burning thermal generating plant.

The first requirement will be a building permit. The utility will have to justify, before the board, why additional generating capacity is necessary, the economics of locating at the proposed site, and how it will fit into the existing interconnected system. The proponent may also be required to justify the sustainability of coal as an energy source, the adequacy of coal reserves, and what arrangements for the transportation of coal are planned. An environmental and social impact statement will also be required with the application.

The ERCB procedures require public hearings in the case of major developments. Their practices are similar to the PUB in regard to intervenors. Those who are granted standing, will receive all relevant information. They will be given the opportunity to argue their case and present evidence, as well as question the proponent. Intervenors, at the Conservation Board's discretion, will have their expenses paid for by the proponent. The ERCB decisions may be appealed on questions of law and jurisdiction.

If the proponent of the project wished to delay the construction of the project, or alter the original plans, after the building permit has been issued, another Conservation Board ordinance would be required. Once construction is complete, (approximately five to ten years later for large facilities). an operating permit must be applied for. At this time the original assumptions about the need for the additional capacity may be reviewed and/or any other issues the ERCB feels is relevant, in the 'public's interest'.

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63 The Electric Utility Planning Council is an informal group composed of representatives from the utilities and related government agencies. The purpose of the group is to supply a forum in which issues of mutual concern can be addressed, and plans developed

If a new coal mine is proposed in association with the thermal plant, another multistage process could occur. First, an exploration permit to locate the resource would be required. The necessity for the new mine would have to be justified, as well as the proposed means of controlling pollution and ensuring environmental conservation, while also having regard for the maximum recovery of coal reserves mined. Environmental and social impacts assessments will be required, as well as approval from various other governmental agencies, and cabinet. Finally, to obtain a operating permit, land reclamation plans must be submitted and a security deposit left with Alberta Environment.

Once the above facilities are operating, the utility is obligated by the terms of the operating permit to disclose specified information about the operation regularly. In addition, "all operations will be under strict inspection and regulation to ensure full compliance with standards and requirements related to safety and industrial health, environmental protection, and resource conservation."[64]

If transmission lines are also required, applications will again be necessary to assess both the need for a new line, and the appropriateness of the proposed route. A new route would require a social, economic, environmental and land-use assessment. An investigation may also occur into the possibility of using an existing right-of-way for the new transmission system.

Although it is implied in this hypothetical situation that separate hearings would be necessary for the simultaneous development of a generating facility, a coal mine and a transmission system, in reality they would probably be handled together within a single application process.

"(The) process that an electric utility must go through to obtain approval for a project is fairly extensive."[65] It can be very expensive and take many months to complete. Once all the permits from the ERCB have been gained and the project is built, the utility must then make a presentation to the PUB as to

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64 C. Hunt & A Lucas (ed.): Canada Energy Law Service, Alberta Volume. (Calgary: Canadian Institute of Resource Law, 1990) p 30-3116.
65 Janet Keeping. p 48.

why the new facility should be allowed into the rate base. Automatic acceptance of a new facility by the PUB is not guaranteed. When one reviews the numerous stages that a utility must go through to develop a new facility, it is easy to see the numerous opportunities that exist to derail projects.

2.6 Conclusion.

In this chapter the three essential components of the EUI were presented. Those components included generation, transmission and distribution. One of the unique characteristics of electricity is that it can not be economically stored. This means the capacity to generate and distribute energy under all scenarios must be available within the system. It was also presented that the system requires a significant level of coordination among the component parts. The system can be viewed as a pool of energy that must be maintained at a constant level or blackouts will result.

In a review of the history of the electric utility business in Canada it was shown that the ownership pattern mimicked the pattern of the dominant technologies. Thus, in the early days of the business when generators were disbursed, the ownership was decentralized. As transmission and generating technologies evolved, the dominant pattern of development became large centralized plants.

Ownership under these new circumstances tended toward monopolistic organization. Due to this monopolistic position as well as the importance of electricity to society, regulation became necessary. The utilities that operate within Alberta were introduced as well as the regulatory bodies that govern them.

In the next chapter it will be argued that the status quo of electric generation is under pressure to change. The factors causing this change will be discussed, followed by arguments that the organization of the industry will return to a more decentralized organization.

CHAPTER 3 - CHALLENGES TO THE EXISTING STRUCTURE

> In the long-run, as Keynes says, we are all dead. In the short run we eat, drink, and are occasionally merry. The theorist, however, must contemplate death - or at least transfiguration - as well as merriment.[66]

This chapter is a discussion of the forces of change that are influencing the direction of the electric utility industry and the centralized station model of power generation. Several forces are converging to cause a shift from the central station paradigm. They include concerns associated with the mature state of the electricity market place as well as the technologies that have dominated the industry. For decades the demand for electricity grew faster than Gross National Product (GNP). However since the mid-1970s the demand for electricity has begun to follow GNP. In an atmosphere where demand increases consistently, adding large blocks of power represents minimal risk. However in a mature market, utilities need to be more concerned with the ability of the market place to absorbed new capacity.

In terms of technological maturity, the generating equipment that has dominated over the last seventy five years has reached an efficiency ceiling where no significant increases in performance can be attained. As well, new generating options have emerged that are more efficient than older equipment. These new technologies are also cost justified in smaller sizes, whereas older generating technologies needed to be large in size to be economically viable.

Another force challenging the central station paradigm is regulatory risk. Central station generators have a construction time-line of approximately ten years. Rational planning requires that demand projections be made a decade into the future. These projections are used to justify the necessity of new equipment. Needless to say, there is a certain degree of uncertainty associated with these projections. To make matters worse, once the generators are built, if the projections made ten years earlier turn out to be incorrect, regulators

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66 Kenneth Boulding: A Reconstruction of Economics. (New York: John Wiley & Sons, Inc., 1950) p 26.

may refuse to allow the new facility into the rate base and the utility is left to manage the debt associated with the project. This threatens utility companies' profitability and hence means of avoiding the situation are sought. The solution is smaller generating units which can be constructed in less time, require shorter projection periods and place less financial stress on proponents.

The final challenge that will be discussed here is the potential role the valuation of finite resources and environmental degradation might have on the decision making process associated with project development. The theoretical basis of Orthodox economics was established before the laws of thermodynamics were developed. Proposals will be offered as to how economic theory might be modified so to recognize the significance of the use of finite resources and the social costs associated with environmental contamination. The result of this modification to economic theory may lead to a reconsideration of the central station model of electricity generation.

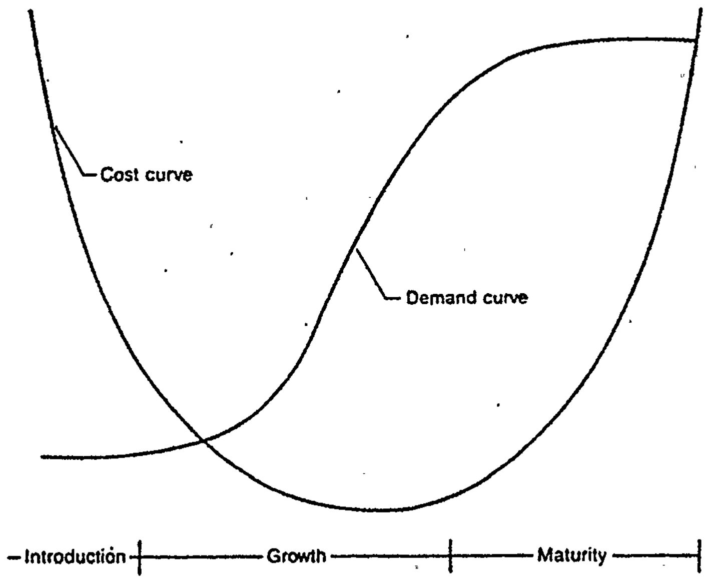
3.2 The Mature State of the Market for Electricity

The first force of change to be discussed is the mature state of the electricity market place. The developed world has reached a stage where demand for electricity is no longer growing exponentially. Just as other products and industries follow fairly well defined periods or cycles of development, so has the electric utility business. These periods include: introduction, growth and maturity periods. During the introductory period it is common that the cost of production decreases as productive capacity expands and the economics of scale are realized. Sales rapidly increase as a result of lower prices, which increase existing uses for the product and foster its expansion into new applications.

During the growth phase, costs stabilize and even begin to increase as technological advancements slow and greater efficiencies become harder to achieve. Typically, new capacity continues to be built in anticipation of further growth. During the later stages of the growth phase, market expansion begins to slow.

Product Life Cycles; Cost and Demand Curves

(figure 3.1)



In the mature phase, costs become more difficult to reduce and prices begin to rise. The markets become saturated and often excess capacity is either left idle or dumped, according to the situation.

> Product life cycle is best portrayed by the theoretical U-shaped cost curve and the S-shaped demand curve. The time for moving through these curves differs for various products. Fad products move through this cycle quickly. Capital goods (automobiles, machine tools) and regulated services (transportation, communication, energy) typically take many decades to go through their cycles.[67]

As discussed in chapter 2, the electric energy business went through its introductory stage in the late nineteenth century, and continued from there to enter the growth phase, using centralized equipment. This growth phase continued until the 1970s.

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67 Katherine Miller: 'Strategies for an Electric Utility Industry in Transition' in Public Utility Fortnightly. June 13, 1985 (Arlington, Virginia; Public Utility Reports, Inc.) p 28.

During the 1970s, the industry entered maturity as prices increased and markets became saturated. Additional evidence that electricity has reached market saturation is a comparison of sales growth with gross national product growth. Prior to the 1970s, electricity sales followed the GNP growth trend, but at a much higher rate of growth. Since 1977, electricity sales have continued to remain GNP-sensitive, but the growth rate in electricity sales has generally been very close to or below the GNP growth rate. This trend further supports the view that electric utilities have reached maturity.[68]

As the utility industry faces this mature market, risks that have never been faced by the industry before in earnest, must now be managed. The industry has reached this point in market evolution through the central station model. The dominant characteristics of a central station include huge capital investments. It is estimated that the cost to build another 400 MW coal burning generator in Alberta would be approximately $1.5 billion.[69] Cost over-runs are not uncommon. The typical time-line for design, construction, and regulatory approval of a new project is approximately 7 to 10 years. These massive units are built on the premise that demand forecasting, 10 and 20 year into the future, is accurate.

The cash flow requirements of a project in the short-term are supplied through debt financing until anticipated future revenues are realized. The risk associated with the central station model emerges when facilities are completed and actual demand does not meet projected levels. Under these circumstances the proponent is left to manage a huge debt load.[70]

This scenario reveals the central station model's greatest weakness, that being its lack of flexibility in an atmosphere of changing demand. This was of little concern during the growth phase of the industry. "Decades of steady rising demand, stable prices, and increasing economics of scale had, by the 1960s, combined to make utility planning largely a matter of where and how big to

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68 Ibid. p 29.

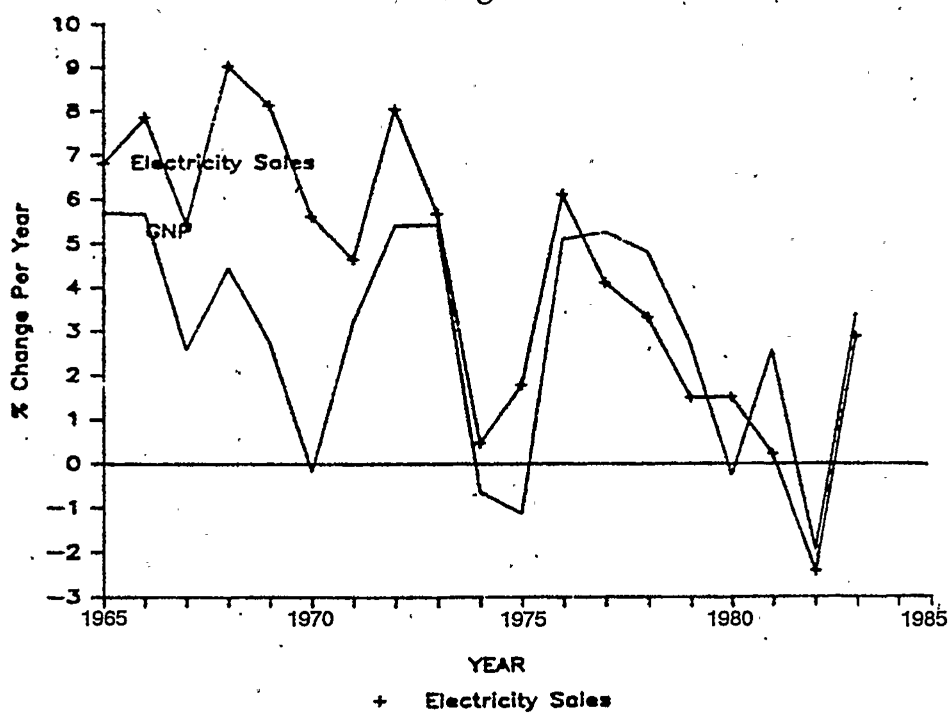
69 This represents the approximate cost of the last thermal electric unit built in Alberta, The Edmonton Power, Genesee plant.

70 In addition, when a new plants is finished, the initial marginal cost per unit of electricity delivered is very high because there exists a large percentage of excess capacity which will not be used for a number of years. To quote Malcolm McDonald of TransAlta Utilities (Personal Communication. Jan. 1993); "With central service facilities, once you are at capacity, a new plant will add large increments of power that will not be needed for several years. They are not paying their way early in life."

build the next plant."[71] However today, with the maturing of the industry and the recognition that accurate forecasting of long range economic trends is difficult, if not impossible, this lack of flexibility is being accentuated.

Electricity Sales and GNP: Historical Figures in USA[72]

(Figure 3.2)



A case in point is Ontario Hydro. In late 1992 and early 1993, the utility received much press coverage related to its debt of approximately $36 billion. In brief, the debt problem associated with the utility has been caused by three factors. The first factor is a perceived over-staffing situation. Second, is the overly optimistic demand projections make by electricity planners during the early 1980s and based on these projections, the over-building of capacity. The third factor is bad luck, with the necessity for existing nuclear plants to be retrofitted with new tubing, at great expense to the utility.

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71 John Ward: 'The Corporate Implications of Competition: A Change of Direction', in Public Utility Fortnightly, June 13, 1985. (Arlington, Virgina; Public Utility Reports, Inc.) p 34.

72 The historical data in Canada is similar.

In regard to demand projections, the financial problems of Ontario Hydro stem from a over-ambitious 25 year expansion program which when originally proposed foresaw increases in demand of between 50 and 100 percent by the year 2014.

> Electricity demand grew by a buoyant 4 to 5 percent a year throughout the late 1980s, but it has been falling since then. Utility planners have been astonished to find that demand has dropped or remained stable for three years in a row (1989-1992), an event that has never happened before, not even during the Great Depression of the 1930s.[73]

In late 1992, Hydro canceled review hearings into its 25-year expansion plan because it was then predicting a power surplus until the year 2009. As an editorial writer in the Toronto Globe and Mail commented: "Why were Hydro's demand forecasts so absurdly out of whack? Could anyone have done better, or is trying to project electricity demand 25 years into the future for a province of 10 million people simply futile?"[74]

Based on the projections made in the early 1980s, Ontario Hydro added additional capacity. By 1992, a huge debt and slumping demand forced Ontario Hydro and its new chairman Maurice Strong to begin a cost cutting program. "But despite proposed layoffs and capital spending cuts, about 75 per cent of Hydro's costs are fixed."[75]

3.3 Technical Maturity

Just as the market for electricity has reached maturity, so has the technical components that make up the central station model.

> The capacity currently being installed ... to the electric utility systems is mature technology. No significant advances in either generation or transmission technology have come forth since the 1960s. Thermal limits prevent further economics of scale. Although many

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73 Martin Mittelstaedt: 'Restructuring a Utility: Why Lights are Dimmed at Ontario Hydro' in The Globe and Mail, March 9, 1993. (Toronto, The Thomson Newspaper Company) p A9.

74 The Globe and Mail: 'Ontario Hydro's Crisis, and the Questions it Raises', March 9th, 1993. (Toronto, The Thompson Newspaper Company) p A18.

75 Barbara Wicks: 'Strong Medicine' in Macleans Magazine, March 1, 1993. (Toronto, Maclean-Hunter Publishers) p 38.

> incremental technological advances have been made since then, the slowdown in technical innovation makes the industry vulnerable to major technological breakthroughs by competing industries in providing or displacing electricity services.[76]

The greatest strength of the centralized system prior to the 1970s was the model's ability to maximize the advantages that could be gained through the economics of scale. With the technologies available over the last 100 years, it was indisputable that a 500 MW generator could supply energy cheaper than two, 250 MW units, or five, 100 MW units. Recent technological developments however no longer make large facilities the low cost supplier of energy.

With the development of advanced technologies such as combined cycle turbines and fuel cells, greater efficiencies are being realized. These technical options will be discussed further at a later time. For the sake of this discussion, the dominant characteristics of these alternative technologies is that they have an efficiency rating of 50 percent or greater and this efficiency rating is not overly dependent on the size of the facility. This efficiency can be pushed even higher when the co-generation concept is employed (approximately 75 percent) so that exhaust steam is utilized. In comparison, conventional coal burning technologies that are presently installed in Alberta have an efficiency ceiling of approximately 33 percent.

3.4 Regulatory Risk

To further add to the adversity facing the central station model, two more items need introduction. The first is the risk associated with projections and the second is regulatory risk.

> There are some policies a regulatory commission chooses which contribute strongly to regulatory risk. The two most notable policies are lengthy delay in decisions which induces revenue erosion, and the setting of relatively low rates of return. .... In addition to these however, there are the long established rules of a commission which are independent of the merits of a particular case such as the handling of accelerated depreciation, fuel adjustment clauses, construction work

76 Miller. p 30

in progress, the choice of the test year and the rate base valuation method.[77]

Of the above listed issues, the discussion here will focus upon the delay in decisions which induce revenue erosion.

Alberta has a two stage process of regulatory approval for a new facility, as discussed in chapter 2. In review, the ERCB issues building permits and the PUB decides when the costs of the new project will be allowed into the rate base. This two part process causes utilities enormous stress. The risk is that a building permit will be issued based on certain projections for demand and ten or more years later, when the proponents of the same project wish to begin earning revenue from this new installation, the demand projections do not materialize. As a result the PUB will not allow the proponent to operate the facility and collect revenues. If this arises, the utility developing the project will be required to pay for the carrying costs of the new facility from their general revenues.

To quote Terry Crowe of TransAlta Utilities;

> this causes us great anxiety and is called regulatory risk. If we build a billion dollar plant we want to be certain that we will be able to earn on it. This is the reason we will never build another (large centralized plant). Too many utilities have been hurt by (the above described regulatory process).[78]

Even the hearing process itself can cause further risk. The justification for new installations is based on long-term demand projections. With a minimum time-line of five years to design and build large projects, further delays because of the regulatory process (often up to two or three years) requires that projections are made even further into the future.

But as previously discussed, the further into the future projections are made, the greater the risk of inaccuracy. And based on these tenuous projections,

77 Philip Fanara Jr. and Raymond Gormand: 'The Effect of Regulatory Risk on the Cost of Capital' in Public Utility Fortnightly. June 13, 1985 (Arlington, Virgina; Public Utility Reports, Inc.) p 33.
78 Terry Crowe: TransAlta Utilities. Personal Communication, Dec. 1992.

billions of dollars must be spent to build a new development. Once the facility is in place, proponents may discover that the regulatory bodies expected the utilities to have perfect foresight, and therefore potentially limit the revenues that can be generated by new a plant. In a mature market situation this is becoming an unacceptable situation for the proponents who take the risks involved in developing large generating and transmission facilities. The answer to both the risk associated with projections and regulatory risk is simply to build more and smaller generators.

An example of the impact of regulatory risk occurred in Alberta during the 1980s with Edmonton Power's construction of the Genesee Generating Station. The Genesee plant was controversial from the very beginning since many felt new capacity was not required and the proponents of the facility were trying to create a make-work project. It is not the purpose here to judge whether the plant was necessary or not, but rather to review the regulatory process associated with its development.

In 1986, the ERCB accepted Edmonton Power's application to construct the plant even though construction had already begun. Within a year the ERCB ruled that the completion of the plant should be deferred, for unit one from 1986 to 1988 and for unit two from 1987 to 1989. A similar deferral was also suggested for the proposed Sheerness Generating Station which is co-owned by Alberta Power and TransAlta Utilities.

Once the Genesee plant was completed, Edmonton Power applied to have the plant's costs included in the rate base. In March, 1989 the PUB ruled that the province had enough electrical generating capacity and refused Edmonton Power's application to have the project included in the rate base. The point of controversy became the ERCB acceptance of the demand projections presented in 1986, to justify the building of the plant, and once completed, the PUB suggestion that since demand forecasts had changed they were not obliged to include the project into the revenue stream of the province. Edmonton Power felt the PUB should not be in a position to question assumptions made by another board. To quote William Paterson of the PUB, "It comes back to the question of who bears the risks of circumstances having changed, the utility or the consumer."[79]

Because of this 1989 PUB decision, the City of Edmonton, owner of Edmonton Power, was forced to carry the construction costs of the plant from its existing revenues. To quote Mr. Binder, an Edmonton City councilor at the time of the decision; "It's not a comfortable situation to any lender to have a huge, non-money-making asset on the books."[80] This alderman estimated that in 1989 that the city would need to borrow between $90 million and $110 million just to pay interest on the borrowed money used to construct the plant. Ultimately, the plant was allowed by the PUB into the rate base.

3.5 The Valuation of Environmental Externalities

This section offers an overview of the potential impacts environmental concerns may have on the electric utility industry. The presentation here reviews the material in a preliminary and general fashion. The essential point to be made here is that the number and weight of policies designed to force individuals and firms to consider environmental externalities in their decision making processes are expected to increase. These policies will impact both the operating costs and the capital costs of EUI projects. The result of this valuation of externalities will likely influence the EUI to pursue technologies which are both more efficient in operation and whose siting will be less damaging to the natural environment.

Centralized institutions such as provincial governments have two basic methods or policy tools to pursue the goals of sustainable development on a macro-scale. The first is through a command and control arrangement and the second is through a market oriented arrangement. The preference here will be toward market arrangements. This preference stems from the view that market options create more consistent results over time, as well as allow

79 William Paterson of the PUB quoted in, 'Very Political Power Indeed: As Genessee Sits, the Buck-Passing Continues.' in Alberta Report, March 9, 1989. (Calgary, Interwest Publications Ltd.) p 18.
80 Mark Stevenson quoting Mel Binder in, 'Very Political Power Indeed: As Genessee Sits, the Buck-Passing Continues.' in Alberta Report. March 9, 1989. (Calgary, Interwest Publications Ltd.) p 18.

for more flexibility under changing circumstances. This method also decentralizes decision making and allows more individuals to participate in the creative process of finding alternatives.

It is not essential here to have a lengthy dialogue on whether market mechanisms are superior to command and control mechanisms. The ultimate goal is the attainment of sustainable development. The final result will undoubtedly be a mix of the two mechanisms, for even the installation of market mechanisms will require some form of governmental intervention into the economy. Regardless of which mechanism becomes dominant, there will be extensive debate about what externalities must be considered and what criteria of valuation will be used. These discussions will inevitably impact the EUI.

It will be argued here that two major modifications are required to make macro-policies more effective in pursuing the goal of sustainable development. The first is the modification of today's orthodox economic model so it includes consideration for material and energy flows. The second will be the development of a methodology to deal with the mixed units controversy by giving a monetary value to ecological systems. Both of these topical areas, in terms of research, are in their infancy. It will take years to develop intellectual models with enough internal coherence to base policies on. It will also then take years to develop a consensus within society as to how they should be applied.

3.5.2 Modifications to Orthodox Economic Theory

The modifications to the orthodox economic model that will be suggested here apply primarily to macro-economic theory. The conventional macro-economics perspective of the economy is seen as an aggregate of all the production equations of micro-economic firms, defined as $Y=f(K,L)$ where (Y), total output, is a function of capital (K) and labour (L).

Material flows, both material inputs (i.e. iron-ore, lumber, petroleum) into the production of goods as well as material outputs or waste from production, have no monetary value in-and-of themselves. Material flows only gain a monetary value as a function of capital. For example, iron-ore as a mineral in the ground has no value. It gains an abstract exchange value through the capital resources involved in extracting that resource.

This lack of appreciation for material flows within the economy reflects two implicit assumptions of orthodox economic theory about the natural environment. The first assumption is that the economic system is both isolated and separate from the ecological environment. This assumption implies, to use Commoner's terms,[81] that the 'technosphere' is not a subsystem of, or interrelated with, the 'ecosphere'. The second major assumption is a two part consideration on material flows, namely that there is no limit to the availability of raw resources and that the environment has a limitless capacity to absorb material.

The outcome of these two major assumptions is an economic system that uses resources inefficiently. Efficiency is a measure of the ratio of outputs relative to inputs. But the only items which gain expression in this calculation are those items which have an abstract monetary value.

"(It) is very important to recognize that all significant efficiency concepts rest on human valuations and that efficiency concepts which are based on purely physical inputs and outputs may not be significant in human terms."[82] That was of course before concerns about environmental degradation and the availability of raw resources for future generations arose.

This shortcoming is a result of an inappropriate view of reality held by the founders of orthodox economic theory and perpetuated over time. The reasons offered for these faulted assumptions was the lack of awareness by the founders about the laws of thermodynamics.

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81 Commoner's terms as outlined in Chapter 1.

82 Kenneth Boulding: <u>Evolutionary Economics</u>. (Beverly Hills: Sage Publications, 1981) p 153.

The fact that economics was a well-developed discipline long before the rise of thermodynamics may account for its lingering Newtonian flavour and for the current attacks on it in the name of thermodynamics.[83]

> We certainly cannot blame Adam Smith, writing in the 1770s, for not being aware of thermodynamics, which begins with Carnot, about 1817, did not even really identify its fundamental concepts of entropy until Clausius in 1865, and developed its basic theoretical structure with Boltzman in the 1870s.[84]

As to the theory's perpetuation over time, apologists look to Schumpeter and his opinions on the 'preanalytic' disposition of research over time. "(We) all start our own research from the work of our predecessors, that is, we hardly ever start from scratch."[85]

The necessary change required in orthodox economics is the recognition that the economy is a subsystem to the finite ecosystem.

> The notion of a closed but infinite system based on an abstract valuing system, unconstrained by the laws of thermodynamics must be superseded. Once this paradigmatic shift takes place, the issue of the economic system's relationship to its parent system (the environment) cannot be avoided.[86]

"No complex system can be managed without clear goals and appropriate mechanisms for achieving them."[87] "Sustainable development should be the primary long-term goal, replacing the current focus on GNP growth."[88]

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83 The first law of thermodynamics addresses conservation by stating that energy/matter in a closed system can not be created or destroyed, but only transformed. The second law refers to the tendency in a closed system towards increasing entropy. Another way to consider the second law is as the law of exhaustible potential, which states that if anything happens it is because there was a potential for it to happen, and that after it happened that potential has been used up.
84 Boulding: Evolutionary Economics. p 147.
85 Joseph Schumpeter: History of Economic Analysis. (New York: Oxford University Press, 1954) p 41.
86 Herman Daly: 'Elements of Environmental Macro-economics': in Robert Costanza (ed.) Ecological Economics: The Science and Management of Sustainability. (New York: Columbia University Press, 1991) p 34.
87 Robert Costanza: 'Assuring Sustainability of Ecological Systems.' in Robert Costanza (ed.) Ecological Economics: The Science and Management of Sustainablity. (New York: Columbia University Press, 1991) p 332.
88 Ibid. p 331.

With the modification of macro-economic theory so that it reflects the law of thermodynamics, two essential questions arise for scientists to answer: what is the carrying capacity of the planet and what should be the optimal size of the economy or throughput of material so as to achieve a sustainable society? These questions may be virtually impossible to answer accurately. But approximate answers would suffice, with modification as more knowledge is gained about carrying capacities.

Even if science can answer what the optimal scale of economic activity should be, how can this information be communicated to human society? What is being suggested here is that this information should be communicated through both the language of economics and the language of science.

This last statement implies many things. First, it is the 'technosphere' that must change. Second, the dominant language of the 'technosphere' is the language of economics. Third, to influence the technosphere the ecosphere needs to be given an monetary value.

As discussed in chapter 1, the 'technosphere' has greater flexibility to change relative to the 'ecosphere'. Perhaps the restructuring of society will take a hundred years or more, but it is still the more adaptive of the two spheres.

Human society tends to resist change. Expecting society to make a quantum leap in its values is unrealistic. Promoting a position of practical incremental evolution is a more reasonable strategy relative to other radical suggestions such as those made by 'deep ecologists'.

Orthodox economics is not just a theoretical model of reality. It is the capsulation of western society's dominant ideology, on liberty and the responsibilities of individuals in society. It has become as influential as the Christian Bible in dictating values and appropriate behaviours. As disconcerting as it may be, 'Rational Man', the icon of orthodox economics is a role model for many contemporaries.

On a less abstract level, orthodox economics has many advantages in the pursuit of a sustainable society. Economics has an effective feedback system to supply information about the most appropriate behaviour under different circumstances. The system is also inherently oriented around the pursuit of efficiency. If the ecosystem were to receive a monetary value, the efficiency concepts could be harnessed to promote ecological ends.

3.5.3 Valuation of Ecological Systems

The notion of valuating ecological systems is controversial.

> (Some argue, how) can one put a value on human life, environmental aesthetics, and a host of other 'intangibles'? In the minds of some, even to think of the problem in these terms is distasteful. But distasteful as they may appear to some, I contend that these valuations are unavoidable, and to deny their existence can only cause sorrow and confusion in the long-run. Without 'value' measured in units that can be compared with other things, humans too often regard ecological goods and services as 'free'. This has produced unsustainable policies at every decision-making level.[89]

But as distasteful as it may be, the challenge is to communicate information about potential long-term environmental impacts to human society. The language of the 'technosphere' is economics and the central issue of sustainable development is changing human behaviour.

As David Orr states;

> God, or evolution was doing a nice job of managing the earth until the scale of the human population, economy and technology got out of control. Planetary management implies that it is the planet that is at fault, not human numbers, greed, arrogance, ignorance, stupidity, and evil. We need to manage ourselves more than the planet and our self-management should be more 'akin to child-proofing a day-care centre than to piloting spaceship earth'. The way to child-proof a room is to build the optimal scale playpen within which the child is both free and protected from the excesses of its own freedom.[90]

If the issue is modifying human action, economics is one of the most powerful mechanisms to direct human behaviour. But the mixed units debate about expressing ecological carrying capacity in economic terms is very

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89 Costanza: 'Assuring Sustainability of Ecological Systems.' p 334.
90 David Orr quoted from Daly. p 39.

difficult. "The 'mixed units' problem arises in any field that tries to analyze interdependence in complex systems that have many difficult types and qualities of interacting commodities. Ecology and economics are two such fields."[91]

> The difficulty with attempting to quantify externalities is that the scope of such an undertaking is enormous and results are crude approximations. Also there are numerous questions related to which level of government should institute such a program and whether international coordination is required to make such programs effective. Valuation of environmental externalities is a discipline still in its infancy, a major research effort is found to be needed.[92]

Attempts to value ecological systems will initially struggle to find an effective methodology. In brief, two basic approaches could be taken. One approach would be the economic methods of calculating the willingness-to-pay model. This method would value a forest, for example, by considering the number of visitors to the area and the amount of money they would be willing to pay to use the area. The obvious weakness in this method is that forests that are close to urban centres have a higher value than forest located a long distance from an urban centre. From a ecological point of view however, both forests are equally significant.

An example of a more ecologically based approach to valuation is offered by Costanza and Farber. Their technique is based on energy analysis and they offered the example of the valuation of a wetland area. The energy analysis technique uses the solar energy captured by ecosystems as a measure of value.

> To estimate this energy in wetlands we measured the Gross Primary Production (GPP) or the amount of solar captured and stored in plants. By converting GPP to a value based on what it would cost to produce the same energy (or calories) with fossil fuels, we can put a dollar value on the energy.[93]

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91 Costanza: 'Assuring Sustainability of Ecological Systems.' p 337.

92 Stan Benjamin: 'Environmental Externalities; Will a Noble Idea Wrongly Applied Wind Up Doing More Harm than Good?' in Electric Perspectives. year unknown (Washington, D.C., Edison Electric Institute, Inc.) p 16.

93 Robert Costanza and Lisa Wainger: 'No Accounting for Nature: How Conventional Economics Distorts the Real Value of Things' in The Washington Post. September 2, 1990. p B3.

The weakness of this argument is that a wetland becomes more valuable than the tundra. But yet it is in the operation of a variety of ecozones that ecological health is maintained.

To be extremely critical of either of these methods is reasonable. As Martinez-Alier states:

> An economic rationale, based either on the market or on central planning and which takes into account ecological side-effects and uncertainties is impossible. It is equally impossible to decide human affairs purely according to ecological planning. This leads to favouring the politicization of the economy. In other words, I conclude that the economy and the ecology of humans are embedded in politics.[94]

What is at stake cannot be answered by economics or ecology alone. Sustainable development demands an ethical/moral position as to the type of future our children will inherent, what will rich people do for the poor peoples of the world and what ecological processes will be protected because they are valuable in-and-of themselves.

These value laden decisions will be made along a continuum of options or value positions as to the guiding principle in policy development. The poles of this continuum are represented by the following two positions.

First is a position based on attempts to achieve an anthropocentric optimum.

> The rule is to expand scale, i.e. grow, to the point at which the marginal benefit to human beings of additional man-made physical capital is just equal to the marginal cost to human beings of sacrificed natural capital. All non-human species and their habitat are valued only instrumentally according to their capacity to satisfy human wants. Their intrinsic value (capacity to enjoy their own lives) is assumed to be zero.[95]

The opposite pole will attempt to achieve a biocentric optimum.

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94 Juan Martinez-Alier: Ecological Economics- Energy, Environment and Society. (Cambridge Mass.: Basil Blackwell Ltd., 1987) p xxiv.
95 Daly. p 40.

> Other species and their habitats are preserved beyond the point necessary to avoid ecological collapse or cumulative decline, and beyond the point of maximum instrumental convenience, out of a recognition that other species have intrinsic value independent of their instrumental value to human beings. The biocentric optimal scale of the human niche would therefore be smaller than the anthropocentric optimum.[96]

3.5.4 Examples of the Incorporation of Environmental Concerns into Economic Models

The following discussion will give examples of how certain topics within the environmental agenda might be incorporated into the economic model. The four areas to be reviewed include:

1. The setting of limits on the environmentally degrading externalities stemming from such human activity as industrial production
2. The protection of natural ecological processes and in particular habitat
3. Allotting resources so that the needs of the present generation can be met without depriving future generations of their ability to meet their own needs
4. Dealing with uncertainty that surrounds projects that have potential environmental impacts but where information associated with those threats is imperfect

As to whether this is a complete list is not relevant for this discussion. All these areas will in some way impact industrial societies generally and the electric utility industry in particular. The expected result of this manipulation of the economic model is a redefinition of the economics of scale as it applies to different industries and situations.

Setting limits on environmentally degrading externalities has been the focus of a large body of intellectual material to date. The use of economic instruments have been proposed to influence firms' decisions about technological choices and production processes.

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[96] Ibid p 40.

The basic argument is as follows. Environmental degradation stemming from industrial production is a problem of the 'commons'. Because air and water do not have any property rights associated with them they are used as common properties, available to all to use as they please.

> (For example, the) earth's atmosphere is a global commons into which the world's population emits the gaseous by-products of its activities on the erroneous assumption that the atmosphere has limitless capacity to absorb invisible gaseous waste without changing its characteristics, and the air pollution is cost-free waste disposal.[97&98]

The response to this problem is to create property rights for the atmosphere. This could be achieved by giving governments legislated power to be responsible for the use of this resource. With this legislative base in place, an optimal level of pollution can be set and permits are issued for the legal right to pollute. Since, hypothetically, there may be many who wish to pollute and only a limited number of permits, the potential exists to create a market for these permits.

Facing this market in pollution permits forces firms to consider externalities in their decision making process. They are essentially left with the choice of either purchasing pollution permits or installing less polluting technologies.

The debate on the valuation of externalities is today (1994) largely a theoretical one with few examples of working models. One of the few examples is the requirement of fossil fuel burning electric utilities in the United States to participate in an air pollution permit trading program.

The second area of consideration is the protection of terrestrial life (habitat and ecological processes) and mineral resources. Ecological processes and mineral resources have no intrinsic value in the economic model's

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97 Richard Ottinge, David Wooley, Nicholas Robinson, David Hodas and Susan Babb: Environmental Costs of Electricity. (New York; Oceana Publications, Inc., 1990) p 127.

98 "The major human source of CO2 emissions into the atmosphere is the burning of fossil fuels which accounts for 5 of the 6 to 8 billion tons of carbon emitted annually as a result of human activity, and which is growing annually at the rate of about 3.6% per year. In the United States, electric utilities account for one-third of all the carbon emitted from fossil fuels." Quote from Ottinge, Wooley, Robinson, Hodas and Babb. p 136.

calculation of Gross National Product (GNP). Today GNP is considered one of the main benchmarks of a country's welfare. "Yet GNP as presently defined ignores the contribution the natural environment makes to human economic well being. Quite clearly, if what is conventionally measured as income ignores the deterioration of the environment, then such an income is overstated."[99]

For example, Daley and Cobb (1989) have attempted to adjust GNP to account for depletion of natural resources, pollution effects, and income distribution effects by producing an index of sustainable economic welfare (ISEW).

> They conclude that while GNP in the USA rose over the 1956-86 interval, ISEW remained relatively unchanged since about 1970. When factors such as loss of farms and wetlands, costs of mitigating acid rain effects, and health costs caused by increasing pollution are accounted for, the USA economy has not improved at all.[100]

A more comprehensive approach to the calculating GNP calls for a complete inventory of environmental assets and the setting of a value on those assets to construct a balance sheet. Then the changes from year to year in the natural assets would be subtracted from GNP.

Certainly it will be no small task to construct such an inventory or assign values. But as Serafy states:

> we must not be too ambitious and aim for a comprehensiveness that will forever remain elusive. Let us adjust income gradually for degradation of petroleum, forestry and fisheries, water quality, soil erosion, one at a time and additionally as our methodology firms up and the physical basis of our calculations improves, leaving economic calculation of thorny areas such as biodiversity to the last.[101]

Under the present situation environmental disasters make a positive net contribution to the economy. As Costanza and Wainger point out:

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99 Salah El Serafy: 'The Environment as Capital' in Robert Costanza (ed.) Ecological Economics: The Science and Management of Sustainability. (New York: Columbia University Press, 1991) p 171.

100 Robert Costanza: 'Ecological Economics: A Research Agenda' in Structural Change and Economic Dynamics. (U.K.: Oxford University Press. 1991) p 345.

101 El Serafy. p 173

> The billions of dollars that Exxon spent on the Valdez cleanup all actually improved (Alaska's) economic performance. (Cleaning) up oil spills creates jobs and consumes resources, all of which add to GNP. Of course, these expenses would not have been necessary if the oil had not been spilled, so they shouldn't be considered 'benefits'. But GNP adds up all production without differentiating between costs and benefits, and is therefore not a very good measure of our economic health.[102]

A third suggested modification for the economic model is consideration for the allocation of resources so that the needs of the present generation can be met without depriving future generations of their ability to meet their own needs. Presently the needs of future generations have no representation in the economic model. Since they are not here to bid for resources, their needs are not considered.

> Questions on the optimality of the inter-generational allocation of exhaustible resources cannot be separated from questions on moral values, against the basic rules of conventional economic theory (which has no regard for future generations).[103]

Martinez-Alier suggests a method of dealing the inter-generational issue is to develop a social rate of discount. "Economic theory can operate assuming altruistic economic agents who apply a 'social' rate of discount lower than the market rate of interest, and who might apply a zero or negative rate of discount."[104]

Today private agents develop rates of discounts suited to their own purposes. Since the availability of renewable resources is considered endless, resources are given a zero rate of discount. For exhaustible resources the discount rate is applied in consideration of how long the resource can be extracted profitably from any particular site.

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102 Robert Costanza and Lisa Wainger. p B3.
103 Martinez-Alier. p 160
104 Ibid. p 170.

The fourth topic of modification of the economic model is dealing with uncertainty that surrounds projects that have potential environmental impacts but where information associated with those threats is imperfect.

Here the precautionary principle offers a solution.

> This principle applies to situations where the probability of future outcomes cannot be known with confidence. Indeed, all that may be known is that the probability of distant, but potentially catastrophic outcomes is positive - even if there is not information on the precise nature, timing or incidence of those outcomes. They are outcomes against which it is impossible to insure commercially because there are insufficient data on which to estimate an expected value for future losses within acceptable limits of confidence. This implies two sources of difficulty. First, it is not clear what relationship should exist between resources committed now and the expected value of future losses. Second, since the principle implies the commitment of public resources, it concerns collective decision making, and so raises the familiar difficulties associated with collective responsibility for future generations.[105]
>
> Events that are thought to have a low probability of occurring, received little attention in decision models. The prospect of catastrophe in such cases is necessarily assigned a weight close to zero. The ethical questions this raises concern the right of present generations to put at risk not just the marginal benefits to future generations of access to a particular resource or ecosystem, but the very survival of those generations.[106]

Costanza suggests the requirement of an

> environmental assurance bond to incorporate environmental criteria and uncertainty into the market system and to induce positive environmental technological innovation. In addition to direct charges for known environmental damages, an assurance bond equal to the current best estimate of the largest potential future environmental damages would be levied and kept in an interest-bearing account. The bond (plus interest) would be returned if - and only if - the firm could prove that the suspected damages had not occurred or would not occur. If damages did occur, the bond would be used to rehabilitate or repair

105 Charles Perrings: 'Reserved Rationality and the Precautionary Principle: Technological Change, Time and Uncertainty in Environmental Decision' in Making', in Robert Costanza (ed.) Ecological Economics: The Science and Management of Sustainability. (New York: Columbia University Press, 1991) p 154.

106 Perrings. p 155.

> the environment, and to compensate injured parties. By requiring the users of environmental resources to post a bond adequate to cover potential future environmental damages (with the possibility for refund) the burden of proof is shifted from the public to the resource user and a strong economic incentive is provided to research the true costs of environmentally innovative activities and to develop innovative, cost-effective pollution control technologies. This is an extension of the 'polluter pays principle' to 'the polluter pays for uncertainty as well.[107]

If the above proposals come into play, the impact on the electric utility industry would be significant. Every aspect of the business and every technology used could potentially be impacted. The expected result would be a redefinition of the optimal scale of operation.

This redefinition would require a re-examination of the central station model of electricity generation. To investigate the potential impact valuating externalities might have, let us consider a proposal for a 500 MW coal burning thermal generator.

If such proposals become legislated, the impact on utilities which primarily use coal are two fold. First, alternative technologies that are more efficient than present technologies will receive more attention. As discussed earlier, present technologies have an efficiency of approximately 33 percent, whereas alternative technologies have efficiencies of 50 percent or greater. Two, alternative fuels may also receive new attention.

> For instance, although 84% of the current CO_2 emissions created by electric generation come from coal-fired power plants, the same amount of electric power could be produced by burning oil or natural gas, reducing emissions by about 20% and 40% respectively. The reductions would be greater if the oil/gas technology were combined-cycle or other efficient technologies.[108]

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107 Costanza: 'Ecological Economics: A Research Agenda'. p 339.

108 The United States Environmental Protection Agency, Office of Policy, Planning and Evaluation, Policy Options for Stabilizing Global Change. Draft to Congress Feb. '89, quoted in Ottinge, Wooley, Robinson, Hodas and Babb. p 136.

In summary, it has been argued here that two major modifications are required to make macro-policies more effective in pursuing the goal of sustainable development. The first is the modification of today's orthodox economic model so it includes consideration for material and energy flows. The second will be the development of a methodology to deal with the mixed units controversy by giving a monetary value to ecological systems.

One of the conclusions of this discussion on valuation techniques, is that it is equally impossible to make monetary assessments according to economic or ecological rationales. Ultimately, the economy and the ecology of humans are embedded in politics.

As this discussion applies to the EUI, it was suggested that if a monetary value was given to environmental degradation the result would be a redefinition of the optimal scale of operation. This redefinition would have an impact on every aspect of the business, the dominant technologies and the dominant pattern of technological use seen today.

3.6 Conclusion

In conclusion, a combination of factors are converging to cause electric utilities and regulators to re-examine the dominant paradigms of the industry. They include concerns associated with the mature state of the electricity market place as well as the technologies that have dominated the industry. For decades the demand for electricity grew faster than GNP. However since the mid-1970s the demand for electricity has begun to follow GNP. In an atmosphere where demand increases consistently adding large blocks of power represents minimal risk. However in a mature market, utilities are looking for generation options which offer more flexibility.

In terms of technological maturity, the generating equipment that has dominated over the last seventy five years has reached an efficiency ceiling where no significant increases in performance can be attained. But just as older technology is reaching maturity, new generating options have emerged that are more efficient in their use of fuel. These new technologies are also cost justified in smaller sizes, whereas older generating technologies needed to be large in size to be economically viable.

Another force challenging the central station paradigm is regulatory risk. Central station generators have a construction time-line of approximately ten years. Rational planning requires that an estimation of the demand for electricity a decade into the future be made. These projections are used to justify the necessity of new equipment. There is a certain degree of uncertainty associated with these projections. To make matters worse, once the generators are built, if the projections made ten years earlier turn out to be incorrect, regulators may refuse to allow the new facility into the rate base and the utility is left to manage the debt associated with the project. This threatens utility companies' profitability and hence, means of avoiding the situation are sought. The solution is smaller generating units which can be constructed in less time, require shorter projection periods and place less financial stress on proponents.

The final challenge considered was the potential role the valuation of finite environmental concerns might have on the decision making process associated with project development. The theoretical basis of orthodox economics was established before the laws of thermodynamics were developed. Proposals were offered as to how economic theory might be modified so to recognize the significance of the use of finite resources and the social costs associated with environmental contamination. The result of this modification to economic theory may lead to a reconsideration of the central station model of electricity generation.

The cumulative effect of all these challenges to the status quo of the EUI will be a shift away from the central station model. This shift or decentralizing trend will require utility planners to make choices among numerous options for generation. These options will be investigated in chapter 4.

CHAPTER 4 - FUTURE OPTIONS FOR THE ELECTRIC UTILITY INDUSTRY

'Sustainable Development' has become the background for decision making in our society. The water the fish swims in.[109]

This chapter will begin with an investigation of the technical options that are available to electric utility planners today (1993) to move the system away from the present centralized model and towards a more decentralized model of power generation.

Once this is complete, scenarios as to when this evolution might occur will be reviewed. Essentially the opportunity to decentralize will be when the installed infrastructure reaches the end of its life-cycle and needs replacement. One conclusion of this section is that if all the challenges discussed in the last chapter become significant forces in the decision making process about the future development of infrastructure, the result will be a redefinition of the economics of scale as it applies to the EUI. With that point made, a variety of supply option may emerge and be cost-justified.

Finally, the suggested evolution of the EUI will be compared with other industries that have experienced restructuring. The long distance telephone industry, the home entertainment/telecommunications industry and the rail road industry will be reviewed. These industries are investigated to determine if analogous situations exist to the proposed changes expected in the EUI.

4.2 Technical Options for the Decentralization of Electricity Generation

Diagram 4.1 is a schematic which outlines both the essential components of today's electric utility infrastructure, as well as the technical options that would comprise a decentralized model of power generation. This overview only considers technical options that are either available today, or on the immediate horizon. No consideration is given to any unforeseen, revolutionary technological development. The economic aspects of the

[109] Philip Lulman: TransAlta Utilities, Personal Communication. Nov., 1992.

options presented will not be considered in this section. The purpose of this section is to make the reader aware of the options available to society.[110]

Diagram 1 displays a greater level of descriptive detail on electric utility infrastructure than previously offered. It should be noted that the lines which represent the transmission and distribution systems have three weights. The heavy, double line represents the high voltage transmission system (240 KV) which transport electricity the long distances between the central station generating facilities and the various communities throughout the service area. Once the transmission system reaches the boundaries of a community the energy enters a substation transformer and the voltage is stepped down to approximately 50 KV and directed onto a local distribution system. This is demarcated as a single, medium weight line.

Branching off from the local distribution system are area distribution systems. Again the energy is directed through a substation transformer to step the voltage down to approximately 25 KV. Just before entering a home or building the power is again put through a transformer and brought down to the 120 volts that operates most home appliances and office equipment. Variations of this configuration do exist according to the service requirements of any particular customer. For the sake of this presentation however, the above archetype will be assumed.

With the transmission system outlines, the various options for decentralized power generation can now be presented. If a continuum of options for generating facilities were to be created, the central station model would represent one extreme and a home generator would represent the opposite extreme. Since the central station model dominates today, any consideration of the other alternatives is a shift towards decentralization.

Between these poles of the continuum, there are two main categories of generation. This first category will be labeled 'Small Central Station' (SCS) units. The most essential characteristics of these generators is that they tie

[110] It will be assumed that there will not be an importing of electricity from other jurisdictions. It will also be assumed that there will not be a major societal collapse from an economic depression or a war.

into the high voltage transmission system. Although there are no minimum size requirements, this category can obviously accommodate large generators since the transmission was originally built to accommodate central station facilities. SCS units will be smaller in size than their central station predecessors, but still relatively large facilities (100-300 MWs) in size. These units represents an incremental shift from the central station model, hence the name of this category.

The second category will be labeled the 'Distribution Based' (DB) generating units. The distinguishing characteristic of this category of generators is that they tie into the distribution system. Distribution systems have limitations to their carrying capacity. Because of this characteristic, there exist limitations within this category to the maximum size of generators.

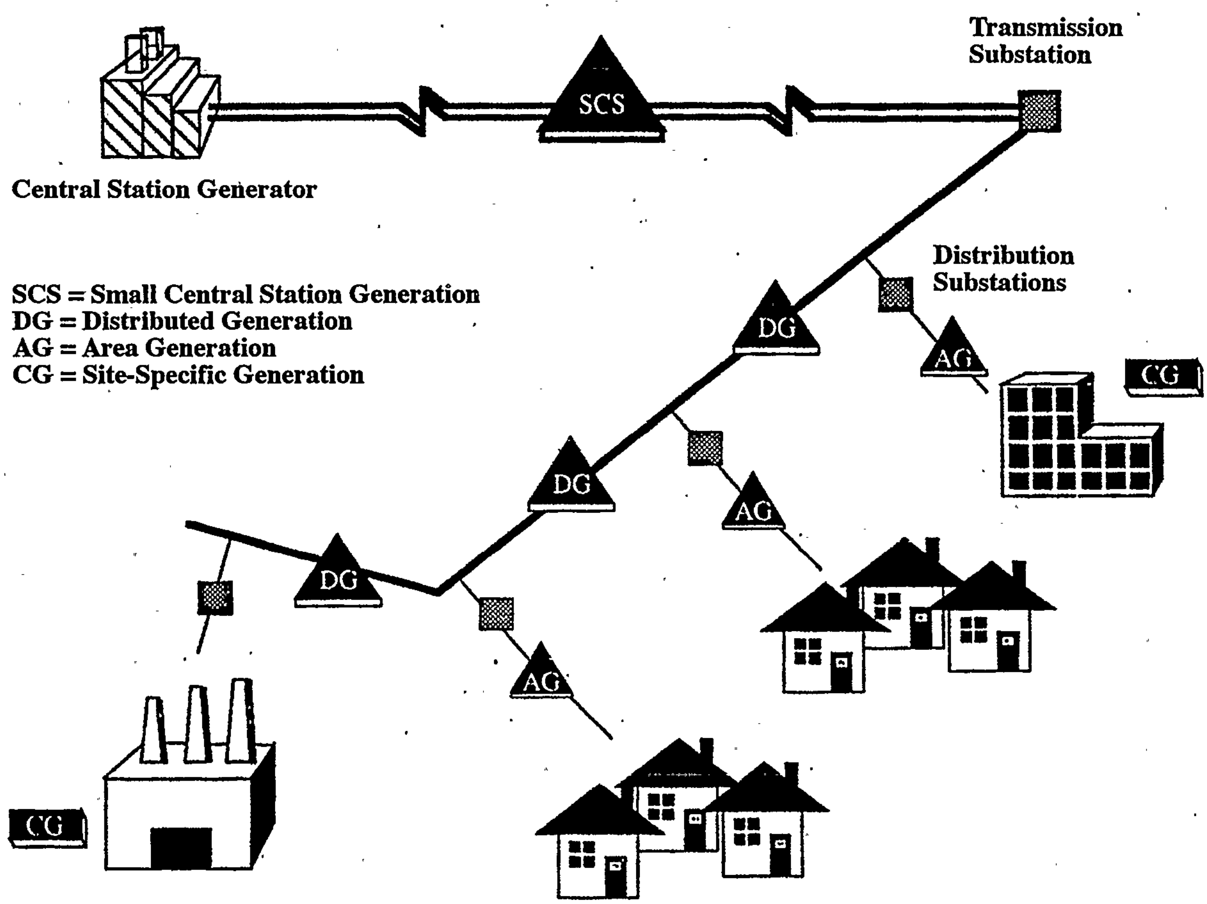
Within the DB category, units that tie into the 50 KV system are typically 25-50 MW in size and are referred to in diagram 1 as distributed generators. Units that tie into the 25 KV system are typically of 1-5 MW in size and are referred to in diagram 1 as area generators. The last subcategory within the DB options include site-specific generators. These generators are typically located at large institutional, commercial or industrial sites.

Because DB units will likely be sited within the boundaries of a community the possibility of co-generation applications exists. Co-generation refers to generating facilities that have been built so that the steam that is created to turn turbines, for example, can be also be used for a secondary function such as heating buildings.

Although co-generation opportunities are also possible within the SCS category, it is less likely to occur. SCS units that have been built to date have tended to be remotely located. This has occurred for several reasons. First, the preference is to locate close to fuel sources, be that coal mines, natural gas wells or locations noted for regular winds. In the case of coal and natural gas it is cheaper to transport electricity than the raw fuel. Second, SCS units are still relatively large facilities which would have significant impacts on a community if they were located in close proximity. Third, steam can only travel so far before it loses its heat qualities. If remote locations are the norm, industries might have to locate closer to SCS units if they wish to take advantage of the co-generation opportunities.

Overview of Installed Electric Utility Infrastructure and Opportunities for Decentralized Generation.

(figure 4.1)



It should be noted that the lines which represent the transmission system have three weights. The double, heavy line represents the high voltage transmission system (240 KV) which transport electricity over long distances. The single, medium weight line represents the local distribution system (50 KV) within a community. The thin line represents the area distribution system (25 KV) found, typically underground, in localized areas such as residential neighbourhoods. The Black triangles represent generating alternatives.[111]

In regard to home generators, little attention will be given to this option. Although it is technically feasible to have, for example, a small fuel cell in

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[111] Graphic is a modified version of a one found in, Donald Glenn: Application and Market Assessment of Fuel Cells in Canadian Utilities. (Unpublished conference paper presented in Vancouver, BC, April, 1993)

each home, economically it is difficult to justify. Capital costs for such a unit would be high and they would have to be added to the cost of a home. "The economics of scale favoured the use of larger units to supply multi-unit residential and commercial sites."[112]

All generation equipment can be subdivided into two classes - 'intermittent' and 'reliable' facilities. Intermittent technologies are dependent on appropriate conditions before they can generate energy. Examples of intermittent technologies include wind and solar projects. Technologies classified under the reliable category are available on demand and they include fossil fuel based generators, as well as turbines that use alternative energy sources such as biomass or refuge. Other options within the reliable category include hydro facilities, fuel cells and technologies which utilize unique opportunities such as geothermal or tidal generators. Intermittent generators are most likely to exist within the (SCS) category. The economics of scale for this category of technologies tended towards larger facilities.[113]

The most cost effective and reliable option available today (1994) within the SCS category are combined cycle turbines (CCT). It is estimated that the cost to construct a CCT facility of the 275 MW size will be in the order of 190 million dollars, with a time-line for construction of three years.[114]

Within the DG category, distributed generators would probably use smaller scale CCT. The siting of distributed generators would require proponents to be sensitive to the social impact of an installation. Because of the noise associated with CCT, it is most likely to be located in industrial areas, or on the outskirts of a community. The capital cost of a 50 MW CCT plant would be approximately 40 million dollars and the construction time-line is also estimated to be three years.[115]

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112 C.D. W. Casson, K. Lee, P. T. Mcullough & D. Pugh (the principal investigators): Application and Market Assessment of Fuel Cells in Canadian Electrical Systems. Volume One. (Montreal, Canadian Electrical Assoc., 1993) p 47.
113 Jason Edworthy: Past President of the Alberta Independent Power Producer's Association, Personnel Communication, Aug. 1993.
114 Estimates supplied by Bryan Holter: TransAlta Utilities, Personnel communication, Jan. 1993.
115 Ibid.

Area generation is the last category to be discussed. Generation at this level will probably only be installed in new residential areas or in large developments such as office buildings. Of the technologies available for area generation, and in particular units to be sited in residential neighbourhoods, there is no technology that rivals the fuel cell because of its quiet operation and low emissions. As mentioned the approximate size of such equipment would be 1 to 5 MW, according to the types of customers within the local area. The capital cost of a 2 MW FC would be approximately 1.8 million dollars and the construction time-line is estimated to be one year.[116] For site-specific generators either CCTs or FC could be used according to the issues surrounding the siting of equipment.

In summary, relative to the weaknesses of the large central station units outline in chapter 3, a dispersed model of generation offers utility planners far more flexibility. All the above listed options have construction time-lines of less than five years, versus the ten or more years associated with central station plants. Smaller units allow increments of power to be added in smaller blocks, thus reducing the probability of under-utilized capacity. Smaller increments of power allow planners the opportunity to make demand projections for shorter time-frames and hence, increasing the probability of their accuracy. More accurate projections reduce the probability of regulators not accepting new facilities into the rate-base. Capital costs are lower and hence proponents of a project will not be required to take on huge amounts of debt. Finally, the technologies that are most likely to find a niche in the above model are all less polluting and more fuel efficient than the equipment installed today.

4.3 Scenarios

If it can be agreed upon that there are significant forces challenging the central station model and a decentralizing process of electricity generation is likely, the question arises as to when this might occur.

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[116] Ibid.

How exactly the industry will restructure itself is a virtually impossible question to answer. Whether SCS or DB options will dominate depends on the outcome of numerous issues such as the cost of technology, energy prices, and public demands for pollution abatement policies at the time when decisions must be made about the direction of future infrastructure development.

There appears to be four essential points where decisions about the direction of infrastructure development must be made. These four points of departure include:

1. When demand surpasses the capacity of the existing generation system, assuming for the moment that demand is still within the capacity of the existing high voltage transmission systems.
2. When existing central station generation plants have reached the end of their operating life and this capacity requires replacement.
3. When demand surpasses capacity of the existing high voltage transmission systems.
4. When the existing high voltage transmission systems has reached the end of their operating lives.

For the sake of ease of presentation, these four cross-roads are presented as if they will occur sequentially, when in fact they are deeply interrelated and their order of consideration may vary according to circumstances.

A further assumption of departure points 1 and 3 is that demand over the long run for electricity will continue to increase. More specifically, it will be assumed here that the market for electricity will behave as a mature economic sector, and that the economy will grow.

This assumption of continued growth is made with the recognition that 'Demand Side Management' will be a significant force in our society.

For example, EPRI (Electric Power Research Institute) has calculated that, if all existing residential commercial and industrial electrical products and equipment in the United States were replaced with the most efficient technologies available in 1990, the projected demand for electricity in the year 2000 would be reduced by 24 to 44 percent.117

However, it is also possible that even though demand for electricity on a per-person level will decrease, that with population growth, overall demand will increase. It can also be argued that if externalities begin to be charged against users of fossil fuels, some industrial users may chose to switch to electrical options. Finally, although new facilities, both homes and industrial projects, may maximize on energy efficiency, the same efficiencies will probably not be achieved in older homes and factories. Based on a standard life-cycle analysis, it can be argued that existing homes and industrial facilities may well be fully operational for a hundred years. Unless they are decommissioned before they are spent, they will continue to operate, and operate at less than optimal levels.

In chapter 3, four challenges to the status quo or influencing factors were mentioned. They included a mature market situation, the availability of more efficient generating technologies, regulatory risk and the valuation of environmental externalities.

The main point that will be made in this section is that if all the challenges discussed, and in particular the valuation of environmental externalities, gain some form of expression, at each departure point there will be economic justification to consider decentralizing the system. This justification will be the result of a redefinition of the economics of scale, or optimal scale of operation, as it applies to the electric utility industry.

Under these new circumstances where the optimal scale of operation is redefined, it is likely that SCS or DB options will come to dominate power generation. The new technologies available within these categories have higher efficiencies and lower externalities than previous technologies. Efficiencies can be pushed even higher if co-generation opportunities are exploited. DB options are potentially well positioned to take advantage of co-

[117] Richard Golob and Eric Brus: The Almanac of Renewable Energy. (New York, Henry Holt and Company, 1993) p 225.

generation opportunities on a scale larger than the localized installations seen today. If the additional infrastructure required to utilize the exhaust steam can be justified, the opportunity exists to establish neighbourhood heating programs and/or a system whereby steam is made available for industrial processes. The discussion here will proceed from here to the development of possible scenarios which may emerge at each of the departure points identified.

4.3.2 Scenarios Related to Departure Point One

Our discussion on scenarios will begin with the situation that exists today. At this time in many jurisdictions, utility planners are preparing for the emergence of departure point one, where demand is beginning to surpass the installed capacity.

The scenario emerging today has two distinct trends. One trend is a situation where franchised utilities are building or purchasing power from 'small central station' units. The other trend being observed is the private introduction of co-generation units. Large industrial users and large facilities such as hospitals are purchasing smaller generators, and developing the infrastructure so that the exhaust heat from the generating process is used in production processes or in the heating of buildings.

In regard to the trend towards 'small central station' units, it appears the perspective of utility planners has gone through only a slight modification from the original 'central station' concept. Because at this time society is in the early stages of giving environmental concerns full expression, the original economic calculations used to define the optimal scale of operations remain essentially the same. The slight modification the 'small central station' model represents is due to the concerns associated with a mature market.

If the first major trend being observed today is towards SCS units, the second major trend being observed is the private introduction of co-generation units. Co-generation style, localized units, are typically installed in situations where the proponent is a large user of electricity and has access to the capital required to both acquire a generator and install the infrastructure necessary to capture the waste stream for reuse.

This category of generators is the first within the DB generating options that has made to date a significant market penetration. These localized options are introduced here incorrectly under the pretext that it is the lack of supply that has instigated their emergence. This is not the case in most jurisdictions. The emergence of localized generation is due to the fact that under certain circumstances it is the lowest-cost means of supplying electricity and steam, relative to other options. As discussed in the previous chapter, the dominant co-generation technology todate has been the combined cycle turbine, burning natural gas. Fuel cells are also penetrating this market.

It should also be noted that localized, co-generators are the low cost suppliers under a situation where environmental charges for externalities largely do not exist. Co-generation is the first indicators of things to come. The concept of smaller generators which are more efficient and which can be sited so that the exhaust steam can be utilized will continue to grow and instigate the continued emergence of DB generators as a supply option.

In summary, in this section it was argued that departure point one has arrived in many jurisdictions. Two trends emerged in response to this situation. The first trend is towards the development of SCS units. The second trend has been towards the development of localized units. Localized, co-generation units have not been developed because of supply problems. Today, they are the cheapest way for electricity to be generated. It is hypothesized here that these localized generators using the co-generation concept represent the first examples of DB options penetrating the market. The next section introduces the issues surrounding the emergence of Departure Point two.

4.3.3 Scenarios related to Departure Point Two

Of the four departure points, the decisions made around departure point two will be of the greatest significance. When this phase of infrastructure replacement begins large blocks of power will need to be brought on line. If the influencing-factors do not create a significant enough force for the redefinition of the optimal economics of scale, it is likely the options within the SCS model will prevail. The next opportunity for significant restructuring of the industry will not occur until this equipment has reached the end of its life-cycle.

In most jurisdictions in Canada the mass replacement of base load generators has not begun. In Alberta, consideration of the replacement of significant blocks of energy will begin in the late 1990s with the scheduled closure of the Wabaman station. This station was build in the early 1960s with a life expectancy of 35 years.[118] As mentioned in chapter 2, 95 percent of the electric energy generated in Alberta is from four large central-station generators, most of which were build in the 1970s and 1980s.

Decisions regarding the replacement of large blocks of power will not be addressed all at one time, but they will represent a cluster of decisions that will have very similar considerations. As each plant that makes up the present day base load system reaches the end of its life-cycle, decisions about future developments need to be made.

This statement of course assumes that the generators are thermal or nuclear plants. Hydro plants are a different situation. It is not unreasonable to assume that the life-cycle of a hydro-electric plant will be well over a hundred years. Most jurisdictions however have equipment that is thermal or nuclear with a thirty to thirty-five life span. Many of these plants were built to accommodate the growing economy of the post World War II period. It is expected that decisions oriented around departure point two will need to be addressed in most jurisdictions over the next 10 to 20 years.[119]

In terms of a scenario development oriented around this departure point, two plots may evolve. What differentiates these two plots will be the influence the <u>valuation of environmental concerns will have on the definition of the optimal economics of scale.</u> At the time that decisions are being made, if the influence of this factor is not significant, the SCS model will prevail (Plot

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118 Holter.
119 Holter.

'A'). If the influence however is significant and a redefinition occurs, DB options will appear and begin to compete with SCS options (Plot 'B'). Both these plots will be developed.

4.3.3a Scenarios Associated with a Situation Where the SCS Model Dominates - Plot 'A'

Plot 'A' is a situation where the valuation of environmental concerns are not significant enough to cause the redefinition of the economics of scale.

Under this situation it will be hypothesized that the first of the two trends seen within Departure Point 1 would continue. A large number of SCS plants will be brought on line to replace the blocks of power that were originally generated by the central station equipment. Further to this, there will also be a continued emphasis on interconnectedness between jurisdictions to keep the amount of excess capacity required by any one participant to a minimum.

4.3.3b Scenarios Associated with the Emergence of the Decentralized Model of Generation - Plot 'B'

Plot 'B' is a situation where the valuation of environmental concerns are significant enough economically to cause the redefinition of the optimal scale of operation. This redefinition will create a situation where DB options will have a more significant role in future generating scenarios.

This hypothesis is based on certain assumptions which were introduced earlier. In review, the first assumption is that smaller generating technologies are more efficient than larger equipment. Second, this efficiency is further promoted by creating situations where the exhaust heat from technologies such as combined cycle turbines and fuel cells is utilized to create even greater efficiencies as can be seen today with co-generation or local-generation installations. The final major assumption that is not developed in this study is that natural gas supply and the infrastructure required to absorb this new demand for the product are either in place or can be expanded to accommodate this new demand.

Further to the economic justification for the consideration of distribution based options, there may emerge for municipalities a political motive to consider these options.

If the cost, on a per kilowatt basis, becomes similar between SCS and DB generating options, why should local governments not act to keep the employment and income benefits associated with generation in the communities? Municipalities could accomplish this by either becoming involved in direct ownership of generators or by contracting a third party to own and operate the generators.

In addition, if the right situations can be created, DB generators can become a strategic advantage for economic development within communities. The availability of exhaust steam, perhaps for manufacturing or pharmaceutical industry, can become a value-added feature to entice industries to locate in that municipality.

As well, citizens of a community may decide they are prepared to pay a premium to promote technological options that are more environmentally friendly. Examples include the promotion of neighbourhood heating programs and the support of wind generating technologies.

4.3.4 Scenarios related to Departure Points Three and Four

Three potential topics may influence the replacement and/or expansion of the high voltage transmission systems. First, transmission expansion will also be strongly influenced if policies are developed which place a value on disturbing wilderness or displacing agricultural lands. What is being suggested is that there may be created a hierarchy of land uses with a premium placed on wilderness, followed by a lower premium for agricultural lands, followed by other land uses.

A second potential issue could be human health concerns associated with electromagnetic fields that surround transmission lines. There exists today an unproven theory that there is a causal link between magnetic fields and cancer. Third, are issues related to the availability of land in major urban centres to locate or expand utility corridors. The lack of availability of land to expand transmission systems may in fact become an additional reason to promote DB generation.

If transmission services are not expanded, then the expansion of SCS facilities is also limited since SCS developments are not only limited by market demand but also by the availability of transmission services.

4.3.4 Possible Future Designs

The purpose of this chapter has been to develop an argument that a great variety of supply options may emerge and be cost-justified. This justification will be based on how efficiency is measured and what is valued.

An exact description of the future is impossible. The cost of equipment, the costing of externalities, societal values and many unforeseen factors may come into play to influence the final outlook. If the reader accepts the argument made here, it must be agreed that all the options presented in diagram 1 are possible.

The question which then emerges is if the technologies that make up the central station model are evolving towards a more decentralized model, can the legislated model of franchised monopoly ownership be justified? Does decentralization scuttle all the basic assumptions of the monopoly model? It would appear so. If this is true what alternatives exist to the highly regulation market of today and would there be any benefits to society? These will be the topics of chapter 5.

The final topic of consideration in this chapter will be an overview of other industries that have been, or are soon to be, restructured due to deregulation and/or technological innovation. The purpose of this assessment is to provide a greater understanding of the significance of the proposed restructuring to the EUI through analogy.

4.4 Analogous Situations

This section will offer a brief overview of industries that have seen, or are anticipating, significant changes in the way they conducted their business due to alterations in the regulatory framework of their industry and/or technological innovation. The purpose of this section is to assist the reader in understanding the relative magnitude of the changes proposed within the electric utility industry.

Three industries will be reviewed. These industries include the long-distance communications industry in the 1980s, as well as the emerging multi-media revolution which is not yet a reality, but is expected to arise due to technological innovation in the near future. Finally, there will be a discussion of the railroad industry and its experience with technological change, as introduced in chapter 1.

Recently in Canada, long-distance telephone services has experienced a form of deregulation. What is significant about this particular case is that alterations in the regulatory framework are the primary force of change. The essential service of long-distance telecommunications has not changed, nor has the essential technologies that deliver the service. What has changed is the method of wholesaling or marketing these services.

Originally, a monopoly franchise holder, such as Alberta Government Telephones, had as its mandated responsibility both the local network within an area as well as the transmitting technologies that tied into long-distance communication carriers. These long-distance carriers could be based on terrestrial, or extra-terrestrial technologies such as cables or satellite systems. Regulations during this time dictated that the ownership of the transmission equipment for inter-provincial communications was to be separate from the ownership of the local networks. The original view of regulators was that since regulated franchise holders controlled the transmitting technologies, they should have the exclusive responsibility for the remarketing of long-distance services.

With deregulation of the long-distance services, what has occurred is the allowance of parties other than the owner of the local network to remarket long-distance services. "(Remarketers) purchase telephone time in large blocks and resell it to smaller companies at attractive rates."[120] The remarketing firm takes the risk that it can generate enough business volume so that the costs associated with that capacity are covered and a profit is earned.

In summary, this restructuring is not driven by technological change. The service itself is the same. The infrastructure for both the local networks and the long-distance carriers has also not be changed. What has changed is the mandate of the local franchised monopolies to allow competition in the remarketing of long-distance services.

In contrast to the long-distance remarketing experience of the 1980s, the emerging multimedia revolution is an example of a number of industries which are on the verge of a major restructuring due to technical innovation.

This situation has developed because of two technological innovations. The first is data compression technologies and the second is fibre optics. Today video, audio and text can be sent, stored and manipulated as a binary code (1s and 0s). Complementing this development are data compression technologies which allow more data to be sent within a transmission bandwidth. "Soon it will be possible to compress a two-hour movie into a two-minute computer code ... ."[121]

The second technological innovation is fibre optics. Fibre optic cables have vastly increasing the amount of bandwidth available. "(A) solitary strand of optical fibre the width of a human hair can carry 1,000 times as much information as all radio frequencies put together."[122]

> The implications of these development are significant for consumers of communications services. The potential exists for a future where

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120 Joel Bleeke: 'Strategic Choices for Newly Opened Markets' in Harvard Business Review, Sept-Oct. 1990. (Boston, Mass: Harvard Business Review Inc.) p 164.
121 Wallace Immen: 'The Big Squeeze: Coming to a Couch Near You', in The Globe and Mail. April 2, 1994. p D1.
122 Editorial, 'Multimedia: The Tangled Webs they Weave.' in The Economist. October 16th, 1993. (London: Economist Inc.) p 21.

> there are 500 television channels, movies-on-demand and electronic newspapers. Interactive teleconferencing for both audio and visual interaction becomes a possibility. As well, improved data communication for computer networks creates the foundation for a global information system.

It also creates a situation where local cable networks can distribute voice or computer data, and telephone networks can deliver television programming.

> Cable, traditional telephony, satellite, cellular, fibre optics, personal communication networks - each is vying to become the pre-eminent means to bring voice, data and video to the home, office, automobile and construction site. They are all racing to deliver a signal of equal clarity and reliability to many of the same customers.
>
> (Turf wars are expected because) the customer doesn't care how the call or image reaches them, ... they just want it to be delivered as cheaply and reliably as possible. How many different pathways do we need once we figure out how to transmit the information over a digitally switched 'highway' that combines them? The answer is, not as many as we soon will have, and therein lies the battle that looms for the telecommunications industry.[123]

The transmission of long-distance communication will see the addition of fibre optic superhighways to the existing options of cellular and satellite transmission. But the area which will be the most contested in this new arrangement is the distribution of the signals from the superhighway to homes and offices. That competition will be between the cable or telephone distribution networks.

These technological innovations have the potential to render obsolete present regulation as it applies to telecommunications and the cable industry. Existing regulations assumed that the technologies used to deliver services are static and that the optimal economics of scale justified monopoly franchises.

> (Cable) and telephone firms have been traditionally prohibited (by regulators) from invading one another's markets. But technology and

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[123] Nancy Hass: 'Telecommunications: A Global Report' in Financial World, September 15, 1992. (New York, NY: Financial World Partners) . p 30.

> competition are now making nonsense of regulatory structures which treat these two converging industries as if they were entirely distinct.[124]

In summary, the restructuring that is expected to occur in those industries involved in data, voice or visual transmission is due to technological change. The original services offered are being expanded or improved and entirely new services will be introduced. There will be a competition between different types of infrastructural technologies. This anticipated restructuring will see the emergence of many firms that in the past did not participate in the telecommunications and cable industries. This restructuring may also lead to the development of a few very large vertically integrated global companies. Finally, the regulatory structures in place today for these various industries will be rendered obsolete and require re-evaluation.

The final example to be reviewed is the rail road industry and the impact the introduction of diesel engines had on this economic sector in the late 1940s and early 1950s. This situation was not driven by changes in the regulatory framework, but rather by technological change.

As discussed in chapter 1, diesel engines out performed steam engines in every way. Steam locomotives had a thermal efficiency rating of 7%, versus diesel's 33%. Steam engines had to refuel every 200 miles and required an overhaul every 100,000 miles. Diesel engines only required refueling every 500 miles and overhauls were only required every million miles.

The diesel engine represented an incremental evolution in train engine technology. Diesels still ran on tracks and pulled rail cars just as their steam predecessors did. The essential service of transporting goods and people continued as before. No major restructuring occurred in the ownership pattern of the industry and regulation did not change because of this new technology. What changed were the internal facilities (fuel tanks, repair depots, etc.) required to operate the rail road. The introduction of the diesel engine did not have as radical an impact on the rail road industry as the multi-media revolution will have on today's communications industries.

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124 Editorial: 'Multimedia: The Tangled Webs they Weave.'. p 22.

After reviewing these three industries, the question arises as to which situation is analogous to the changes occurring in the EUI. If a continuum were to be created of industries that have experienced, or will experience change, the deregulation of long-distance remarketing would represent (1) and the multimedia revolution would represent the opposite end of the continuum at (10). The rail road industry would be a (5), and the proposed changes to the EUI would be a (7).

The deregulation of long-distance services as seen in the 1980s was not driven by technological change. What changed was the original regulatory framework. The emerging multimedia revolution is driven by wholesale technological change. The rail road's experience with the diesel engine did not cause a restructuring of the industry, nor a change in the essential services offered, but rather a change in the dominant technology to deliver those services.

The proposed restructuring within the EUI is not driven by a wholesale changes in technologies. The forces of change are the introduction of more efficient generating technologies as well as a economic redefinition of the optimal size of generating facilities. As significant as they are, these factors represent an incremental change versus a wholesale change in technologies. Most generating technologies will still involve turning a rotor within a magnetic field to create an electrical current. The basic categories of generation, transmission and distribution will persist. The essential service of delivering electricity will also remain the same.

4.5 Conclusion

This chapter investigated the technical options that are available to electric utility planners today (1994), to move the system away from the present centralized model and towards a more decentralized model of power generation. Scenarios were developed as to when this might occur and described as departure points. Essentially, the opportunity to decentralize will arise when the installed infrastructure reaches it capacity ceiling and/or the end of its operating life.

One conclusion of this section is that if all the challenges discussed in chapter 3 become significant forces in the decision making process about the future development of infrastructure, the result will be a redefinition of the economics of scale as it applies to the EUI. With that point made, a variety of supply option may emerge and be cost-justified.

It was also suggested that DB generators could become a strategic advantage for economic development within communities. Expanding on the co-generation concept, exhaust steam could be made available to manufacturers, hence creating a value-added feature to entice industries to locate in that municipality.

As well, DB generators could offer citizens of a community the choice to pay a premium to promote technological options that are more environmentally friendly, for example, the promotion of neighbourhood heating programs or the supporting of wind generating technologies.

Finally, the suggested evolution of the EUI was compared with other industries that have experienced restructuring. The long distance telephone industry, the home entertainment/telecommunications industry and the rail road industry were reviewed. The conclusion of this section is that the changes proposed for the EUI are the result of new technologies that are more fuel efficient and a redefinition of the optimal scale of operation. This does not represent the same magnitude of restructuring as will be seen in the entertainment/telecommunications industry due to major technological innovation in the areas of fibre optics and data compression.

The question which then emerges is if the technologies that make up the central station model are evolving towards a more decentralized model, can the legislated model of franchised monopoly ownership be justified? Does decentralization scuttle all the basic assumptions underlying the monopoly? This will be the topic of chapter 5.

As a closing point to this chapter, the infrastructure requirements to support decentralized generation heavily relys on the assumption that natural gas will remain abundantly available and that the infrastructure is in place, or can be expanded, to accommodate new demand. Natural gas has a low carbon content and if a pollution charge is introduced and this system is based on carbon, demand for natural gas will be high.

This anticipated expansion of the natural gas network does not represent a quantum leap in infrastructure development. The natural gas production and delivery industry is highly developed. At issue is the expansion of the system. Although not to understate the time or money it would take to expand the system, it is not unreasonable to anticipate this expansion.

CHAPTER 5 - THE NATURE OF A RESTRUCTURED ELECTRIC UTILITY INDUSTRY

No complex system can be managed without clear goals and appropriate mechanisms for achieving them.[125]

This chapter will begin with a discussion of the original goals of regulation and the organizational structure created to accomplish these goals. The present structure in place, as mentioned, is based on a model of franchised monopolies using the 'cost of service' system to determine the price of electricity.

The discussions will then proceed with an overview of the criticisms of the 'cost of service' system. Theoretical positions will be outlined as to why market mechanism will alleviate the weaknesses associated with regulated monopolies, while also better meeting the original goals of regulation. But if a market structure is to be introduced what will be its form?

If one created a continuum of options of market organization, a monopoly structure would represent one extreme and a perfectly competitive industry would represent the opposite extreme. A review of the theoretical literature will outline the essential components of a 'Perfectly Competitive Marketplace'. Once these components are identified the conversation will focus on how well these principles will apply to the EUI. The conclusion of this discussion will be that the technological aspects of the EUI make it difficult to have a perfectly competitive situation and hence, regulation will have a continued role in the future.

With the point made that there is a continued role for regulation, the focus will then turn to options that exist for regulators to create a situation where more market mechanisms are introduced into the EUI. Theoretical explanations and analogies are all that can be offered at this time since there

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125 Robert Costanza: 'Assuring Sustainability of Ecological Systems.' in Robert Costanza (ed.) Ecological Economics: The Science and Management of Sustainability. (New York: Columbia University Press, 1991) p 332.

are few examples of marketplaces for electricity. One exception is the United Kingdom where a program of privatization and the introduction of market mechanisms into the electricity industry was begun in 1991. In this chapter the U.K. program will be outlined.

The majority of the literature available today on the topic of deregulation and the introduction of market mechanisms assumes the technological paradigm is limited to the central station and small central station options. There are three primary conclusions made in this section. The first is that the decentralization of generating technology will not solve the controversy surrounding the deregulation of EUI, but rather add further to the confusion. The second overall conclusion is that the movement towards deregulation should be supported because a market oriented system is better suited to deal with an evolving, dynamic situation.

The third conclusion is that the public will be better served by an EUI organized around a market oriented system. The customer under the present monopolist model are the regulators. Decisions are highly centralized and regulators, acting in the public interest, make all the relevant choices. The end-user is relegated to the position of a bystander. Regulators impose a single way of doing things on every citizen in the province. There is no accommodation of a plurality of ideas. In a market oriented system, decision making will be decentralized and a plurality of ideas is more likely to be accommodated.

5.2 Goals of Regulations

The purpose of regulatory institutions is to serve the public interest by trying to direct the electric utility system to accomplishes the following goals. The first goal of regulation is to create and maintain a reliable system. As discussed in chapter 2, all components of the electric utility industry (generation, transmission, distribution) have to date been considered natural monopolies. The industry's present form of geographically based monopoly franchises reflects this assumption.

The underlying disposition of regulators has been risk intolerance. The mandated responsibility of a franchise holder is to maintain the infrastructure and plan for its expansion. The planning of the system is with the goal of ensuring that adequate capacity exists within each component of the infrastructure to handle various scenarios of demand, including short-term (peak-load) situations, as well as the accommodation of long-term growth. These plans are then reviewed by regulators. Since this monopolistic creation allows for a vertical integration of the essential components of the EUI, a high degree of stability is created.

Since the monopoly franchise system is the invention of regulation, the second goal or responsibility of regulators is to oversee this monopolistic situation and act as a substitute for the market pricing mechanism. The balance regulators are attempting to attain is one where end-users are paying the lowest possible price, while also ensuring that utility companies remain financially stable and credit worthy.

> The economics of regulation is the economics of 'market failure'; that is, it is concerned with failures of the market mechanism to allocate resources properly. Market failure due to 'natural monopoly' is a special case of structural failure. Natural monopolies occurs when economics of scale are so extensive, relative to the size of the market, that only one firm can operate efficiently within the bounds of market demand. Economic theory prescribes that (unregulated) monopolists may restrict supply of a product to ensure high levels of profit.[126]

To remedy this, direct regulation has been utilized to both set prices and mandate that no one who has a reasonable request be refused service.

These societal goals are pursued through the 'cost of service' method of regulation as discussed in chapter 2. In summary, the operational costs of the franchised monopoly are reviewed by regulators. Once accepted, the utility is

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126 Almarin Phillips (ed.): Promoting Competition in Regulated Markets. (Washington DC: The Brookings Institution, 1975) p 2.

then granted the opportunity to charge end-users at a rate that will generate enough revenue to cover 'costs', plus a set rate of return.

There exist numerous critics of the monopoly franchise, 'cost of service' method. The arguments of this group are primarily based on theoretical economics. They believe the goals of regulation could be better met through the use of market mechanisms.

Their position has been further promoted with the technological changes within the generation area, as discussed in chapter 3. No longer do the economics of scale justify large plants and their monopoly ownership status.

5.3 Critics of the Franchised Monopoly Model

In this section the franchised monopoly method of market arrangement, along with the 'cost of service' system of regulation, will be critically reviewed and its failings identified. Once this review is completed, an alternative means of organizing the EUI based on market principles will be introduced as a means to counter the weaknesses identified within the monopoly model.

Critics of monopolies argue that this form of market organization is inherently inefficient and hence, society is not best served by this arrangement. When competitive pressures are removed then the incentive to be productively efficient will be reduced. "The carrot remains but the stick is absent - i.e. monopolists gain by keeping their costs low but their continued existence does not depend on being maximally efficient. We may therefore expect the average and marginal cost curves to drift up."[127] This phenomenon is referred to as 'X-inefficiency'.

> The failure of (electric utility) regulation stems from the stifling effect that ('cost of service') pricing has had on the incentive to be efficient. When the regulator sets rates in a rate decision, all of the benefits of innovation and efficiencies that have occurred to that point are included in the utility's cost base and passed onto ratepayers. Benefits

[127] Dennis Swann: The Retreat of the State: Deregulation and Privatization in the UK and US. (Ann Arbor: The University of Michigan Press, 1988) p 53.

from efficiencies that arise after the rate decision accrue to shareholders, but only until the next rate decision passes them onto ratepayers. There is no incremental regard for being exceptionally efficient, and as long as gross mismanagement or imprudence is not evident, there is no penalty for being somewhat inefficient.[128]

Another major criticism of monopoly franchising and the 'cost of service' system is that "the regulated nature of the industry makes risk aversion a reasonable approach"[129] and hence, innovation is not a priority. "(With) the absence of market rivals (actual or potential) there will be a tendency for firms to rest on their technological oars."[130]

Another criticism of the cost of service system is its inability to respond to changing conditions. Decisions about options for infrastructure development are made every few years by regulatory boards. Once that decision is made, with the best information available at that time, it is usually not reviewed again until the next rate hearing, typically a few years latter. Once options are chosen, the franchised monopoly is theoretically not punished if those turn out to not be the most efficient.

Today more technological options are available, and regulators make decisions which will have ramifications for years. When the options for technology were few it was straightforward to make decisions on infrastructure development.

From a macro stand-point, regulation has performed reasonably well when the (EUI) was growing along well-established trends such as during the 1950's and 1960's. However, it has fared very poorly in times of rapidly changing conditions. During the latter two decades, regulation has produced rates that have been unnecessarily high at times (when earlier decisions turn out to not be the most efficient), imposed severe financial penalties on investors (if they choose to

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128 Charles M. Studeness; 'An Agenda for Electric Utility Deregulation' in Public Utilities Fortnightly. Aug. 1, 1991. (Arlington, Virgina; Public Utility Reports, Inc.) p 25.
129 Ronald Doades: 'Making the Best of Best Practices' in Public Utility Fortnightly. Aug. 15, 1992 (Arlington, Virgina; Public Utility Reports, Inc.) p 15.
130 Swann: p 55.

punish franchises for exercising options that the regulatory body approved years earlier) and caused the miss-allocation of resources.[131]

Finally, the notion of the customer is vague under the franchised monopoly system. Individual citizens have minimal opportunities to participate in the decision making process or even the establishment of the criteria of evaluation. Under an monopolistic arrangement the customer is the regulatory system. The actual end-user is largely a bystander. An appropriate analogy would be a 'large male sibling' purchasing clothing for his younger brother. The clothing is worn by the younger person but it is big brother who decides whether the price is appropriate and if the item will serve its function.

Electric Utilities have to offer regulators options and they choose among these options in the 'public interest'. This system does little to allow the individual consumer to judge the 'value added' options available. The notion of adding value to a product is one where the customer gains something over and above the original product being sold. From the producer's point of view, the 'value-added' option could generate extra profit or protect market share.

In the EUI, adding value may mean the option to have electricity generated by a technology that is non-polluting. It may also mean that customers are prepared to pay more to have the economic benefits derived from the construction and operation of a generator within the economic sphere of their community. The notion of a plurality, where different groups have different criteria for purchasing a commodity, is not at all accommodated by a centralized regulatory system.

To counter the weaknesses of the franchised monopoly form of market organization, adversaries believe that it is time to introduce a new model of organization based market principles. Proponents of reorganization see two essential changes that are required to achieve this market reorganization or deregulation. The first is the privatization of those electric utilities which are presently publicly owned institutions. This privatization should distribute

131 Charles M. Studeness: 'The Failure of Utility Regulation and the Case for Deregulation' in Public Utilities Fortnightly. Sept. 15, 1991 (Arlington, Virgina; Public Utility Reports, Inc.) p 26.

assets among numerous owners. This concept will be further developed in the next section.

> The notion (of privatization) is that privately owned firms are driven (to be efficient) by the instincts of self survival whereas nationalized industries do not have to be as efficient as possible in order to survive. (The) 'bottom line' faced by private property owners is precisely the reason they will ensure that their assets are managed efficiently.[132]

"State Industries are dependent for their survival on the government, not the markets."[133]

The second essential component of deregulation would be the establishment of a spot pricing mechanism. The decisions to buy and sell will be made by independent profit oriented producers and consumers who will respond to current prices. "Thus the 'invisible hand' of prices and profit will replace direct central control (as the organizer of the marketplace)."[134]

> "(One) of the critical characteristics of the free market argument is its hypothesis that the market, if left alone, will generate socially desirable results. This hypothesis is supported by modern economic theorists, who have proven what have been called the Fundamental Theorems of Welfare Economics or the invisible hand theorems."[135]

"Adam Smith claimed that nothing more than selfishness is necessary for society to achieve optimal social outcomes."[136]

Competitive market places inherently create a tension between participants. Competition between rational, self-interested individuals is assumed to lead to the development of optimal efficiency. A spot pricing mechanism defines in the short-run who is the most efficient producer. This will put pressure on

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132 G.A. Davis: 'The Privatization of Electric Utilities: Economic Aspects.' in The South African Journal of Economics, vol. 59., No. 2 June 1991. (The Economic Society of South African, Pretoria) p 168.
133 John Moore: 'British Privatization - Taking Capitalism to the People' in Harvard Business Review, Jan.-Feb. 1992. (Boston, Mass: Harvard Business Review Inc.) p 118.
134 R. Bohn, B. Golub, R. Tabors and F. Schweppe: 'Deregulating Generation of Electricity Through the Creation of Spot Markets for Bulk Power' in The Energy Journal, 5(2) April 1984. (Cambridge Mass.: Energy Economics Educational Foundation) p 73.
135 Andrew Shotter: Free Market Economics: A Critical Appraisal, Second Edition, (Cambridge Mass.: Basil Blackwell Inc., 1990) p 39.
136 Ibid. p 2.

the least efficient producers to reconsider their technical and management arrangements to increase efficiency.

Risk is also inherent in a competitive marketplace. Innovation which might give a producer an advantage over competitors is constantly sought. If a producer fails at their attempt to introduce innovation during times of changing circumstances, they will go bankrupt. This inherent tension of competition requires participants to endlessly pursue efficiency and innovation.

The notion of a continuous supply of information from the spot pricing mechanism makes this system more responsive to changing circumstances. From a micro-economic perspective, the spot market price gives producers feedback as to how they are doing relative to their competition and what is the optimal scale of production to maximize short-term profit.

In the long run, pricing information from the spot market will help clarify which mix of technologies and fuels are consistently the most efficient. "(Markets) offer the only way to test the merit of various approaches against the basic yardstick of price."[137]

Rather than the regulatory approach of making decisions every few years, decisions in the market place are being made constantly. From the macro-economic point of view of the producer, the average price dictated by the market combined with the long-run average costs associated with production determines profits. These profit levels will either attract or deter entrants into the market. In theory entrants are free to enter the market at any time, hence pushing out the least productive. This stands in contrast to the regulatory system which makes decisions every few years and has legal barriers to stop new entrants to the industry.

"The nation needs to find the most efficient way to choose the best mix of supply and demand approaches."[138] There are more choices for meeting

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137 Martin Allday: 'Outlook for the Electric Industry' in Public Utility Fortnightly. May 15, 1991. (Arlington, Virginia; Public Utility Reports Inc.) p 26.
138 Ibid. p 26.

power demand than ever before. New technologies are emerging for many fuels. Conservation and other demand-side approaches will play a larger role in the future. More choices means more decisions. The invisible hand of the market with its disposition towards experimentation and comparison of alternatives using price as a mechanism of comparison can supply the ultimate organizing principles replacing the command-and-control structure of today.

In summary, the critics of the 'cost of service' system attack the model's propensity to be inefficient, risk adverse to innovation and unable to respond to rapidly changing conditions. They believe the introduction of a market place into the EUI would resolve these problems. The introduction of a market place would require two essential changes. The first is the privatization of publicly owned utilities with the assets distributed among numerous owners. The second is the introduction of a spot pricing mechanism. This mechanism would allow the invisible hand of the market to seek out the most efficient options available through the mechanism of price.

These positions against monopoly organization are largely based on economic theory and ideological dispositions. Few examples exist of countries where the EUI has been deregulated. One exception, the United Kingdom, will be discussed at a later point.

When reviewing the ideological arguments which attack monopoly organization there is always the assumption that the reader will by default find market solutions superior. Hidden behind these ideological and utilitarian arguments are numerous nested, self-promoting positions. These hidden agendas include the desire of certain parties to end the legal barriers of entry to the electricity generation market. These parties include natural gas producers and various independent power producers (IPP) who believe that they have some type of strategic advantage to move into this market.

Perhaps surprisingly, many monopoly franchise holders are also supporters of deregulation. Concerns about imprudence ruling, as outlined in chapter 3, have created an impetus for regulated firms to get out from under the demands of regulation. Even if a monopoly franchise loses its dominant position, it is strategically positioned to excel under a deregulated situation. Monopolies have the management expertise and the access to capital to ensure that they would prosper under a new arrangement.

The dominant ideological position of the 1980s/1990s has been toward deregulating monopolies wherever possible. Deregulation is fashionable. Perhaps in a different time, under different ideological influences, the monopoly structure may have continued to prevail. This is not to imply that this writer opposes the deregulation of electric utility monopolies. At a future point in this paper, deregulation and the options for the construction of a market for electricity generation will be promoted. However, it is often difficult for a neutral party to wade through material where self-interested parties concealing their positions behind a cloak of arguments about what options best serve societal interests.

The point of the system is to strike a balance between a number of objectives, including supplying electricity to customers at the lowest possible price, offering those customers as many choices as possible as to how this service is delivered, and the promoting of societal goals such as minimizing environmental contamination. And all this is to be accomplished with the underlying attitude of risk aversion. If these critical arguments against monopoly franchises are correct, the first question which arises is how should the EUI be restructured to accommodate market mechanisms?

5.4 The Electric Utility Sector as a Perfectly Competitive Industry

If a continuum of options for the organization of a market were developed, a regulated monopoly would represent one extreme and a perfectly competitive industry with numerous producers and no regulation of any kind would represent the opposite extreme.

Economic texts suggest that a perfectly competitive marketplace is based on five assumptions. These include:

Assumption 1 - All the firms in the industry sell an essentially homogeneous product.

Assumption 2 - There are numerous consumers of the product, acting as rational individuals and they have complete knowledge of the product being sold and what represents a competitive price. No one consumer dominates the situation (monopsony).
Assumption 3 - The level of a firm's output is small relative to the industry's total output. No one producer dominates the situation (monopoly).
Assumption 4 - The producing firm is assumed to be a price taker. This means that the firm can alter its rate of production and sales without significantly affecting the market price of its product. Thus, as stated earlier, a firm that is operating in a perfectly competitive market has no power to influence that market through its own individual actions. "It must passively accept whatever happens to the ruling price."139
Assumption 5 - Both producers and consumers have the freedom to enter and exit the market place as they wish.

Beyond these essential elements, a perfectly competitive industry requires a real-time, spot pricing mechanism. The role of a spot market is to supply a steady flow of information on the condition of supply and demand as it fluctuates from hour to hour, day to day.

The question which now arises is to what extent the assumptions associated with the perfectly competitive market place apply to the EUI. Assumption 1 as it applies to the EUI is straightforward. The product is homogeneous in its most basic form. Any value added aspect to the essential service offered may include reliability and perhaps the opportunity for municipalities to keep as many utility jobs as possible within the community.

Assumption 2 states that there are numerous, informed customers judging competitive products. Two problems arise applying this assumption to the EUI. First, one does not choose among different types of electricity. Electricity is a phenomenon of physics, not a manufactured product like an automobile. What variation exist in the nature of electricity relates to voltage, wattage, amperage and whether the current is alternating or direct. However, the

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139 Richard Lipsey, Douglas Purvis and Peter Steiner: Economics: Seventh Canadian Edition. (New York, NY: Harper Collins Publishers, 1991) p 226.

complexities of the generation and distribution system, plus the requirement by most service technologies (computers, televisions) for standardized voltage, wattage, etc., removes choice as a consideration. What choice exists relates to the means or technologies used to generate electricity.

Second, is a conditional aspect about the way customers and their interests are defined in a perfectly competitive industry. The assumption is that the market place is not concerned with equity, but only efficiency. "Policies that promote equity often contradict those that promote efficiency and stabilization, and consequently planners must make tradeoffs when formulating policy."[140]

Because of the significant role electricity plays in our society, governments have mandated utilities to make the service available to everyone. Hence regions, communities or house-holds that may in a unregulated market not be profitable to supply, are serviced. Presently, such parties are supported by cross-subsidies from larger communities or larger users of energy.

The application of assumptions 3 and 4 as they apply to the EUI are difficult. Assumption 3 states that the output per firm is so small that the action of any one firm can not influence the market and since no one firm's output can influence market prices, they are price takers (Assumption 4).

Assumptions 3 and 4 do not consider the role of the economics of scale as it applies to the EUI. Although it has been argued in this paper that the central station paradigm will evolve to a more decentralized model of generation, some optimal size of plant will emerge. Radford mockingly refers to this as "the First Law of TechnoEconomics: $D=MT^2$. Deregulation equals market size times technology squared."[141]

If 'Plot A', as presented in chapter 4, comes to be the dominant model for generation, it is possible that a few large players may control the market. This position is based on the following argument. Even through generating plants

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140 Shotter. p 13.
141 Bruce Radford: 'TechnoEconomics: The Life and Death of Unnatural Monopolies.' in Public Utilities Fortnightly. Sept. 15, 1993. (Arlington, Virginia; Public Utility Reports Inc.) p 45.

may no longer be measured in billions of dollars, they certainly will be measured in millions of dollars. Since there are relatively few suppliers of generating equipment in the world, all using the same essential technologies, a firm is not likely to gain a competitive edge through technology[142].

Since all competitors will have access to the same essential technology, other strategic advantages will be important such as management efficiency, access to capital at low rates and fuel sourcing. Management efficiency may rely on entrants having experience in a related field. Access to cheap capital typically goes to those firms which have a large asset base. Fuel sourcing advantages may relate to volume purchasing. All these considerations make ownership concentration a concern. If a few large generating firms emerge, the influence of any one firm may be great (oligopoly). Collusion may lead to a situation where price is manipulated by varying supply, hence contradicting assumptions 3 and 4.

Of all the assumptions presented, it is assumption 5 that is the most difficult to apply to the EUI. Neither the consumer nor the producer is in a position to easily access or depart from the electricity market. These parties are constrained by unique technological characteristics associated with the EUI.

These characteristics are dictated by the unique economics of the sector, the laws of physics and the role electricity plays in day to day life. First electricity, for all practical considerations, cannot be stored economically in large volumes. Hence, the millisecond electricity is demanded, it is created. Or conversely, the second that electricity is created it travels through the system at the speed of light and is used. This implies that a great deal of coordination and integration is required to ensure the various components of the system (generation, transmission and distribution) are in place to meet demand both in the short-term and the long-term. To not have the necessary coordination could lead to 'black-outs'.

142 Bryan Holter: TransAlta Utilities, Personal Communications. Feb. 1994.

For the consumer, the demand for electricity is inelastic.[143] Access to electricity is not only an amenity, but an essential service. We as a society have been seduced by the virtues of this energy currency and in the short-run most households and business do not have the option to switch to an alternative energy form or an alternative source of electricity. To have a market failure, where supply did not meet demand, would be both economically disastrous and life threatening.

There are two reasons why a producer might desire some form of regulation. First, success for generating firms depends not only on the efficient operation of their fixed asset, but also access to transmission services with enough capacity to allow generators to maximize revenue.

Second, again the economics of scale comes into consideration. As mentioned, regardless of what the optimal scale of operation becomes with decentralization, the basic capital investment will still involve millions of dollars. Since generators are hostage to the transmission system and the capital investment is great, there has to be some stability or guaranteed revenue stream to gain the confidence of investors.

Great Britain recently reformed its electric supply industry. Funding projects in Britain, from a financier's point of view, drew the following comment from Eric Jeffs. "Before banks will finance a project they must be sure of the economic viability of the project. This depends on a secure long-term contract for fuel supply and power sales."[144]

As well, from a societal point of view, the notion of producers randomly exiting and entering the market is unacceptable. Abundant and affordable electricity is an essential ingredient of an affluent society. To create economic abundance, electricity must be accessible to all, and the service must be unconditionally reliable, both in the short-term and in the long term. In a

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143 Inelasticity refers to a market situation where significant changes in price do not lead to significant changes in demand. This is in contrast to elasticity which refers to a situation where demand varies greatly according to the price charged.
144 Eric Jeffs: 'Financing in the U.K.' in Independent Energy. March 1992. (Milaca, Minn..: Alternative Sources of Energy Inc.) p 60.

world where political jurisdictions compete with each other, a reputation for unreliable electricity services would have pervasive consequences.

> (Critics) worry that the quality and reliability of service would decline under deregulation. They point to the high fixed costs of present generating technologies, and argue that the industry might undergo wide profit swings during cycles of over and under capacity. (As well, the) opposition argues that a deregulated system could not effectively coordinate the myriad decisions necessitated by multiple generating plants.[145]

Both consumers and producers will want some type of protection from a perfectly competitive marketplace so as to gain some level of stability. Regulation will continue to have a role in the EUI since competition with no regulation of any kind would be an unacceptable risk for all involved. With this necessity, the spot pricing mechanism and its associated 'invisible hand' of the market will not alone dictate how the EUI will be arranged.

In conclusion, a perfectly competitive situation in the EUI is not likely to occur. A perfectly competitive situation implies certain assumptions must be met. But 'TechnoEconomics' and risk aversion create a situation where several of the assumptions of a perfectly competitive situation can not be met. "(Electricity) obeys (the) laws (of physics) and not those of economists."[146]

Once it is accepted that a perfectly competitive situation is not to occur, the debate then becomes one of developing a situation which tries to meet the original goals of regulation, and reconcile the dialectic between system reliability and coordination, with the benefits of a competitive marketplace. The answer will be with the creation of a centrally administered, bounded market.

145 R. Bohn, B. Golub, R. Tabors and F. Schweppe: 'Deregulating Generation of Electricity Through the Creation of Spot Markets for Bulk Power' in The Energy Journal, 5(2) April 1984. (Cambridge Mass.: Energy Economic Educational Foundation) p 72.

146 F.E. Bonner: The Electricity Supply Industry: Critiques of the Privatization Proposals in Energy Policy. (U.K.: Butterworth Scientific Ltd., 1989) p 16.

5.5 Options for Deregulation and the Introduction of Market Mechanisms

This section will discuss what alternatives exist for the restructuring of the EUI along the continuum of options between monopoly organization and a perfectly competitive marketplace. If it is agreed that the potential benefits of moving away from the monopoly model are worth considering, a bounded or highly controlled market will be the ultimate result.

The questions which then arise include, how that market might be structured and what criteria should be used by policy makers in choosing options. In an earlier section the goals of regulation were summarized as serving the public interest by creating a reliable system that delivered energy at an affordable rate. These goals will remain priorities as alternatives are considered, but the opportunity does exist to broaden those criteria.

If regulator bodies are here to serve the public interest, one area that seems to be deficient with the franchised monopoly model is the opportunity for end-users to have more control over the evolution of the energy system. As has been argued, the customer within the monopolistic model is the regulatory board and not the end-user.

Choices in regard to priorities, energy sources and processing technologies, are all made by provincial bodies in a top-down, autocratic manner. When decisions are made by regulators, they impose a single solution on the entire jurisdiction. The system presently is incapable of incorporating the multiplicity of opinions that exist on energy issues.

One virtue of markets is that producers offer choices to customers as a means of gaining an advantage over their competition. One lesson of the competitive market places is that for many consumers price is not always the highest ranking priority on their purchasing criteria list.

The present regulatory world seems to have price as its top priority. Certainly environmental concerns have received greater attention in the last decade, but all that has been done is to modify regulatory priorities to ensure utilities pursue the lowest cost, least polluting options.

This focus on price is a result of the way the EUI is presently perceived by regulators. That perception is that the EUI is a fuel processing industry versus a customer oriented industry. The priority is the efficient conversion of one energy form to another. In the past when there were few technological options and the economics of scale justified large facilities this may have been an appropriate form of thinking. But with the opportunity for decentralization of the system, this mind set needs to be changed to recognize the point of the system is energy services and choice for the consumer.

In diagram 1, in chapter one, it was presented that an ideal way of viewing the industry should be:

service-service technology-currency -fuel processing - raw fuel

The present mode of thinking however, perceives the essential process to be:

raw fuel - fuel processing - currency

Free markets are inherently focused on the customer and the delivery of services to the customer. It is very much a bottom-up process of consideration. This represents a significant opportunity for regulators to enhance the definition of serving the public interest by pushing the decision making process down as far as practically possible. Bonner correctly points out that market mechanisms create a situation where, "(instead) of having a production-led industry, emerging is an industry intended to be more responsive to the needs of consumers ... ."[147]

The challenge is to find a way to decentralize decision making while having a situation where reliability on a province wide basis still exists. This accommodation can be made by considering the numerous distribution systems that exist within the province as the customers and the basic unit of planning. Although this does not represent the ideal of an individual consumer making choices, a distribution system would be as open to influence as a municipal government. Cynical critics may claim that

147 Ibid. p 16.

municipal governments are not all that open to influence, but it certainly is more likely to accommodate the local majority opinion than a provincial government.

This section will begin with a conversation about the options for the macro-economic restructuring of the industry. It will then proceed to introduce market mechanism options that will organize the micro-economic activity within these restructuring options.

No effort has been made to present in detail all the possible options for deregulation. The scenarios present here are the options which have received the most attention in the literature. They also represent ultimate or ideal situations, without a detailed discussion of how the EUI is to move from its present state towards these ideals.

Throughout the discussion, financial relationships and physical relationships must be recognized as separate issues. When one is talking about the introduction of market mechanism it is a manipulation of the financial aspect of the EUI. The essential physical components of generation, transmission and distribution remain intact.

Even if a market system is created, the transmission system and the various distribution systems are assumed to remain as natural monopolies. The justification for this monopolistic status is that the cost of building a competing transmission system within a province or a second distribution system within a community is not cost justified. Hence, it will be assumed throughout this discussion that these two components will remain regulated monopolies, even if they have different ownership patterns from today.

The point of deregulation is to create a situation where the cost of electricity is reduced and the service to customers is improved. The promise of cheaper energy is based exclusively on economic theory versus the conclusive results from observation. It is impossible at this time to ascertain which option might create the lowest cost, while meeting the goals of reliability. This aspect of deregulation will receive little attention here.

What will receive attention are the policy options that promote the public interest. The concept of a 'value-added' aspect to products has been introduced and will be further developed here. The definition of improved service should include the opportunity for end-users to have a greater say in infrastructure development, while also deriving greater economic benefits from the energy dollars they spend.

There are today few examples of jurisdictions that have markets in electricity. One of few operating examples is the United Kingdom. This experiment was began in 1991. Because this example is so young, offering conclusions as to its success or failure are difficult at this time (1994).

The final two areas of discussion will include, what role regulators will play in the day-to-day operations of the EUI after restructuring occurs and two, what effect the wide spread use of decentralized generation equipment will have on the restructuring process and the promotion of policy goals. As mentioned, the contemporary conversation about the introduction of market mechanism assume that the technological paradigm is the CS or SCS model. Such will be the case for the first part of this discussion. Later, the implication of decentralized generation on deregulation will be discussed.

5.5.2 Macro-economic Considerations

From the macro-economic point of view regulators need to make decisions as to what market structures should be created for the industry, and what mechanisms should be used to control entry into the EUI. In a perfectly competitive industry (PCI), the inherent nature of the market is to experiment through trial and error in establishing the structure of the market place.

Since it has been established that regulators of the EUI are risk adverse and the technologies involved demands constant coordination and hence is not predisposed to experimentation, it will be regulators that dictate the structure and the allowable behaviour within that structure. Also in a PCI participants are free to enter and exist the market as they please. Again, in a desire to protect both producers and consumers, control over who enters the market is important to maintain stability.

"When reviewing the options available for the introduction of market mechanisms into the EUI, the essential tradeoffs that must be considered are between cooperation and competition."[148] The competitive aspect of this tradeoff involves having a significant number of participants, without oligopoly, so as to create a competitive environment and an effective spot market. Spot market concerns will be discussed in the section on micro-economic considerations.

The cooperation requirements of all participants include the following considerations:

1. Generating equipment must be interconnected and integrated in a regional transmission coordination system which is monitored constantly. Generators cannot operate independently of one another and must accept commands from an outside coordinating body.
2. Some mechanism for coordinating maintenance schedules must exist.
3. The infrastructure must be in place to meet yearly peak demands.
4. Someone must be responsible for making projections and planning for the orderly expansion of the entire system.
6. Agreements must exist upon mechanisms to deal with emergencies.

The policy options for a market structure are essentially options as to where the points of market transaction should be. The point of market transaction refers to the place, physically or hypothetically, where the customer and the supplier meet to arrange transactions. For example, for stocks and bonds this would be on Wall Street in New York or Bay Street in Toronto. For toothpaste it would be at your local grocery store.

When considering the introduction of a market place for the EUI there are two possible points of market transaction, and a third alternative that includes both. The options for these transaction points are where the

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148 Douglas Houston: 'Privatization of Electricity in the United States' in Michael Crew (ed.): Competition and the Regulation of Utilities. (Boston, Mass.: Kluwer Academic Publishers, 1991) p 198.

essential components (generation, transmission and distribution) of the system interconnect, in other words, at the transformer locations.

The first possible point of transaction is between the generation sector and the transmission system. This option is often referred to as the deregulation of wholesale transactions. Under this scenario, the customer is the owner of the transmission system. The relationship between distributors and the owners of the transmission system remains as it is today, with distributors dependent on the larger body.

This option offers a high degree of stability for it is but an incremental evolution of the monopoly model. The generation sector, although separate in ownership is in a monopsony situation. The number of generators who participate in the market can be controlled through either licensing by the regulators or the requirement of a contract with the transmission system. The customer is both the regulator and the owner of the transmission system. End-users are still exposed to a single way of doing things and decision making is still centralized.

The second possible point of transaction is between the transmission system and the distribution system. The basic notion here is that the various distribution systems become legally separated or divested from the transmission system, if they are not already separated. Arrangements are made between distributors and generators directly. Under this scenario the transmission system operator is a more passive participant, accommodating the agreements made between the generators and the owners of the distribution system. For this service the operator charges a rate which covers the cost of operating the distribution system.

This option promotes the decentralization of decision making. Viewing the distribution system within a community as the customer creates a situation where there is a large enough identity to coordinate and plan the local system while still being more accessible and open to influence than a provincial body. This arrangement accomplishes both decentralized decision making and the possibility for system wide stability.

Regulators may set a minimum size that a customer or distribution system must be before it can participate. If any one community is too small, it can join forces with the surrounding rural area or other local communities to meet the minimal size.

This model of market structure could control entrants through the use of contracts. This will be discussed further in the micro-economic section. These contracts will probably have a long time horizon and the competitive bidding process would only occur at the time of contract negotiation. Decisions would be made infrequently and once an option is chosen the customer is locked in. This may create a situation where end-users' options are not maximized over time.

Also with this model, concerns arise about system wide stability. Having the transmission system operator technically responsible but not financially participating in the system may create problems. Who will plan for the entire system? There will also be a tendency for the cheapest producer to be drawn to the largest customer. This strategy reduces the costs for the producer associated with negotiating contracts. What will happen to smaller consumers? Who will contract and pay for the excess capacity required for long-term stability? Many difficult questions remain unanswered within this arrangement.

The third basic option is a combination of the first two proposals. As in the second case, ownership of the distribution systems is separated from transmission and generation ownership. Under this scenario, the distribution owners have the option of purchasing from a wholesale pool, or obtaining direct contracts with specific generators. The organization and operation of the wholesale pool would be by the transmission system owners. However, transmission capacity would also be made available for direct contracts.

This option would require new entrants into the generation sector to have a license to operate. Once this is acquired, an operator is free to negotiate contracts or join the wholesale pool or both. Since the number of participants is limited, all generators are assured a revenue stream.

The customer is the distribution system owner. The customer under this scenario will have numerous options including making short-term or long-term contracts for a percentage or all of their requirements, or purchasing power from the pool.

Today the United Kingdom is one of the few examples of a jurisdiction that has reformed its EUI to create a market for electricity. "(The conservative government of the day was committed to) increasing economic efficiency through greater competition and improved incentives."[149] The original structure of the industry had a state owned monopoly, the Central Electricity Generation Board (CEGB), that controlled all generating facilities and the transmission network in Britain. There were 12 regional distribution companies that were also state owned.

Reform broke the CEGB into three private companies. Two of these were to become generating firms, the larger of which inherited 70% of the original generating capacity. The third company would own and operate the transmission system. The twelve state-owned regional distribution corporations were also privatized and ownership of the transmission system was transferred to them. "Entrants (into the market) require a license to operate and the licensing system provides a framework for regulation."[150] This arrangement is highly concentrated compared to Norway's privatization effort which has 70 producers and 230 distribution companies.

> The reasoning behind one operating firm's controlling over 70% of total generation was to make the sale of nuclear installations attractive. Because of the poor commercial prospects for the nuclear stations, it was widely argued by financial analysts that the nuclear stations would only prove acceptable to private investors if bundled with a large portfolio of fossil-fuel plant. It also recognized that such 'packaging' of nuclear power would be insufficient to guarantee viability. In addition, therefore, an obligation was to be placed upon electricity suppliers to

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[149] John Vickers and George Yarrow: 'Reform of the Electricity Supply Industry in Britain: An Assessment of the Development of Public Policy." in European Economic Review. #35, 1991. (U.K.: Elsevier Science Publishers) p 486.

[150] Stephen Littlechild: 'Regulating the New Electricity Industry' in Energy World. Oct. 1991. (U.K.: The Institute of Energy) p 13.

purchase at least a designated fraction of their requirements from the non-fossil fuel stations (called the nuclear Quota).[151]

Needless to say, these policies restricted competition. Since the most expensive producer is also the largest producer the notion of offering end-users low cost energy has been distorted. Presently there is little incentive for either the dominant player or the other producers to be optimally efficient. The hope is that as the nuclear plants are decommissioned, this dominance by one firm will disappear and be replaced by a large number of competing generating facilities.

5.5.3 Micro-economic Considerations

Micro-economic considerations as they apply to the EUI are related to the day to day prices that are to be charged for electricity. Even though regulators dictate the market structure, there still are opportunities for the introduction of market mechanisms. The essential decision that must be made is whether the price of electricity to end-user is to be deregulated or not.

If prices are deregulated there is the opportunity to create a real-time spot market. It also means however an end to flat rates for electricity as well as cross-subsidizing. In chapter two it was discussed how EEMA was an instrument where by southern Alberta subsidized northern Alberta, and all Albertans subsidized Edmonton. Such programs would be difficult to administer if end-users were charged rates based on the spot market prices.

Under a deregulated situation, consumers would be charged the hourly rate established by the spot market, as well as the charges associated with the transport of energy. With end-users being exposed to different charges according to the demands on the system it will be hypothesized that electricity in urban areas will be cheaper relative to rural areas because of the cost saving associated with bulk transport of energy and proximity issues. It is also hypothesized that demand side management projects will be further

[151] Vickers and Yarrow. p 489.

promoted in an atmosphere where end-users were charged extra during peak demand periods.

Since on the macro level the number of participants is controlled, a shakeout of inefficient producers will not occur. The spot market will establish a order of merit which will over time create a yardstick that will identify efficient producers and optimal technological arrangements. This information will be used to make decisions when the system is further expanded.

If the prices charged end-users remain regulated, it is difficult to imagine the establishment of a spot market. Under this scenario the prices charged end-users would probably be contracted. This again represents but an incremental change from a monopoly model.

The third option is a combination of a spot market and contracts. In this situation generators can negotiate contracts with either the wholesale pool or the distribution operators for a percentage or all of their production. Or as an alternative, they can contribute directly to the spot market without contractual relations. Since the number of suppliers will be controlled, the situation will probably be one where each firm will have some form of revenue.

From the customer side of the equation, an operating spot market allows contracts to be compared against the going prices. With this type of situation, it is also possible to develop a futures market. "Future markets provide a risk-sharing instrument for producers and consumers facing uncertain prices of the commodity."[152] By combining contracts and a spot market mechanism there is both stability in the system as well as some form of price comparison between producers and competing technologies.

With the introduction of market mechanisms, the spot market replaces the central planner as the organizer of the system. "Linkages between

[152] Eirik Schroder Amundsen and Balbir Singh: 'Developing Futures Markets for Electricity in Europe' in The Energy Journal Vol. 13, #3. 1992. (Cambridge Mass.: Energy Economic Educational Foundation) p 98.

distribution, transmission, and generation now occur across markets, both regulated and unregulated, rather than through internal organization."[153]

The U.K. model reveals a differently designed spot market from the theoretical models introduced so far. The U.K. example also reveals other considerations which theorists originally did not make. Just as is suggested in the theoretical literature, the British system is also organized around a spot market.

The actual operation of the U.K. spot market is as follows. Generators are expected to submit price-bids to a central dispatcher.

> The dispatcher schedules the least-cost combination of stations to meet demand in the system. Since the marginal cost of production for the generators vary from plant to plant, in practice the generators will submit a schedule of price/quantity combinations at which the different plants are offered for operation instead of one single price.[154]

The U.K. model allows distribution companies or large customers to purchase from the spot market or make contracts. The supply schedules of the generators and the demand schedules from the consumers are balanced to obtain a market price. The spot market clearing price is obtained every half hour on the basis of bids submitted one day in advance.

What is different about this spot market is that offer prices are ranked in increasing order versus decreasing order as suggested earlier. The most expensive bid sets the charge for all electricity traded in that half hour. This high bid is referred to as the system's marginal price. The notion here is that all power plants, except the highest bidder will be able to operate for that half-hour at a high level of output and therefore achieve a surplus above marginal cost which can contribute to their fixed costs.

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[153] Paul Joskow and Richard Schmalensee: Markets for Power - An Analysis of Electric Utility Deregulation. (Cambridge, Mass.: The MIT Press, 1983) p 104.
[154] Amundsen and Singh. p 106.

However, it was found that the revenue from the spot market was insufficient and that there was the necessity to add a capacity charge as well to ensure generators have adequate income.

> The capacity charge is calculated by multiplying the probability of demand exceeding supply by the value of any lost supply to the consumer. For example, when there is more generating plant available than is needed to meet demand, the capacity charge is very low or even zero. When the position is reversed and demand stretches the ability of generation to meet supply with the threat of blackouts, the charge will be high. This gives a clear signal when existing surplus should be closed or extra capacity is required.[155]

The system marginal price and the capacity payment form the pool or spot market input price. The pool output price includes a further charge for the maintenance and operation of the transmission charges, as well as the cost of distribution.

The U.K. model also made considerations for fluctuations in demand for electricity. The level of electricity demand varies greatly from season to season, day-to-day and even hour-to-hour. These variations cannot easily be predicted, since they depend on the level of economic activity and weather conditions. The result is huge swings in demand which makes it difficult to predict pool prices.

> Since the capacity must be in place to handle these various scenarios of demand, special financial instruments have been agreed upon between the generators and the (distribution owners). To protect customers there is a price ceiling for electricity during times of great demand, and during times of low demand there is a price floor to protect generators. In doing (this) they protect both sides against very low or very high pool prices that can result from the big swings in demand.[156]

Currently producers can supply only large consumers directly and only up to a limited proportion of the overall business of the distribution owner. These limits are in place during the transitional period and are due to be removed

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155 Philip Johnson: 'Electricity Supply in the 1990s' in Energy World. Oct. 1991. (U.K.: The Institute of Energy) p 10.
156 Ibid. p 10.

by 1998. At that time generators will be free to sell electricity to any customer, no matter how small the load.

In conclusion, when considering the macro and micro economic proposals made above the combination of a market structure which divests today's prototypical utility of both the generation sector and the distribution sector, combined with the option for the distribution system to negotiate contracts or participate in the spot market appears to offer decentralized decision making as well as a high degree of technical coordination.

Under this type of arrangement, the owners of a distribution system can take a variety of strategies to fulfill their energy needs. If the community feels it is prepared to pay a premium to be associated with technologies that are less environmentally damaging they can negotiate contracts so that a percentage of their power needs is supplied by this source. They may choose to reward a generator who locates within the region with a contract for energy. These strategies may be mixed with a strategy where peak demand are satisfied by purchasing power as needed from the wholesale spot market.

With a spot market option, as well as a contract options, distribution systems will not be forced to become involved in long-term (20 year) contracts. Terms can be shorter and if energy options change, the distribution system over time will have the flexibility to change strategies. The spot market also supplies a yardstick measure of who are the efficient firms and which technological mixes are the most efficient. Although there will not be the shakeout that one would experience in a perfectly competitive industry, there will be ample information to compare alternatives.

Within this new atmosphere the role of regulators changes from one of accountant to one of a referee of a game. Trying to maintain a balance between technical coordination issues while allowing competition will be difficult. "(Electricity) obeys its own laws and not those of economists."[157]

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[157] Bonner. p 16.

"(A) complex web of potential market failures (needs) to be considered."[158] Sources of possible problems seem virtually endless and the need for vertical coordination often conflicts with the ideals of a market place.

> It is said that when competition in generation increases, the burden of regulation should diminish but it may not prove to be as simple as that since the regulators will have to ensure both the generators and the distributors do not act in a way whereby they carve up the market between them.[159]

Concerns about generation becoming an oligopoly situation remain constant. If the economics of scale do not justify multiple owners, will legal separation be justified? Other concerns include ensuring that companies do not discriminate in favour of large consumers. Rules must exist and be enforced about access to the grid so to promote competition among generators. There will also be a need to ensure generating firms meet contractual or license responsibilities. All this is to be accomplished while balancing both the need to have the market mechanisms operate freely, while at the same time not allowing market failure in the short or long run to occur.

Bonner called the situation a Pandora's box.

> Will there really be improved productive and allocative efficiency as compared with the present structure? Will the losses of benefit which seem likely, exceed what are at present hypothetical gains? One is unlikely to be able to answer these questions until some years after privatization has taken place.[160]

But the ideal of deregulation has momentum within western societies, be that momentum derived from ideological rhetoric, stakeholders' frustration with regulation or entrepreneurial firms which believe they can be competitive with new technological options. The introduction of market mechanisms within the EUI is receiving serious consideration in many places.

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158 Vickers. p 486.
159 Bonner. p 19.
160 Ibid. p 21.

5.6 The Implications of Decentralized Generation on Market Proposals

The more decentralized generation becomes the more choices end-users will have. But this decentralization will be at the expense of making technical coordination of the system more difficult.

If 'distribution based' (DB) generating options' most essential characteristic is that it ties into the grid through the distribution system, it implies that a significant amount of the economic benefits of constructing and operating the facility will be experienced within the community. Communities may choose to entice operators of decentralized generators into their community by offering them contracts for energy.

For owners of co-generation type equipment, the business opportunities are not only for electricity, but also for the sale of the steam it produces. If a customer exists for the steam, this unit will want to operate at a constant rate while steam is in demand. The preference for producers would be a customer who wants steam 24 hours a day. Hence, the constant operating of this unit will imply that it is contributing to base-load power. From the information offered in earlier chapters it was hypothesized that DB generators are the cheapest producers of power and therefore will receive high merit in a competitive bidding process.

In the beginning, from a technical point of view, while decentralized generators are being installed, the situation will probably be one where communities demand less of the transmission pool because a certain percentage of their base load is being generated locally. It is however possible, if a significant number of these DB generators are installed within a community, that the distribution system itself may become an net exporter of energy during certain times of the day, while at other times of the day it returns to its traditional role of consumer of energy.

This may further add to the coordination issues that the transmission operators will have to consider. It is not that today these coordination issues are not possible, but there is a cost associated with developing the computer system necessary to coordinate the system and communication network need to maintain contact with the various players. There will also be a cost associated with installing transformers that will allow current to flow in both directions.

5.7 Impacts on Today's Utility Companies

The implications of deregulation and decentralization of electricity generation of today's electric utilities will be significant. Monopoly franchises that exist today were created by regulation and justified by central station technologies. With a change in the essential model of technological organization the monopolistic means of market organization becomes difficult to justify.

Due to society's predisposition against monopoly structures, as well as the criticism that they are inherently inefficient, it would seem likely that an evolution away from franchised monopolies will occur. A restructured EUI will respond to the dominant patterns of technology, just as today's electric utility industry originally evolved in response to the dominant technological pattern of centralization. With smaller generating technologies, numerous participants may enter the generation aspect of the industry. There is no reason not to believe that among these firms will be the original utilities.

Assuming for the moment that the U.K. model of ownership dominates, generation, transmission and distribution must become legally separate identities and therefore the original monopoly franchises must divest themselves of certain assets. Again there is no reason to assume that today's utilities cannot form a holding company that has subsidiaries in every aspect of the business including generation, the operation of transmission systems, as well as the ownership and/or operation of distribution systems.

Today's utilities are well positioned to excel in an atmosphere of deregulation. Possessing a high level of technical know-how, experience in project planning and management, plus well developed contacts in capital markets, today's utilities should be significant forces in a restructured industry. Restructuring, assuming it comes into force in numerous jurisdictions, will allow firms to enter markets other than their home region.

There may also emerge economic arguments that efficient operation of transmission systems should allow for interprovincial ownership and/or reorganization based on eco-regional considerations versus provincial boundaries. Eco-regional considerations refer to, for example, that northern Alberta may be better served by tying into a North West Territory grid versus a southern Alberta or prairie based transmission grid.

From an operational perspective the largest change that utilities will need to undergo is a change in their self perception and corporate culture. As discussed, today's regulatory structures have placed these firms in a position where they are perceived as monopolistic, fuel processors responding primarily to the concerns of regulatory boards. This focus will have to change to one where the corporate culture is oriented around supplying energy services, in a competitive marketplace and responding more to the concerns of end-users.

5.8 Impacts on Communities

This section will argue that decentralization of electricity generating equipment and the deregulation of the EUI will influence communities and regions in positive ways. In this section the positive influence of deregulation, decentralization of generation equipment and the expansion of the co-generation concept to create community integrated energy systems will be discussed.

Many of the implications of deregulation for end-users have already been alluded to in previous sections. Potentially there are three major benefits. First, the establishment of a market for electricity, with numerous suppliers, creates the opportunity for consumers to choose directly among energy alternatives. This stands in contrast to today's electricity market where centralized regulatory bodies, acting in the public interest, choose among options and apply those solutions uniformly to all citizens of the province.

A market will allow communities to participate more directly in an energy marketplace. It was hypothesized here that the customer will likely become the various distribution systems throughout the province. Although this does not represent the ideal of individuals making choices, it represents a compromise between the smallest practical unit for planning and coordinating the system, and the desire for individuals to participate directly in the market. It was also argued that owners of distribution systems, be they privately or municipality owned, will be easier to influence than a centralized regulatory body.

It was further hypothesized that with the opportunity to choose among energy alternatives several scenarios may emerge. Communities may choose to pay a premium to promote less polluting technologies. They may also choose, assuming that costs are competitive, to offer contracts to generating companies who are prepared to locate in or around their community. This second point will be expanded upon in a moment.

The second major benefit of deregulation, and in particular if a spot market is created to price electricity, is to make demand side management programs more effective. Today's regulatory system imposes a flat rate for electricity. This rate has many built in cross subsidies. There is, for example, no economic signal sent to consumers to reflect the stress placed on the system during peak load periods.

With a spot market and an accompanying system of billing consumers based on a hour-to-hour rate, the market would communicate to end-users the advantages of shifting loads to non-peak times, as well as the benefits of energy efficient service technologies.

The third benefit according to economic theorists is that with a market system electricity rates should decrease. Markets according to the theorists will create a business environment that will go further to promotion operating efficiency than the monopoly structure of today. This claim cannot be verified today because of the lack of examples of electricity marketplaces.

Beyond the advantages which deregulation offers, the economic implications of decentralizing generating technologies may be potentially significant. Annually, communities spend a significant amount of money on electricity.

But the economic spin-offs of those expenditures (employment, tax revenues, re-distribution of income) all leave the community.

In the past when the economics of scale dictated that the low cost means of delivering the electricity was via the central station model, keeping energy expenditures within the community was a non-debate. It is acknowledged that there were local benefits derived from the construction and maintenance of local distribution systems. But, as discussed in chapter 2, the generation aspect of the EUI represents over fifty percent of total expenditures and all this money typically leaves the community.

If decentralized generating units can deliver power at comparable costs, the impetus exists for municipalities to become involved, directly or indirectly, in generation. By doing so, communities may enjoy the economic spin-offs associated with the construction and maintenance of generation equipment.

A final benefit associated with the emergence of smaller generating facilities is an end to the boom and bust cycle associated with large central station developments. Typically, billion dollar developments will bring to a region a short period (2 to 10 years) of economic frenzy and social disruption while the facilities are being built. When construction is completed and operations begin, although there may be a net increase in employment relative to the pre-project period, it rarely if ever matches the level of economic activity experienced during construction.

Numerous smaller facilities may in fact see more people permanently employed per mega-watt of electricity generated than with centralized generation. However, the employment opportunities associated with construction and operation of smaller facilities will be distributed across the jurisdiction and therefore the net effect both economically and socially will be less disruptive.

5.8.3 Community Integrated Energy Systems

The opportunity to further promote the positive benefits of decentralized electricity generation could potentially come from with the expansion of the co-generation concept, as part of a larger evolution of urban infrastructure towards a community integrated energy system (CIES).

To develop an understanding of the opportunities a more holistic approach may achieve requires the development of a model of urban infrastructure systems. Urban infrastructure can be described as a system having three principal components, a 'market' for services, a 'process' where material is generated or destroyed and a 'distribution' network to collect or distribute materials.

> In these terms, the city can be viewed, with varying degrees of complexity, as a 'box' (figure 5.1) incorporating the distribution networks of the infrastructure in the form of pipes, cables, streets, etc. Buildings and facilities corresponding to the source and purpose of the infrastructure are connected to this 'box'.[161]

Using drinking water as an example of a desired service demanded by the market, water treatment plants represent the process aspect of the infrastructure and water mains are the distribution system. With the removal of solid waste as the desired service, the distribution aspect is the collection of the waste and the processing aspect has typically been the disposal of waste material into a land fill. Solid waste removal and sewage treatment today are essentially a pollution moving process from urban areas to locations which will not endanger the health of urbanites.

Traditional planning for urban infrastructure perceives the overall system as a number of separate and independent technical components (water, sewer, etc.) for satisfying different community needs.

> Many researchers, however, find that a view of this kind constricts our conceptions to existing system structures. It obscures the holistic perspective. The topics of inquiry are reduced to mere engineering technology, with interest being made to focus on individual parts of the system.[162]

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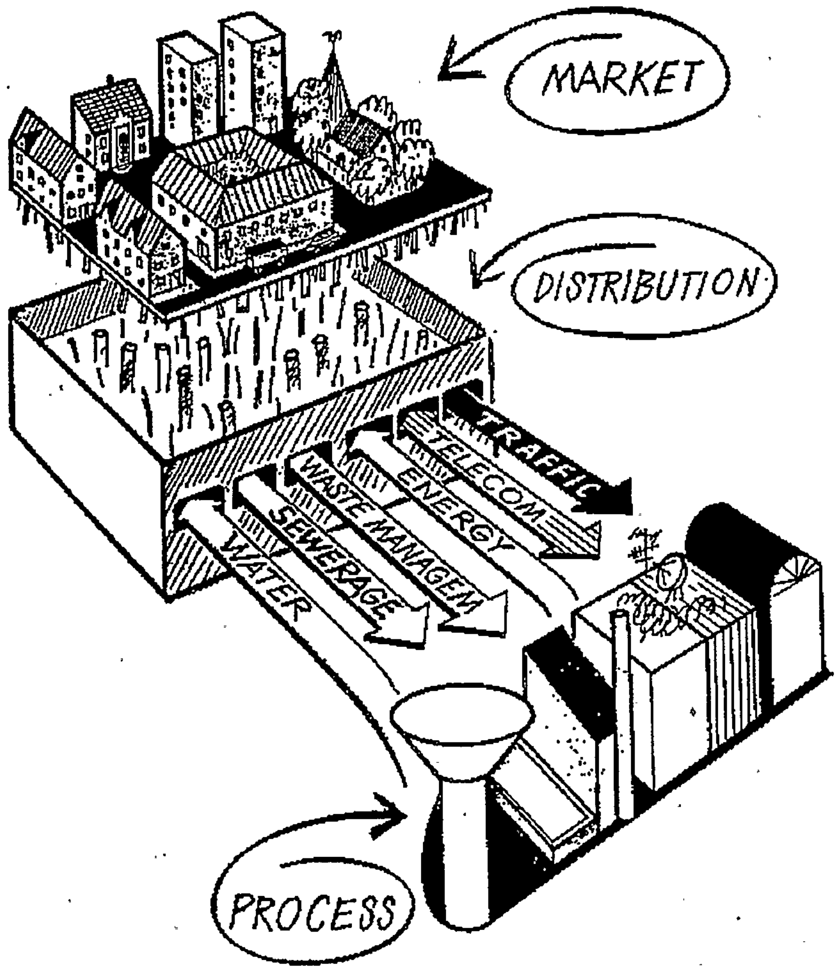
161 Bjorn Svendinger: The Technical Infrastructure of Urban Communities: A Survey of Current Knowledge. (Stockholm: Swedish Council for Building Research, 1991) p 29.

162 Ibid. p 29.

A Model of Urban Infrastructure

(figure 5.1)[163]



Just as electric utilities are facing a future where environmental concerns will play a significant role in determining the evolution of their industry, so will be the case with urban infrastructure. In the desire to promote efficiency and minimize pollution, urban infrastructure will need to evolve towards the 'industrial-ecosystem' model discussed in chapter 1, where "the consumption of energy and materials is optimized, waste generation is minimized and the effluent of one process ... serves as the raw material for another process. The industrial ecosystem would function as an analogue of biological

163 Modified version of graphic found in Svendinger. p 30.

ecosystems."[164] This model will require of planners to develop a paradigm of practice which involves integrated resource planning

Optimization as a means of promoting efficiency will require that the various components of the urban infrastructure be combined, where possible, to create an integrated technical solution which limit material throughput. "In a longer perspective, there are large scale environmental threats, which may have a profound impact on the prerequisites for urban development."[165]

This notion of combining or expanding infrastructural developments, as it impacts the EUI, is the expansion of the district heating and cooling concept. Since exhaust steam is a useful by-product of electricity generation, the opportunity exists to develop a distribution system where electric generators could make a significant contribution to the heating and cooling of buildings.

District energy systems supply the energy requirements for heating and cooling of buildings from a central plant or plants. A network is required to connect heating plants with the individual buildings to be serviced through a network of underground pipes. These piping networks actually consist of two parallel pipes, one supplying steam or hot water which is extracted within buildings and the second which returns the cooled water back to the central plant.

"The network can range in length from several hundred meters to many kilometers."[166] Electric generators could be a major contributor to such a systems, along with other contributors. "A principal environmental benefit of district energy is its ability to use what would otherwise be waste products. These may include biomass, garbage, industrial waste heat (including waste heat from electricity generation) and sewage effluent."[167]

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164 Robert Frosch and Nicholas Gallopoulos: 'Strategies for Manufacturing'. in Scientific American. (New York: Scientific America Inc., Sept. 1989) p 48.

165 Svendinger. p 13.

166 Gordon Bond: Promotional Manual for District Energy Systems. (Published by the Netherlands Agency for Energy and the Environment, 1993) p 10.

167 Morgan MacRae: Realizing the Benefits of Community Integrated Energy Systems. (Calgary: Canadian Energy Research Institute. 1992) p 49.

Efficiency through integration is promoted since the waste heat from electricity generators is utilized, solid waste becomes a energy source and overall air pollution is reduced since it is believed that one large emitter will have less of a net contribution to air pollution than several small emitters. "Compared to individual, on-site building systems, community integrated energy systems produce fewer emissions to heat and cool the same number of buildings and are easier to monitor and control."[168]

The benefits of the evolution of such a CIES would see benefits experienced by several parties including building owners, communities and society as a whole. These benefits are summarized in chart 5.1.

"Building owners avoid capital expenditures for installation of on-site systems and save labour costs for boiler operation and management."[169] Space that would typically be allocated to boiler systems can now be made available for other uses.

Owners of buildings will have access to low cost energy, both thermal heat and electricity. If the most efficient means of generating electricity is through the utilization of the co-generation concept, with a minimal distance between the generator and the end-user, this should translate into the lowest cost option for energy.

For the community, the promotion of CIES will not only promote environmental ends, but in fact become a source of economic development. "Urban infrastructure is a major determinant of the location of industry, commerce and housing."[170] Steam can be used to attract industries that require heat as part of their manufacturing process. Conversely, CIES can also increase revenues to industries who are in a position to sell waste heat, while at the same time reducing the costs for these parties associated with waste heat disposal.

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168 Ibid. p 48

169 Ibid. p 47.

170 Svendinger. p 9.

In the Swedish town of Landskrona, nearly 3000 jobs were lost in the early 1980s when a major shipyard went out of business; however, the city used the construction of a new CIES to attract several new industries, adding over 1500 new jobs to the community.[171]

Summary of Benefits of Community Integrated Energy Systems

(Chart 5.1)[172]

Types of Benefits	Building Owners	Municipalities	Society
Energy Utilization and Management	• Assured access to lowest cost energy source	• Utilization of available energy sources within the community	• Increase efficient use of energy
Operations Management	• Increased reliability of supply of thermal energy • Eliminate on-site boiler operation and maintenance		
Economic Attractiveness	• Eliminate capital for on-site energy system • Make space available for income or other purposes	•Significant employment during construction • Local sources keep energy expenditures in the community	• reduced capital for power and heating which frees monies for other needs
Environmental Enhancement	• Avoid future more stringent regulation of stacks, etc. • District cooling and steam absorption systems may provide options for CFC replacement	• Greater efficiency reduces total emissions • Single tall stack dispenses emissions faster from a metro area than multiple smaller and shorter stacks • Utilization of waste energy	• Greater efficiency reduces total emissions

Employment benefits from CIES include not only temporary and permanent jobs created from system construction and operation, and from industrial growth, but also from the retrofitting building systems to be compatible with the CIES system. On a broader scale, employment opportunities will also be created in the industries that supply equipment used to construct district energy systems. Such

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171 MacRae quoting from the City of Toronto: 'The Changing Atmosphere: Strategies for Reducing CO2 Emissions, Technical Volume. (Special Advisory Committee on the Environment, Report No. 2, Vol. 2, Toronto, Ontario, March 1991) p 7.

172 Modification of chart found in International Energy Agency: Promotional Manual for District Energy Systems. (Published by the Netherlands agency for Energy and the Environment, 1993) p 19

> employment opportunities would be primarily in the steel, pipe and boiler manufacturing products sector.[173]

And mixed with economic opportunities are numerous environmental benefits. "European cities that extensively employ CIES have very low levels of locally generated air pollution. For example, Stockholm, Sweden reduced its SO2 emissions by 95 percent in 25 years, due in part to the extensive development of CIES."[174]

> "Using a community's rejected energy material resources in CIES helps displace fossil fuels that might separately have be used to produce electricity, space, or process heating and cooling. Co-generation of heating, power and cooling are well proven technologies that have been applied in many places. Combined heat and power gives a major improvement in energy efficiency. This means that considerably less fuel is consumed, resulting in a reduction in waste emissions of all forms."175

But, as with all major proposals to revamp existing infrastructure, problems exist.

> District systems require very large initial capital investment with returns spread over a lengthy period. Few opportunities exist for investment in district systems which yield short paybacks (i.e., high returns on investment) for their sponsors. The economic advantages for new district systems, when based on calculations of project costs and returns, are, in fact, marginal in many cases. Only when economic, environmental and other social benefits are included in the assessment do most new district heating and cooling systems become attractive.[176]

This comment, made in 1993, however did not consider the influence the valuation of environmental externalities might have on the cost/benefit analysis of projects. Perhaps if pollution permit programs existed at the time when the existing urban infrastructure had reached maturity and replacement decisions needed to be made, CIES may be justified. This justification would derive from the efficiency the CIES system offers to limit

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173 MacRae. p 48.
174 Ibid. p 51.
175 Ibid. p 51.
176 International Energy Agency. p 29/30.

material through-put which could translate into both cheaper energy as well as less polluting options to deliver the same level of services.

Finally, just as was suggested with the final configuration of the EUI, a variety of options exist but it will be local conditions that determine the most economic mix of district heating, electric power from the grid versus locally generation, and natural gas use.

5.9 Conclusion

This chapter began with a discussion of the original goals of regulation and a critical review of the monopoly franchise model of market arrangements. Critics of the 'cost of service' system attack the model for being inefficient, creating an atmosphere where participants are risk adverse to innovation, and for its inability to respond to rapidly changing conditions. These critics believe the introduction of a market place into the EUI would resolve these problems.

The discussion then focused on the possibility of restructuring the EUI so that it might become a perfectly competitive industry. The characteristics of a perfectly competitive industry were reviewed and it was concluded that a such a situation was unlikely to evolve. Demand for electricity is inelastic and is considered an essential service. In the short run, consumers have limited opportunities to switch to an alternative source of electricity or energy currency. Loss of electrical services could be life threatening. Producers of electricity must spend millions of dollars to build new projects but ultimately require access to transmission services to be successful. Both these parties desire a level of stability and hence regulation will continue to have some role in a restructured EUI.

Options other than a perfectly competitive model were then investigated. It was however noted that a reorientation of the EUI with elements of a competitive marketplace might create the opportunity for regulators to expand their original mandate. That expansion might include a greater opportunity for end-users to have more say in and more control over the evolution of the energy system. Choices in regard to priorities, energy sources and processing technologies, are all made today by provincial bodies in a top-down, autocratic manner. When decisions are made by regulators, they impose a single solution on the entire jurisdiction.

With a perfectly competitive system ruled out, macro and micro-economic alternatives for restructuring were considered. Macro-economic consideration included the possible points of market transactions. The options for these transaction points are where the essential components (generation, transmission and distribution) of the system interconnect. To offer the protection both consumers and producer desire, it was considered necessary to require some form of control over entries into the market. This control could be achieved through the requirement of an operating license or the requirement of a contract.

Micro economic considerations included the deregulation of prices to end-users so that they pay an hour-to-hour rate, plus the development of a spot market. The spot market would establish a order of merit which would over time create a yardstick to identify efficient producers and optimal technological arrangements. This information will be used to make decisions when the system is further expanded.

Discussions then turned to the implications restructuring would have on today's utility companies, as well as communities and regions. Utility companies will need to divest their assets to promote restructuring. However, they may emerge as holding companies with subsidiaries in every aspect of the business.

Communities and regions should be influenced in a positive way by deregulation and decentralization. Deregulation will create a situation where citizens can choose directly among energy alternatives. Decentralization of generation may create a situation where more of the economic benefits associated with energy expenditures are enjoyed locally. But the greatest opportunity to both minimize pollution and promote economic growth will come through the expansion of the co-generation concept as part of a larger evolution of urban infrastructure towards community integrated energy systems.

CHAPTER 6 - CONCLUSIONS

This paper has been a discussion of the future of the electric utility industry. First, the status quo or dominant structural patterns of the industry as it exists today were outlined, both conceptually (chapter 1) and through a case study of the industry in Alberta (chapter 2) as a representative of a prototypical situation. Second, the challenges facing the EUI were reviewed (chapter 3) and various scenarios were developed as to possible technical responses to these challenges (chapter 4). With alternative scenarios developed, the implications of these changes were reviewed as they might impact regulators, utility companies and communities (chapter 5). The basic method of research was historical, with emphasis on economic considerations, followed by scenario development.

In chapter one a conceptual model (figure 1.1) for the interpretation of the energy sector was developed. This model assisted in clarifying the causal links within the energy sector, as well as developing a common vocabulary that was to be used throughout the paper. One of the central points of the model is that the entire industry is driven by the demand for services, not by energy sources. Service technologies have changed with time but the desire for service has not.

The discussion then proceeded to outline the ideological position of the writer. Commoner outlines the dominant characteristics of the 'technosphere' and the 'ecosphere'. The attitude of the technosphere has been that the ecosphere is available for exploitation at will. This attitude is one of the causes of the environmental crisis faced today. A peace treaty has been developed and it is called sustainable development.

A time perspective was also offered for the discussions of this paper. It was hypothesized that it would take 50 to 100 years for society to evolve from a fossil fuel based society towards energy forms that are less harmful to the environment. Not included in the conversation was a consideration as to whether society has that much time.

Chapter 2 began by outlining the essential technical components that makes up today's central station model of electricity generation and distribution. A historical review of the electric utility business in Canada was conducted and it was shown that ownership patterns mimicked the pattern of the dominant technologies. Thus, in the early days of the business when generators were decentralized, ownership was also decentralized. As transmission and generating technologies evolved, the dominant pattern of development became large centralized facilities. Ownership under these new circumstances tended toward monopolistic organization. Due to this monopolistic position as well as the importance of electricity to society, regulation became necessary.

The discussions then reviewed the utilities that operate within Alberta as well as the regulatory bodies that govern them. The essential breakdown of regulatory responsibilities were for the Public Utility Board to set rates end-users were charged for electricity, using the 'cost of service' method evaluation. The Energy Resource Conservation Board responsibilities as they apply the EUI were to evaluate the need for new facilities and to issue building permits.

The discussion then proceeded to identify and discuss the challenges facing the EUI (chapter 3). Several forces are converging to cause a shift from the central station model. They include concerns associated with the mature state of both the electricity market place and the generating technologies that have dominated the industry. For decades the demand for electricity grew faster than GNP. However since the mid-1970s the demand for electricity has begun to follow GNP. In an atmosphere where demand increases consistently adding large blocks of power represents minimal risk. However in a mature market, utilities need to be more concerned with the ability of the market place to absorb new capacity.

In terms of technological maturity, the generating equipment that has dominated over the last seventy five years has reached an efficiency ceiling where no significant increases in performance can be attained. As well, new generating options have emerged that are more efficient than older equipment. These new technologies are also cost justified in smaller sizes, whereas older generating technologies needed to be large in size to be economically viable.

Another force challenging the central station paradigm is regulatory risk. Central station facilities have a construction time-line of approximately ten years. Rational planning requires that an estimation of the demand for electricity a decade into the future be made. These projections are used to justify the necessity of new equipment. There is a certain degree of uncertainty associated with these projections. To make matters worse, once the generators are built, if the projections made ten years earlier turn out to be incorrect, regulators may refuse to allow the new facility into rate base and the utility is left to manage the debt associated with the project. The solution is smaller generating units which can be constructed in less time, require shorter projection periods and place less financial stress on proponents.

The final challenge discussed was the potential role the valuation of finite resources and environmental degradation might have on the decision making process associated with project development. The theoretical basis of orthodox economics was established before the laws of thermodynamics were developed. Proposals were offered as to how economic theory might be modified so to recognize the significance of the use of finite resources and the social costs associated with environmental contamination.

Chapter 4 began with an investigation of the technical options that are available to electric utility planners today, to move the system away from the present centralized model and towards a more decentralized model of power generation. With this completed, scenarios as to when this evolution might occur were developed. Essentially the opportunity to decentralize will be when the installed infrastructure reaches the end of its life-cycle and needs replacement.

One conclusion of this chapter was that if all the challenges discussed in chapter 3 become significant forces in the decision making process about the future development of infrastructure the result will be a redefinition of the economics of scale as it applies to the EUI. With that point made, a variety of decentralized generating supply options will become cost-justified.

Monopoly franchises were created by regulation and justified by central station technologies. If the dominant pattern of technologies associated with the EUI change from a centralized to a decentralized model, the monopolist structure in place today may no longer be justified.

There is no lack of critics of the monopoly model and these criticisms of this model were reviewed in chapter 5. The discussion then proceeded to investigate options for the creation of a more free market oriented EUI. The discussion began by reviewing the basic assumptions of a perfectly competitive industry and it was concluded that such a model of reorganization was not likely to occur in the EUI. This is because of the significance of electricity in societies, plus the technical nature of the industry where producers' success depends on access to transmission services. Both consumers and producers desire a level of stability and hence regulation will continue to have some role in a restructured EUI.

It was however noted that the introduction of market mechanisms would create the opportunity for regulators to expand their original mandate. The original mandate focused upon concerns about the creation of a reliable system which delivered electricity at an affordable price. The mandate could be expanded to include the opportunity for end-users to have a greater say in and more control over the evolution of the energy system. Choices in regard to priorities, energy sources and processing technologies, are all made today by provincial bodies in a top-down, autocratic manner. When decisions are made by regulators, they impose a single solution on the entire jurisdiction.

With a perfectly competitive system ruled out, macro and micro-economic alternatives for restructuring were considered. Macro-economic consideration included the possible points of market transactions. The options for these transaction points, are where the essential components (generation, transmission and distribution) of the system interconnect. To offer the protection both consumers and producer desire, it was considered necessary to require some form of control over entries into the market. This control could be achieved through the requirement of an operating license or the requirement of a contract.

Micro economic considerations included the deregulation of prices to end-users so that they pay an hour-to-hour rate, plus the development of a spot market. The spot market would establish a order of merit which would over time create a yardstick to identify efficient producers and optimal technological arrangements. This information would be used to make decisions when the system is to be expanded.

Discussions then turned to the implications restructuring would have on today's utility companies, as well as communities and regions. Utility companies will need to divest their assets to promote restructuring. However, they may emerge as holding companies with subsidiaries in every aspect of the industry.

Communities and regions should be influenced in a positive way by deregulation and decentralization. Deregulation will create a situation where citizens can choose directly among energy alternatives. Decentralization of generation may create a situation where more of the economic benefits associated with energy expenditures are enjoyed locally. But the greatest opportunity to both minimize pollution and promote economic growth will come through the expansion of the co-generation concept as part of a larger evolution of urban infrastructure towards community integrated energy systems.

6.2 Recommendations

1. The greatest opportunity to move industrial society closer to the ideals of sustainable development occurs when major infrastructural installations have reached the end of their lifecycle and require replacement. Although it may require some patience to wait for these opportunities to arise, when they do they should not be missed.

2. Research associated with integrating environmental concerns into the economic model should be fostered. Two major modifications are required to make economic policies more effective in pursuing the goal of sustainable development. The first is the modification of today's orthodox economic model to include greater consideration for material and energy flows. The

second will be the development of a methodology to deal with the mixed units controversy by giving a monetary value to ecological systems. Both of these research areas today are in their infancy.

3. Utility planners should recognize that the introduction of market mechanisms represents an opportunity to give end-users greater direct input into the evolution of the EUI by decentralizing decision making. With the franchised monopoly model, choices regarding priorities, energy sources and processing technologies were all made by provincial bodies in a top-down, autocratic manner and a single solution was applied to the entire jurisdiction. This system is incapable of incorporating the multiplicity of opinions that exist on energy issues.

In contrast, free markets are inherently oriented around the end-user. It represents a bottom-up process of consideration. With the proposal to make the various distribution systems the customer of a reformed utility industry, there will be a greater accommodation of diverse opinions. Although making the various distributions systems the basic unit of planning does not represent the ideal of an individual consumer making choices, distribution system owners are more likely to be influenced by local opinion than a centralized body.

4. The electric utility industry is unlikely to become a perfectly competitive industry. Dealing with the requirements for system reliability and coordination, while trying to gain the benefits associated with a competitive marketplace will require a centrally administered, bounded market.

Policy goals defining the structure and mechanisms of the marketplace to be created should be developed through public consultation. Once the market structure is in place, leadership will be required by legislators and regulators to move the industry in this direction.

5. Municipalities should recognize that decentralization of the EUI represents an opportunity to promote economic development, reduce pollution and promote fuel efficiency. If the electricity used by a community is generated in

and/or around that community, the economic benefits associated with the construction and operation of these facilities will remain in the area.

With the development of a community integrated energy system (CIES) the opportunity arises to reduce the material throughput generated by urban areas. Since material waste can be used to create steam, along with the steam from electricity generation, less fossil fuels are consumed. It can also argued that a single large source of air emissions is less polluting that numerous small sources. As well, CIES in themselves become sources of economic development since they may attract industries that require steam or have excess steam to sell.

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