(Decision No. C89-1622)

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

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IN THE MATTER OF PUBLIC SERVICE COMPANY OF COLORADO TO HAVE UPGRADES IN DOUGLAS COUNTY.	)))))	DOCKET NO. 89A-028E DECISION OF THE COMMISSION GRANTING APPLICATION SUBJECT TO CONDITIONS

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December 20, 1989
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Appearances: Kenneth V. Reif, Esq., Denver, Colorado, Joseph Skinner, Esq., Grand Junction, Colorado, and Thomas Watson, Esq., Washington, D.C., for Public Service Company of Colorado;

Steven H. Denman, Esq., and Karen H. Duwaldt, Denver, Colorado for Douglas County Board of County Commissioners;

Lawrence F. Herbert Pro Se;

William E. Myrick, Esq., Denver, Colorado for William E. Myrick and McArthur Ranch Associates;

James F. Weber Pro Se;

Suzanne Weber Pro Se;

John E. Archibold, Esq., Assistant Solicitor General and Commission Counsel, for the Commission.

STATEMENT

BY THE COMMISSION:

Public Service Company of Colorado (Public Service) filed this application on January 12, 1989, seeking an order from the Commission permitting it to upgrade and provide betterments on an existing 115 KV transmission line located within Douglas County. A procedural history of this docket is appended as Appendix A-1.

The Commission discussed this docket initially at its open meeting on November 2, 1989. This decision is entered on December 13, 1989, and is subject to the provisions of § 40-6-114, C.R.S., and § 40-6-115, C.R.S., concerning reconsideration by the Commission and review by the district court.

FINDINGS OF FACT

A. Introduction

Public Service filed this application for the Commission's approval to upgrade an existing 115/115kv transmission line to 115/230kv. The application was filed pursuant to § 30-28-127, C.R.S., which states:

> Public utilities exceptions. None of the provisions of this part 1 shall apply to any existing building, structure, or plant or other equipment owned or used by any public utility. After the adoption of a plan, all extensions, betterments, or additions to buildings, structures, or plant or other equipment of any public utility shall only be made in conformity with such plan, unless, after public hearing first had, the public utilities commission orders that such extensions, betterments, or additions to buildings, structures, or plant or other equipment are reasonable and that such extensions, betterments, or additions may be made even though they conflict with the adopted plan. (emphasis added)

Section 30-28-127, C.R.S., provides that notwithstanding a conflict with the adopted county plan, this Commission may order that public utility extensions, betterments, or additions to buildings, structures, or plant or other equipment are reasonable and that they should be made. The key word in the statute is the word "reasonable" which is not otherwise defined.

Initially Public Service proposed an upgrade of the existing overhead 115/115kv transmission line to an overhead 115/230kv line which runs between the Daniels Park substation in Douglas County and the Greenwood substation in Arapahoe County. During the course of hearings in this docket, Public Service indicated its willingness to upgrade the line from 115/115kv to 230/230kv. The portion of the upgrade involved in this application is within Douglas County. The line was originally installed in 1957 and upgraded to its current configuration in 1971, prior to most development in the area. Public Service filed two applications seeking zoning approvals from Douglas County for a portion of the upgrade. Douglas County, acting through its Board of County Commissioners in a two to one vote, determined that the upgrade was in conflict with its zoning plan and denied Public Service's applications.

Public Service then filed this application with this Commission for approval to construct the upgrade notwithstanding the denials by Douglas County. Douglas County, an intervenor in this application docket, and several other individual intervenors contend that Public Service's application before this Commission for an upgrade should be denied. Alternatively, Douglas County contends that, if this Commission deems that an upgrade of facilities is necessary, the upgraded facilities should be buried. Public Service believes that its application for upgrade should be granted without the additional requirement of burying or undergrounding the line.

After a careful review of the evidence presented in this docket, together with the well-presented positions made available to the Commission by the parties, it is our considered judgment that Public Service's application should be granted subject to certain conditions which are discussed in this decision. We shall now discuss the three phases of this docket which have led us to reach the foregoing conclusion.

B. Phase I - the Need for the Transmission Line Upgrade

Public Service contends that the transmission line upgrade is needed in order to serve the demonstrated need of residents in Douglas County for more electricity. Douglas County countered that the transmission line upgrade is not needed because Public Service load projections are inaccurate and unreliable. We find that the transmission line upgrade, requested by Public Service in its application, is reasonably required for electrical service in the southeast load area generally and in Douglas County in particular. We further find that the transmission line upgrade is the more reasonable proposal vis-a-vis the potential alternative suggested by Dr. Robert H. Sarikas who testified for Douglas County, which was the installation of an adequately sized 230/115kv auto transformer at the Greenwood substation in conjunction with the upgrading of the second Smokey Hill to Leetsdale circuit from 115kv to 230kv.

William J. Martin, Public Service's Vice President, Electric Engineering and Planning, testified to the physical configuration of Public Service's transmission system for providing power to the Denver metropolitan area (including Douglas County) from its metropolitan area power plants and from sources outside of the metropolitan area. Mr. Martin also testified that the demand for power in the southeast load area presently exceeds the ability of the system to supply that power in certain outage situations. Public Service's transmission grid in the Denver Metropolitan area is basically a ring and spoke configuration. Public Service has four power delivery points, namely Cherokee on the north, Lookout on the west, Smoky Hill on the east, and Daniels Park on the south, as depicted in Exhibit A-5. Currently the auto transformer at the Daniels Park substation is loaded to near capacity. In a single contingency outage the auto transformer will be overloaded and insufficient power will flow from Daniels Park to Public Service customers in the southeast load area of the metropolitan area. If the auto transformer capacity is increased, this will result in an

overloading of the existing 115/115kv transmission lines from Daniels Park to Greenwood, in a single contingency outage. Accordingly, these lines must be upgraded to 230/230kv (although operating the line at 115/230kv would be sufficient to carry loads for the next several years to the area).

The Daniels Park to Greenwood transmission line is one of several transmission line "spokes" connected to an outer transmission belt which interconnects the various power importation points around Denver. The spokes were originally built to operate at 115kv. However, it reasonably could have been anticipated that as demand for electricity increased in the Denver metropolitan area additional power would have to be made available, either by building more spokes or increasing the capacity of the existing spokes to 230kv. For the past 20 years Public Service has been upgrading 115kv spokes in Denver to 230kv. The upgrade from Daniels Park to Greenwood is one of many planned upgrades.

Although Douglas County pointed out many discrepancies and problems, we are not persuaded by its attack upon Public Service's load projections. Exhibit A-11 sets forth Public Service's load projections which were made in 1983 for the years 1983 through 1988, and the actual loads that occurred from 1975 through 1988. The total load projected for the southeast load area, depicted on Exhibit A-11, is compared with the actual loads that occurred. It can be seen that the demand for energy in the total southeast load area has been about two percent higher than Public Service's projections even though the Prairie substation, among others involved in this application, was consistently over projected and the projections ignored the 1973 and 1984 figures.

While the growth in the southeast metropolitan area continues to be very high, it is now less than projected in 1983. Douglas County argues that while the allocated coincidental peak loads only slightly exceeded the allocated coincidental peak load projections, the actual non-coincidental substation loads were less than the projections from 1985 through 1988 and the non-coincidental total southeast substation load from 1985 to 1988 was substantially less than the actual allocated coincidental peak load. Thus, Douglas County argues that the comparison demonstrates that the use of allocated coincidental peak load figures (whether actual or projected) inflates the actual loads carried by the southeast substations in the Daniels Park powerline. Douglas County further argues that, since the Commission does not allocate costs in its average and excess demand cost of service study using coincidental peak loads or demand, Public Service's reliance on coincidental peak load studies is misplaced. We do not agree. Coincidental peak load as used in a power flow analysis measures the physical capacity that must be available to avoid power outages or blackouts. Cost of service studies, on the other hand, do not determine what is physically necessary but how the costs of what is physically necessary are going to be allocated. Accordingly, we believe that Douglas County misdirects the focus of this docket by mixing the issue of what is physically necessary in a power flow analysis with the economic issue of how costs are to be allocated in

a cost of service study. This docket does not involve a rate case, but rather whether certain physical facilities should be allowed to be built, notwithstanding a contrary zoning decision of Douglas County.

Although it is likely that the line originally proposed by Public Service was based upon projections, it does not appear that Public Service attempted in this docket to demonstrate the need for the upgraded line merely by presenting future load projections. In fact, by the time Public Service witness Mr. Martin prefiled his direct testimony, actual load figures for the southeast load area were available. These were the figures relied upon by Mr. Martin to demonstrate the need for the upgraded line. He testified that in February 1989 the southeast load area required 576 megawatts. He also testified that had there been a single contingency outage on that peak day, the lights would have gone out. Mr. Martin also indicated that on January 25, 1989, there was a power outage because the actual demand on the system exceeded the ability of the system to supply it. As a result of outages, both Leetsdale to Smokey Hill 230kv transmission lines were out of service. There were only two other sources available to make up for the loss of that power to the southeast load area, mainly the Arapahoe and Daniels Park power sources. The Daniels Park auto transformer became loaded to 133 percent of its capacity; the Arapahoe to Greenwood 115kv transmission line became loaded to 121 percent of its capacity; and the Greenwood to Leetsdale 115kv was loaded to 100 percent of its capacity. Voltages dropped to below normal operating levels. Accordingly, the system was unable to transfer required power through its Daniels Park and Arapahoe substations. Approximately 500,000 people were without power for periods lasting from one minute to an hour and 30 minutes with the average outage being approximately 8 minutes. Had the proposed Daniels Park to Greenwood upgrade been in service, the outage would not have occurred because the upgrade would have more than tripled the capacity of the Daniels Park to Greenwood line. As Mr. Martin pointed out, if the line is upgraded it will have a capacity of approximately 650 megawatts when it is operating at 230/115kv, or 870 megawatts when it is operating at 230/230kv. The 650 megawatts supplied by Daniels Park would have been sufficient to meet the load, even with the outages.

Douglas County contends that Public Service has not adequately studied other alternatives to the transmission line upgrade. Public Service counters that it had studied many alternatives to the upgraded transmission line, including system alternatives which might provide more power to Greenwood and Prairie without upgrading the Daniels Park-Greenwood. These alternatives were not presented in Public Service's case initially. Approximately two dozen alternatives were considered and a brief synopsis of the various alternatives was contained in Public Service's Exhibit A-16. Most of the alternatives were rejected in the early screening process, but four alternatives were seriously studied to a point that cost estimates and power flow analyses were done. As a result of Public Service's study, these alternatives were rejected as well.

On cross examination by Commissioner Lehr, Mr. Martin testified that Public Service had not analyzed the cost or benefit of demand management options as alternatives to the upgrade of the transmission line. Mr. Martin, agreed that such an analysis was possible, that demand reductions could eliminate the need for the upgrade and that such a program of demand reduction should be compared to the supply side option of a transmission upgrade, both on the economics of such an alternative and as to factors external to the economics, such as aesthetics, notice, and exposure to electromagnetic fields. Mr. Martin also stated that he understood that the time had passed in which Public Service could approach this Commission with a supply side alternative in the absence of engineering and financial analysis of demand side options.

Douglas County witness, Robert Sarikas, testified that the installation of an adequately sized 230/115kv auto transformer at the Greenwood substation, in conjunction with the upgrading of the second Smokey Hill to Leetsdale circuit from 115 to 230kv, if necessary, would provide a solution for the overload. Dr. Sarikas was of the opinion that the environmental impact of transformer additions at the existing Greenwood substation, particularly because space is available, would be less than the impact of the transmission line upgrades or construction of additional lines. He stressed that the proposed upgrade of the Daniels Park-Greenwood 115kv line forces resolution of the Arapahoe-Sheridan overloading problem. Since these areas are coterminous in part of the southeast transmission system shown on Exhibit A-6, a resolution of both problems simultaneously, in his opinion, is more desirable than the upgrade.

The alternatives suggested by Dr. Sarikas are essentially variations on the theme of getting power to Greenwood either through Smokey Hill or the Arapahoe power sources rather than through Daniels Park. However, his alternatives fail to deliver sufficient power to the southeast load area and they do not appear to increase the reliability of the system because they fail to relieve the Daniels Park bottleneck. Although Dr. Sarikas says that there is room at the Greenwood substation to upgrade the transformer, it may well be that the Greenwood upgrade, as proposed by Dr. Sarikas, would require the demolition of about seven homes in the area.

We find that in order for Public Service to provide adequate electrical service in that southeast load area, its amended proposal to upgrade its existing overhead 115/115kv transmission line to a 230/230kv transmission line running between the Daniels Park substation in Douglas County in the Greenwood substation in Arapahoe County is reasonable and should be approved.

C. Phase II - Consideration of Non-Need and Non-Health Impacts of Proposed Transmission Line Upgrade

Phase II of this docket was devoted to a consideration of non-need and non-health impacts of the proposed transmission line upgrade. Land use, noise, aesthetics, and property value impacts were considered by the Commission.

1. Land Use Impacts

Douglas County witness Steven Wilson testified that the proposed upgrade should not be approved because of unfavorable impacts upon land use. However, Mr. Wilson's testimony establishes the substantial compliance of the proposed upgrade with the zoning policy and procedure of Douglas County. In fact, the Douglas County planning staff found the Public Service applications in compliance with the county plan. Mr. Wilson's opinion conflicts with the opinion of other members of the planning staff and the documents contained with the file of the planning staff. For example, Exhibit J-5, the memo of July 6, 1988, from Mr. Wilson and Mr. Hainlen to the members of the Douglas County Board of County Commissioners, includes the attachment of the memo of March 16, 1988, finding the application to be in compliance with the Douglas County zoning resolution and indicating that the planning staff's concerns over visual aspects could be dealt with through either coloring the towers or using single steel poles. Finally, the memorandum indicates that the referral agencies to whom the application was submitted had no negative comments.

If we were to accept the notion that adverse land use impacts are a sole basis for our finding that Public Service's proposed power line upgrade was unreasonable, arguably the statute (§ 30-28-127 C.R.S.) that allows review by this Commission from adverse local government land use findings would be nullity. This result follows in logic since this Commission has no land use control jurisdiction and local governments are vested with such powers. If we cannot override a local land use decision affecting utilities, then the statute is meaningless.

2. Aesthetic Impacts

Public Service presented the testimony of Mr. Kim Dreese who presented visual simulations of the proposed upgrade, both with lattice towers and single steel poles. Public Service has agreed to provide either steel lattice towers or single steel poles. We find that the additional visual impacts from the proposed upgrade are minimal. Thus the aesthetics impact aspect of this docket has not been a material factor in our decision. While the natural beauty of the state may someday result in legislative diction regarding undergrounding, we are not willing at this time to require all ratepayers to pay the additional $13.5 million cost based on aesthetics.

3. Property Value Impacts

The Commission is not clothed with power to award damages as a result of property value losses, even if they result from the upgrade. The Commission did rule previously in this docket that the effect of the transmission line upgrade on property values was one of a number of factors that the Commission was entitled to consider in making its determination of whether the upgrade was reasonable. Douglas County witness Mr. Bowes testified that the upgrade will adversely affect property values. Mr. VanCourt for Public Service testified that the upgrade will not affect property values. Mrs. Davis of Greenwood Village said that her land value was lowered significantly when the line running near her house was upgraded from 115kv to 230kv. The transmission line was built in 1957 before most, if not all houses were constructed. There is insufficient evidence on the record to demonstrate that a negative inpact on property values, even in combination with other factors, is so great that the Commission could make a finding that the transmission line upgrade was unreasonable.

4. Noise Impacts

Public Service presented the testimony of David L. Adams on noise. Mr. Adams performed measurements of the transmission lines most similar to that proposed in this docket, both energized and unenergized, and compared those with other measurements taken by Public Service. Based upon his own measurements and his comparison to those of Public Service, and his determination of the noise increase resulting from a wet conductor, Mr. Adams testified that there would be a slight increase in noise, but that the noise would be reasonable. The determination of Mr. Adams that the audible noise from the proposed line is reasonable was supported by his Exhibit F-10, a graph contained in the Electrical Engineers Handbook, 12th Edition, which shows noise complaints arising generally only at levels exceeding that found on lines similar to the proposed upgrade.

Douglas County witness, Michael Summers, testified that Public Service and Mr. Adams should have evaluated the lines under wet conductor conditions and provided an audible noise profile for the proposed 230kv line. Mr. Summers also was of the opinion that Mr. Adams' measurements were good for the single purposes of stating what the noise levels were on the day he performed the test, but his one day test was not sufficient to conclude that noise will not be a problem at the proposed 230kv line. Mr. Summers also criticized Mr. Adams' measurements as being made only during fair weather conditions. Mr. Summers calculated an audible noise profile for the proposed 230kv line under wet conductor conditions which indicated that the upgraded line would reach noise levels of 58.3-53dBAs 5 percent of the time, and noise levels of 49-44dBA 50 percent of the time.

Public Service counters that the noise levels from the proposed upgraded line will be reasonable since the noise levels fall below the maximum noise levels that are permitted in residential areas in

accordance with § 25-12-103, C.R.S. It should also be noted that Public Service has agreed to construct the transmission line upgrade with a larger conductor than it has previously used on similar upgrades. A larger conductor, as a general rule, will operate more quietly than a smaller conductor. Douglas County is apparently of the view that noise in excess of the statutory limits is a public nuisance. It also argues that what is defined as a statutory public nuisance is not the standard governing the need for the construction of electric transmission lines or whether construction is "reasonable." Accordingly, according to Douglas County, it would be unreasonable to use public nuisance standards to define "reasonable" in this docket as far as noise is concerned.

Based on the record in this docket, we find that the increase in noise levels which is likely to be occasioned by the transmission line upgrade is reasonable under the circumstances.

5. Summary of Phase II Impacts

Based upon the foregoing, we conclude that the Phase II impacts, including land use aesthetics, property values, and noise, either singly or in combination, do not adversely affect the overall reasonableness of the transmission line upgrade.

D. Phase III - The Health Impacts

In recent years recognition and concern over the possible adverse health effects of power frequency electric and magnetic fields have increased. This is the first docket at this Commission in which a health effects issue has been specifically raised by the parties in connection with a power project. It was the Phase III health impact issue that garnered the most testimony of the parties and public witnesses who testified in this docket. Many of the public witnesses who testified at the public hearings made known to the Commission their concerns about the possible adverse effects of electric and magnetic fields emanating from overhead power lines. Three individuals were concerned enough about this issue to intervene as pro se parties in this docket and to testify and present exhibits to the Commission. The pro se intervenors, specifically Mr. Herbert and Mr. and Mrs. Weber, in this docket materially assisted the Commission in its overall determination with regard to the health effects issue. Their participation was highly commendable, and is appreciated by this Commission.

Public Service sponsored the testimony of three recognized medical experts. Dr. Darwin R. Labarthe is a medical doctor, researcher in epidemiology and teacher employed by the School of Public Health at the University of Texas Health Science Center in Houston, Texas and also by the Baylor College of Medicine. Dr. Labarthe's other qualifications as an expert are set forth in Appendix B-1.

Dr. Labarthe testified as to the development of epidemiology as a science and the methodologies of the various epidemiological studies in which he and others have been involved described in Appendix B-1. In

explaining what epidemiologists look for in assessing groups of studies for a relationship of a purported agent to a disease, Dr. Labarthe testified that epidemiologists consider several factors with respect to such relationship, including strength, consistency, specificity, time relationship, and coherence. Dr. Labarthe further testified about his review of the epidemiological studies involving power frequency, electric, and magnetic fields in human health.

One of the studies about which Dr. Labarthe testified was a study by Wertheimer and Leeper (1979) in Denver which reported results of a comparison of cancer cases and controls in relation to high and low current wiring configuration codes. Dr. Labarthe stated that in addition to numerous problems in the design, conduct, and analysis of this study, later follow-up studies have not been able to replicate the results of the Wertheimer and Leeper childhood study of 1979. Some of the problems in the Wertheimer and Leeper study included the method of statistical analyses, problems with the experimental design, and problems with the measure of exposure. As an example, a fundamental problem with the Wertheimer and Leeper study, according to Dr. Labarthe, was that it was not a blind study. A blind study is one in which the investigator evaluating exposure does not have advance knowledge of the health status of the individual subjects for whom the measurements are being made, and thus a blind study would limit the chance for bias or error in coding exposure data. Dr. Labarthe also related that a study by Fulton in 1980 attempted to replicate the findings of the Wertheimer and Leeper study concerning childhood leukemia but that the conclusions of the Fulton study were in conflict with those of Wertheimer and Leeper in that no relationship was found between childhood leukemia and wiring configuration codes.

Dr. Labarthe also discussed the Savitz studies (1986, 1988) which looked at several disease categories, two different types of control groups, four measures of exposure, and differing numbers of stratification of exposure in data. The Savitz study had over 1,500 calculations which showed no significant associations between cancer and magnetic fields when the actual measurements of magnetic field exposure were used. According to Dr. Labarthe, the only times Savitz identified any significant association was when wiring configuration codes, an estimate of exposure for a particular residence, were used. According to Dr. Labarthe, the Savitz study consistently found no statistically significant associations between cancer and magnetic fields and only a few irregular statistically significant association between cancer and wiring configuration codes. With respect to childhood cancer studies taken as a whole, and the degree of validity of individual studies within that group, Dr. Labarthe concluded that there is no consistent pattern of increased risk across or within the studies, that no studies have established a dose-response relationship between any type of childhood cancer and any measure of exposure, and that there is no increased risk of childhood cancer when actual electric or magnetic fields were measured. Dr. Labarthe also discussed several other studies (e.g., Milham (1982, 1985, 1988), Coleman (1983, 1985, 1988), McDowall

(1983, 1986), Stevens (1988), and Stearn (1986)) which have not shown any consistent patterns of risk that would provide a scientific basis for concluding that electric and magnetic fields are associated with cancer.

Finally, Dr. Labarthe testified as to certain other epidemiologic studies concerned with power frequency fields and other health indicators, other than cancer. He discussed the Perry (1981) study on suicide, the Singewald (1973) study of electric utility linemen, and the Strumza (1970) study of individuals living in the vicinity of electric transmission lines. Dr. Labarthe affirmatively answered the specific question of whether sufficient research had been conducted in his area of expertise, namely epidemiology, for him to reach a professional opinion concerning the power frequency electric and magnetic fields and human health. Dr. Labarthe's opinion was as follows:

> Taken together, the epidemiologic studies on power frequency electric and/or magnetic fields do not show that exposure is associated with cancer or any other adverse health effects. The group of epidemiologic studies concerning power frequency electric and magnetic fields and human health have examined a variety of health end points including childhood and adult cancer and overall use of medical facilities and/or prescription medicines. The studies vary widely in their strengths and weaknesses, i.e., in their validity. The studies indicate that, regardless of how it is measured, increased exposure to power frequency fields is not associated with increased risk of any disease or illness, i.e., there is no dose-response relationship, no consistent pattern of increased risk of disease or illness associated with field exposure either within or across studies. There is neither specificity of disease or illness nor a time relationship of exposure and disease or illness that indicates a cause-effect relationship. Further, indications from related fields of science provide no persuasive pattern of any adverse health affects from exposure to power frequency electric and/or magnetic fields.

Dr. Edward Paul Gelmann, Chief of the Division of Medical Oncology and Professor of Medicine and Professor of Anatomy and Cell Biology at the Georgetown University School of Medicine also testified on behalf of Public Service. Dr. Gelmann is a specialist in medical oncology and cell biology. Dr. Gelmann's other qualifications as an expert are set forth in Appendix B-2.

Dr. Gelmann was asked to conduct an independent literature search and independently examine the relevant scientific studies in the fields of molecular and cellular biology to assess whether power frequency electric and magnetic fields cause any adverse molecular and cellular effects that lead to cancer or other adverse human health effects.

The key point that needs to be understood about molecular and cellular biology and cancer, according to Dr. Gelmann, is that any agent that causes a change in DNA, that is, that causes a heritable genetic change, can have adverse effects. It is most important to understand that genetic change is necessary to create cancer cells. Once it occurs, the genetic change is permanent and is transmitted to "daughter cells." Thus, when a particular cell with a DNA change that causes cancer divides, all subsequent cells will be cancer cells.

Dr. Gelmann testified that the mutational analyses studies with electric and magnetic fields showed that exposure to 60Hz fields have no affects on mutations. Dr. Gelmann referred to the Frazier (1984) study which found no effect on the frequency of genetic changes in ovary cells, the Trent (1987) study which found no effect of power frequency fields with human colon cancer cells, and the Whitson (1986) study which found that DNA repair processes were not affected by exposure to power frequency fields.

Dr. Gelmann testified that chromosome studies concerned with 60Hz electric and magnetic fields showed that they were not associated with damage or other changes to chromosomes. Dr. Gelmann also reviewed other studies on cell proliferation, studies on DNA synthesis and cellular transcription and concluded after reviewing the in vitro studies that there is no persuasive scientific data showing that power frequency electric and magnetic fields in any way cause or promote cancer, and that these studies show no cellular or molecular damage or harm that could lead to adverse health effects.

In addition, Dr. Gelmann reviewed a number of animal studies that had been conducted in both controlled laboratory settings and with organisms living directly under transmission lines. One of the most important of theses studies is one by Benz and Carsten (1987). Benz and Carsten studied thousands of experimental animals during three generations of exposure to various levels of both electric and magnetic fields and they looked at many different indicators of health, including fertility, growth, development, mortality, general health, and genetic indicators. According to Dr. Gelmann the results of the Benz and Carsten research found no effects of power frequency field exposure on any of the many end points examined and the studies also demonstrated that exposure to power frequency of electric and magnetic fields did not cause, promote, or otherwise influence cancer or cause other adverse health effects.

Dr. Gelmann also reviewed tumor growth studies in which researchers either exposed cells to the agent in question, then

transplanted those cells to the animal host, or transplanted cells to the animal host and then exposed the entire organism to the purported agent of interest. Dr. Gelmann stated that tumor growth studies involving electric and magnetic fields showed no effect on the growth of cancerous cells or other adverse effects on health.

Finally, Dr. Gelmann came to the conclusion that sufficient molecular and cellular biology research had been conducted to adequately assess the possible risk of DNA change from exposure to electric and magnetic fields and that based upon his education, training, experience, and position within the field of molecular and cellular biology that no adverse effects of exposure to power frequency are indicated by the research in cellular and molecular biology, including the animal and tumor growth studies.

The third physician who testified in this docket for Public Service was Dr. Richard Steven Bockman, an Associate Professor of Medicine and an Associate Professor of BioChemistry at the Cornell University Medical College in New York. Dr. Bockman's other qualifications as an expert are set forth in Appendix B-3.

Dr. Bockman was asked by Public Service to examine whether power frequency electric and magnetic fields have adverse health effects on living systems, especially on the endocrine and immune systems, including effects on reproduction and development.

Dr. Bockman testified that power frequency fields are not stressors inasmuch as responses to electric fields at levels great enough to cause perception can cause a momentary rise in adrenal hormones, just like a noise or any other perceived stimulas of interest would, but that the hormones rapidly return to base line levels with the continuous exposure to power frequency fields. Dr. Bockman specifically stated that exposure to power frequency fields does not make a person more susceptible to disease or illness nor does exposure have any adverse effects on the immune system. According to Dr. Bockman, animals exposed or not exposed to electric fields behave in the same way to challenges by ineffective bacteria or viruses. Dr. Bockman discussed, in his testimony, the Krueger and Reed (1975) study and the Cerretelli (1979) study which found no differences in mortality between exposed mice in a control group of unexposed mice to a 75Hz electric field for 21 days.

Dr. Bockman also discussed studies in the area of reproduction and development and found that the effects of exposure to electric and/or magnetic fields did not reflect adverse effects on mammalian and non-mammalian reproduction and development. Dr. Bockman also discussed the Rommereim (1987) study in which multiple generations of laboratory rats were examined to determine whether chronic exposure to electric fields would produce any fetal effects. Dr. Bockman stated that no fetal malformations or other adverse birth-outcome effects were noted and that there were no effects on reproductive behavior, mortality, or body weights of the exposed offspring compared to the non-exposed control rats. Dr. Bockman concluded that as a result of a 1985 study on chick

embryos as well as a Benz and Carsten study at the Brookhaven National Laboratory on rats, that there was no indication of a dose-response relationship for measurements of fertility, body weight, or growth development.

Based upon his education and experience and review of the research in areas of endocrinology, immunology, and reproduction and development Dr. Bockman concluded that exposure to 60Hz electric and magnetic fields from electric lines fails to show adverse health effects on the endocrine or immune systems of the body or on reproduction and development.

Douglas County contends that Public Service failed to address many areas of human health and has focused only on the narrow specialties of its three expert witnesses. More specifically, Douglas County contends that Public Service has not addressed possible effects of electro-magnetic fields on learning, behavior, circadian rhythm, cancer promotion, calcium efflux, central nervous system function, or function at the cellular level other than as related to cancer initiation. One of the exhibits introduced in this docket was Exhibit K-7 which is a background paper entitled "Biological Effects of Power Frequency Electric and Magnetic Fields" commissioned by the Office of Technology Assessment from the Department of Engineering in Public Policy at Carnegie Mellon University (OTA Report). Douglas County contends that the two areas identified as most worthy of concern with respect to public health effects by the OTA Report, central nervous system effects and cancer promotion, were virtually ignored by Public Service's expert witnesses. Thus, according to Douglas County, even if Public Service's experts are deemed credible, they failed to establish that there are no adverse health effects associated with electro-magnetic fields. The OTA report commented on the status of scientific opinion on the effect of electro-magnetic fields as follows:

> As recently as a few years ago, scientists were making categorical statements that on the basis of all available evidence there are no health risks from human exposure to power frequency fields. In our view, the emerging evidence no longer allows one to categorically assert that there are no risks.

In the opinion of Douglas County, the fact that Public Service's three witnesses disagreed with the OTA Report's conclusions, and refused to allow any room for error, makes their opinions "patently unreasonable."

Douglas County presented the testimony of Dr. Daniel A. Goldstein and Dr. James P. Kornberg whose qualifications as experts are set forth in Appendix B-4 and Appendix B-5, respectively. These doctors acknowledged that they have no specific expertise, training, or research experience in any of the medical disciplines in which electric and magnetic field research has been conducted. Dr. Goldstein is trained in pharmacology and pediatrics and has practiced medicine for three years.

Dr. Kornberg is trained in occupational medicine and does not conduct research in medical specialties on a regular basis. Both of them devote a substantial part of their professional work to litigation and expert testimony. Dr. Kornberg conceded that he did not conduct a critical review of a specific study. Dr. Goldstein acknowledged that in forming an opinion about possible health risks, "primary" research sources, that is, the actual documented research, are more valuable than secondary sources in which studies are summarized by others. Nevertheless, Dr. Goldstein's review of the literature consisted largely of secondary sources.

Dr. Goldstein discussed a number of studies, the results of which he believed were inconclusive and not always consistent. The essence of his testimony was the proposition that the standard of proof in regulatory affairs must differ from that used in science. According to Dr. Goldstein, while it must be admitted at the outset that present data regarding biological effects of magnetic fields are inadequate to allow a final determination of the issues, there are clearly some indications of possible risk. He stated that, given the uncertainties of scientific research and the responsibility of regulatory bodies, the regulator, unlike the scientist, must consider possible as well as known risks. Dr. Goldstein acknowledges that there is no area where low intensity - low frequency fields have been definitively shown to have an adverse effect upon humans. However, he believes there are areas in which the existing literature indicates the need for further investigation in order to more fully exclude or to define the level of risk. For these reasons it was Dr. Goldstein's testimony that caution is warranted in allowing uncontrolled exposure of humans to magnetic fields.

With this proposition we agree. These areas include, (a) the relationship between power transmission structures and the induction of human cancers, (b) the relationship between electro-magnetic fields in the development of the human embryo and fetus as defined as by both anatomical and neuropsychological examination, (c) the relationship between electro-magnetic fields and infertility and reproductive loss, (d) the relationship between electro-magnetic fields and suicide, depression, or other psychological effects, (e) the relationship of magnetic field exposure to other disease states not so far investigated in available surveys, and (f) the possible mechanisms of bio-magnetic interaction, the understanding of which will allow a better extrapolation of available animal research.

Dr. Goldstein states there may be unknown risks which are assumed by a portion of the populace who live in close proximity to transmission equipment. Accordingly, he advises that caution is warranted on the part of regulatory bodies in order to protect the public from possible adverse effects of low frequency electro-magnetic fields. He believes that the unknown risk can certainly be reduced by the burial of transmission lines or increasing the width rights-of-way. Another alternative is the rerouting of electric power transmission through less populated areas.

Dr. Kornberg, who also testified on behalf of Douglas County, basically agreed with Dr. Goldstein's testimony. Dr. Kornberg was of the belief that there has been inadequate research performed to persuade him, as a practitioner of environmental medicine, that he should not be concerned about possible adverse effects related to electro-magnetic field exposure and that, accordingly, Public Service should delay proposed voltage upgrades and consider rerouting and line burial options until there is a greater scientific consensus on the matter of electro-magnetic fields in human health.

Dr. Kornberg discussed formaldehyde and asbestos in his testimony. Dr. Kornberg stated that besides its corrosive and irritant effects, formaldehyde was not recognized to be the insidious hazard which he says we know it to be today. In the 1950s there was emerging literature that formaldehyde can cause asthma, and in the early 1960s there was some evidence that it may be mutagenic in animals. Dr. Kornberg stated that extensive research during the 1950s and 1960s, however, revealed no evidence for any carcinogenic potential in either humans or animals. In 1981, the medical community was officially alerted to the human carcinogenic potential of formaldehyde. Likewise Dr. Kornberg made reference to the fact that despite some early reports in the late 1940s and 1950s that excess bronchogenic cancer in male asbestos workers was clinically emerging, asbestos continued to be used unabated until the mid 1970s.

Dr. Kornberg was of the opinion that the failure to recognize the magnitude of the asbestos problem resulted in delays in preventive action and undoubtedly also resulted in an increase in the size of our present day epidemic of asbestos-related disease. In Dr. Kornberg's opinion, if more attention had been paid to the "yet to be proven" asbestos-related disease association of the 1950s and 1960s, the search for asbestos alternatives and the development of better programs of exposure reduction and medical surveillance would have been accelerated.

We find that Douglas County's sweeping criticism of Public Service's medical experts is not well focused. As indicated above, Douglas County claims that no attention was given by Public Service's medical experts to such subjects as "learning, behavior, circadian rhythms, calcium efflux, central nervous function, immune response, and hormones and enzymes. With respect to cancer promotion, Dr. Labarthe did review all of the epidemiologic evidence in assessing whether 60Hz fields have a role in the development of cancer. And he also specifically addressed the subject of cancer promotion and concluded that there is no scientific basis to believe that electric and magnetic fields cause, promote, progress, or in any other way are associated with cancer.

The conclusion of the Public Service doctors and the Douglas County doctors, although differing in emphasis and focus, can be reconciled. As a result of the evidence presented in this docket on health effects, we arrive at the summary finding that, as of this time, there are no known or apparent adverse health effects resulting from electric and magnetic fields from low level overhead power transmission lines.

We acknowledge the possibility, with perhaps more humility than the Public Service experts, that future scientific and medical research may negate the truthfulness of this finding and that the exercise of "prudent avoidance" is appropriate. The necessity of our deciding what is in the public interest, in the face of man's awesome and growing power to effect the environment in which we live, is at once humbling and challenging.

E. Prudent Avoidance as it Relates to the Application for Upgrade

Since the Commission has adopted a finding that, as of this time, there is no known and demonstrable adverse health effect resulting from low level electromagnetic field produced by overhead power transmission lines, one of the policy options available to the Commission is to do nothing with respect to the health issue until the scientific information relating to power line health effects becomes more defined. A second option would be to advise the public of information available health issues, but take no further action. A third option which bears the appellation of "prudent avoidance" is to look for ways to minimize the possible adverse health effects, if such exist, consistent with the cost which would be required and our current scientific understanding about possible risks.

Prudent avoidance means the striking of a reasonable balance between avoiding potential harm and the attendant costs and risks. This Commission believes that prudent avoidance carries with it the common sense assumption that economic resources are not unlimited and that some prioritization needs to be made in how they are to be spent. In connection with this last point, there is the danger of over simplification and misunderstanding. We explain this economic point in the following way: Assume that there is a finite number of dollars to be spent for public health purposes, which amount of dollars is to be raised either through taxes or utility rates or a combination of the two. Assume for illustration purposes only, that a finite number of dollars only can be spent either for burying a power line (thus reducing possible harm from electric and magnetic emanations from overhead power lines), or the money could be spent for prenatal care. Where should the money be spent? Obviously, this Commission has no authority to spend money or to authorize the spending of money for prenatal care. However, the Commission can assess the possibility that in the above described scenario the authorization to spend money to bury power lines may well affect the economic possibility of spending money for prenatal care. In other words, if society has a finite number of dollars to spend on utility rates and to pay taxes, and if utility rates go up in order to pay for burying a power line, society would have less resources to pay taxes which, in turn, might be used to finance prenatal care or other clearly beneficial health programs. With commendable candor, Dr. Goldstein, Douglas County's witness, when questioned by Commissioner Nakarado on making a choice, based on current scientific knowledge, between spending money on prenatal care versus moving away from the right-of-way that had a transmission line, candidly opted for prenatal care.

The concept of prudent avoidance necessarily carries with it the exercise of prudential judgment. A quotation from the OTA Report illustrates this, as follows:

> For example, broccoli and cauliflower may contain anti-carcinogens. Dietary fiber may help to reduce the risk of certain cancers. Conversely char-grilled meats may carry increased risks of cancer. The evidence on these things is suggestive but inconclusive. As a matter of prudence many people have tried to increase the frequency with which they eat cauliform vegetables, increase their fiber intake, and reduce the amount of char-grilled meat they eat. But reasonable people do not rent a helicopter to fly high fiber bread into them when they spend a week at a mountain ski resort which serves only regular bread. Families who eat meat, would not buy lobster for their kids every night for a week at the same ski resort if it is the only meat on the menu that is not char-broilled. Nor do reasonable people rent their own refrigerated truck to supply them with broccoli and cauliflower when they travel in places where these foods are not available. Such steps go beyond prudence. At the least they would be foolishly expensive, at the worst signs of serious paranoia. OTA Report (Exhibit K-7) at page 79

Thus the question becomes how much is it prudent to spend, or to do, in order to reduce, but not necessarily eliminate, the risk of potential harm? We start with one of the observations made by the OTA Report that although it might make sense to avoid exposing people in siting new lines, but that in most cases, with our current knowledge, it would not make sense to tear out and rebuild old lines. In this docket, Public Service is not making an application to build new lines, but rather to upgrade existing lines. We find that the concept of prudent avoidance, in this context, does not extend to burying them. The additional cost would be approximately $13.5 million which we find would be an excessive expenditure of rate payer funds to reduce a risk, which Public Service's medical experts have said has not been shown to exit and which Douglas County's medical experts argue as potentially existing.

Currently about 390 people live within 500 feet of the transmission line. The record in this docket does not indicate that people will have significant exposure from the upgraded line at a distance of 500 feet. On the contrary, Public Service witness Silva stated that, in all probability, field levels within 180-200 feet of the upgraded line will be the same as the levels associated with a buried line. Even using the figure of 390 people and the $13.5 million actual

additional cost of burying the line, it is clear that burial of the line does not fit within the hypothetical level of a few thousand dollars per person investment in order to obtain prudent avoidance which is recommended in the OTA Report.

The policy of prudent avoidance means taking steps to reduce exposure at reasonable or modest cost. Such steps would include the use of reverse phasing on the line, higher ground clearances, and larger conductors than otherwise necessary. Public Service witness James Silva's Exhibit K-4b shows that the fields would be less using single steel poles as compared with using lattice towers because the conductors would be closer together. Accordingly, the fields would be attenuated. If the lines are configured as double circuit 230/230kv rather than double circuit 115/230kv and if one circuit has reverse phasing then there would also be a reduction in the fields because the fields from the reverse phasing will tend to cancel each other out. It is also true that in terms of magnetic field, the use of single steel poles rather than lattice towers would result in a reduction of exposure and in a lower magnetic field both on the right-of-way and on the right-of-way edges than exists at the present.

Public Service has agreed to forego an interim 115/230kv configuration and construct a 230/230kv configuration as well as using steel poles in lieu of lattice towers. Public Service has also indicated that the ground clearance for the upgraded line is more than required by National Electric Safety Code requirements of the line and that it will also use larger conductors than necessary. These proposals by Public Service will lower fields significantly, reduce noise, and thereby constitute a reasonable implementation of prudent avoidance.

It should also be noted that there was ample evidence in this docket, as exemplified by Mr. Silva's testimony in his Exhibits K3a and K3b that the general public encounters substantial electric and magnetic fields of numerous sources in everyday life which are not significantly different from those that will emanate from the proposed upgraded line. [1]

Intervenors James F. and M. Suzanne Weber, in their reply of Statement of Position, indicated that Public Service's existing easement is 80 feet wide with the power lines being positioned in the middle of the easement. The Weber's state that on the west side of this easement, Public Service owns another five feet of easement with purposes unknown to a Highlands Ranch business properties developer. Next to the five foot easement is a 60 foot easement owned by The Denver Water Board thus making a total air space easement of 145 feet wide. The Weber's suggest

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[1] For example, magnetic field levels from 230/230kv would involve a maximum value of 8-22 milligaus (mg) on the right-of-way and 3-12 mg at the edge of the right-of-way. By comparison, at the doll house display of the Colorado State Capital, the mg level was 87. Exhibit K-2 forcibly indicated that the mg levels from various appliances are typically much higher than would be experienced from an upgraded 230/230kv line.

that the Public Service poles be moved out to the middle of the 145 feet which they say is a much better 72 1/2 feet away from their property line. The Weber's also say that positioning the poles in this way would also be 72 1/2 feet away from future Highlands Ranch residents. Since the Public Service Lines are now 37 1/2 feet from the Weber's lot lines, this alternative, according to the Weber's, would give them 35 more feet and cause the milligauss levels to drop. Although this information was not formerly introduced during the hearing phase of this docket, we believe that Public Service should examine the possibility of positioning the steel poles on its right-of-way, taking into consideration other open right-of-way whether owned by Public Service or not, which will maximize the distance of the poles from residential and other inhabited properties. Finally, we believe that prudent avoidance means that Public Service should quantify and continue its support of industry research in this area and should begin to develop in-house capability to survey and measure electromagnetic fields. We will expect Public Service to submit its plan for further research and for its own survey of electromagnetic fields to the Commission within 90 days of this decision.

F. Conclusion

Based upon our foregoing findings, we conclude that the application filed by Public Service for approval to effect the transmission line upgrade, pursuant to § 30-28-127, C.R.S., is reasonable and should be approved. The approval, however, is granted subject to certain conditions which we believe operate to implement a policy of prudent avoidance of an unknown risk of potential harm due to electric and magnetic fields. Based upon what we know now, it can reasonably be anticipated that research into the relationship between electric and magnetic field emanations from overhead power lines to possible adverse health effects will be continuing for a number of years. Further research may well confirm the confident conclusions expounded by Public Service's three medical experts that adverse health effects are not known to exist and probably, do not exist. If further research tends to weaken or negate those conclusions, then regulatory bodies, such as this Commission, must respond accordingly.

The Commission will consider the feasibility of entering into rulemaking with respect to the entire issue of the design and placement of overhead power lines. At this point of time, the Commission is obliged to respond to the particular question posed to it by the need of Public Service's customers in the southeast metropolitan area for additional power, on a reliable basis, and the possible negative impacts which the proposed upgrade might have on the people who reside in certain specified portions of that southeast metropolitan area. We have done so, using our best judgment in response to the respective presentations of the parties in this docket. Finally, Public Service should be on notice that it is no longer acceptable to appear before the Commission to seek supply side enhancements to its system without apprising the Commission what efforts have been made, together with the results of those efforts, to reduce or mitigate the necessity of supply side enhancements with demand side alternatives. Public Service witness Mr. Martin acknowledged

that demand side alternatives are a legitmate Commission concern and will have to be addressed in future proceedings dealing with supply side enhancements. We find that Mr. Martin's commitment, presumably made with the knowledge and approval of Public Service, should be a further condition to the approval of this application.

As we have already indicated above, we believe that all of the parties, including the pro se intervenors who expended considerable time and effort in making their written and oral presentations to the Commission, have done an excellent job in providing this Commission a record upon which to base its decision.

THEREFORE THE COMMISSION ORDERS THAT:

1. The application of Public Service Company of Colorado, filed on January 12, 1989, seeking an Order permitting it to upgrade and provide betterments on existing 115kv transmission line located within Douglas County, Colorado, pursuant to the provisions of § 30-28-127, C.R.S., is granted subject to the following conditions:

A. The upgraded lines shall be configured at 230/230kv;

B. The lines shall be configured in reverse phase;

C. The transmission lines shall be strung on single steel poles in lieu of the present lattice towers;

D. Conductors and other equipment shall be used which will mitigate noise effects of the lines;

E. To the extent feasible, the single steel poles shall be placed on the Public Service Company of Colorado right-of-way-way, taking into consideration other open right-of-way whether owned by Public Service Company of Colorado or not, which will maximize the distance of the poles from residential and other inhabited properties.

F. Public Service Company of Colorado shall comply with the Commission's discussion in the conclusion above to address demand side reductions and mitigations in future proceedings dealing with supply-side enhancements.

G. Public Service Company of Colorado shall submit to the Commission its plan for further research regarding electromagnetic fields and its survey of its electromagnetic fields. Such plan shall be submitted to the Commission in writing within 90 days of the effective date of this Decision.

2. The 20-day time period provided for by § 40-6-114(1), C.R.S., to file an application for rehearing, reargument, or reconsideration begins on the first day after the mailing or serving of this Decision and Order.

Unless otherwise subsequently ordered by the Commission, this Decision shall be effective 30 days from this date.

DONE IN OPEN MEETING December 20, 1989.

(S E A L)

ATTEST: A TRUE COPY

James P. Spiers
Executive Secretary

THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF COLORADO

ARNOLD H. COOK

RONALD L. LEHR

GARY L. NAKARADO

Commissioners

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