HAN-HIST-0028

WORK

at

HANFORD

1943 - 1983

In DOE Public Reading Room

W. J. Dowis

June 1, 1986

William J. Dowis, the author of this account of his experiences at Hanford, is a scholarly professional electrical and nuclear engineer. He is soft spoken, deliberate, and a perfectionist. His work as described here was over a period of 40 years. He loved engineering, and enjoyed his lifelong career in that field. He is a graduate of the University of Colorado, a Professional Engineer registered in New York and Washington states, and a Fellow in the Institute of Electrical and Electronic Engineers. He is registered in Who's Who in Engineering, and in Who's Who in the West.

He served 17 years of volunteer work for the City of Richland on the Board of Adjustment, the Planning Commission, and the Utility Advisory Board. He likes Spanish history, traveling to Baja and Peru. He has a collection of Explorers' medals. He studies family genealogy, enjoys country and classical music, and dabbles in painting. He likes fishing and golf. At golf he is strictly a duffer but was lucky enough to make two holes-in-one in one season.

He and I were married in Boulder, Colorado in 1932, 54 years ago. We have had three children and eight grandchildren, for whom he has written this account. now - 64 yrs. in 1996

— Helen Dowis

He died in June, 1995

My First Ride to the Construction Site

On December 20,1943 I arrived at Richland, one of the first of the Operating force to report. After a night at the Transient Quaeters I joined a group of new construction people waiting to be taken to the construction site. Our vehicle soon rolled up. It was a cattle carrier, or "cattle car", a long, covered flatbed. The wood floor bore the marks of cattle hooves, and had a little straw sprinkled over it. There was a small raised portion of flooring at the front end. Two long benches were placed along the sides. Apparently this carrier had been pressed into service in lieu of a bus.

The "car" filled up with about 40 people, all men except two young women. We got moving, and soon all one could see through the cracks in the side pAnels was frosty sagebrush covered desert. Then, probably egged on by the men in the front of the car, the two young women took off their shoes and started an impromtu dance on the raised portion of the floor, a makeshift stage. This brought cheers and song from the body of men. When the girls got tired a man would take the stage and offer a jig, or his version of some dance, to hoots and hollers from the crowd. At first I wondered about the lack of decorum, but soon got into the spirit of the occasion and enjoyed it as much as the next guy.

One may have expected to see signs of anxiety on the faces of some of these men, anxiety about what lay ahead of them in unfamiliar working conditions and life in this isolated construction camp, but no signs like that appeared here. If there had been any the diversion in this car would have wiped it out. Also no one seemed the least bit concerned about being subjected to the indignity of being shipped out to the job in a cattle car !

As the carrier approached the construction site the merriment subsided. On arrival the group got off and merged into the 40,000or more workers already there. I never saw any of them again. They were typical Americans who, as subsequent events proved, could get the job done, and who liked to have a little fun too.

William Dowis
1603 Judson
Richland, WA 99352

Tel. 943 1805

WORK AT HANFORD

My work at Hanford, a federal complex at Richland, Washington, started with the Manhattan Project in 1943 and ended with private consulting on nuclear-electric matters in 1983. These 40 years of work coincided with the first 40 years of the atomic era. In the Manhattan Project massive energy release from atomic nuclei took place in a man-made device for the first time. By 1983 there were some 350 nuclear-electric plants in service around the world, and many nuclear weapons were being held, hopefully never to be used.

Briefly, my work at Hanford was in supervision of maintenance and design of electric systems for plutonium production plants; consulting on N-Plant, a dual purpose producer of plutonium and electricity, and on other projects, as an employee of a prime contractor to the Atomic Energy Commission; and in the later years private consulting with various firms in the Pacific Northwest.

In this paper I describe the circumstances and the people with whom I worked. It has some historical content, but only from my personal experience and viewpoint.

THE MANHATTAN PROJECT

When I reported for work at Richland, Washington in 1943, I had no idea that I would be embarking on a life's work, and certainly no idea that it would be in the field of nuclear energy. At that time, the promise of release of energy from the nucleous of the atom was unknown except to a few scientists working in laboratories. The Remington Arms plant in Denver, where I had been employed, had closed down, and I was looking for work that would contribute in some way to the World War II effort, and in which I could support my wife and two daughters (our son was born later). I had been told that a construction project that was very important to the outcome of the war was underway at Hanford, called the Manhattan Project. It was under the jurisdiction of the U.S. Corp of Engineers. Its prime construction and operating contractor was the E.I.duPont Company. Its specific purpose was secret.

I reported to the Richland administrative headquarters of the operation in mid-December 1943. I was the sixth employee to report on the operating roll; in the hustle and bustle of the time I helped to orient some of the operating people arriving soon afterward. There were, of course many construction people who had been at the site for months, some of whom joined the operating force when construction was complete. I was to live in the construction barracks at Hanford for several weeks until living accommodations were constructed in Richland for operating employees.

Life in the construction camp, and later in the fledgling city of Richland, is to be related at another time--this account concerns the work in which I participated during the several stages of activity here.

After the employment paperwork had been cleared, I reported to the plant manager, Earl Swenson. He was an impressive manager, radiating confidence. His responsibilities seemed to rest easily on his shoulders. He was backed up by the great duPont managerial structure. He seemed completely open to his employees, and genuinely interested in each one. Knowing him was a key to understanding the loyalty to the Company exhibited by many old-time duPont people who had been transferred here.

He referred me to the Works Engineer, Lyman Darling. He was a big bear of a man, who spoke softly, but who like Swenson seemed to be in complete charge of his department. He loved to eat a meal at the construction mess hall where food was plentiful and he would be in the company of other trenchermen, the construction workers. He would give you a humorous glance as he launched into a heaped-up plate.

Darling took me on a tour of the construction sites. During the drive through the fields of sagebrush in this semi-desert country, he told me that earlier that week he had had four Nobel prize winners in physics and chemistry in his car. The following famous men were among those involved in the activities of that time. Some of them traveled under assumed names so that the nature of the project could not be deduced from knowing the fields of expertise of the participants. They were:

E. Fermi	H.C. Urey
A.H. Compton	J.A. Wheeler
J.B. Conant	E. Wignor
C.O. Lawrence	F.H. Spedding
G.T. Seaborg	

Lyman Darling then told me, in secrecy, the purpose of the project; the production of plutonium for an atomic bomb. A companion Manhattan Project team at Oak Ridge, Tennessee was attempting to produce Uranium-235 for the same purpose, by three possible methods.

How was the plutonium to be produced? In a nutshell it was by (1) splitting some of the Uranium-235 and releasing neutrons, (2) allowing the neutrons to pass through a moderator to slow their speed to that at which they were more likely to be absorbed by Uranium-238 atoms to keep a chain reaction going and to form Plutonium-239, (3) separating the plutonium from the other constituents of the irradiated fuel, and (4) using the plutonium to construct a bomb, offsite.

In this sequence nuclear energy is released as heat in the reactors in the course of plutonium production, which is absorbed by Columbia River cooling water. When the plutonium bomb is exploded, a second energy release takes place, resulting from the fission of plutonium nuclei.

The plants in which this process was accomplished consisted of (1) Fuel Preparation, in which metallic uranium cylinders were enclosed in an aluminum jacket, performed at a site near the City of Richand, (2) Irradiation, in which fuel elements were inserted into a big block of graphite called a "pile", where they would undergo fission, and (3) Chemical Separations, where fuel discharged from the "piles" was dissolved and the plutonium extracted. The plutonium was then shipped off site, and the remaining functions were performed at Los Alamos, New Mexico.

The semi-arid land around Hanford in eastern Washington State was chosen for the site of the plant for three reasons: there was a large land area, 580 square miles, sparsely populated, that could be taken over and controlled by the government to provide isolation from population centers; there was a plentiful supply of cooling water in the Columbia River; and there was an ample electrical power supply in the Bonneville hydro-electric system to drive huge pumps for reactor cooling.

The original plant complex consisted of a fuel preparation and laboratory area, three reactor plants strung along the Columbia River, two chemical separations plants in a central location, laboratories, shops, village, and electrical transmission system. My job was to keep the electrical equipment in the fuel preparation, chemical separations, village and laboratory areas in operating condition. So after the eye-opening tour with Darling, I started to plan and assemble an electric plant maintenance force.

My force eventually involved about 70 people, including area supervisors, engineering specialists, foremen and electricians. For the engineering and foremen positions, I drew on the people being released from Remington Arms and other duPont plants. For craftsmen I drew from the same sources or from construction forces being released by Hanford contractors.

The electrical superintendent to whom I reported was Philip Skaff, a duPont man who stayed at Hanford for two years, then returned to that company at a Texas plant on the Gulf. Hank Carlberg was his assistant. My co-workers under him were Tom Lambert in the reactor area, and John Badenoch in electric power transmission and distribution. John was descended from a Scotch family. His grandfather had been the Police Chief of Chicago and had been in corn brokerage. On one of our trips, John showed me an oil portrait of his grandfather hanging on a Chicago office wall. John liked to cook and was a fine host at social gatherings. He and I fished the lakes in this area for several years, using his army-issue inflatable boat.

After Skaff's departure, Hank Carlberg took his place and Fred Mollerus became his assistant. Hank had worked on transmission systems in upper New York State, and knew people in the Bonneville Power Administration (BPA) who were responsible for supplying electric power to Hanford. As will be noted we worked together in a number of ways as the history of the project unfolded. Helen and I served as surrogate godparents to Hank and Eileen's daughter, Wendy.

Fred Mollerus came from Schenectady where he had been working with the General Electric Company. He had been assigned to a post in South America for the previous few years and had great stories about his experiences there. He was affable and conscientious in his work as assistant superintendent. He, along with John Fox and Ray Jessen, became my fishing partners after Badenoch's departure. Marge, his wife, was a good firend of Helen's. About the same time Tom Lambert returned to duPont and Ed Weyerts took his place. Ed Weyerts, a son of a German immigrant family of the late 1800's, is a fellow Coloradoan who worked at the Remington Arms plant in Denver at the same time I did. He has a comprehensive knowledge of electrical equipment, and how to manage crews to maintain it. He is small in stature but great in spirit. He was active in hunting, the stock market and in his church. He, along with Fred Mollerus, became my golf partners. He and Dorothy became Helen's and my lifelong friends.

As stated previously, my job was to maintain, protect, and modify as necessary, the electrical equipment in the four areas named. This included all motors, switching, controls, lighting, alarms, communication, heaters, etc., including the equipment operating in high-radiation zones requiring remote manipulation. One of the most pressing problems occurred early in the game, in the Fuel Preparation Plant. The uranium fuel slugs were bonded to their aluminum cans in a press having electric heaters. The heaters were being used at near their allowable maximum temperature, and burned out frequently. As Henry Smyth notes in his official report "Atomic Energy for Military Purpose", "No one who lived through the period of design and contruction of the Hanford Plant is likely to forget the 'canning problem', i.e., the problem of sealing the uranium slugs in protective metal jackets."

An effort was being made to load the first reactor, and the production of fuel was being slowed up by the heater failures. Attempts to keep the heaters working, and to alleviate the stress on them, took a lot of overtime on our part. These were awkward times in family life, because one had to go back at night but couldn't discuss the problem with his wife and children. Eventually the technical problem was solved by bonding the fuel elements in a liquid metal bath, eliminating the press with the vulnerable heaters.

In the early days, when I was trying to educate myself on the processes of plutonium production, I would go into the experimental reactor and separations buildings in the laboratory area, look at the equipment, talk with the supervisors, and read the process manuals. Of course, I could speak about this only with people who had similar clearances and who had access to information on the same level as I had. It was not necessary to know all of this to fulfill the requirements of my job, but in my opinion the insight was necessary to best fulfill it. I could not pass any of it to my subordinates until after the veil of secrecy had been officially raised.

During those first two years, plants were starting up, organizations being set up, bugs being worked out, new friendships and acquaintances being made, and everyone was working hard, sometimes feverishly. On the whole, things went very well. There was one near-crisis when the physicists tried to start up the first reactor. The power level would build up a bit and then die out, and no response was obtained when the control rods were in their all-out position. What could have been a serious set-back was avoided by charging into the reactor more fuel than had been calculated as being needed. A subtle nuclear effect had caused the building-up of a poison isotope that had to be over-ridden by increasing the size of the critical mass. Only the foresight of a duPont designer who had insisted on putting into the pile 20% more fuel tubes than had been in the original design saved the day! Since my responsibilities at that time were in areas other than the reactor, I did not get to observe this crisis, but could only hear about it. It would have been an unforgettable sight to have seen Enrico Fermi and his associates puzzling over the phenomena that caused this temporary panic.

As a supervisor my relations with my exempt personnel and electricians were generally trouble free with two exceptions. One of the men I had as an area supervisor, turned out to be a troublemaker, and was insubordinate when I made efforts to direct his work. He was transferred to the reactor group, and not long afterward left the organization. The other case involved the craftsmen, at the Separations Plant, who were not unionized at the time. On one occasion a group of them had some grievance and wanted to meet with me and my area supervisor, Howard Remaly. After some discussion--not too heated--they backed down. I don't remember the details, but Howard had taken some kind of position, and when I found it to be worthy of my support at the meeting, he became a staunch supporter of everything I tried to do later--and a very good friend for life. The craftsmen didn't pursue the grievance, so they must have found the disposition of the case fair--if not palatable.

When the secrecy as to the purpose of the plant (but not the technology) was made public on July 16, 1945, and soon after that, when two bombs were dropped on Japanese cities and the war brought to an end, a different atmosphere pervaded the operation. Everyone wondered what the future of the plant would be. DuPont made preparations to leave, as they had intended to do when the war ended. The urgency of the project seemed less, but operations did continue while post-war plans were being laid.

The initial Hanford project had been brought to a successful conclusion. The duPont Company had done a magnificent job in bringing a heretofore unknown process into production in a very short time.

This ended the first stage of my work here.

THE EXPANSION PROGRAM

After the operation of the Hanford Plant had been turned over to the General Electric Company in 1946, the Atomic Energy Commission announced plans for expansion. In the ensuing years 1946 to 1955 the number of reactors was increased from three to eight, using the same general design but with improvements to increase production capacity. Additional separation plants, Redox and Purex were built. Plutonium processing and isotope separation facilities were added. Laboratory and village facilities were expanded.

As the General Electric Company took over, an Engineering and Construction Division was formed with Frank Wilson as manager, and James DeLong as assistant.

Frank Wilson was a former college professor, a likable and courtly man. He picked competent men for his organization, and set good policy for carrying out the work. He might have seemed like a worrier, but rather than being one I think he was only trying to convey a sense of urgency to his crew. He and his wife were good at setting a social agenda to help his new people, coming from other long established organizations and cities, to feel that they were a part of the new organization in a new city. Prior to 1946 everyone knew that one's tenure here might be limited to the war years. After 1946 there gradually became a feeling that "We are here to stay."

James DeLong was a good lieutenant, a competent manager of engineering personnel, patient and fair in his dealings.

I joined the Division as Electrical Project Engineer. Other Project Engineers were: Claude Quackenbush, mechanical; Sam Sawin (later Henry Struck), civil; E.L. Nugent, power and water; and E. Hilgeman, instrument. As time went on and changes took place in the management of the Section, Orrin Pilkey assumed the leadership.

Orrin Pilkey was a Civil Engineer who had past experience with a steel company building bridges, water towers and the like. He was a solid professional man, and a good manager, liked and respected by his men. He could not understand how steel transmission towers with their slender bracing members could stand, but finally seemed to figure it out to his satisfaction. Later, he moved to Huntsville, Alabama and after retiring, co-authored technical books with his two sons. Orrin Pilkey, Jr., appeared on television recently as an expert in beach erosion on the eastern seaboard.

Claude Quackenbush was a mechanical engineer. He was an easy-going co-worker, who gave an impression of being old-school, very conservative. One of his sons was a fighter pilot who flew missions over England with nuclear weapons payload as a precautionary measure at a certain stage of the cold war. Claude surprised (and delighted) everyone when after his death it was learned that he was ten years older than the age he had given at the time of his employment, and he had gotten away with it!

In addition to these groups the Division had Process Engineering groups in Reactors, Separations, Plutonium Processing and Laboratories headed by R.E. Burroughs, E.W. Seckendorff, D.D. Streid, and C.O. Henning, respectively.

Forming an engineering organization under the prevailing conditions was a formidable task. Frank Wilson would call staff meetings and lament the fact that he had $200 million in backlog work, and his organization was not shaping up fast enough, or did not have sufficient office space or other facilities. Gradually these deficiencies were corrected, but the management suffered in the meantime.

The duties of the Design and Construction Division were to determine what should be built to meet the requirements of the AEC; to engage and instruct architect engineers and construction contractors and monitor their work; and to design some of the facilities with their own people. Generally, the design of larger process buildings and equipment was contracted out, and simpler buildings and facilities and interconnecting electric and pipe lines, were designed in-house along with certain special features in the process equipment.

After we had assembled an organization, we began to get a firm hand on that backlog of work so vividly described by Frank Wilson. I recruited some people from those in operating departments, and was fortunate in getting some from Bremerton Navy Yard and Bonneville Power Administration. BPA had had a reduction in force, and Earl Peabody and Ed Barrett were available. Ivan Garcia came from Bremerton. Les Vosmer came from a Denver contracting firm.

Ivan Garcia had come from Puerto Rico. He was versatile and inventive, and always cheerful and helpful in getting things done. As the years went by and I had moved into consulting work, he headed my old electrical group, and eventually the whole Design and Construction Division in its final days. He worked with me on many of the special studies to be described later, and we enjoyed this association throughout the 1950's and 60's. After retiring he had a quadruple heart bypass operation but has survived it and is going strong.

Earl Peabody was a great asset to the design group. He had a very sound grasp of engineering principles, and a straight forward logical approach to problems. He got along well with all kinds of personalities. He was an early enthusiast of stereo-music, and made his own electro-static flat speakers. He moved to San Jose with GE and had a responsible role in the design of commercial reactors and in customer relations with utility personnel.

Ed Barrett, when he came to Hanford, had just been wiped out by a flood that submerged the part of Portland, Oregon where he and his family lived. They literally came out with only the clothes on their backs. Ed, a good electrical engineer, didn't let it bother him too much. He had overcome other obstacles before that. Now retired, he and his wife have traveled around the world.

I knew Les Vosmer through his son Al, who was in my original supervisory crew. Al Vosmer and I first met in Bridgeport, Connecticut while in training for work at the Denver Ordnance Plant. He was a young Denver man who had graduated from the University of Colorado, my college. On days off we would rent a canoe and pass through beautiful country paddling along the Heusatonic and other rivers in the vicinity. Ethel, his future wife, was a nurse at the Denver Ordnance Plant. They were married after coming to Richland. Al had the great misfortune to get polio after a few years here, and was left with partial paralysis, but has worked from a wheel chair all these years and supported his family. He was an engineering estimator until retirement.

Les Vosmer was a great help to me in getting the design group statistics. He had extensive experience in dealing with common electric system design, and carried a big load while we were getting started.

For an organization starting from scratch and under much pressure to perform, the Division worked together rather smoothly. The intent of the management was that the Process Engineering Section heads would coordinate the work on each project or subproject using their own people for physics and chemical engineering needs, and using our people in the conventional engineering fields under loan, subject to surveillance of their work by us.

As the work progressed, the Process Group Heads tended to want to absorb our men into their own organization, and we in the electrical, mechanical, and civil groups had to struggle to protect our positions in the overall organization. One of the persistent tendency in a rapidly growing engineering organization, is for middle management men to "build their empires." It is just another symptom of the natural tendency of many men to seek power. It was easier for me to keep the electrical group intact, than it was for mechanical and civil, because of the specialized expertise not easily challenged by those in general engineering.

After about a year the AEC and the GE Company, which was not as experienced as duPont in managing large government construction projects, asked duPont to send a group of design and construction engineers to assess GE's design organization and to assist temporarily to get things on track. A group of some 25 people arrived, headed by R.P. Genereaux. His assessment of my electrical engineering organization was that it was satisfactory. No change was required, that is, my crew of twenty was adequate for the task and was keeping abreast of the work.

As we got into the work, we encountered the usual problems and one unusual one. Among the former were the problems of communication with, and control over, architect engineers whose ideas of good design might differ from ours. Then there was the problem of writing specifications so that they evoked proper competitive bidding, but would keep out those manufacturers of inferior products. Complaints about, or rejection of, inferior products after requisitioning and delivery can waste a lot of time.

The unusual problem was that the GE Operating Division, consisting largely of men and women trained and employed by duPont only a year or two before, being the only people who had nuclear plant operating experience, felt that they should have a larger say in the nature of the designs than the Design and Construction Divison thought consistent with its own responsibilities. Meetings would be called to discuss forthcoming designs, which would often be loaded with people, sometimes up to 30, with the majority of them coming from Operations. This impediment to rapid progress was removed by the creation of the Design Council, to be discussed later.

The difficulties in launching a design program described above was followed by difficulties in the Construction program. Some friction arose between the GE management, and major construction contractors and labor unions, with consequent delay in the program, a national program that still held high priority. President Harry Truman sent his emissary, Frank Creedon, to help resolve the difficulties. He had a great deal of influence with labor unions and big construction contractor management. Soon after his arrival here things settled down and progress resumed. He instituted procedures that put more order into the work of the Design and Construction Division. After this, the construction work of remaining expansion went quite smoothly.

During the period in which the above movement was taking place it was interesting to attend the meetings that were called, and observe the forces at work in a big-time government construction project. We at the middle-management level seldom particpated in the exchanges at these meetings, but were present to provide information if necessary. Another man was beginning to be heard at this point, and became prominent sometime later, Jack Parker. He had come from the top management of a wartime shipyard in California employing 20,000 people, and later went back to

GE corporate offices in New York and became a group Vice President, i.e., among the top four managers of the entire General Electric Company. He had headed Design and Contruction for awhile. Later on I would tell people that one of my claims to fame was that I had "acted" for Jack Parker for two weeks during one of his absences.

When Hanford was well into its second expansion wave about 1950, I was moved into a Section headed by Roy Beaton, charged with (1) preparing the scope of new projects, (2) following procurement--especially of critical materials or equipment--and seeing that corrective measures were taken as necessary, and (3) performing the same function for specifications on which purchasing or design was based. The functions were all intended to keep design and construction schedules on track. I served in this capacity from 1950 to 1953. In the latter part of the period I reported to E.W. Seckendorff who had succeeded Roy Beaton.

Ernest Seckendorff was at that time an older and more experienced man than most of those I have mentioned. He had enough experience to be able to exert firm pressure on the organization toward orderly progress. He had the image of a German scientific man, short, heavyset, proud and with a slight accent. He was an asset to the program.

One of my duties was secretary of the Design Council. This Council, mentioned previously, was set up as a vehicle to incorporate advice and information from Operations and Technology Laboratories into the Design and Construction Division decisions. The Council consisted of the representatives from each Divison. The Laboratories were represented by O.H. Greager during this period, and much of the research development was carried out under his direction. Operations was represented by Hank Carlberg in some of the Design Council meetings.

My duties included assembling pertinent information --drawings, letters, specifications, etc.--on impending projects for Council consideration. I attended all meetings, and wrote minutes recording the essence of the discussion, and the decisions reached. The operations of the Council were effective in keeping the design work moving while maintaining harmony between Divisions in connection with design choices that would satisfy the technical (scientific) interests as well as the people who would operate the facilities upon completion of construction.

In the meantime, W.E. Johnson had come from the parent GE Company, spent some time in the Design and Construction Division and then had been promoted to General Manager of GE at Hanford.

Wilfred E. (Bill) Johnson was a topnotch mechanical engineer who had come from the GE refrigeration and gas turbine operations in the east. He rose rapidly here at

Hanford to the position of general manager, served for many years in that capacity, and went on to become a member of the Atomic Energy Commission in Washington D.C. His years of management here were filled with accomplishment--good relations were maintained between GE and AEC and between management and labor. Production was increased. After a shaky start under other GE managers the construction of new facilities under Johnson proceeded effectively and smoothly. He espoused the construction of a dual-purpose plant (N-Plant) and worked to get the necessar y legislation passed through the Congress. He could dictate long technical letters that went out with little or no revision. Some employees thought that he was cold because he would pass them in the hall without even a nod, but actually he would only be deep in thought. He was really kind and thoughtful in dealing with people. We would needle each other in the event of some minor plant difficulty or failure--he being a mechanical engineer, would blame it on the electrical apparatus, and I being electrical would blame it on mechanical failure. In actual fact he was receptive to my ideas and gave me entry into many of the interesting jobs to be described later. He was an ardent horseman and I helped out by making an electrical prod for use in training his horse for jumping. His wife, Esther is a musician and contributes to the culture of the Tri Cities by supporting the Symphony and Community Concert Series.

Some time after he had taken charge, GE engaged Booz, Allen, and Hamilton to give Hanford middle and upper managers a psychological test to determine their fitness and potential. In my case their recommendation was that I was best fitted for staff work rather than line management, with which Johnson concurred. I was somewhat disgruntled at the time, as the common view was that promotion in the managerial ranks was the only route to positions of substance. Actually, the decision to put me on staff work was a good one for me. From that time on, I was involved in all the forward planning and interesting changes that took place, and had the opportunity to exercise my engineering capabilities to the utmost--not only in a narrow engineering field but in overall plant design, and in the investigation of major problems as the new plants came on line. My level of compensation exceeded that of many middle managers. My title became Principal Engineer, then Consultant. I reported to Orrin Pilkey, later Jack McMahon, but received many of my assignmens from the General Manager, Bill Johnson, Al Greninger, or Ray Dickeman. These GE men were believers in the usefulness of staff work. Those that followed years later, Douglas United Nuclear, successor to GE made less use of staff people.

In my consulting capacity I could receive assignments from Jack McMahon to whom I reported or the General Manager, take requests for assistance from anyone in the Design and

Construction Department, or I could work on topics of my own choosing. I worked with the Subsection managers who were preparing technical reports or who had responsibility for designs.

Jack McMahon was the man to whom I reported for a number of years, to my good fortune. He headed the Design and Construction Division for part of that time. Tall, handsome and affable, he was a good communicator--held some long staff meetings to get everyone working together. His trademark was enthusiasm. He exuded it and others picked it up. He was at his best in an emergency, would act promptly to get his force organized. He was not a stickler for line organization in my case, and was not concerned when I received reports directly from higher managers. However, I always kept him informed of my activities. He was a top-notch golfer and past president of the Kennewick Country Club.

Examples of tasks undertaken in this period are:

(1) Ivan Garcia and I prepared a report on voltage supply for critical reactor instruments. Some malfunctions had occurred as a result of induced voltages from adjacent cables or interconnected devices. We conducted tests to find the causes and ways to avoid exposure to such malfunctions in new plant designs.

(2) On several occasions, attempts had been made to determine whether the heat energy in the low-temperature coolant of the eight original production reactors could be used to generate some electric power or the reactors could be converted to dual purpose or power only operation. The efficiency of energy conversion would be relatively low, but it was hoped that some benefit could be derived. I reviewed several reports and expressed my opinion which was that there was little prospect of success. Also, it had been suggested that the potential and kinetic energy in the coolant stream flowing from the reactors might be recovered, but here again the economics were unfavorable.

(3) A development engineer had designed and was testing a machine for charging and discharging fuel while the reactor continued to operate. I was asked to review the design for its workability and maintainability. It was very complex. In my opinion it tried to do too many things automatically; the use of some manually controlled steps would make it much simpler and more reliable, and more easily maintained. I tried to convey these opinions diplomatically. The project finally was abandoned--a victim of its own unnecessary complication.

(4) The K Plants were the newest and largest reactor plants prior to N Plant, and the architect engineer, instructed by the Design and Construction Division. had proposed an electrical supply and emergency-supply-system switchgear arrangement for the main coolant pump motors. This supply system had to have the utmost reliability, since continuity of service was essential to plant safety. Orrin Pilkey asked me to review the proposed design, and to suggest the operating mode best suited for it. My recommendations were followed.

(5) In 1963 Sam Rhyneer of the AEC, and Fred Mollerus and Charles Salina of GE, got involved in a discussion with BPA and electrical manufacturers regarding a high-voltage test laboratory in Grant County. The manufacturers needed a station at which great amounts of fault current could be delivered momentarily to test the interrupting capacity of circuit breakers. A site in Grant County near one of the Columbia River dams was proposed. Hanford was interested because such tests, even when backed up by the great capacity of the Pacific Northwest system, would cause voltage disturbances in the Hanford area. Hanford was a consumer with massive loads, some of which were critical, and we didn't want the reactors to trip off line every time a test was run at a Grant County test laboratory. At the same time we could see the desirability of having such a test laboratory.

After some months of discussion of this proposal it was dropped. There was some opposition from existing labs in the east, of less capacity, and no agency exerted a strong influence to keep the proposal alive.

(6) Between 1963 and 1965 Hanford had a number of failures in 15000 volt insulated cables that carried power underground or on poles from substations to the points of usage. The cable was fairly new and the multiple failures were obviously due to some shortcoming in manufacture. I was asked to determine the cause and recommend a course of action.

The cable manufacturer did not seem to be forthcoming about the cause. I contacted a GE Company cable expert, Ken Mathes, obtained his assistance, and sent him samples for testing. Eventually he developed a theory for the failures. Some of the cable was replaced, and a crisis of failures was averted.

Some months later when Hanford attorneys were trying to get compensation from the manufacturer, I received a letter addressed to AEC from a Yakima engineering firm in defense of the cable manufacturer.

I was asked to rebut the letter. On reading it I found it embarrassingly naive. My only trouble in the rebuttal was to avoid being unnecessarily sarcastic. I knew of the engineering firm, one whose main business was the installation of irrigation pump houses. Later on, I understood that the cable manufacturer made suitable restitution.

N-PLANT (NPR)

By 1953, engineers at Hanford had begun to discuss whether the heat to be generated in any new reactors could be utilized to generate electric power. Although use of heat from the then-existing reactors would be impractical, a new reactor might be designed to use the heat economically. There were indications that the AEC would need another reactor (the ninth) to provide additional production capacity.

I made a very rough study of the economic potential of a dual-purpose reactor, using my estimate of value of electric power. I then put the results in a memo to W.E. Johnson, proposing a formal study of the possibility of the next reactor being dual-purpose, that is, designed for plutonium and electric power production. His response was to ask Hank Carlberg, Paul Gast and me to prepare a somewhat more detailed memorandum on the subject, which we did in document HW-35294. **This was the beginning of the study of feasibility of N-Plant**, leading eventually to its being built as a dual-purpose reactor, the first and only one of its kind in the USA and in the world at that time. On October 15, 1953 Johnson wrote to the AEC proposing that the next reactor be dual-purpose (HW-35295).

The Atomic Energy Commission was the government successor to the US Corps of Engineers at Hanford. The local AEC staff was in charge of the Hanford Operations during the NPR planning, design, and construction stages. Later on, it was replaced with ERDA, Energy Research and Development Administration. ERDA was later replaced by DOE, the Department of Energy. These bodies were all responsible for Hanford, assigning operating responsibility to their prime contractors but exercising control over those operations as necessary. The AEC kept its force to a relatively small number but large enough to exercise the necessary control. The general manager of the AEC in the 1950's to 1960's, when W.E. Johnson headed the General Electric Company as prime contractor, was James Travis.

He was an ideal man to work in close cooperation with Johnson. He knew that he could trust the GE Company management team, how much leaway to give them, and when to impose his own views. On the GE side they respected Travis and cooperated with him to pursue the goals of Travis' chiefs in Washington, D.C., who in turn were administering the Atomic Energy Act. It was a harmonious relationship. Travis' chief lieutenant on the NPR Project was H.H. Schipper also a man who was very cooperative in the pursuit of NPR and other projects. Travis' chief in Washington, D.C. was Frank Baronowski, who will be mentioned later.

At that time the legislative oversight was vested in the Joint Committee on Atomic Energy (JCAE). It was a powerful committee, but seemed to be a very responsible one.

It had to authorize expenditures for AEC facilities, and any provisions for generation and disposal of power from a dual-purpose reactor.

In 1960-61 when such items were coming before them, the chairman was Chet Holifield of California, the vice chairman John Pastore of Rhode Island. The members included Henry Jackson, and Jack Westland of Washington State, Clinton Anderson of New Mexico, Burke Hickenlooper of Iowa, Craig Hosmer of California and eleven others. The executive director was James Ramey who later became an AEC commissioner. His technical advisor was Edward Bauser, with whom I worked on several occasions.

These AEC and JCAE people were those whom Johnson had to convince to undertake this new venture, a dual-purpose reactor.

With preliminary consent from the AEC, engineering studies continued and some technical research was carried out. During the period I supplied Bill Johnson with up-to-date information on the economic prospects of the project. Much of it had to be in secret documents since production rates and unit product costs were classified. In June 1957 Johnson testified before the JCAE on the subject, and obtained authorization for a $3 million engineering study. This study report, later known as "Big Yellow" was issued in August 1958.

After being authorized, the NPR design and construction project proceeded in two phases over the next eight years--first, the plutonium production plant, and then after a short period of operation, the addition of the electric generating plant by Washington Public Power Supply System (WPPSS).

The technology of the dual-purpose reactor was unique. It was a large project, about $3/4 billion in today's currency. Some aspects of it had to remain secret. It was touchy from a political standpoint in that the federal govenment was very wary about getting into thermal-electric power generation. As will be seen in the following discussion all parties involved--the AEC, the JCAE, GE, BPA, and WPPSS had to move very carefully to assure the success of the project. A failure would have a disastrous effect on all parties to the agreements.

Basic to the question of feasibility of a dual-purpose reactor was the value of electric power it would produce. In the early studies it was assumed that the electric power would be sold at its "value", and the proceeds credited against the cost of the plutonium produced. The resulting unit cost of plutonium was the test of economic feasibility (or cost effectiveness); if it were estimated to be less than it would be in a new plutonium-only plant, then the dual-purpose plant would be the preferred alternative.

The "value" of electric power depends on where and when it is generated and used. It depends on how it fits in with existing generating and transmission capabilities. It is generally considered that value is equal to the cost of meeting incremental system loads with the lowest-cost alternative method of generation. In the Pacific Northwest at that time the lowest cost alternative as a combination of new hydro power and some thermal generation with fossil fuel. I had been in touch with the Bureau of Reclamation and obtained some data on power value that I used in the original studies and in the economic section of "Big Yellow."

Another test was the estimated cost of plutonium and electricity after allocating the capital operating costs to each of the two products. Such an allocation takes place in federal dam projects where the cost of the dam is allocated to irrigation, electric power, flood control, navigation, and fisheries. The method is called "Separable Costs, Remaining Benefits." It was applied to the NPR Project at various stages to determine the costs that had to be borne by WPPSS so that the government in no way "subsidized" electric power, and, from the WPPSS standpoint, to determine that electric power users were not subsidizing plutonium production.

The initial promotion of a dual-purpose reactor took a lot of spade work by Bill Johnson, Jim Travis, and Jim Ramey.

I provided the information to Johnson, and often accompanied him on his trips to Washington, D.C. to consult with, or testify before the JCAE or to meet with AEC people at their Commission headquarters. Following the completion of the $3 million study, a best case had to be selected, and authorization obtained for design and construction of the first phase, i.e., the reactor with all of its plutonium production facilities.

Bill Johnson testified in 1957 and 1958, Al Greninger in 1961, and Ray Dickeman in 1964. In each case I wrote draft material for the principals, and attended the hearings with them.

Al Greninger followed Bill Johnson as general manager. Prior to that he had been manage~ of production, under whose direction Hanford had greatly exranded its capacity. He had worked at a mining operation in South America, and had known Fred Mollerus there. He was quite convivial and in good voice at Elfun gatherings until he had trouble with his health and became more subdued. As a manager he kept a steady hand at the helm.

My role in these proceedings as an engineering and economics consultant was the most interesting of my career.

I felt that I was helping to bring to realization a project which I believed to be beneficial and I was working where I could observe the maneuvers in a game which had considerable political overtones. The project involved electric power generation--earlier noted as being politically sensitive; it was being promoted principally by Democrats; and when WPPSS entered the picture, it involved publicly-owned power interests which had always been opposed by the privately-owned power sector. The JCAE staff wanted to be sure it was on good technical and economic ground as they considered NPR for approval, and I was expected to give them the information they needed or wanted beyond what was in the formal reports. Sometimes I would work with Ed Bauser to write paragraphs on justification of the project to be published in the Congressional Records of hearings or authorizations.

Attendance at these meetings was great experience. We could see the inside workings of the federal government, and observe the senators and congressmen at work, in an atmosphere of anticipation of great events. Such an atmosphere did exist at that time. The utilization of nuclear energy was in its infancy, and it was generally believed in the halls of Congress that peaceful use of it would be a boone to mankind in the future.

Usually the testimony was well-received, and a few questions answered satisfactorily. Sometimes some follow-up work with the staff would be required. From our standpoint these hearings were generally successful; the N-Plant Project proceeded along the lines laid out by Hanford people in GE and AEC, and later, WPPSS.

The feasibility studies had started out assuming that the generating station would be owned by the federal government, but it soon became apparent that this was not possible from a political standpoint. No one wanted the federal government in the thermal power generating business. Other alternatives were explored, including private utilities, the State, or a Public Utility District. This question remained until 1962 when WPPSS was authorized to receive the steam from the N-Reactor.

During this and other periods when the welfare of Hanford depended on Congressional action, the Tri-City Nuclear Industrial Council (TRINIC) was very helpful. The principals in the Council were Sam Volpentest, and Glenn Lee and Bob Philip of the Tri-City Herald.

After the authorizing legislation for construction of the reactor had been passed in 1958, several bills for adding the generating plant, were defeated but a bill was approved in 1962 and signed by President Kennedy. Later that year he came here to inaugurate the project by throwing a switch to begin construction of the generating facilities.

The feasibility of generating electric power at a dual-purpose plant was studied formally by Stone and Webster in 1958, the Federal Power Commission in 1959, and R.W. Beck in 1962. The results of the Stone and Webster report were negative, and I had to review and comment on their findings. They had made some pessimistic assumptions not warranted by the situation in the Pacific Northwest. The Federal Power Commission (FPC) and R.W. Beck reports were more optimistic; the latter was used to support the WPPSS bond issue. I acted in a liaison capacity on the FPC and Beck studies, obtaining information on the reactor for them as required to conduct their studies. E.C. Starr provided information from BPA, and when the PUDs entered the picture Owen Hurd was their spokesman for WPPSS. For all these studies I had to compare their results against those we had arrived at from our own studies at Hanford. Explanations were found for items on which there was a divergence of fact or opinion.

Gene Starr, mentioned above, was a highly placed consultant with BPA from World War II days until 1980. He was a former professor in electrical engineering at Oregon State University, very knowledgeable about the BPA system. He spoke with authority, but with a genial hearty manner that made one enjoy dealing with him. He had a sturdy build, and liked to hunt and hike in the mountains, which he did even at an advanced age. He served in an overview in the WPPSS program--a job in which he probably found it difficult to protect BPA's interests.

Owen Hurd was a public-power utility man who envisioned the Public Utility Districts in the Northwest having their own central station supply of electricity rather than having complete dependence on BPA or other outside sources. He was a dignified, quiet-spoken man, who had succeeded in getting a group of PUDs to embark on that program. They started out with Packwood, a small hydro-electric station in Central Washington, then became the owner-operator of the N-Plant electric generating station, and finally embarked on the building of five commercial nuclear plants. Owen retired before the latter program got very far, moved to Arizona and died before he had learned the depth of the trouble that WPPSS had encountered in that program. His successors were victims of run-away costs, larbor strikes, ineffective architect engineers, and inflated load forecasts. They did not realize how much management competance is needed to keep even one nuclear power plant construction project under control!

Because of the touchy political situation noted above, each of the entities involved in the NPR project had to examine its position. Hanford GE management had to meet with the parent-company management to review the relationships, avoid any conflict of interest, and also avoid any undue risk to the reputation of the company in event of failure. Meetings were held at Palo Alto with L.R. Fink and his staff, which I attended as a consultant to Hanford management.

The General Electric Company was the prime contractor for operation of Hanford, but was also in the planning stage for manufacture of commercial nuclear power stations, a potential vendor for the turbine-generator machines to be used at N-Plant, and, finally, a supplier of equipment to privately-owned utilities, with whom maintaining good relations was essential.

The AEC was a government agency that operated the plutonium production plant, and by law promoted the peaceful use of nuclear energy, but it was not in the power generating business.

It was necessary, therefore, for these entities to establish a posture with respect to a dual-purpose plant. The Hanford Plant attorney, C.H. Crandall, and I attended a meeting of GE officials from Hanford Atomic Products Operation (HAPO) and Atomic Products Engineering Division (APED) at Palo Alto to formulate GE's position, and drafted the result for approval of the principals.

The General Electric Company would fulfill its obligations to the government at Hanford insofar as it involved the delivery of steam for power generation, but would not enter into the choice of an entity to whom steam would be sold, or be a party to the steam sale negotiations.

The AEC posture seemed to be arrived at naturally, the principal aspect being that mentioned above, i.e., the AEC would not subsidize steam production; the negotiated payments had to be such as to repay the added costs at the reactor plant, and represent an equitable division of remaining benefits.

The AEC monitored the NPR design effort but it didn't have the staff to cover all areas of expertise, and relied on GE for major design decisions. It was concerned that no misrepresentations be made to the JCAE as to the technical and economic feasibility of the project. Therefore, it was necessary for Hanford people to inform and reassure Frank Baronowski and his staff in Washington D.C. on occasion, and a number of meetings were held there for that purpose.

BPA was to enter into agreements with AEC and WPPSS for marketing of the power, and had to be assured as to government intentions for continued operation of the reactor, or as to conditions for turning it over to WPPSS in the event of cessation of plutonium production. Meetings were held in Portland on this and other subjects.

WPPSS had concerns similar to those of BPA, and sought contractual conditions that would cover them in event of unforeseen emergencies.

In 1959 I headed a task force of engineering, financial, administrative, and legal GE people to study the problems of a two-entity operation of a dual-purpose plant. We searched for all the possible points of friction that might arise and result in disputes or lawsuits between the entities. By anticipating such problems we hoped to design the plant and pave the way for the agreements so as to avoid problems later on.

Another study was made of the possible way in which GE might damage WPPSS equipment or pose a danger to its personnel while going through the reactor testing programs. Here again, the aim was to avoid problems that possibly could arise. Also GE management asked for a study of the licensing requirements of the WPPSS electric plant, which was in a unique position. Ivan Garcia and I went over the licensing, laws and regulations of that time, and found no great problem. Hanford people did not want WPPSS to find out late in the game there were serious impediments to its licensing because of some feature or conditions of the reactor supplying steam to the WPPSS turbines.

On the whole, these precautionary measures seemed to be successful. Things that did go wrong were limited to a few of no great consequence. In the meantime the design of the reactor plant was proceeding, and I was asked for certain reviews and recommendations:

(1) As noted earlier, the electric supply routes to the reactor coolant pumps had to be of the utmost reliability. Each new architect-engineer had his own ideas how this might be best accomplished. I was asked to review several different schemes, some of them modified to save construction costs, and made recommendations to management.

(2) The reactor instrument systmem grew to appear exessively large and complex, and I headed a task force to see if it was safe, reliable, and maintainable. We made a number of changes and submitted a report.

(3) The question came up--should certain auxillary pumps be driven by steam turbines rather than electric motors. This question was considered in the light of reliability criteria, and recommendation made.

(4) The questions regarding design steam pressure proliferated and called for a great amount of explanatory effort on my part, as explained below.

A peculiarity of a dual-purpose plant is that its ideal combination of plutonium production and electric power generation is at a relatively low steam pressure, with consequent low efficiency of energy conversion. This is contrary to modern steam-electric single-purpose practice, in which steam pressure is high and therefore the efficiency of energy conversion is high. To anyone in the power field, dropping back to a low pressure is tantamount to regression to the technology of 75 years ago--in a word, it is highly suspect. Burns and Roe, the architect engineers, understood the reason they, and GE engineers who instructed them, had selected the steam conditions, but no one else understood. Inquiries came from all quarters.

One of the most significant inquiries came from Glenn Warren, a GE Vice President and consultant in steam turbines. Ed Kratz and I made a trip to Schenectady to explain the choice of design parameters in this case. After he understood our reasons, he searched in his mind for some solution that might maintain the plutonium production rate but also yield better efficiency of energy conversion. He asked if we had considered use of a flash boiler or of Lamont boiler principles.

When we reported back in Richland I was asked to investigate Lamont boilers. Our mechanical engineers were not familiar with them. Upon researching it I found that they were boilers that converted part of the cooling water to steam within the heater tube, so that part of the heat was absorbed in evaporation rather than all being absorbed as sensible heat. Our heat transfer specialists said that such a method was not suitable because our required heat transfer rates were too high. I took another trip to Schenectady to present our findings to Mr. Warren, who was earnestly trying to help Hanford find a better solution if one were possible.

This was only one example of the doubts that were raised when persons having some responsibility for the project learned of the design steam conditions. Inquiries came from JCAE and AEC members in Washington D.C. whose engineering advisors had been shocked when they heard of the design conditions. There were people at Hanford who knew a lot more about thermodynamics than I did, but our management seemed to feel that I could convey the explanation well. In the case chosen for construction, a sixth heat-exchanger loop was added to somewhat improve the steam conditions for a given generating capacity. This was the only concession made to better efficiency. There was so much thermal heat generated in the process of plutonium production that had the efficiency been higher the generating plant would have been too big, that is, have too much capacity for one heat source.

The overall economics of the project came under much scrutiny. Basically, the project was very profitable as long as the government continued to produce plutonium for military purposes. If and when that program were terminated, the cost of continued electric power production would rise, and the economics would be less desirable, although acceptable if the termination did not occur too soon. No one knew how long the plutonium production program would continue; this was one of the bug-aboos of the project.

This situation was appraised continuously, and from time to time I was asked to estimate the break-even period of dual- purpose use, that is, the number of years of dual-purpose operation that would make the lifetime economics of the plant such that the costs of the plutonium and electricity would be the same as they would have been in new single-purpose facilities. Of course, the length of this period changed with the estimates of cost of alternative ways of producing plutonium and generating electricity, and as the costs of NPR actually materialized during construction. However, the break-even period remained acceptably low, somewhere between five and ten years. As long as the government could foresee the plutonium production campaign lasting that long, the project continued to be attractive. As the Hanford consultant who was held responsible for appraising the economic prospects of the project I did some worrying as the actual construction costs went 30% beyond the estimate. Still the break-even point remained acceptable. (This cost overrun in construction was regrettable, but was not nearly as great as that of most of the commercial nuclear plants started at later times.)

As the reactor plant was being constructed certain problems arose, and had to be investigated. For example, "After part of the large-diameter, high pressure carbon steel pipe required for the primary loop had been manufactured, it was found that the longitudinal welds contained subsurface cracks of the shrinkage or hot-tear variety not detectable through the use of ordinary X-ray or ultrasonic inspection techniques." This was a situation in which such cracks were of concern only because this was a nuclear installation; they had existed before in such piping used in ordinary steam plants, and had not caused failure of the pipe. Jack McMahon asked Bill Love and me to work on this problem. With the help of many people we prepared an AEC Research and Devleopment Report HW-75065, November 1963. After a number of tests were made it was found that the pipe was acceptable for the service intended. Had the finding been negative, considerable construction delay could have resulted--it seems that the steel pipe manufacturers could not eliminate such small cracks from their product without extensive changes in manufacturing methods.

At one point it seemed that the architect-engineer was issuing an excessively large number of electrical drawings, presumably at added costs, and I was asked to review the matter. I found that the large number was justified in that the drawings would be of considerable help in maintaining the complex control circuits.

As the reactor went into operation in 1964 the number of interruptions of service became a matter of concern. Interruptions or outages that reduce the number of hours during the year that the plant is available for use do, of course, affect plutonium production levels, but have a more serious effect on the quality of the electric generation. A large generating unit must be dependable in its operation. If it is not it places too great a demand on the emergency reserves on the Pacific Northwest system.

Interruptions were caused by failed fuel elements that had to be discharged from the reactor, or by equipment failure or instrument malfunction.

I was asked to review all the statements that had been made by GE in the proposal and design stages regarding the anticipated number of unplanned outages in plant operation, and give reason for discrepancies between our earlier estimates and the number of outages being experienced.

Fuel element failures were highly technical, and were covered by Hanford Laboratories personnel, but Design and Construction personnel had to be accountable for equipment shortcomings. Ray Dickeman who had become Plant Manager asked me to head a task force of 15 people, including Ivan Garcia, to investigate the causes of outages and recommend ways to reduce their frequency, and thereby improve the plant availability factor to the level that had been anticipated earlier. The task force was designated IRACS.

We met periodically over a year or so, and effected a number of changes that gradually improved plant performance to an acceptable level.

In the meantime a long series of studies and meetings were held among the principals to resolve the question of steam pricing. Finally a schedule of steam payments was negotiated. (This schedule has changed considerably since that time, with changing conditions in the Pacific Northwest and at Hanford.)

During the ten years of NPR development, management continually probed the conditions surrounding the Project, checking for any weakness in its justification or in the major features envisioned for the plant. Some of these questions in which I was involved are:

> Does location affect the feasibility of a dual-purpose plant? Would it be more advantageous in a location other than Hanford?
>
> What special transmission lines by BPA or WPPSS would be necessary?

What would be the advantage of private ownership and operation over governmental ownership of a dual-purpose plant?

Would superheating of the steam in a fossil-fueled boiler before admission to the turbines of the generating station be economically advantageous?

What price obtained for steam would reduce the fuel costs of the reactor to zero?

If the reactor were operated to produce $12/g fuel-grade plutonium rather than weapons-grade, what would be the resulting cost of the electricity produced?

What economic results would come from increasing or decreasing the electric capacity of the plant by 10%.

How much heat can the Columbia River absorb at low flow without the temperature being increased by more than one degree Fahrenheit?

When the time comes to shut down the last of the original eight reactors (the K-Plant) with only N-Plant operating, what would be the economic effect of keeping the K-Plant operating and converting N-Plant to power-only?

The information developed in response to these questions did not, for the most part, change the direction of N-Plant development, but did serve to reassure management that all possible contingencies had been considered.

Years later, in 1969, a study headed by Ron Robinson was funded by WPPSS for the purpose of preparing a detailed design of power-only; uranium-oxide fuel for N-Plant, and establishing the reactors operating characteristics with such fuel. I was a team member assigned to the study of off-plant fuel processing, and the overall economy of power-only operation. The steps in the transition of dual-purpose to power-only were carefully considered.

During the study it was found that there were some objectionable subtle physics effects that would be encountered with oxide fuel, rendering the plant less flexible to a conversion to power-only use than had been calculated in the original design. A new oxide fuel design, or continued use of metallic uranium, would be required in a power-only mode. The design of a new oxide fuel element was not undertaken at that time.

This concludes the account of my work on N-Plant, except that in 1981 when the plant had been operating for 17 years, and when I was working as a private consultant, I assisted Bill McSpadden of United Nuclear Industries (UNI) in a study being made of a possible replacement for N-Plant in the future. The study considered five possible types of dual-purpose reactors, including one of the Hanford type and one of the commercial light-water type. Sites being considered included Hanford, Savannah River, South Carolina, and Idaho Falls, Idaho.

I worked on the economics of the fuel cycle, and on certain aspects of the electric power marketing. As of now no decision has been made as to the building of an N-Plant replacement.

The plant continues to operate satisfactorily, but still suffers an occasional unplanned outage from fuel failure.

STUDIES OF OTHER POSSIBLE REACTOR APPLICATIONS

In the 1950s and early 1960s before the General Electric Company, Westinghouse, and Combustion Engineering had fully developed their choices of reactor types for electric power generation, the AEC Division of Reactor Development sponsored studies of reactor types suitable for power-only operations. The types of reactors in use at Hanford and Savannah River were considered, of course, since they were the only types that had been in use very long, with proven records of operability. They had been designed for plutonium or tritium production, and would have to be modified for power-only usage. NPR was a partial step in that direction, but still retained the plutonium production capability.

Among possible uses for Hanford-type reactors other than the production of weapon-grade plutonium considered at that time were the following uses.

Electric Central Stations

In an attempt to adapt the Hanford-type reactor to electric central station use, the N-Reactor Department proposed a graphite superheat reactor (HGSR) in Report HW-73130. It seemed to be a good concept, but like several others being developed at that time it had many technological features that would require extensive development and testing before solid claims could be made for its performance.

We did not have a concept for a Savannah River type reactor designed for electric power only, but did have a concept for a reactor of that type adapted to desalination. Hank Kosmata, Ron Robinson, and I made a comparison of the prospects of conversion of an existing production reactor of each type to power-only use. We came to the conclusion that the Savannah River reactors were slightly more adaptable to economic conversion than the Hanford reactors. However, to my knowledge there was never any serious attempt to convert either reactor type to power-only use.

Hank Kosmata was a young man with an interest, like mine, in the economic effects of engineering decisions. He was a handsome muscular man, who bore no resemblance to the man one might expect to see who had a Japanese sounding name. He and I worked on a number of jobs together. Years later he joined WPPSS and had a responsible position in the planning and financing of some of their proposed plants. This program, of course, had trouble later but not through any fault of Hank's.

Ron Robinson was an up and coming engineer who later became head of the United Nuclear Industries

Inc., the successor to General Electric Company for operation of the reactor plant portion of the overall Hanford complex.

Columbia River Water for California

In 1963 there had been some public discussion of the possibility of delivering water from the mouth of the Columbia River to California via a series of aqueducts and pumping stations. Fred Albaugh posed the question--Could power from converted Hanford reactors be used for this water pumping task? I discussed some of the considerations in a memorandum of November 16, 1963.

Later, in 1965, Ray Dickeman and Jack McMahon posed the question--Would new nuclear plants installed at the pumping stations, using steam turbines to drive the pumps, and using the water in the aqueducts for reactor cooling, provide an economical solution to the California water problem? In answer to this question Ivan Garcia and I prepared rough plans and estimates, using the construction cost of the aqueduct prepared by other engineering firms. We found that the costs of water delivered in this manner would be reasonably close to the price that might be acceptable to California users, but that the direct use of steam turbines, that is, elimination of the electric drive link, was of only minor economic advantage, with some loss in flexibility of operation.

When a ten-year moratorium was placed on any large diversion of Columbia River water, discussion on this matter ceased. Even without the moratorium the rising costs of nuclear energy in recent years would cause a new estimate of the cost of water delivery to California to show prices at an unacceptable level.

Smog Control Over Los Angeles

A GE man at Schenectady, K. Tomiyasu, applied for a patent on an idea to dispel smog around Los Angeles by installing several nuclear reactors to generate heat, causing a rising column of warm air that would cut through the inversion air layer and relieve smog conditions on the land surface. The GE patent attorney asked for a Hanford opinion on the likelihood of success of such a scheme. I was asked to respond. Working with Garcia and meteorological people we looked for some way to test the adequacy of such a heat source to accomplish the desired result.

The only approach we could find was to compare the heat generated by a large reactor with the heat of the sun's rays falling on a given area of the earth's surface, and from that comparison consider the probability that air currents from the reactor would be powerful enough to do the job. If the localized effect above the reactor location could trigger natural beneficial air flows the scheme might succeed, but we could postulate no such effect. We described the kind of plants, as we understood that Mr. Tomiyasu had intended, and estimated their cost for the information of the patent office reviewer, but in the end, had to state that in our opinion, the energy that would be released would not have the required driving force to offset the natural state of the atmosphere above the city. Later, Mr. Tomiyasu said he intended the applicaion to be more localized than we had thought. Whatever its merits may have been, we have heard no more of it.

Desalination of Seawater

In 1963 I was appointed to an AEC group whose purpose was to review large low-pressure-steam reactors for use in salt water desalination. The group, headed by Bob Ritzman of the AEC, included members from Savannah River, Oak Ridge, Argonne, Brookhaven, and certain architect-engineering firms. As a result of the review, interest in the use of nuclear heat for the purpose was stimulated, and research and development funds were requested.

Use of nuclear reactor plants for desalination of sea water was considered an attractive application. In the distillation processes in use for large scale desalination plants the cost of heat for evaporation of the water was an important part of the overall cost per gallon of pure water produced. The nuclear reactor appeared to be a good source of heat for this purpose in that the needed coolant temperatures and pressures were not as high as were needed for efficient electric power generation; the unit cost of heat was low (as estimated prior to the many impediments to reactor licensing introduced later); and the desalination plant location did not have to consider bulk supply of fuel such as coal. I acted as the representative of Hanford interests and the author of proposals to the AEC for funds to study the matter in more depth. In 1966 John Riches was appointed to represent the Laboratory. In this capacity John and I attended meetings in Oak Ridge, Tennessee and Savannah River, South Carolina, in Washington, D.C. and in Burlington, Vermont where GE had a factory making small desalination units using an ion separating film method. We issued a number of documents on the subject.

After 1966, interest in use of reactors for this purpose waned. Plans for a follow-on full-sized plant after the pilot plant at Guantanamo Bay were abandoned. Estimates of cost of nuclear heat were rising; and there did not appear to be a pressing need that could not be served in other ways. Finally, I saw the idea of sea water desalination with nuclear energy as being ahead of its time. Perhaps in 50 years expanding populations and a decline in the fear of nuclear energy will make such applications feasible and attractive.

Over the three-year period we worked on these proposals, I accumulated a thick file of correspondence. I read everything I could find on the subject of desalination, until each new paper or article I read seemed to repeat what had been written earlier. New information or a new approach to the problem were rare.

Critique of a Russian Nuclear-Electric Plant Design

In 1961 piecemeal information appeared in several places regarding one of the first Russian nuclear electrical plants, the one at Beloyarsk in the Urals, intended for power use only. Hanford was asked to comment on the quality of the design as it could best be understood with rather meager information. I participated in the review, looking at the electric systems and the overall economics of energy generation.

Compared with our design the Beloyarsk plant differed in many respects, one being the use of stainless steel in the core. The systems seemed to be built with adequate capacity, but were not indicative of superior performance. There seemed to be less refinement, and less coverage of backup safety devices than in our designs. In other words, the design looked more rough and ready than ours, but certainly workable. The economic performance was not expected to be outstanding but could be improved at higher fuel exposures. Perhaps at that point the Russians were looking for something that would perform well and not necessarily be economical by western standards. Later we saw mention of this plant in a few places, but never learned how successful it was.

(The foregoing paragraph was drafted prior to the Chernobyl plant accident on April 26, 1986. Apparently, the Chernobyl reactor was a later and different type design from that of the Beloyarsk unit, but has some of the same characteristics, i.e., vertical tubes, graphite moderator, and superheated steam (water cooled but with some steam formation). The fuel in the Beloyarsk design was thought to be a molybdenum uranium alloy, as inferred from a paper given at Vienna. The Chernobyl fuel was reported to be ceramic, an oxide of uranium. Our report mentions that graphite temperatures would be higher in our reactors if ceramic fuel were used. However, no conclusions as to the cause of the Chenerobyl accident can be reached from these comparisons.)

Interpretations of Aerial Spy Photographs

Soon afterward, the CIA sent an aerial photograph of a Russian installation taken from a high flying spy plane for interpretation by Hanford people. The photo had been blown up to desk-top size and showed buildings, pipe lines, roads and substations. We collected as much opinion as made sense, and two of us went back to Washington, D.C. to the CIA headquarters and discussed the matter with one of their agents. (We entered the Pentagon Building, and were directed to our agent's office--but didn't see anything else of that agency's operations to satisfy our curiosity.) We heard no more about this matter so don't know what conclusion was arrived at as to the nature of the installation, or whether our input had helped.

Thermal Plants in the Pacific Northwest

The manner in which nuclear thermal electric plants would fit into the electric power system of the Pacific Northwest was of great interest to Hanford people. At the beginning, the Hanford plant was a great consumer of electric energy; after N-Plant came into operation it would be feeding power into the system. I have already mentioned the need to determine the value of that power. Beyond N-Plant, it was believed that Hanford would be a good site for commercial nuclear power plants. Whether they would be at Hanford or elsewhere in the region, we were interested in how they would fit in with the hydro-electric plants for which the region is famous, how competitive they would be with remaining undeveloped hydro and with coal fired plants, and how soon the need for such thermal plants would develop.

As plans for N-Plant developed we met several times with BPA officials in Portland to discuss the transmission and operating problems of the project. E.C. Starr and Hector Durocher represented BPA. Later on, when we had meetings at Washington, D.C., the BPA administrator attended. Sam Ryneer or H.H. Shipper represented the AEC at the Portland meetings.

In 1959, I prepared a report "Comparison of Unit Energy Cost from Federal Plants of Nuclear, Hydroelectric and Conventional Thermal Types". This, of course, was before it had been determined that the federal government would not operate the electric plant portion of N-Reactor. Later, in 1961, at W.E. Johnson's request I made a study on "Hydroelectric vs Nuclear Power Generation in PNW." These studies showed the changing nature of power system characteristics in this region. The undeveloped hydroelectric sites that remained were in trouble with environmentalists, and were also less desirable economically than those developed previsouly. Thermal plants would be coming on the system before many more years.

These studies anticipated the advent of plants such as the Trojan Plant in the lower Columbia, and the one WPPSS plant at Hanford. They did not anticipate the conservation programs of later years or the abrupt reduction in load growth brought about by that program and by the effects of business recession on industrial load growth. The conclusions of the studies were correct in that nuclear power would come into existence here in preference to such remaining potential hydro projects as High Mountain Sheep on the Snake River.

FUNDED WORK

Although most of our work as employees of the prime contractors to the AEC was related to weapons plutonium production, various requests were made for our services from outside commercial or governmental entities. This work was funded by them and was done with the consent of the Atomic Energy Commission. The work to be recounted here came from the parent General Electric Company, the privately-owned utilities of the Pacific Northwest, the City of Richland, and the Port of Morrow, Oregon.

General Electric Company

In 1954 Frank McCune, who was heading GE's effort to get into the atomic energy business, met with W.E. Johnson and nine of us from his staff to discuss the matter. He said that--"the time had come for the company to do something, but the problem is to know just what to do," and he was getting ideas from all sources. The discussion covered a number of alternatives, and ended with a request that O.H. Greager assemble the comments and forward them to McCune.

The graphite-moderated (Hanford) type reactor was still of interest at that time. Meetings such as the one held here were part of the search for the best type for commercial use. Hanford people gave information and advice that assisted GE management in the formative stage of making an important decision. Of course, the final choice was the BWR, light-water-moderated boiling-water reactor.

MacCready Special Study

In 1954 and 1955 a "special study" was conducted by Ken MacCready, Ken Robertson, and me, with assistance in the later stages by Bob Wolcott and A. Janos. MacCready was a duPont man who had been with the Manhattan Project from the beginning. He had keen political sense as well as engineering knowledge, and was a good choice for a study involving diverse interests. His manner was pleasant, and his western drawl put people at ease. After leaving Hanford he went into cattle ranching near Prosser, and came close to running for a state office. At a good restaurant he would engage the waiter in a discussion of the merits of well-done prime beef, and end up with a portion of meat much larger than anyone else's!

Ken Robertson of the Finance section was practical and tenancious in looking at the business aspects. I kidded him about always having a copy of The Wall Street Journal with him. He later became Mayor of Richland.

The circumstances under which the study was made were:

(a) The parent GE Co., was still studying the Hanford graphite-moderated and the boiling water types for adoption for its atomic product line of electric generating equipment,

(b) A group of privately-owned utilities in the PNW were interested in determining whether they should take an early interest in nuclear power, and

(c) The dual-purpose plant concept was being considered as a possible type for initial entry into the new technology by electrical utility companies.

We investigated the legal, financial, engineering, and administration aspects, and held meetings with representatives of the utility companies here, and with people from the Atomic Power Study Group in Schenectady. Fred Albaugh accompanied us on the visit and we prepared proposals for the study of the Hanford type reactor for their purposes which would conform with the development aims of the AEC.

A final report was prepared at the end of the study in 1955. It was then becoming evident that GE was favoring the development of the boiling-water type reactor, and that the utility group had obtained the knowledge it wanted but was not prepared to take any action at that time.

DSEF--Division Safeguards Evaluation Function

In July 1965, J.F. Young, who then was heading GE Company's fledgling commercial nuclear equipment business, wanted a review of the measures that his organization was taking to limit the liability risk that the company would be taking in manufacturing and selling such equipment. He appointed the DSEF group to examine the procedures in use in the various Divisons to assure a safe product, to note the care with which the procedures were being followed, and to look for any obvious safety shortcomings in the product. This group was headed by Paul Reinker, and included 7 or 8 members, including Art Carson, who had transferred to APED and was with the Chemical Separations Division.

Art Carson has been mentioned before, as heading the engineering group that produced the "Big Yellow" NPR Report. He had served in the Air Force in the early stages of the war as a bombardier, and had many stories about his experiences. When I was attending the first DSEF meetings at San Jose, Art was looking for a house and in the evenings I would go with him. He was told to get the most expensive house he could afford. Real estate there was increasing in value very fast at that time, and an expensive house would appreciate more than one of lower original cost.

We met about every two months from mid-1965 through 1966, at Palo Alto or at one of the other GE plant operations, for example, those at Idaho Falls and Cincinnati.

The work was extremely interesting; it covered all safety aspects of work in progress, and included discussions with the forward-thinking men in DSEF with respect to how atomic products might affect the health or well-being of customers and the general public.

The committee made recommedations, but much of its value probably resulted from the GE Section managers knowing that their procedures would be scrutinized, so they kept a tight rein on their people. Presently I know of no case in which injury had occurred as a result of failure or short-comings of GE atomic equipment. After I left the DSEF it or the equivalent probably continued on past 1966.

KRB Safety Review

Another job for APED was the Hanford safety review of the reactor design for KRB, a nuclear plant to be sold in West Germany. It was one of the first boiling water reactors. GE at Hanford was asked to review the design with AEC permission. This involved many people at Hanford. I served as liaison engineer for the job since I was involved with San Jose-GE people in my DSEF capacity.

The Hanford Reservation as a Site for Commercial Nuclear Power Plants

As the tempo of the development of nuclear energy for commercial electric power generation picked up, Richland organizations began to explore the suitability of the Hanford Reservation as a site for such plants. In June 1970 the City of Richland contracted with Douglas United Nuclear, then prime contractor for operation of the Hanford reactor, to undertake a general site study. Bob Bell assigned the leadership of the study to me, with people in various fields of expertise being available as necessary.

We looked at the pros and cons of using one or more of the existing production sites where operation was shut down or planned for termination and where some existing facilities could be salvaged, and also at potential new sites in the reservation. In the final analysis, use of the old sites was found to be less attractive than some of the new sites for a commercial reactor.

The City of Richland made our report available to interesting utilities, including WPPSS which began to study sites not long afterward. Of course, the architect-engineers for WPPSS made their own study. They did not select the site we had given first preference, but another near one of our second choice group, feeling that its nearness to the City was more of a plus than we had assigned to it.

Irrigation

Irrigation of crop lands was another function envisioned for nuclear plants, the irrigation water being the warm water discharged from the condensors. Irrigation was an adjunct to the main purpose of the plant, electric power generation, but was seen as an important adjunct that would make the nuclear plant more attractive economically, in certain locations, and that would remove the objectionable environmental effect of discharging warm water to cold water streams or lakes.

Experiments had been conducted showing that warm water irrigation accelereated the growth of certain crops, bringing them to market earlier, possibly made them more hearty. If irrigation water, instead of being cold water pumped from a river, could be warm water allowed to flow by gravity from a cooling pond to crop lands, the effect on the crops should be beneficial.

Interest in such an application arose in the mid-Columbia region in 1970, when I was working in the Commercial Group of Douglas United Nuclear (DUN). The Port of Morrow, in Morrow County, Oregon, and the Boeing Company which owned properties in the same county, were both interested.

At that time DUN was seeking ways in which its engineering forces could be used in commercial work, switching from government work which was on the decline.

The Boeing work was being done by Cornell, Howland, Hayes and Merryfield, who asked us to assist them in a limited way on reactor construction problems. Their task was similar to that which we were asked to perform for the Port of Morrow. It was to select a site in Boeing Industrial Park at which a nuclear power plant could be built, on terrain on which a cooling lake could be formed by building a dam, and where canals could carry away all the cooling water to irrigated fields by gravity flow.

The administrator of the Port of Morrow was Ruppert Kennedy, a man of considerable imagination and enterprise, well schooled in public relations. He wanted to promote a large project for the Port, but he didn't have much money to work with. We did considerable work on the project with the expectation that if it materialized DUN would have a major role in the engineering. Bob Bell and, later, John Riches was in charge of the Company's effort to get into commercial business.

Bob Bell, who had been manager of one of the reactor plants, was reassigned to head up the small commercial group. He was very personable, and could make a good impression in any company. He and his wife were prominent in local society. He drove a Mercedes Roadster, sporty in a subdued way. Before that he had a Corvette. One day at a racing meet, one of the drivers told him his car was good enough to race, and offered to drive it in the next race if Bob wanted him to. He said yes--and no doubt got a kick out of the race, but was rudely shocked when he found his new Michelin tires without any tread at the race's end!

John Riches was a good technical man, who was mentioned before in connection with desalination studies. He and I went to New York together and saw some of the sights there, and also went to Burlington, Vermont where we saw the GE rapid-firing gun--the Vulcan.

With the help of my DUN associates I prepared rough plans for locating a nuclear plant in Port of Morrow territory, and for distributing warm water to 185,000 acres of crop lands. A cooling lake was to be formed by construction of a dam across one of the canyons with gently sloping walls in that area. Estimates were made of the cost of electricity and irrigation water. I attended meetings of the Port of Morrow Board, the Oregon Commission on Nuclear Siting, and organizations conversant with financing of agricultural projects. I gave speeches to the County citizens at school building auditoriums.

In the course of this work I learned a great deal about cash crops, and what kind of crops could be considered for warm water irrigation.

Finally it became clear to me that the farmers and ranchers on the Port Board, although some were big operators and had extensive agricultural holdings, did not comprehend the immensity of the effort that had to go into the planning, promotion, and building of a nuclear power plant. Even with Kennedy's urging, the Board seemed unwilling to make any kind of initial investment to promote a project. The Portland General Electric Company did build the Boardman coal-fired generating plant in the area we had studied, with a cooling lake, Carty Reservoir. It provided opportunity for use of warm water for irrigation. I don't know how much use has been made of it, since I left DUN shortly thereafter, and went into private consulting.

While speaking of irrigation projects I recall a request from a developer to take a preliminary look at irrigation with water discharged from the Boise Cascade pulp manufacturing process some miles below the Tri City area on the Columbia River. The land to be irrigated was a former sheep grazing area now a farm, called the JoSo Ranch. The water discharged from the plant had some chemical residue, and some small fibers but tests at a university had shown it to be suitable for irrigation. I surveyed the terrain, saw how the water might be pumped up to the higher levels where it could be used, and estimated the cost of making a more thorough study. We heard nothing more from the developer and do not know whether the idea for use of the water was pursued, or whether the water still goes into a settling pond and thence into the Columbia River.

ALTERNATIVE USES FOR AEC FACILITIES AFTER 1965

In the mid-1960s the plutonium needs of the national defense program began to decline, and shutdown of some of the Hanford reactors was planned. The government and its prime contractors began concerted studies to determine (1) how the changing military needs could best be served in a complex which was not operating at full capacity, and (2) whether there were peaceful uses for facilities no longer required for military production.

A group was appointed to review the entire AEC complex in a search for answers to these two questions. The review included Hanford and Savannah River plutonium and tritium plants, the Oak Ridge, Paducah, and Portsmouth uranium enrichment plants, and other plants involved in the fuel chain, such as the Fernald Plant in Ohio. The group was designated AECOP, AEC Operational Planning, and was headed by John Schacter of Oak Ridge.

At Hanford our Advance Planning group was set up for similar purposes, to operate in conjunction with AECOP. It represented Hanford in the overall studies, and independently studied Hanford internal problems in a stage of declining production needs. It was headed by Roy Nilson, and included W.Kelly Woods, Linton Lang, Gene Eschbach, me, and others.

Roy Nilson was a chemical engineer with a good background for such work. He was soundly based in engineering research, and knew how to deal with scientific-minded as well as with engineering-minded people. He had good judgment, and didn't waste time on fanciful ideas, but did pursue ideas that had real promise. He was respected by the top management of the laboratories and the operations divisions. Later, he joined Exxon Nuclear and headed its safety and licensing operation, spending considerable time in West Germany.

Gene Eschbach was a man of ideas with a flair for discussing them. He was well versed in basic nuclear technology. When I first came to Hanford I took some night courses in nuclear theory. A lot of it was over my head, but Gene, then a young man, was the star student, way ahead of the rest of us. Later, among other things he developed computer programs for study of flow of nuclear materials in a USA-wide electric power generating system of the future. If, in advance planning, his ideas were somewhat fanciful, he stimulated all of us to think, and if he went too far Roy Nilson was there to keep things under control.

Linton Lang came from the Laboratory Division, and was a respected research analyst. In the Advance Planning Group he was the advocate of thorium as an alternative for uranium. He looked at the use of thorium from all angles, and predicted its future supremacy as a nuclear fuel. He had a pet monkey, and would tell us about its escapades.

W.Kelly Woods was a PhD in engineering and a nationally known expert in heat transfer. After leaving Hanford he went with the State of Oregon on Power Plant Siting and Licensing.

Other Isotopes

In addition to Pu-239 and tritium, the AEC reactors were capable of producing other isotopes needed for military or peaceful application. Some were needed as an energy source in remote stations or in space; some for process irradiation, tracer, or medical applications. For example, the following isotopes were among those considered:

Curium 244
Cobalt 60
Polonium 210
Plutonium 238
Neptunium 237

Each of these products required its own particular target material, and had its own effects on the physics of the reactor and on reactor operation. Some were not end products but steps toward one. The "value" of the product had to be weighed against the costs of producing it, and of course, AECOP had to be convinced that the job could be better done at Hanford than at Savannah River, or vice versa. A major factor in these considerations was that the demand for the isotopes at that time was very small compared with the capacity of the reactors that would be available. The small amounts needed could be produced in the reactors still operating, with only a minor displacement of plutonium-239 production.

C A G E

In addition to production of these isotopes, the Planning Group considered other options that might improve plutonium production efficiency, that were available with reduced loads. For example, would uranium of different enrichments from that in current use be beneficial as fuel for the reactors, or mixtures of highly enriched uranium and depleted Uranium-238?

An attempt was made to find answers to these and other questions in a computer program, CAGE, set up for the AEC. It covered the entire complex and was intended to show performance capability and economic merit of the many possible cases. In April 1966, Ray Dickeman who was then plant General Manager, asked me to critique the CAGE program. Dick Shimer, R.R. Bloomstrand and I analyzed the program and reported on it. Our concern was that CAGE could, if biased in some way, not show up the true advantages of Hanford processes as compared with others, and result in less work being assigned here. Our analysis did not reveal much bias but did find that the program would not be as helpful as Frank Baronowski would like, because it required numerous case studies, and the results were not showing marked benefits of one case over another, but a rather broad band of closely competitive results.

A concommitment concern abut CAGE was that its results might be used for budget purposes. Along with Roy Nilson, John Riches and five others I attended a meeting in May 1966 in Washington, D.C. with Baronowski and his staff, to discuss CAGE cases and budget effects. The outcome was satisfactory in that it was agreed that undue use would not be made of the theoretical CAGE cases in setting up the budget, but only as supported by hand calculations of selected cases made at Hanford.

These events demonstrated the rivalry that existed between the Hanford and Savannah River prime contractors. The reactor types were different, but they could each perform well. Savannah River was built later than Hanford, and had most of the tritium production assigned to it. The rivalry was with respect to the economy of Pu-239 production. Hanford, by raising its power levels and by taking economic measures maintained a favorable position in this respect when the whole complex was going full-bore, but found itself somewhat less flexible in adapting to changed production schedules.

We attended meetings with AECOP people at Oak Ridge. Gene Eschbach was remarkable there for the variety and range of his ideas and his colorful presentation.

Plutonium Pre-Production

Another possible use for the old reactors was the production of plutonium to be held for future use in fast breeder reactors. The reactors were perfectly capable of doing this if it were economical.

In the 1960s it was anticipated that fast breeder reactor types would be in the second wave of commercial nuclear-electric plants in the USA and certain other nations. They were to be fueled with plutonium extracted from the spent fuel of the commercial light-water reactors, that would by then have been operating for some decades. There were tentative designs for fast breeders specifying the required amounts of in-core plutonium fuel. The question was: Would there be enough plutonium by the time it was needed? It was anticipated that the spent fuel of the LWRs would be separated, i.e., the plutonium and reusable uranium would be extracted from the fission products. Research and development people in GE had developed computer models of the generating units of utility systems as they would be constituted under the anticipated growth of the number of nuclear-electric units on the systems.

If the oncoming fast breeder demand for plutonium were expected to exceed the supply, the pre-production of plutonium in Hanford reactors might be justified. It would depend on the value of the plutonium for that purpose, the cost of producing it, and the interest charges of storing it for the intervening years. It was necessary to make a number of assumptions as to value and timing of need.

As a member of the Advance Planning Group I was assigned the job of determining plutonium "value". In the economic studies on light-water rectors a value of $12 per gram was in common use, but in the economy of LWRs the credit for plutonium in spent fuel was a comparatively small factor. In fast breeders the unit value of plutonium would have far greater importance. One approach to value as a source of heat for generation of electricity was comparison with the lowest-cost alternative fuel for which the value was known. Uranium-235 was the alternative, which could be used in fast breeders or in LWRs. Its cost of production had established a measure of value. Their performance in fast breeders differed but that could be accounted for.

After months of getting all I could find on the subject from American and British sources and referring to the computer study results I arrived at a value of $20 to $25 per gram of Pu-239 for that usage. However, the big stumbling block to preproduction was the timing of need. If production were to precede use by many years the inventory interest costs would mount so that the initial production cost would have to be very low for pre-production to be economical.

As it has turned out, the USA nuclear power program became stalled before fast breeders were devleoped; and we now know that it would have been futile to have produced any plutonium for fast breeders. They are under development in France, but the USA has only a fast-fuels test program, the FFTF reactor at Hanford.

Low-Grade Heat for Industrial Processes

The old reactors could produce a great amount of heat energy at relatively low temperatures, in hot water or, with added facilities, in low-pressure steam. The planning group prepared a list of all known processes that used such kinds of energy to reveal any opportunities for use of the plants. Since the reactors were in isolated locations they would have to provide cheap energy, to an industry for which energy cost was an important element of its overall costs, to attract that industry to the vicinity of the reactors. Such application would be more feasible if the reactor could be built near an industrial manufacturing area.

Here again, there were two options, (1) a reactor producing only heat for industry, and (2) one producing electricity, and making the reject heat available to industry. A proposed example of the latter was the Detroit Edison-Midland project, which eventually ran into difficulties and was not completed. Since a project designed for the purpose was in trouble, it seemed unlikely that a feasible use in that category could be found for the old reactors.

The Hanford reactor type was excellent for its initial purpose, the production of Pu-239, but was not easily adapted to other uses with peacetime objectives. We can state that fact with some certainty, since a great deal of effort went into trying to find alternate uses for it.

In the end, our efforts and those of AECOP failed to find any suitable alternative use for the weapons-plutonium production reactors. The uranium enrichment facilities at Oak Ridge and elsewhere have been used, at less than their capacity, for production of slightly enriched fuel for commercial nuclear-electric plants.

EXXON CONSULTING WORK

In the early 1970s the Exxon Company formed a nuclear division under the leadership of Ray Dickeman. He brought some of the Hanford people he knew into his organization, including Gene Astley, John McCurry, Jack Frame, Roy Nilson, Jack Fastaband, and Pat O'Neil. I signed a consulting contract with him in 1972.

Ray Dickeman was a young man working in the General Electric Laboratories Department when I first knew him. He was adept at writing proposals that would attract research funds. He grew in managerial competence until he became General Manager of GE at Hanford, and then head of the new Exxon's Nuclear Division. He was a sharp thinker with a commanding presence. He could work long hours with little sleep. He had a broad forward-looking view of things. His employees regarded him highly, and he treated them well. He liked a friendly game of poker and had some memorable ones with that high-roller Bill Harty. He gave me my first substantial contract as an independent consultant, for which I was grateful.

It was Exxon's intention at that time to enter into all the operations in the fuel chain for nuclear-electric plants if and when the federal government would open up to private enterprise those operations it then reserved to the AEC. The fuel chain consisted of uranium mining and refining, enrichment of uranium in the 235 isotope, fuel manufacturing, chemical separations, and waste storage. Exxon was interested in all parts of the chain.

The work assigned to me was in the field of uranium enrichment. Exxon Nuclear was forming preliminary plans for a gaseous diffusion uranium enrichment plant similar to those of the government at Oak Ridge, Paducah, and Portsmouth. It was also conducting research on centrifuge and laser processes for enrichment. My initial assignment was to study the "power and site-related aspects of the economy of uranium enrichment in a gaseous diffusion plant."

The estimated construction cost for the enrichment plant with its own 2600 megawatt electric plant was about $2.5 billion. The electric load would be too great to be supplied from existing utility systems, hence it would have its own "captive" generating station consisting of two commercial nuclear reactors or the equivalent in coal or hydro generating capacity.

The study covered estimated enrichment costs as affected by construction cost indices, taxes, labor supply, community support and electric power supplied by the federal government, a privately-owned utility, or a Public Utility District. The sites studied were in the Pacific Northwest.

the Tennessee Valley, Wyoming (near coal fields), the Ohio Valley, and Churchill Falls, Labrador (a new hydro-electric development).

I submitted my report in November 1973, and I was told later that it was well received by people in the parent Exxon Company. The most attractive sites were in the PNW and Labrador. The dam in the latter site was in progress of construction but it was not known whether the builders could meet their construction schedule and budget under the severe weather conditions there. (Later it was reported that they had come close to doing so.) A supplement to the report was prepared for sites in Alabama and Texas. Part of Texas is the least earthquake-prone of any land in the United States.

In the course of this study I met with people at TVA in Tennessee. John McCurry and I met with Hector Durocher, BPA manager of Power marketing, and the BPA attorney to get their views on the legal, political, and economic aspects of a "captive" generating plant in the PNW, and on who would be likely to operate a thermal power plant under these conditions. These conversations included consideration of a centrifuge-type plant of equal separative work capacity but with an electric load of only 300 megawatts.

We also made a preliminary investigation of how land for such a plant might be obtained in or near the Hanford reservation or within Richland City limits by purchase or lease. The Exxon Fuel Manufacturing Division had obtained land in the northern part of the city. A much larger tract would be needed for a uranium enrichment plant.

Also, a study was made of the licensing and environmental aspects of site regions of interest. It included the impact of such a plant on present use of land, the exposure to earthquake and tornado, cooling water availability, isolation, transmission facilities, community goals, and experience in past licensing hearings. The Wyoming coal fields were at a disadvantage relative to other sites in these respects.

In March 1974 a seminar was held on gaseous diffusion technology in Malta, New York. Malta was the site of research activity by Exxon on the centrifuge process. (It is near Safatoga Springs, so I went by to see the horses in the stalls where I had seen Gallant Fox in 1930.)

The seminar was attended by Exxon people, its contractors and government personnel. Some of the work being done there was secret, and we had to be cleared.

At that time there was an air of great expectations in this Exxon operation. A great energy corporation was entering the nuclear field, headed by a knowledgable man. It was expected that commercial nuclear power would grow rapidly in the USA, and that the government would allow private enterprise to participate in all stages of the fuel cycle. Efforts similar to those described above for uranium enrichment were being made for chemical separations, and a tentative site had been selected for a plant. Fuel manufacturing had already started in Richland. This optimistic outlook was to prevail for a few years, then subside as those expectations were not realized.

A number of lesser assignments I handled on my Exxon contract followed. I was asked to make an estimate of the price of separative work to be set by the US government in the future for work done at its plants. This required projecting the cost of electric power, and other elements of production cost at the government plants. Although the governments' costs could be estimated, its policy on pricing was another matter. It could set prices higher or lower than costs for various economic or political reasons, and the probable course was difficult to predict.

Another assignment was to predict cost escalation rates for construction and operating labor and material. Such rates were needed for insertion in computer studies of alternative courses of business action. I sought advice from appropriate sources, and came up with a table of factors. I think they might have agreed fairly well with near-term cost escalation, but I never checked them later to see how close they were to actual rates ten years later.

Ray Dickeman then asked me to study a government corporation as a building and operating entity for a uranium enrichment plant. Such a corporation was an alternative to direct federal or private ownership and operation. Government corporations had been used for such things as putting communication satellites in space and the operation of railroads.

I got information from various sources, including the General Accounting Office in Washington, D.C. and made comparisons with other kinds of ownership. I never heard what Ray Dickeman thought of my report, but I suppose that after he saw nothing beyond what he already knew, that is, no unexpected advantages over the private enterprise case, he relaxed. His request was probably triggered by some mention of such a possibility by Representative Hosmer, a well informed and influential member of the JCAE at that time.

Another Exxon assignment came from Brent Fryer who was looking into a proposal to generate electricity from the hot cooling water coming from the Oak Ridge uranium enrichment cascades. Theoretically, some 30 megawatts of electric power could be generated. Cooling water for the condensers would come from the Clinch River and be discharged back into it. I had to find out if this would be permissable under the laws governing Clinch River temperatures, and how the temperatures and consequent power generation might be limited under low-flow conditions in the river, also how downstream TVA plants might be affected.

Finally, Denny Condotta of Exxon asked me to review and comment on a scheme for storage of electric energy in the magnetic field of a very large supercooled electro-magnet. Research had been done at the University of Wisconsin, and Denny was interested in the practicality of the magnet for application in electric utility systems.

The coil at cryogenic temperature would carry a large current, 157,000 amperes, which, after it was built up, would continue to flow with little resistance. The magnet would be 300 feet underground, and the structural forces developed by the field would be carried to bedrock. Enough energy would be stored to carry the peak load of a large nuclear plant. Power could be delivered to the magnet or taken from it, by phase-shifting of the rectifier units connecting the DC magnet to the AC utility system.

In theory the magnet looked feasible. However, I was concerned about the dewar (the tank enclosing the coils with their refrigerant stream) maintaining its integrity under the stresses of load cycling, and ground tremors. The research report said that not even microscopic cracks or openings could be tolerated. I recommended building a pilot device much smaller than the one being proposed, to test the integrity of such a container.

The concept had some interesting aspects. For one, the earth's magnetic field would be altered for a radius of about five miles. Also, if an open circuit ever occurred in the coil, the collapse of the magnetic field would release so much energy instantaneously that great destruction could result.

After this, I fielded a few questions by Exxon people on electricity availability and cost, but except for the Fuel Manufacturing activity, the Exxon effort in the nuclear field was on the decline. They do have fuel manufacturing plants at Hanford and in West Germany and Belgium.

BATTELLE CONSULTING WORK

Battelle Northwest offered me a consulting contract in 1975. It was administered by Harold Harty who was instrumental in obtaining a number of very interesting assignments for me. He had a good knowledge of Battelle affairs, and knew where I could be of some help. Tall and distinguished in appearance, and very courteous in his demeanor, he could chair large meetings effectively, and guide a diverse group into agreement on a course of action. He is imaginative and flexible in his dealings. I valued my association with him.

Transmission for Commercial Plants at Hanford

In one of the first assignments the objective was to determine how transmission requirements would affect Hanford as a site for commercial nuclear-electric plants. This was before WPPSS had decided to build here. There had been considerable discussion about where nuclear plants could be located in the Pacific Northwest, whether they could be placed at the tentative sites being considered by PNW utilities for the next series of thermal-electric plants, or whether environmental and political factors would force any nuclear plant to be at Hanford. There had been much public speculation that if the plants had to be on the eastern side of the Cascades, away from the principal load centers, the transmission system costs and the environmental effects would be prohibitive. Battelle had arranged with BPA to make a study to resolve the question, and I was asked to carry it out wih Dick Richardson. Our BPA contact in Portland was Ed Weitzel, assisted by Dave Gilman and Rick Poon.

Dick Richardson was a young graduate in electrical engineering when I interviewed him at the University of Colorado for employment with General Electric Company. He liked the idea of living in the PNW where the hunting and fishing was relatively good. Here, in addition to fulfilling his engineering duties he teaches mathematics and electrical engineering courses at Hanford's University Graduate Center. He is also an ardent student of weather forecasting.

The approach we decided on was to use load growth predictions for the next 20 years, and assume that they would be met by (1) new plants at the sites that had already been selected for future thermal-electric plants, or (2) new plants all located at Hanford. The additions to and changes in the transmission network required for each of the two cases were worked out and costs estimated by BPA. Using the results, we calculated the average effect on electricity prices in the region and discussed the effects on the reliability of the system and the environmental problems of the transmission lines. We found that the average increase in price due to locating the generating plants at Hanford was only one-tenth of a cent per kilowatt hour: that with adequate design there would be no deleterious effect on reliability; and that the environmental effects would be minimal since the higher-voltage lines could be placed in existing transmission corridors. The report was distributed widely over the region, and put an end to the speculation about the ill effects of locating any new thermal plants at Hanford. It was updated and reissued three years later.

Station Service Study

Shortly after the report was completed Richardson and I did another study in collaboration with BPA. The report concerned the station service requirements imposed by the Nuclear Regulatory Commission (NRC) as applied to the situation at Hanford. Critical loads at a nuclear plant have to have certain duplicate electric feeders from offsite available to them if the plant is to continue in service. We wanted to see whether the configuration of transmission facilities in the Hanford area is such that the requirements would be met without adding extensive new transmission lines from distant sources of power. The analysis showed that existing transmission lines and power sources, with minor additions, would meet the NRC requirements. The results would have been applicable to WPPSS planning, but I don't know if they were used by Burns and Roe, WPPSS's first architect-engineer.

Cooling Condensers in Hot Dry Areas

Soon afterward, Walt Laity of Battelle conducted a study of nuclear-electric plants located in hot dry areas where they would use cooling towers of a type suitable for such atmospheric conditions. He had selected a site at Galt, Nevada for study purposes. Part of his study concerned the transmission facilities necessary to connect a plant at that site with load centers on the coast.

On this study Richardson and I worked with Cliff Diemond, a retired electrical engineer who had been with BPA and had worked on DC transmission lines. He performed transmission line calculations, and we prepared maps and made cost estimates of the lines that would be necessary to carry power generated at Galt (Near Las Vegas) to load centers at which it could be absorbed.

It was necessary for us to travel to Las Vegas to look at the lay of the land in that area. (Of course, we had to take in a Las Vages show, and was it spectacular!). We found suitable ways to meet the requirements of the case study and made our contribution to the report. This was one of those studies that may have been used as a reference in the design of nuclear plants in the southwest.

Nuclear Energy Centers

In the later 1970s there was considerable interest in nuclear-electric energy centers. It was still expected that many new plants would be required. Those in the industry did not yet realize that the estimates of growth of electric loads were too high, and that new nuclear plants built in the immediate future would be relatively few. They did not know that a move toward conservation of energy would be ignited by the rise in oil price, and be a strong influence on load growth.

The questions were--If a number of nuclear plants could be built in one complex, how much would they benefit in construction and maintenance costs; Could fuel processing facilities be included in the complex, thus eliminating the need to transport radioactive spent fuel to distant locations; and, Would the concentration of generation give rise to proliferation of objectionable electric power transmission lines?

The government undertook studies on this subject, with Battelle participation. As a consultant to Battelle I looked at the transmission aspects, reliability, costs, and environmental effects.

Soon afterward I was asked to assist Bob Jaske who was working on a national study of energy centers for the government. The study was being done at Bethesda, Maryland and I was to work there for six weeks.

This study considered the feasibilty of nuclear energy centers in various locations in the nation--in areas of high-, medium-, and low-load density. In areas of low-load density, the length of transmission lines to carry power from a generating plant of given size would have to be greater than for areas of high-load density. When I got to Bethesda, Bob had information from groups that had done preliminary studies on the subject, but it was not in good shape for a review meeting of utility and government people that was to be held shortly. I attempted to pull the writeup into shape for the meeting but time was too short to do a good job. Anyway, we got through the review, took the comments, and proceeded to draft our section of the overall report. This report was issued as NUREG-0001. It was found that the transmission problems of energy centers could be handled with the higher voltages that were coming into vogue, with varying costs depending on load density and the extent of transmission network already in place. Any advantage due to concentration of the fuel cycle operations in one place, which was small, was negated when separations was outlawed because of the fear of weapons proliferaton. Actually, the load growth rate expected at that time soon began to decline, because of conservation efforts and business recession, and any need for large energy centers would be far into the future. The conclusions regarding smaller energy centers were applicable. WPPSS plans, if they had materialized, would have resulted in a small energy center at Hanford, three plants, but only one has been built as of this date.

National Electric Power Grid

Continuing on the theme of electric power transmission, in 1978 a politician, Enver Masud, instigated a study on whether or not the USA ought to have a national transmission grid, as some European countries do, to better serve the nation in peacetime and in emergencies. The sections of the study on (a) the transfer of power to areas where it might be needed in an emergency, and (b) the load diversity in different areas that might benefit from an exchange on a transmission grid, were assigned to TVA and BPA people. BPA had no one to assign to the task of writing the report, and since they had been favorably impressed by our joint BPA-Battelle Hanford transmission report of 1975 they contracted with Battelle to do so using information developed by TVA and BPA.

TVA had conducted joint studies with the privately owned utilities in the east, using a computer program in which they could insert study cases. BPA had its program for the PNW, and also joint studies with California utilities.

As before, Richardson worked with me on this job. Our first meeting with the people who were to supply information was in Chicago. We arrived there late and entered a room in which there were about 40 people assembled. There seemed to be an undercurrent of hostility, not toward us but toward the study itself. Many of the people were of the opinion that the industry had already done all that was necessary and desirable in extending and interconnecting USA transmission systems. Others, like Dick and me, were willing to wait until the study was over before forming an opinion.

The work continued for several months, with more meetings and with a great quantity of undigested information coming in to us. The principals in these meetings were Chuck Winn of TVA and Ralph Gens of BPA. Positions and statements were hammered out, then we would go home and try to put them in the right context.

As the work proceeded it became clear that, (1) the three grid areas already developed for the eastern and western states and in Texas were already taking advantage of any diversity within their areas, and that interconnecting the eastern and western grids across the sparsely populated Rocky Mountain zone would not be economical, and (2) no emergency or disaster in peacetime or war could be conceived that would necessitate or justify interconnecting those grids. We did find that an additional North-South line in the western grid would be justified; this is being planned now. Thus, we came to the same conclusion that a number of the study participants had anticipated from the beginning.

When the summary and supporting facts were written our BPA and TVA sponsors and also the private utilities representatives were pleased, but I doubt that Mr. Masud was, since he thought it a political issue. To my Knoweldge no similar proposal has surfaced since then.

Fusion Central Stations

The Battelle jobs included two others dealing with transmission. Duane Dionigi was studying possible future fusion nuclear-electric generators and their applications. They were expected to be economical in very large capacities, and again, the question arose--What would be required in electric transmission to serve such a plant. The problem was basically the same as for energy centers, except that the generation would all come from one unit. This aspect was considered in the discussion on this topic.

Fossil Fuel Shipment vs Electric Transmission

Another task was that of correcting a report on coal or oil shipment versus electric power transmission, previously written, that had been severely critized for its statements on electric-power transmission. Cliff Diemond had provided basic information on electric power transmission, but it had been used erroneously in the text, and Diemond had demanded that his name be removed from the references in the report. The author was in over his head in trying to write that section. I was asked to rewrite it. Apparently my rewrite was to Diemond's satisfaction since his name reappeared in the final report.

Electric Loads of Federal Facilities

At one point the question came up--What are the electric loads of federal facilities in the West? I checked the Army and Navy bases and other government operations (Hanford included) in western coastal states to arrive at an approximate figure, 300 Megawatts, a load that is substantial but still less than the capacity of a single nuclear plant.

Electric Consumption Incentives

In 1980 John Emery of Battelle was preparing a report on Electric Consumption Incentives, and asked me to prepare a section on the incentives that had been offered by the federal government and what had resulted from them. As a part of this he wanted a brief history of the development of the electric power industry in the USA "preferably with some anecdotes."

Quite simply, the incentive of the government was to make low-cost electricity available to people by building hydro-electric dams, and by extending lines to rural people who otherwise would not be served. I elaborated on these efforts, and wrote the history with what I had hoped would be interesting anecdotes.

A young engineer who was my contact was greatly impressed and wondered what he could do to become a consulting engineer. At that time I had worked in the profession for 50 years. I didn't have the heart to tell him to come back and ask the qustions when he had another 25 years under his belt!

Solar Energy

Kevin Drost, who was preparing a report on solar energy "farms", i.e., many reflector dishes spaced over acres of ground, wanted help on design of a collecting system for the electricity generated at the many points in the field. This was a different sort of challenge. The power at each collection point was relatively small, but the cummulative effects were large. The controls at each point had to be simple for best economy, but the system as a whole had to have good protection against failure on any branch. When the solar radiation fell to a low level the generators had to cut off or they would become motors, drawing power from the system instead of delivering it. I designed a system that met all requirements and, as requested, was in enough detail for a good cost estimate.

Hanford Site Master Plan

In 1980, some of the privately-owned utilities in the PNW were interested in long-range possibilities for siting new commercial nuclear plants at Hanford. By that time WPPSS had already made arrangements for sites for its plants. Nuclear Regulatory Commission requirements for approval of sites were becoming more specific. For these reasons Battelle undertook preparation of a Hanford Site Master Plan. It considered all aspects: earthquake, tornado, flood, land characteristics, meteorology, and electric facilities for station service and for bulk power export. Here again, I contributed to the master plan on the electric power topics.

The private utilities mentioned above did identify a possible site, and investigated ways and means of land acquisition. However, the marked slow-down in load growth, and the things that have caused utilities to shy away from nuclear plants nationwide, were becoming more pronounced, and the interest of the utilities in this matter was placed on hold.

Another Battelle study related to the above was concerned with how siting commercial nuclear plants here might affect present government activities. This was interesting because of the type of "possible future activities", that the Department of Energy advanced for purposes of the study. Even though some of these ideas sounded pretty far out, we found that the reservation could accommodate them with an extremely low probability of interference with government operations. If a nuclear plant would get in trouble and emit radioactive gases, and if the wind were blowing in the right direction some interference might occur, but the probabilities are so low that they should not deter beneficial use of the land. The effects could be in reverse, that is, the government activity conceivably could interfere with commercial power plants, but that also is of a very low order of probability.

Hydro Diversion for Fisheries

In the early 1980s the Northwest Power Council began to fulfill its legal requirement of directing the use of Pacific Northwest hydro-electro dams so as to preserve fish life in the Columbia River and its tributaries. This entailed the "wasting" of some river water, that is, diverting the flow around the turbines so that fingerlings swimming downstream would not be killed in passing through the turbines.

Battelle wanted to know how much electric power generating capability in the system would be sacrificed for this purpose under one of the committee's plans, and Harold Harty asked me to compute it. After making a number of assumptions, and considering the seasonal aspects of the bypassed flows, I came up with a figure of about 1000 megawatts, which is about 7 percent of the total hydro-generating capacity on the system. Although this is a significant reduction, perhaps it isn't too much to give up to preserve Columbia River salmon, that magnificant species that were so numerous when Lewis and Clark first saw the river.

Reliability of Generation at Hanford

In 1977 there was still interest in multiple nuclear power plants at Hanford, and the government through Battelle instigated a study on the reliability of generating plants concentrated in that location. They wanted a measure of the exposure to simultaneous failure of a substantial portion of the regional generation in the event that a number of plants were to be built here in the future.

The study was to consider the exposure to natural disruptions such as earthquake and tornado, and to failure of man-made structures such as Grand Coulee Dam or the containment vessel of an adjacent reactor.

Bob Clark and I listed all conceivable disasters, and tried to gather enough data to compute the probability of causing a generating plant outage, how many plants would be affected, and how long it would take to get them back into operation.

Bob Clark is a quiet-spoken engineer who is well versed in a broad range of nuclear engineering subjects. He is a good golfer. He serves the profession by acting on the state board for licensing of engineers. I helped him one year by grading the exams of young people seeking a license in electrical engineering, but found that grading these exams is a tough job.

In looking at local environmental factors I came across one notation regarding ash from volcanoes in the Cascade mountain range. To my surprise, when we calculated the probability of affecting all or a large portion of the generation we found that ash from volcanoes would be second only to earthquake in the probability of its occurrence and the severity of its consequences. This was in late 1977, before the May 18, 1980 eruption of Mount St. Helens. I took some satisfaction in having noted this type of risk in my report. The recent eruption left only a fraction of an inch of ash in this area, which did not interfere with any plant operations, but there is geological evidence that previous eruptions have deposited as much as six inches of ash here, which would have seriously interferred with power plant operation. Since my study preceded the last St. Helens eruption I had to get basic data from Japan through some of Battelle's connections there.

The general findings of the report were that the risks were acceptable. Many people think that we should have a society that is entirely risk free, but that is impossible. Society can be hamstrung in an attempt to make its existence entirely risk free.

After this I participated briefly in some Battelle work on simplification of nuclear plant licensing, and standardization of design, but was nearing the end of my contract with Battelle and with the fine people I worked with there.

MISCELLANEOUS

In addition to work performed on major contracts discussed above I worked with:

(1) Douglas United Nuclear (later United Nuclear Industries) in the N Plant Replacement Project noted previously, and in efforts to find ways in which that company could enter the commercial market for engineering services.

(2) Puget Sound Gas & Electric as a local contact man in the early stages of their interest in getting a tentative nuclear electric plant site at Hanford in anticipation of future need, and

(3) WPPSS in the preparation of one of its environmental impact reports.

With reference to DUN's attempt to enter the field of commercial nuclear services, Ace Swenneson was working with us on that subject in 1971. We considered the design, construction, and licensing of nuclear plants as carried out at that time, searching for ways in which Hanford people under DUN could apply their expertise commercially.

Swenneson moved back to AEC in Washington, D.C. not long afterward. Before he went he brought to my small retirement get-together a bottle of wine from his California vineyard. It was a premium wine; the White House was among his customers. It was indeed far superior to any I had tasted other than a French champagne in Denver, a nice touch for my last day in the world of 8-hour work days.

As I reviewed my file of documents to write this account, sets of initials at the end of letters reminded me of other people with whom I worked at Hanford. My first secretary was Sue Olson. She was young, newly married, beautiful and reserved, and she put up with the rather rough office settings of the working areas. She would tell me of weekend trips with her husband to explore this area new to them. Years later he was injured in a ski-lift accident, got cancer and died in middle age. Sue became a successful real estate broker. She now lives a block from us at a house of the same number. Sometimes we get her mail and she gets ours.

In my next job Mary Sloulin was my secretary. S'e was rather plain in appearance, but a good worker with a pleasing disposition. One Monday morning Mary didn't report for work, and we soon learned that she had drowned in the Pacific Ocean at a beach in Oregon. She had gone on an excursion with a group and while swimming in the surf had been carried out in an undertow. It was very sad. Her brother came a day or two later for her personal things from her desk.

Then there was Belva (McGrew) Pleake. It was her first job out of business school. She was small and pert, an accurate typist, with a very active mind. She would converse on almost any subject, but she was especially interested in her high school studies of the history of Hitler's rise to power. Later she had a bad first marriage but a good second one with two children. She was still a secretary with UNC when I did some work for them under contract in 1981.

Betty Kent was a young married woman with two small daughters. She was very pretty, but when she came to be interviewed for the job she put on some rather ugly glasses (although she didn't ordinarily wear glasses) to make her look more "secretarial". She was very capable and reliable on the job and got along well with everyone. In short, she was the perfect secretary. She told me of her husband's efforts to get a beer distributor franchise. He got one, and the last time I saw Betty was at the Budweiser hospitality center at the unlimited hydroplane races on the Columbia River, near Richland.

Marie Lawler was the wife of Joe, a lubrication engineer. She was petite, tanned and a good golfer. She and Joe accompanied Helen and me on an overnight boat trip up the Snake River into Hell's Canyon, white water and all. On my last consulting job with UNC, I saw her and learned that she also was just about ready to retire.

Ruth Rodman was a professional secretary from Denver. She was capable, and loyal to her employer. She was delighted with a Christmas gift we gave her one year, and gave us a Christmas arrangement with a ceramic choir boy that is still a great favorite of ours. She, also, was still working for UNC in 1981, she had been divorced and never remarried.

Also there were secretaries who reported to my superiors but who did work for me. Frances McBarron, our neighbor, was a member of the crew that made the power-only fuel study out at N-Plant, and one of our car pool drivers who negotiated icy roads in the early morning hours of winter days in 1969.

Ginger Sather was Roy Nilson's secretary. After she and I were retired we met in a Spanish language course. I dropped out, but if she stayed she must speak Spanish well by now.

When I went into private consulting my dear wife Helen typed my letters and reports from handwriting that was barely legible, then the secretarial staffs of my clients would do the final work on their word processors. Among these latter were Nancy Gerber, of Exxon, daughter of the then manager of the Richland First National Bank, whom we last saw at a grand opening reception of the new bank building. Also, there was Naomi Brimhall of Battelle, Harold Harty's secretary, who typed some of my material and also relayed many welcome messages to me at my home office.

All of these women and others not mentioned helped in the work described above, and brightened the offices where they worked.

CONCLUSION

Work at Hanford during the years I was there was a sort of pioneering. Many false trails were followed for a while until they were shown to be false. My consulting work was in many cases a search for the truth--the truth as to how nuclear energy might be beneficial. Nuclear energy was a field in which there were no beaten paths to success in the 1943 to 1983 period in which I worked.

I was lucky to have participated in this pioneering effort, I am lucky to have worked with the people I have named and many others. I have been asked--Are you not uneasy that much of your life's work has been in the production of plutonium for atomic bombs? My reply is--absolutely not! In the beginning we were in a hot war in which, if Hitler's Germany had developed the bomb before we did, the consequences for mankind might have been much worse. Since then, for a long time we were in a cold war in which deterence played a major role in preventing war and in our keeping our way of life.

Nuclear Energy, which first came to fruition in wartime, is a secret of nature that man has been allowed to discover. It is up to man to use it for good or evil. I am confident that its major use will be for the good of mankind. To my grandchildren, it is up to you and your generation to bring this about.

William J. Dowis
June 1, 1986