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WATER
LAND
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STUDIES
DESIGN
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EXPERT TESTIMONY

MY GENERATION TO YOURS

Presentation by Dr. Ellis L. Armstrong[1] at the 1986-87 Brigham Young University College of Engineering Lecture Series - Provo, Utah - December 4, 1986 (Illustrated with 160 colored slides)

It is an outstanding recognition of this great University for Dan Barge, the National President of the American Society of Civil Engineers, to present the Ridgeway Award to you today for the most outstanding ASCE student chapter in the nation. I eagerly support and applaud the accolades he gave you, and I add my congratulations.

So I am greatly honored to now have the privilege of talking to you. The freshness, the warmth, the eagerness, the strength, and the good humor reflected by your faces - the high standards of honor, integrity, and morality in your code as students of this University - the dedication here to the development of ethically sensitive and responsible mature individuals and the never-ending search for truth - all combine to give great hope for the future. The entrance to this University proclaims "The World Is Our Campus", and indeed it is for all of us, whether we like it or not.

Now that I am over the hill, that is I have now well exceeded the 3-score and 10 years considered my allotment, I seem to think I've now inherited the right to be philosophical in talking to young, bright, eager, embryo engineers such as you. This approach implies a learned, logical, rational, judicious and thoughtful discussion of basic truths and universal laws. Such wisdom at my stage in life is based upon a system of beliefs, convictions, principles and my now viewing the world with patience, forbearance, and a certain amount of serene resignation. Quite a contrast from the days I was a young engineering student, such as

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you are now, chomping at the bit with an eager resolve to immediately design and build a better world.

But this world is very real and there is no magic. It is not a risk-free world; it is a dangerous world and the problems to many seem to astronomically increase in number and complexity. Some have given up on mankind and momentarily expect doomsday to occur. Too many young idealistic reformers have had their rainbow of hope shattered when they actually encounter the stark reality of the world's problems, and have looked at the tremendous obstacles to betterment. The world is very real and swinging around on hypothetical skyhooks don't help much in solving problems.

But you as Engineers are being trained to face up realistically to the problems with full appreciation of the physical dimensions and limitations and then to work with technology to design and build for improvement. So I want to discuss how we got to where we are and what my generation of Engineers accomplished. Then I want to outline briefly the challenges and opportunities that you now face. This will be a broad, overall perspective, and with my slides we are going to cover a large comprehensive panorama, so hang on.

I'm always a little apprehensive when I talk to today's student engineers. It seems to me you know so much more than I did when I was a student, but of course the more you know the more there is to know. I am a product of the slide rule age and the accelerating developments in computers have left me far behind.

A computer chip the size of the tip of a pencil provides millions of circuits for computations, and we talk a lot about the developing of artificial intelligence. So I seek comfort from statements such as the one recently made by the chief technical officer of Texas Instruments that the entire production of the computer industry for a year is about equivalent to one human brain. And it would be well for you to keep this in mind. As you look at this slide, and identify the beauty of this world of ours, consider that human vision involves 100 billion computations per second, and that one trillion computations are required for you to see, to interpret the various shapes and the shades of color, and to then enjoy this beauty. I didn't make these figures up; they came from recent advances in the studies of the human brain by scientists at Carnegie-Mellon University. However, I don't understand just how they counted the computations. Anyway, never forget that you are still the greatest, most complex, remarkable, magnificent, glorious, splendid, noble miracle of all creation with unlimited potential.

Well, lets get down to some fundamentals. So lets go to the bible. Genesis speaks of the creation with universal accents in its mighty opening phrases: "In the beginning God created the

heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep." And after the sixth day... "God saw everything that he had made, and behold it was very good." Certainly there is no question but that He was an Engineer. And He then, according to Genesis, "planted a garden eastward in Eden" with a perfect environment for Adam and Eve. But I guess just sitting around enjoying balmy weather, smelling the flowers, watching the young animals play, listening to the birds sing, and eating apples is not the way to progress.

So, it turned out that for mankind the flawless environment of the Garden of Eden was not to be. For Adam and Eve were banished from the garden and given the engineering assignment to adapt the hostile environment outside of the Garden by the sweat of their brow and make it compatible for the life of people.

You see, while the world was quite well roughed out, the creation was not finished. Nothing was all done, nothing was ended. The good Lord wisely provided for continuing, vibrant and throbbing growth, throughout all time. He left forests that were impenetrable; mountains and glaciers stretching as far as eye can see that were impassible; canyons that were formidable, savagely beautiful barriers; roaring rivers that were uncrossable and uncontrollable; rainfall that was erratic, producing rain forests and forbidding deserts; storms that brought forth hurricanes and rampaging floods, and lack of storms that produced searing drouths. He left the heat of summer and the cold of winter. He left challenge to mankind.

Ample natural resources were provided for the life of people, but they were, and are, resources that require work and knowledge and cooperation and will to develop and use; resources that must be utilized with wise and sound principles or the development boomerangs. You see, nature in the raw is brutal and inhospitable and cruel and destructive and capricious as well as beautiful and bountiful. Nature is governed by laws which have no sympathy or tolerance for stupidity or ignorance, no matter how well intended. Mount St. Helen certainly was not concerned about EPA air pollution regulations. And the Great Salt Lake doesn't understand very well the 1979 law passed by the Utah legislature for the level of the lake to stay below elevation 4202; it is now nearly at elevation 4212 and may go higher.

So people must adapt and use the environment so that they can survive and they must do it with understanding and knowledge of natural laws, and with wisdom and intelligence in their application. There is no magic, and there are no shortcuts. We must work with nature to make this a better world.

So the job of Engineers since the beginning has been to work at finishing the creation; to apply scientific principles to creating materials and machinery and harnessing energy so that

people can fashion the environment to meet their needs. Engineers have the constantly increasing responsibility of providing for the physical well being of people and at the same time, protecting the world's overall life support system. And the process has brought along the spiritual and social growth and development of people. You see, early man soon found that to control the floods and to conquer the mountains required people to work together, to cooperate for their common good. Man found that he needed other men; and they needed him; that every person is a part of the whole; and civilization was on its way.

In early Egypt, the Engineer - the Master Builder - was second only to Pharaoh, and directed the planning and construction of the physical base of that ancient kingdom which for centuries was the center of the civilized world. And so it has been down through the ages. The ancient Greeks reached their heights from engineering their physical base. The Roman civilization endured for centuries because Engineers built 40,000 miles of durable hard-surfaced highways to tie their Empire together, and water aqueducts to bring water hundreds of miles to make their cities possible - engineering structures that still exist.

Change down through the centuries was slow until about the last 100 years. The speed of travel and communication is illustrative. For thousands of years the speed of communication depended upon the muscles of man and his speed as a runner. Then camels and horses were the limit for hundreds of years. Waterways and ships provided transport of goods and people across the oceans and along the rivers, relying on man-powered oars or wind for the energy force. But with advent of the steam engine about 150 years ago, which was an early application of engineering knowledge, change began to speed up.

Soon steam-powered railroad travel became faster than horses, and railroads began to take over shipment of goods and people across the land, as horse-drawn wagons were left in the mud. Then, as now, change was vociferously opposed by many, mainly through fear of the unknown. One group of academic "concerned scientists", and unfortunately we still have some of them around today, postulated that the top speed "must not exceed 30 miles an hour or the passengers will suffocate." Another group, probably a Naderite type of consumer's interest group, admonished that "all railroad passengers are sure to contract a new type of mental illness, termed delirium furiousm." But change prevailed, and by the beginning of this century, Engineers had designed, developed, and built railroad engines and machinery and a 2-million-mile railroad network across America that were engineering marvels. Similar developments were occurring worldwide.

A brave politician on the floor of the U.S. Senate in 1900 got carried away and predicted that with the railroads and the steam-powered ships "the time may come when <u>even travel</u> will be

available to the common man." Even travel - I wonder what he would think if he were around today.

In Colonial America overland travel was limited except along foot and horse paths, although by 1773 a road of sorts was hewn through the wilderness between New York City and Boston, and Benjamin Franklin, as postmaster of the colonies, made one of the first trips to deliver mail. While cobble, brick and timber street surfacing in the cities came along early, it wasn't until 1823 that engineering principles began to be applied to rural roads when the first macadam pavement was built in Maryland.

In those days, the life of an Engineer was great as no one questioned his direction. The rock-breakers hammered the rocks down to weigh not more than 7 ounces and pass through a 3-inch brass ring before the material was accepted for placement in the "scientific pavement." The Engineer retained a helper to check out the rocks under his careful scrutiny, while he stood by in a top hat and striped pants.

In the later part of the last century, bicycles came into wide use and were a powerful force for change with their "good roads" movement. But the event that changed your life and mine was Frank Duryea trying out America's first horseless carriage on the streets of Springfield, Massachusetts in 1893.

Within a few years, Engineers were designing and building cars that ventured out from the cities, raising dust clouds in the countryside, terrifying horse-drawn travel, and alienating the farmers. But Engineers soon came up with portland cement and bituminous concrete pavements and travel increased. Visionaries dreamed of America tied together with a vast highway network that would free the average person from confining distance and loosen the bonds of isolation of the farmers. When I came upon the scene in 1914, Congress had just provided the first federal funds to improve roads, the U.S. mail routes, and the first improvement was on this mail route in Alabama. Then in 1916 the Federal Aid Highway Act was passed to provide a national system of highways, unimpeded by state lines.

And today we have nearly 4 million miles of roads and highways in the United States, about half of which are paved with concrete. Mountain barriers have been penetrated with tunnels, such as the Eisenhower tunnel through the Continental Divide west of Denver. Over 470,000 major bridges span rivers and canyons and cross bay areas such as those of San Francisco.

Few people realize that while I was Utah's Director of Highways in the 1950's, I was also Admiral of the Utah Navy. This was a ferry across the Colorado River at Hite. With the building of Glen Canyon Dam and the creation of Lake Powell, the Navy has now been replaced with a bridge - and the Admiral of the

Utah Navy became an endangered species that disappeared, a casualty of the changing world.

Our Interstate highway was labeled the world's greatest public works undertaking, which indeed it was. In 1959, a year after I was enticed to go back to Washington, D.C. as United States Commissioner of Public Roads to get the lagging states into high, we were excavating and compacting every day over 20 million cubic yards of earth and rock into beautiful, safe, smooth riding highways all across America.

So today, with over 170 million cars, trucks, and buses on our highways, America has become one big neighborhood for social activities and a gigantic assembly line for production. On an average, we each travel about 13,000 miles per year on our highways, with access to all the beauty and magic of scenic America and to the vitality and excellence of America's great cities. Engineers planned and designed and built this transportation system that has changed America. But we left some problems for you to solve. We are not adequately maintaining our public works, and your challenge is to communicate this problem more effectively than my generation has done, so this will be corrected.

Our first air flight was in 1903 but it took 22 years before the first commercial activity got underway with awarding of the first air mail contract. Today we have 200,000 general aviation planes, about 5,000 commercial jets using our 15,000 airports. Our commercial passenger planes carry about 400 million passengers per year within America. The millions of passengers on worldwide travel, in planes such as the 400-passenger jets, is making this a small world - no spot on earth is much more than a day away from any other spot.

And ever since Cousin Neil Armstrong landed on the moon and we've had a good look at our spaceship earth, we are better appreciating what we've got - this is it - and we've got to take good care of it. And we certainly can now appreciate how small it is.

For instance, shortly after going to Washington as U.S. Commissioner of Reclamation, and while still eager to improve the world, I left my office at 4:00 p.m. on Tuesday, spoke at a water resources conference dinner in San Francisco that evening; had a breakfast meeting in Honolulu with Hawaiian public works officials where they went all out to keep me alert; spent the afternoon in Manila meeting with our team of Reclamation engineers there; and that night and the next morning I was in Bangkok, Thailand attending and giving a talk at the United Nations Regional Natural Resource conference; then to Athens, Greece for a short meeting; then to London to inspect facilities for fabrication of high voltage cables for Grand Coulee Third Powerhouse; and then back to Washington, D.C. arriving there so I could check into my office and begin

testifying to a congressional committee at 11:00 a.m., I think it was on Friday, I'm still not sure. I don't recommend such a trip. Most of the time I couldn't tell whether I was sleepy or hungry; and I'm still not sure whether overall I'm a day ahead or a day behind as a result of crossing the International date line. But this I am certain of, our world is sure smaller than it used to be.

The rapidity of today's change is illustrated by my father. As a young man he drove stage coach through the wilds of southern Utah, Nevada, and California, and lived to fly from Los Angeles to New York in four hours, and he nearly made it to see Cousin Neil land on the moon. Dad was quite observant and had a quick wit. As we were about to take off in Los Angeles, a Marriott food service truck drove up to load lunches for the flight, and knowing Bill Marriott, we remarked concerning his remarkable success story, which received a major impetus from his pioneering food services to air flights.

As we landed at New York, I remarked to Dad, "Isn't this fantastic, clear across the continent in four hours!" He agreed that it was wonderful and was hard to believe. Just then a Marriott service truck drove up and Dad said, "Bill Marriott's lunch wagon didn't do bad either."

Water is one of our most important resources, a necessity for all life in our world - and especially precious in our arid areas. We have an ample supply on a worldwide basis, but for people, it is often in the wrong place at the wrong time and in the wrong quantity. Rampaging, destroying floods are nature's most destructive force and have wrought more damage to civilization than all other natural forces combined.

When I was four years old we moved from Cedar City to Idaho, about 12 miles northeast of Idaho Falls where Dad bought a farm alongside the Snake River. A year later, the all-time flood of the Snake washed out all our crops, and washed away most of our farm along with Dad's lifetime savings. And so 28 years later I gained great satisfaction from designing Palisade Dam which stores the raging flood waters for use later in the summer when crops dry up and die without water. So Engineers work with nature to control floods, store the otherwise destroying flood waters for use when needed, and provide canals and pipelines to transport water to the areas of need. And that's one reason I became an Engineer.

One third of the land area of the world is arid where there would be little life without the magic of water. But with irrigation, the deserts have become veritable gardens. The control of water has progressed with the development of engineering capabilities until today, for example, we have about 80 million acres of irrigated land in America providing heavy production of high

quality food. This has involved large dams and reservoirs, canals and control works, most of which have been constructed the last 50 years. I've been on the construction of 12 dams and I was responsible for the design of 32, half of which have been constructed.

Hoover Dam, completed in 1936, was the nation's first large multipurpose water resource project, providing flood control, irrigation, hydroelectric power, municipal water, river regulation, fish and wildlife, and recreational benefits. Many other large multipurpose projects followed, such as the Central Valley Project in California and its key Shasta Dam structure and the Provo River Project here in Utah, with its key Deer Creek Dam where I invested four years of my life as materials Engineer.

Municipal water systems have come a long way from the village pump of the "good old days" - the good actually existed only in fantasy. The village water periodically became contaminated and water-borne diseases reduced the urban population by 10 to 20 percent. We sometimes forget that only about a hundred years ago, the water supply of Chicago became contaminated by floods and 90,000 people died, 12 percent of the population.

Water treatment and delivery, which makes our large cities possible, have improved to where quality water at the tap is expected without question nationwide, although we are still working for improvement and have much to be done as increasing populations and the supporting industries generate more pollution that we must minimize and treat. In 1981, I officiated as Senior Vice President at the annual conference of the International Water Resources Association in Lisbon, Portugal as we cooperated with the United Nations in launching the Decade of Clean Water to get worldwide efforts underway to provide potable water to all people in the world. That objective will not be reached this decade, although a good start has been made. This is another goal we have left for you to reach.

Our seaports and navigation systems have come quite a ways since the wind-powered ships landed at Plymouth Rock. In America we now have 32,000 miles of navigable inland waterways where 2,000 commercial barge companies transport over 250 billion ton-miles of freight each year. Large ocean-going ships now have access to the middle of the continent with the 1956 completion of the St. Lawrence Seaway and Power Project where Florine and I invested four years of our lives. As Project Engineer, and with the help of 17,000 workmen and over $100 million of construction equipment, we completed this billion dollar project (with today's costs it would be over $6 billion) in 3½ years. For me it was an engineering paradise.

Engineers have planned and built the public works - the streets and highways, water systems, waste disposal systems,

communication systems, energy systems, lights and power systems- that have given our cities the potential of being wonderful places to live, and have created our neighborhoods. Thus we truthfully can be labeled "The Miracle of America." And while we have shortcomings still - and are continuing to struggle to improve - we basically are the envy of the world. America, and what America stands for - freedom, opportunity, hope, recognition of the dignity of each individual - is still a beacon light around the world. This is so, despite the cynical pessimists and our periodic self-flagellation episodes, promoted by our adversary news commentators. In my travels around the world, I've often been touched by the greetings I've received when being introduced as an American - greetings in many languages which roughly translate to "God is good to you."

Engineers conceived, planned, and built industrial facilities which enable us to utilize nature's mineral and energy resources to produce goods and make life better, worthwhile, and more secure. And industrial operations have been continually improved. Pollution effects are being reduced by pollution control facilities. And Engineers, working with medical disciplines, have designed facilities to produce medicines, to build artificial organs and provide life saving equipment for people.

In agriculture, the growing of food has progressed a long way. For instance, at the beginning of this century, agriculture methods weren't much different than in ancient Egypt - one man on the farm produced food for only 2 or 3 off the farm. In 1953, for example, in America this increased to 16 off the farm. But today Engineers have designed and built machines and facilities that make farming operations efficient, provide effective fertilizers with proper application, and provide control of water, all of which enables the timely planting, cultivation, and harvesting of crops. Now one man on the farm in America provides food and fiber for over 80 off the farm - and 3 years ago we exported 60percent of our wheat to help feed a hungry world. However these improved facilities and methods are becoming available in other areas of the world, and this year we will import more agricultural products than we export. This gives your generation another series of problems to solve.

Further a higher percentage of crops grown, becomes quality food reaching our tables, such as fresh vegetables the year around. We now harvest crops at the peak of quality and efficiently transport them from all around the world. Packaging preserves the quality all the way to the consumer. Our distribution systems makes available to the average person in America a variety and quality of food unequaled in all history - much greater than that available to Kings of yester-year. We are able to do this with intelligent engineering application of technology and energy.

Further, and we don't always appreciate this, we do it with a lower percentage of our income than anywhere else on earth, and lower than every before in history. From 26percent of our income expended for food in 1946, the cost has steadily decreased until it reached 14percent in 1970, and now has leveled off at just above that level. The next lowest nation is about 25percent. So you see Engineers of my generation have helped farmers provide a $200 to $300 billion a year dividend to the consumers of America.

I hibernated the two years of 1974 and 1975 writing the History of Public Works in the United States - 1776-1976 as a contribution to our Bicentennial celebration. That increased my appreciation of how our free enterprize system - even with all its faults and shortcomings - with its vitality, and its generation of individual responsibility, has accomplished wonders. We need to keep reminding ourselves that in just 200 years, through freedom, innovations and hard work, America has changed the world. And with our highways including the Interstate system, our thousands of dams and man-made lakes and waterways including the St. Lawrence Seaway, our industrialized farms, our modern cities, my generation of Engineers has literally changed the face of America and of the World - and changed your life and mine.

The progress Engineers have made possible in agriculture, industry, medicine, transportation, natural resource utilization and all the rest, now for the first time in all history, we can dare to hope for a good life for all people all over the world. For we now have the technology and the capability to utilize the world's resources intelligently so that we can, collectively with the rest of the world, accomplish that goal. And that is the challenge my generation hands to you. Remember resources and a quality environment basically are a function of applied technology, a direct result of the capabilities and performance of Engineers.

A report just last month by the U.S. Commerce Department points out that today we in America are enjoying a better standard of living with more income, more money spent on leisure activities, and more affluent lifestyle than ever before. My generation has had our standard of living increased about 20 percent each decade. The amount of goods and services consumed by each individual has doubled in the last 30 years. And it goes on and on with statistics of improvement, and it is improvement made possible largely by engineers building the physical base and the capabilities for our society.

These accomplishments have been possible because Engineers have harnessed energy sources to perform work. Progress was very limited when dependent only on the muscle-powered energy of people or animals. Steam powered engines harnessed the energy of burning coal and wood. Then in 1857 the convenient energy resource, oil, was discovered in a 57-foot well at Titusville, Pennsylvania, and the petroleum age was born. The utilization of oil was

violently opposed by an environmental group of that time, because they claimed the oil was in the ground for a purpose, and that was to fuel the fires of hell. And the environmentalists vociferously proclaimed that if the oil was removed,the wicked would not receive the punishment they so richly deserved, and that could not be tolerated.

But others prevailed and oil began to replace coal, and today even with coal, hydropower, nuclear reactors, and other energy resources, we are dependent for 75 percent of our energy on our finite oil and gas, which is rapidly been used up. And this is a most serious problem my generation is passing on to you to solve, and not just for America but worldwide. And this challenge is far greater than ever before because the survival of civilization is at stake.

Here's why. When my Dad drove stage coach through the wilds of Southern Utah, it didn't matter much what happened on the other side of the globe. If any effect occurred, it took years for it to be felt in the great American desert. But today with our supersonic travel and our instant pictorial communication, what happens anywhere, immediately happens everywhere on this spaceship world of ours.

When I was born there were about 1½ billion people in the world. Now there are 5 billion of us - and by the time most of you reach your 50's, there will likely be 9 billion people. After that objective analysis and studies indicate the population will stabilize at maybe 12 billion.

At present 17 percent of the population is in the countries we consider the industrial free world - that is Western Europe, North America, Japan, and Australia - and by the year 2020 we'll represent only 10percent of the world's population. The centrally planned countries, Russia and China and their satellites, now compose 33 percent of the world population; by 2020 this is expected to be 25 percent. The developing countries now include 50 percent of the world's population and by 2020 will comprise 65 percent, and will then involve about 6 billion people. They will be working for improvement, struggling for security and for better human conditions to make life worthwhile. In many areas the struggle is to escape the tightening bonds of extreme poverty and misery and disease - where now mercifully life is short. And what happens to the people in the developing world, happens to you and me for we are involved in our one finite world grown small. Our most urgent task is somehow to bridge the economic gulf that exists between us and the developing countries. As shown by this map, the 17 percent of the world's population in the democracies consume 60 percent of the income; the 33 percent in the centrally planned countries have 25 percent; and the 50 percent in the developing countries have only 15 percent of the

income. This is a basic problem for you to solve. Then other problems will yield.

You see, when millions of people face stark survival, social and political chaos results. And our technology along with production creating our good life, has also produced weapons of destruction that literally can destroy civilization. So we must as Engineers work with all other disciplines in helping people all over the world to cooperatively work together. And we must solve the mal-distribution of resources and people, not by destroying our standard of living, but by making it possible worldwide. This requires building trust among nations. For less than 20 percent of our world armament costs, solutions to most of our problems could be financed.

And it can be done; it is now up to you. Basically energy and its intelligent use is the key. The 80-nation World Energy Conference has been working for 60 years to promote the efficient and effective use of energy for the benefit of all mankind. I have been heavily involved for over 20 years. Each year an executive committee meets with 2 to 30 delegates from each nation,and every third year a full-scale congress is held with 4 to 7 thousand delegates. There is continual activities with a multitude of committees. Following the 5,000-delegate congress in Detroit in 1974, at the end of my term as Chairman of the U.S. National Committee, we organized the International Commission on Energy Conservation and spent four years determining and analyzing the world's energy resources and needs.

The commission consisted of 80 members whom we considered to be the most knowledgeable, energy wise, in the world. In addition large task forces were involved in each of the energy areas, such as oil, coal, nuclear and so on, and including a large group analyzing energy needs. This was headed up by Cambridge University in England with one of the world's largest computer complexes. I headed up the task force on hydraulic energy resources. We met every other month at various locations around the world where each task force would present the progress being made in their studies, and then the reports would be discussed and scrutinized by the full commission.

In analyzing energy needs and resources it was necessary, of course, to look at all the natural resources of the world as related to the most likely growth and change in people populations. The results have been published and have been continually updated since; my statistics have been developed from this study. I could spend the rest of the day discussing these reports, but you've got to get back to classes.

Basically the bottom line is this: there are ample resources, including energy, to take care of people in the foreseeable future; and the carrying capacity of the world is likely twice

the 9 billion expected by 2020. This is on the basis that all people cooperatively work to apply our technology with intelligence to provide for our needs, and at the same time, keep in balance with our natural environment. It is on the basis that our political activities will be handled with wisdom so that we don't self destruct. And it is on the basis that education will progress so that people everywhere become assets instead of liabilities.

As mentioned, our immediate problem is our worldwide increasing use of, and over dependence on, our convenient finite oil and natural gas. This chart shows our dilemma. We have a physical capability of producing perhaps 25 percent more oil than we are now using, which gives us our present "oil glut", and lulls us into complacency. But there is a finite supply of oil, and some say actually we are heading for the cliff at 80 miles an hour.

Taking into account all variables, by the world's most knowledgeable oil authorities, it is likely that we will peak out at about 80 million barrels per day in 10 or 15 years, and then drop rather sharply to half that mount or less. Our growing needs for oil, caused mainly by the increasing populations and improving human conditions in the developing world, will then exceed our physical capability, and unless we have other energy resources available to fill the widening gap between needs and supply, we face worldwide chaos. Further, our studies indicated that coal and nuclear are the only two resources that can produce enough energy to fill the gap, and there are problems with both, although we are making progress in solving them. The extensive research program regarding coal carried on at this University, is helping solve the problems. Then, 40 years or so ahead, hopefully we'll have the engineering problems solved on how to mechanically harness the energy of 2000 degrees Centigrade temperatures from nuclear fusion; when this becomes commercially viable we'll have it made.

The biggest problem you face as Engineers in a fast changing world is not technology itself, for as the Japanese proclaim: "What man can dream, technology can achieve." Your problem is communicating and working with other disciplines to define the programs needed and then to get support so they can be accomplished. Our society is now sophisticated enough to question everything - and also is just sophisticated enough to be suckers for half truths, especially when they are used by charlatans to mislead, frighten and alarm. This puts a double burden on Engineers in this age of technology, when few in the political arena or in our news media have a technical background; too many are technical and physical dimension illiterates.

You, as professional Engineers, must have a broad-gaged understanding of the overall systems that operate to improve the welfare of people - and of our political system - and an understanding of people so that you can work effectively with other disciplines

and the general public in accomplishments. Your assignment as Engineers is to put pieces of technology and science together into a system to make life better for people, to solve the problems of people and to maintain an overall quality environment. Then you must communicate understanding. This is not easy. So you must be sure to sharpen your communication skills.

From a careful objective viewpoint, it seems to me that even with all our difficulties, our problems, and our periodic stupidities, progress actually is being made. For instance, our multi-billion dollar per year program is now beginning to clean up some of our polluted rivers so that fish swim in them again. Our air quality is vastly improved, although we still have a ways to go. Our wastes are being more effectively handled; waste dumps are being turned into areas of beauty such as this garden, the most beautiful I've ever seen.

Structures are being built that are functional and beautiful. As we built for the future, where appropriate such as in Boston, we also preserve the treasures of the past. And Engineers build for man's spiritual growth, and to inspire and to lift up our perspectives, so well illustrated by the St. Louis arch, the Gateway to the West.

And as Florine and I have traveled around the world involved with consulting assignments and with activities such as those of the World Energy Conference and the International Water Resources Association - In India, Istanbul, Saudi Arabia, Bucharest, Tokyo, Hong Kong, Bogota and most other places - and in Moscow with its incomparable ballet - we can see great hope because of the basic greatness and goodness of most people; of competent, high integrity, dedicated Engineers and officials, unselfishly working for peace and betterment of all mankind, and struggling to build faith and trust between nations. And the United Nations, even with its faults, provides communication so we can move ahead. And our multinational corporations and the hundreds of millions of tourists around the world, increases our understanding and appreciation of each other. Organizations, such as Rotary International with a million top leaders in 60,000 clubs in 160 countries, with the guiding principle "Service above self", are having a tremendous impact for good.

One on one, most people are wonderful - and so we must be concerned for each other - and I believe this concern is growing and improving and along with it is increasing confidence and trust. For all around the world, even with all our problems and obstacles, we can see basic understanding and cooperation improving. And this our generation is passing on to you.

Keep in mind that all over the world we are all pretty much alike. That is so whether it is with Abdul Mohammed in the deserts of Sudan; or a hermit on the Salmon River in Idaho, the

river of no return; or a shopkeeper on the streets of Lahore, India; or working girls at the Electroshelia plant in Leningrad, Russia; or the resident engineer in charge of the Irongate Dam Construction on the Danube River in Rumania - she is a brilliant engineer and I had the honor of recommending her for membership, and she is now a fellow of the American Society of Civil Engineers; or a beautiful farmer's daughter in the corn fields of Nebraska. We are all in this world together - and it can be and actually is a great and wonderful world. And your job now is to keep it that way and improve it.

As we look down the road stretching ahead, I can see great hope and tremendous potential for the future. Our understanding and application of natural laws are steadily improving and we're learning more about our environment and about each other so that we can work and design and build and adapt with wisdom for a better balance between people all over the world - and between people and nature.

And I think there is an assured potential for all mankind and for man and nature to exist in productive harmony in the true sense. But if we can get away from negative obstructionist zealotry and from non-productive confrontation polarizations, and sit down and reason together, we're going to make it. And that is the challenge of my generation to you in the accelerating changes you are going to encounter, changes which you will help bring about - and control - and guide. And along with your technical abilities this requires your working to continually bring out the best in people, and above all, to bring out the best in yourself.

For this is a beautiful world - and the environment, both natural and man made, is and continues to be uplifting and inspiring and helps to keep a positive perspective in a changing world.

Along with your knowledge and capabilities you must hold tight to those attributes which have made America great - those attributes that remain constant despite the batterings of change and time. These include high ethical standards, truthfulness, integrity, hard work, and responsibility. Keep concern for each other; be involved with people; remember the golden rule; work for spiritual growth and development; recognize and maintain and continue to improve your personal worth and potential. And as you grow and develop and become, don't ever forget the importance and the great worth of every individual, and of yourself.

These are now your challenges as Engineers and as individuals in today's world. It is actually the dawn of a new age where with understanding, capability and technology, your generation can bring about a good life for all people all over the world. The potential is there and it is real.

And as I meet with and talk to groups like you all across America and consider your potential, I'm more convinced than ever that from my generation to yours, if you will just get with it- and I'm sure you will - there are great days ahead. Good luck.

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