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In the Wake of the Fukushima Daiichi Accident

For EarthEcho International by Cathryn Berger Kaye, M.A.

NUCLEAR ENERGY

Interview with Susan Hess, AREVA, Inc.

Nuclear energy often makes news headlines. The issue has become even more relevant since the March 11, 2011, earthquake and tsunami that damaged the Fukushima Daiichi Nuclear Power Plant in Japan. To better understand this issue, Cathryn Berger Kaye, on behalf of EarthEcho International, spoke with Susan Hess, Director, Public Relations and External Communications for AREVA Inc. on February 15, 2012.

According to Ms. Hess, "AREVA is the leader in clean energy solutions, primarily nuclear; however, we also have an arm in renewables—offshore wind, solar, and biomass. As Director of Public Relations and External Communications, I get to go out and talk to people about clean energy and have fun doing it."

What are the basics of how nuclear energy works?
Just to give a bit of historic background to start, nuclear energy has been around in the United States since the end of the 1950s before making its way to several European countries. Some of those countries still use nuclear energy to this day, as does the United States. There are different kinds of nuclear reactors, the main being: 1) a pressurized water reactor, and 2) a boiling water reactor. The pressurized reactor turns water into steam, which goes through tubes and turns a turbine that makes electricity; this electricity leaves the power station where it is generated and goes to substations through high voltage lines, and from those substations follows the power lines into your home—so when you flip a light switch, the lights go on. The boiling water method boils the water to make the steam to produce the electricity. Otherwise, the processes work more or less the same.

What makes this process "nuclear"?
Basically, nuclear energy generates when a uranium atom is hit. Some atoms are unstable, meaning they separate and form two nuclei and emit particles. The particles are like rockets, shooting in all directions. They stop when they hit an obstacle, like another nucleus. That causes another reaction, and so on. The nuclei of some of the atoms break into smaller pieces. This reaction is nuclear fission and gives off an amount of energy in the form of heat. All forms of generating electricity need an energy or fuel source. In solar energy, for example, the fuel is the sun. In nuclear energy, the fuel is enriched uranium-235, a highly radioactive substance, and the chemical process employed creates nuclear fission.

How does this work?
A solid form of uranium-235 is put into pellets—each pellet looks sort of like the eraser on the end of a pencil. These pellets are stacked in fuel rods and these fuel rods are bundled into a fuel assembly. The fuel assembly is placed into the reactor, along with water used

as a shielding mechanism. This water keeps the radiation and resulting energy inside the reactor rather than freely dispersing it. The nuclear fission occurring in this immersion heats the water, makes steam, and makes energy. Control rods enhance or stop nuclear fission from occurring.

How much do we depend on nuclear energy in the United States and in other countries?
Nuclear energy provides a little over 20% of the energy in the United States, meaning that about one out of every five homes is essentially powered by a nuclear power plant. In comparison, 80% of France's energy is provided by nuclear power. There are countries all around the world that depend more or less on nuclear power plants for their energy supplies. Currently, 435 nuclear power plants operate globally, with 104 in the United States.

In the United States, nuclear energy is part of the entire energy grid. There are 31 utility companies across the country with nuclear reactors as part of their generation system. This means that all of the nuclear energy produced goes onto the power grid along with the other sources of energy. For example, Arizona has the biggest nuclear power plant in the United States, with three reactors. The energy they generate benefits users throughout Arizona and helps provide power to Los Angeles.

Are there plans to decrease or increase dependency on nuclear power in the United States?
There are currently plans to expand. The Nuclear Regulatory Commission (NRC) is reviewing new designs from the nuclear reactor vendors, of which AREVA is one. At this time, the NRC has approved the construction of two Toshiba Westinghouse nuclear power plants in Georgia. This country has not built a new reactor since the accident that caused a partial-core meltdown at Three Mile Island nuclear power plant in Pennsylvania on March 28, 1979.

Countries around the world differ in their philosophies on nuclear energy. At the moment, China is building new nuclear power plants. France and Finland are each building one nuclear power plant. India is looking into designs.

Of course the situation in Japan raised new questions about the safety of nuclear energy across the globe. Germany has shut down seven of the oldest nuclear reactors in their reactor fleet. They will shut down all of their nuclear power plants when they establish how they will replace that power with other sources. They had this plan before Fukushima but were still unable to determine adequate power sources. Italy has called a one-year moratorium on construction of nuclear facilities.

What actually happened in the Fukushima Nuclear Power Plant on March 11?
We have learned more about what happened throughout the course of this year. The earthquake occurred at about 2:45 pm. This earthquake registered a 9 on the Richter Scale, a very large earthquake and the largest Japan had ever experienced. Then, 41 minutes following the quake, the first of a series of what appears to be seven tsunamis began.

The first one was estimated at 13 feet, probably the smallest. The nuclear power plant was designed to withstand a tsunami in this height range so this was manageable.

Although the tide gauge failed to measure the height of the second wave, all indications suggest that it was about 25 feet, and this began the damage. At least one wave was measured at 46-49 feet based on water level marks on the buildings.

The Fukushima Power Plant was designed with earthquake and tsunamis in mind. All power plants are designed for their seismic area and have seismic design parameters they must meet. Unfortunately, the earthquake and tsunamis that occurred on March 11, 2011, were at strengths and heights that exceeded all expectations. The Fukushima Nuclear Power Plant was designed to withstand a magnitude 8.2 earthquake; the 9.0 earthquake was stronger. The plant was designed to withstand a tsunami of 18.7 feet. These tsunamis flooded and caused damage to some of the emergency diesel generators and the switch gear rooms. In essence there was a lot more damage than what anyone could estimate at the time of the actual event.

When the earthquake hit, all of the Fukushima reactors responded according to plan. Three of the reactors had previously been shut down for maintenance. The three in operation—reactors 1, 2, and 3—shut down automatically as they are supposed to do when an earthquake occurs. To make matters worse the tsunamis came with such force that they took away—I mean literally removed —some of the backup systems in place at the plant, including the backup diesel fuel generators and some of the diesel fuel. Some of their DC power from batteries was available for a limited time, though soon there was no power to the plant. Nuclear power plants, all power plants, require energy to operate. While nuclear power plants generate electricity, they don't necessarily create energy for their own use. With power sources flooded throughout the region and power lines damaged, the Fukushima Power Plant was unable to access electricity from plants in unaffected areas anywhere in Japan. This was a critical situation. The batteries at the plant could only sustain safe operation for a minimal amount of time and not for the amount of time needed to make the plant secure.

It's taken the full year to reveal what we know now, and it will take many years to really go in and clean up the area sufficiently. We will never know exactly what happened. You just can't, because the damage wasn't just at the reactor. The damage was all along the Japanese coast.

Over 500 residential buildings were gone as were other essential parts of the infrastructure— roads, railways, and public buildings. They lost all electricity. Worst of all, thousands of people lost their lives. The tsunamis covered about 217 square miles and there are still 4000 people missing. Even as we concentrate on what happened at the reactor site, we must remember first and foremost the sorrow and damage that all the people of Japan suffered.

How did this create a state of danger?
There was an unidentified release of radiation from reactors 1, 2, 3, and 4. In nuclear power plants, water acts as a shield covering the nuclear fuel. The force of the earthquake and tsunami resulted in the hot cores in the four reactors being deprived of the necessary coolant leaving them partially uncovered; we don't know how this happened since entering the plant still has associated dangers. The high level of radiation tempers what people can do inside the building; we want to avoid undo harm to the people who

have to go inside. Robots, used in many nuclear plants, have been developed to eliminate human exposure to these high levels of radiation.

What is for certain is this: eventually there was no water left in the plant, so this fuel got hotter and hotter and hotter, and there was an explosion from a buildup of hydrogen in units 1, 2, and 3. Hydrogen was released inside the containment building following overheating of the reactor core, and the overheating and melting of fuel rods. Exposure to other accumulated elements caused a fire and explosion. This released radiation into the atmosphere.

Per their safety guidelines, the area was evacuated. The priority was protecting the population. The challenge was containing the radiation with no power and no clean water, and to keep the fuel cool so that they would not have a second explosion. So the plant managers began pumping sea water into the plant to cool the reactors.

What is the current situation at the Fukushima Nuclear Power Plant?
Right now in the Fukushima Daiichi Nuclear Power Plant, all the damaged reactors are under control. This is only one of the power plant sites in Japan, which has a total of 55 reactors in the country, six located at the Fukushima site.

The choice to use sea water to cool the reactors essentially destroyed the plant's reactors, since sea water is harmful to their operation. Reactors 1, 2, and 3 are permanently shut down, though this process will take several years to complete. Why so long? It will take years to ensure the fuel is cool, to determine what parts of the reactors were damaged and what were not, and to ensure that the radioactive part of the reactor is properly stored and contained. There are still international teams examining data and continuing to determine what happened and the sequence of the occurrence. The whole world is still watching. There is much that is not known and this also will take years to decipher.

Are people who work in nuclear power plants at risk?
Employees at the Fukushima plant did the best they could within this situation, and many people who worked at the plant placed themselves at personal risk to protect the larger community.

Unfortunately this was a natural disaster of extraordinary proportions. The employees did the best they could given the magnitude of the situation. They also performed a lot of their work in complete darkness–passages and rooms were flooded and there was no electricity on site. Many lost their homes and families yet they continued to work. Some workers slept on the floor of the station. They experienced food shortages and may have had a biscuit for breakfast and noodles for dinner. The dedication of the workers is beyond admirable. In some ways they sacrificed aspects of their personal lives to ensure their countrymen would have the minimal amount of harm.

One of my colleagues talked to people who were on the ground at the site. They were trying all they could to come up with remedies and solutions. For example, they knew they needed the backup power and some of the workers went outside to remove batteries out of their cars but the cars were gone, swept away by the tsunamis. They were thinking out of the box: How can we get more energy? They did everything they possibly could to keep

the plant safe. Still, there were two operators killed in Unit 4, trapped inside while performing inspections when the tsunami hit. And people continue working to this day in unified efforts to protect the Japanese population.

Are people still at risk of radiation or contamination from this incident?
Much has been stabilized. The reactors are not operating. The other plant up the coast is also not operating. Quite a few of their power plants are not "on the grid" right now due to extensive inspections. As an industry, we take safety most seriously. The safety of our plant workers are our utmost priority. We have redundant systems, meaning backup systems for backup systems.

Think about this: there are people who live near and work in the power plants every day of the week. These folks do their jobs well so their families are safe and also so communities safely receive the energy produced by the power plant.

How are United States regulations different from those in Japan? If a natural disaster caused a breach of operations how would we respond and how would we be effected?
In the United States, we have the Nuclear Regulatory Commission (NRC) that oversees the 104 operating nuclear power plants in the United States. The NRC has a staff of about 4,000 people and a budget of roughly $1 billion dollars a year. They are responsible for ensuring the established rules and regulations are strictly adhered to. Each plant has at least one if not two NRC staff on site every day of the week, and most live within the same communities where the plants are located. This on-site monitoring is a key part of maintaining the safety. So there is no excuse. With this level of supervision, a plant operator can't suddenly say, "Oops, I forgot," or "I didn't know that." The rules must be followed.

In the aftermath of Fukushima, we are revisiting the safety procedures of power plants in the US and making them even more strict. We are re-evaluating documentation from when they were first built and reviewing all maintenance upgrades.

Each country has its own safety authority. They all have their regulations to a greater or lesser extent than the United States' NRC. Culture plays a part in the differences among models.

Culture also plays a significant part in a country's response to disaster. In Asian culture, for instance, asking for assistance can be considered shameful. Keep in mind that the situation in Japan was unprecedented in Japan and everywhere in the world. Because of all of the damage to the country, especially the structural damage to the roadways and bridges, it was difficult and at times impossible to get to places in Japan where help was most needed. In the aftermath of the earthquake and tsunamis, the Red Cross and volunteers who wanted to help couldn't even get to the sites. If only that first tsunami had hit, the reactors would not have suffered these horrendous consequences. These seven tsunamis that happened within a short timeframe, just minutes, resulted in this horrific scenario.

Why should we utilize nuclear energy when it has so many risks?
Nuclear energy is a carbon free energy source; no carbon is released in our atmosphere when nuclear energy is generated. Nuclear energy helps curtail the climate change we

generate electrically. Also, with nuclear energy, the baseload, the minimum amount of power a utility company must make available to meet customer demands, is available 24/7, 365 days a year. A nuclear power plant keeps operating nonstop for up to two years. With unpredictable fuel costs, it's relatively inexpensive to operate a nuclear power plant. We know how much uranium is around and how much we are paying since contracts last for five, ten, or fifteen years. And while not practiced in the United States, some countries recycle used nuclear fuel and this helps to establish a lasting energy source. In the United States, used nuclear fuel is stored at each individual nuclear power plant site.

How can we be sure nuclear reactors are safe?
By taking information we have and making concerted efforts through research and development to continually make designs more efficient and safer. This is what AREVA does daily. We apply global lessons locally. We are still helping in Japan to understand what happened and applying gathered insights to reactors here in the United States. As are many people, not just the United States or our company, the industry is lending a hand and learning. We apply every lesson learned to the best of our ability as future generations continue working and improving the delivery of nuclear energy.

How have changes in environmental awareness impacted the field of nuclear energy?
I think carbon emissions have played the largest role. We pay attention to how much we drive and consider electric and hybrid cars. We recycle. We take actions that are good for the environment. And if you step back and look at a carbon-free energy sources, you have to consider nuclear energy.

We even have the ability to recycle used nuclear fuel. This is already being done in other countries, though not in the United States. The technology was developed here, but in the 1970s under President Carter a law was passed that the United States could not recycle used nuclear fuel due to his concern about non-proliferation or the reduction of nuclear weapons. So rather than recycling, we store this spent fuel. We could actually recycle 96% of this used fuel, a tremendous reduction of what is now seen as hazardous waste. An informed populace may want to help change this law.

Where is the science of nuclear energy headed?
Nuclear energy is headed to a safer, more secure future. By "more secure" I am referencing our present dependence on foreign oil. Nuclear energy is here in the United States, the fuel source is here and in Canada and other counties who are friendlier than some oil-rich countries. Nuclear energy is built on a strong foundation. The nuclear industry has systems that operate with multiple backup systems, and backup systems to those backup systems. We live is a world where one backup system isn't good enough and now we may require a fourth or fifth to be more confident. We are headed for a safer and safer industry and surely one that integrates very sophisticated technology.

What would happen if we stopped nuclear energy production in the United States?
Nuclear energy in the United States supplies about 20% of our energy daily. If you didn't have 20% of your energy this would be equivalent to one day a week with no computer, telephone, lights, air conditioning, or heat. This might be drastic but we need to think about this reality. Those in favor of shutting down nuclear power plants haven't yet offered alternatives to supplement and replace the energy these power plants now provide.

What additional thoughts do you have one year after the Fukushima Daiichi Accident?
When we think about Fukushima one year later, our first obligation is to look at the strength of the people who live and work there and throughout Japan. The workers at the plant continued to work through darkness and in an uncharted course. They didn't have all the dials and meters that we expect in a control room, they had no monitors. Still, they continued to work to protect their countrymen and the industry. They still are doing this now. We have come together as an industry to help where we can, to identify what went wrong, and to ensure no one else anywhere in the world will have to experience this kind of tragedy; however, in truth, we can't control Mother Nature. But we can sure do our best to mitigate some of the challenges she presents. There is a quote I use in presentations, a Native American proverb, "We do not inherit the Earth from our ancestors, we borrow it from our children."

Today, I know young people have the capability for great contributions and accomplishments. As long as you strive to learn with an open mind, you can make the world a better place. Our future depends on you.

MARINE DEBRIS

Interview with Nicholas Mallos, Ocean Conservancy

Nicholas Mallos is a conservation biologist and marine debris specialist for Ocean Conservancy. Nick manages a diverse range of marine debris projects at Ocean Conservancy including International Coastal Cleanup® data analyses, at-sea research in the North Pacific Ocean, and an inter-disciplinary working group on marine debris.

In May 2012, Nicholas will be part of an expedition that will sail along the projected path of the tsunami debris in search of answers to many questions regarding the quality and dispersion of marine debris from the March 2011 tsunami that devastated Japan. To better understand this issue, Cathryn Berger Kaye, on behalf of EarthEcho International, spoke with Nicholas Mallos on March 2, 2012.

What do we know at present about the debris generated by the tsunami in Japan?
This is first and foremost a human tragedy with significant impact on the lives of many Japanese people. We must keep this in mind at all times as we determine ways to be of assistance.

The tsunami on March 11, 2011, devastated the Northeast coastal region of Japan. Debris generated from this natural disaster was unpreventable. Homes, construction materials, fishing gear all washed into the sea. This is distinctly different from the common ocean trash comprised of our consumer products, largely plastics, which enter the waste stream every day and remain for a long time in smaller and smaller pieces.

Much about the tsunami-generated debris remains unknown or uncertain. What we do know is that a considerable amount of this debris is making its way eastward, riding ocean surface currents in the North Pacific. Researchers and experts estimate that 4 million to 8 million tons of debris washed into the ocean. Of this, it is largely unknown what is afloat and what will sink and degrade over time. At present, the estimate is that approximately 1 million to 2 million tons are still afloat. Up to 5% of this amount may make landfall in the next few years.

Where and when this debris will arrive on land is largely unknown. Models change daily and predictions remain as estimates. By 2013-2014, we expect to begin seeing this debris wash along the west coast of the US and Canada; the Hawaiian Islands may see this sooner. We do not know what this will look like. It may be hard to distinguish tsunami debris from traditional ocean trash that arrives daily. Initially, the abundance and dispersion of the debris was tracked by satellites; however, about one month after the tsunami, the debris field could no longer be tracked by satellite. Which means this large concentration of debris was already dispersed over a large region of ocean.

What risks does this debris pose?
While it's hard to predict the full impact, some of the debris can pose navigational hazards. Other forms of debris potentially washing into ecosystems could be a hazard to scuba divers and recreational swimmers. Fishing gear is designed with the intention of catching fish, so large fishing nets and gear set afloat could potentially entangle any form of marine wildlife as it makes its way across the ocean. Again, there is much uncertainty.

There is also the possibility that chemicals or other potentially hazardous (not radioactive) types of items like coolants were washed out. If they end up by sensitive reefs this could pose problems. These risks are among the unknowns.

Has any of this debris already been intentionally retrieved?
There is a record of a Russian vessel sailing out of Hawaii that came into contact with several fishing boats and home and construction materials at sea and did retrieve and return this debris to Japan. This is not common practice, both due to the vast area of the North Pacific Ocean where these items are dispersed, and because of the extreme difficulty and expense in carrying these items aboard a ship. There is information that a Japanese high school as well as other fishing training vessels off the coast of Japan have been looking and documenting some of the debris they are seeing.

Is it also likely that some of this debris will be added to the North Pacific Subtropical Gyre?
Research out of University of Hawaii leads us to believe that at least 95% of the debris will remain in the ocean and ultimately end up in North Pacific Gyre. This will be another contribution to the already massive problem we have out there. As this issue unfolds and we gain an idea and more precise estimate of the tsunami-generated debris, we will better understand and have a better sense of how this compares to our daily debris. At present we believe this to be a small piece of the established, larger problems.

What are the priorities of the Ocean Conservancy regarding all of this debris?
Because the debris is making its way across the Pacific and some will make landfall on Hawaii and the west coast of the United States, including Alaska, as well as British Columbia, we want to be out on the water to identify and capture a snapshot of what the debris looks like. This will enable us to report these findings and put in place adequate preparation measures to deal with this debris as it washes upon our shores.

In an ideal world, it would be truly wonderful if we could capture some of the tsunami debris and send items back to the Japanese consulate to be returned to family members. This remains one of the top priorities.

One of the big challenges is how to determine with the utmost confidence that the debris we find washing ashore was from the tsunami. As we move forward, we must examine items found onshore with great scrutiny and determine the likelihood that they were generated by the tsunami. I do not know any confirmed debris to date that has been confirmed as associated with the tsunami.

What can the general populace do regarding ocean debris?
This is most important: reduce the amount of trash entering the oceans every day to make a more resilient ecosystem, so that if another tragedy of this or any magnitude occurs, the ocean has the ability to be resilient and handle these events in a better fashion.

Trash continually enters our waterways and ocean system. To prevent more trash from entering our waters and to restore our ecosystems, here are two basic yet highly significant and impactful practices:

Clean up. Get out there on the ground and participate in Ocean Conservancy's International CoastalCleanup. Or any day, go out and pick up trash while strolling down the beach or walking along a river, lake, or down the street. Dispose of all trash properly. While it's hard to do something about what is already floating in the Pacific and other parts of the ocean, we can be sure that trash in our waterways and streets never has the opportunity to enter the water now. This simple yet essential act even boosts local economies because of the direct and indirect impact of healthy fish stocks, pristine beaches, and whale watching industries. Cleaning up is a vital step.

Stop trash at the source. Make sure trash doesn't occur in the first place! How? By re-thinking our daily choices and reducing the amount of one-time-use disposable goods. A host of available goods can actually make our lives more convenient. Reusable shopping bags are becoming the norm. Carrying a reusable water bottle saves money and dramatically reduces waste. In restaurants, ask your server to skip the straw in a beverage. These tasks are actually easy with just a little bit of effort to change our thinking. The real choice is either to go about our day and not pay attention or choose to be more attentive. Then we see options everywhere.

As noted, Ocean Conservancy sponsors the International CoastalCleanup. We also enter every collected item into a database and review this data carefully. Then, we approach the industry that manufacturers items posing a re-occurring threat. We have seen successes. For example, the plastic six-pack-ring soda holder is now made to break down faster if it enters the marine environment, reducing the chance that birds and marine life will become entangled. The Trash Free Seas Alliance®, a partnership of industry, academics, organizations, and government, is now collaborating to create solutions through re-thinking and reducing the impact of humans on our ocean systems. What's so empowering is that we have many of the answers, we know the solutions. Kids get it. There should be no trash on the beach or in the ocean. It's alien in nature. Now the challenge is to re-think our ways.

Where do we start?
With a first step. Start with a reusable bag—that's a huge first step. When this becomes a habit, add another step. Focus on where we can make our small difference today and tomorrow! With each person participating, we have a HUGE collective impact at the end of the pipeline the ocean.