

# JAPAN AND THE NUCLEAR NIGHTMARE

## Introduction

### Focus

In early March, a massive earthquake rocked a large area of northern Japan. The quake was followed by a huge tsunami that killed thousands of people and badly damaged a nuclear power plant. In this *News in Review* story we'll look at the quake aftermath and the desperate attempts to prevent a nuclear catastrophe.

**Note to Teachers:** Discussions of natural disasters may provoke emotional responses from students such as fear, anxiety, and hopelessness. Care should be taken before the lesson to ensure that the learning environment is safe and supportive. Journal writing and partner or small-group discussion are some ways in which teachers can ensure that students have appropriate time to process their feelings.

### Introductory Activity

1. Do you have personal knowledge about Japan (you were born there, have visited there, have friends/family living there)? If yes, share what you know about the March events, the landscape of Japan, and/or the potential risks of volcanoes and earthquakes.
2. List words that you associate with the term *nuclear meltdown*.
3. Do you think nuclear power is a good energy source? Why or why not? What information do you need before making your decision?

On Friday March 11, 2011, at 2:46 p.m. a massive 9.0 earthquake hit northeast Japan. The offshore quake occurred at a depth of 24 kilometres, about 125 kilometres off the coast. Aftershocks of considerable strength (7.1, 6.5, and 6.4) continued days after the first earthquake. The earthquake was so powerful that it rocked the Earth's axis, shifting it 25 centimetres, and shortened the length of the day by a fraction of a second.

The quake also caused a series of massive tsunamis that swept in to the northeastern coast of Japan, destroying boats, cars, buildings, power lines, trees, rocks, earth, and people. Massive fires, a byproduct of the quake and

aftershocks, burned in many northern communities. Buildings collapsed and landslides began. An oil refinery was badly damaged as were the country's nuclear power plants. The world held its breath as massive search-and-rescue efforts began, although the death toll was already estimated to be over 25 000.

Just as problematic was the fact that damaged nuclear reactors looked like they might melt down—and a full-scale nuclear disaster might occur. At the time this story went to press, there had been some progress on cooling the reactors and reducing the nuclear threat, but it was clear that radiation had been leaked, and that water, farms, and food had been poisoned.

### To Consider

View a photo essay on the destruction caused by the March 11 earthquake-tsunami in Japan. Write down as many single words or phrases that you can that express what you see and feel when looking at the pictures. Share your responses with a partner and note similarities and differences. Together, create a mind map that notes the short-term and long-term social, economic, and environmental impacts of this multi-faceted disaster.

Photo essays to explore include:

- *National Geographic*: "Japan tsunami: 20 unforgettable pictures"
- *The New York Times*: "Satellite photos, Japan before and after tsunami"
- CBC News Interactive Video Map: "Japan quake, tsunami cause 'major damage'"

# JAPAN AND THE NUCLEAR NIGHTMARE

## Video Review

### Did you know . . .

The total number dead in Japan is expected to climb to over 20 000, with another 500 000 people left homeless.

### Did you know . . .

On April 3, 2011, workers in the Fukushima nuclear plant discovered a crack in a maintenance pit that is believed to have been the conduit for contaminated water that leaked directly into the sea.

### Focus for Viewing

After discussion with a partner or in a small group, record your responses to the following questions.

1. To what extent can nations prepare for natural disasters?

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2. To what extent can people prepare for natural disasters?

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3. Predict why this disaster is of global concern.

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### Questions for Viewing

As you watch this video, record your responses to the following questions in the spaces provided.

1. How powerful was the earthquake that hit Japan on March 11, 2011?

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2. What did workers at Fukushima nuclear plant do to try to prevent a nuclear meltdown?

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3. List three hardships faced by survivors.

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4. What challenges are the self-defence forces facing in assisting survivors?

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5. a) Why are people scrambling to leave cities near Fukushima?

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b) Who are the "Fukushima 50"?

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6. How much time did the inhabitants of Noda have to evacuate when the tsunami alarm sounded?

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7. What are the prized possessions that one survivor shows the reporter?

8. What is the damage estimate of this disaster?

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9. What evidence is there that radiation has leaked from the damaged reactors?

10. Why has there been a run on purchases of seaweed in Canada?

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11. What is the predicted timeline to the end of the nuclear emergency?

### Post-Viewing Activity

1. Predict the possible impact of the Japanese earthquake-tsunami on Canada.

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2. What can we learn from this disaster?

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3. What additional questions do you have regarding the disaster?

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4. Do you know someone who has witnessed a natural disaster, or have you ever witnessed a natural disaster? Share these stories.

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5. Consider two or three ways in which you can become an active citizen versus a passive observer of this world event.

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# JAPAN AND THE NUCLEAR NIGHTMARE

## **VI** *Double Tragedy: Earthquake and Tsunami*

### **Did you know . . .**

The 1923 Great Kanto Earthquake in Tokyo killed more than 100 000. It registered 7.9 in intensity.

### **Focus for Reading**

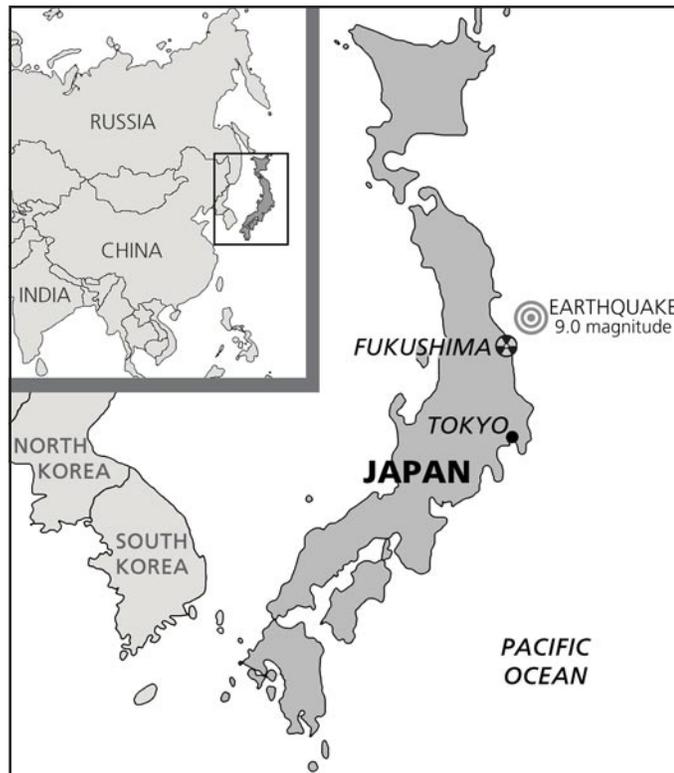
As you read the following information about the earthquake and tsunami, ask yourself if you would be willing to live on an island as vulnerable to natural disasters as Japan.

### **The Geological Reality of Japan**

Japanese people have always faced risk. Their nation is located in one of the most volatile regions of the world, known as the Pacific Ring of Fire. There are 75 active volcanoes in Japan, as well as four intersecting tectonic plates. Japanese people have long lived with the knowledge that an intense earthquake could occur at any time. With more than 300 tiny earthquakes rattling Japan each day, it's difficult to forecast when a big one will hit.

hit northeast Japan. The offshore quake occurred at a depth of 24 kilometres, about 125 kilometres off the coast. Aftershocks of considerable strength (7.1, 6.5, and 6.4) continued days after the first earthquake. This quake is the most powerful to ever strike Japan. Despite scientifically based government disaster planning and societal readiness for emergency situations, the earthquake and resulting tsunami were beyond the scope of what was anticipated. The quake was so powerful it rocked the Earth's axis, shifting it 25 centimetres, and shortened the length of the day by a fraction of a second.

The quake caused a series of massive tsunamis to sweep in to the northeastern coast of Japan, carrying boats, cars, buildings, power lines, trees, rocks, earth, and people away in its four- to seven-metre-high waves. Japanese officials urged people near coastlines to move to higher ground. Embankments that had been built to protect the coastal regions from tsunamis were crushed, causing the destruction of several communities and triggering a massive oil-refinery fire. A state of emergency was declared near a damaged nuclear power plant, prompting the evacuation of people living in that area. Massive fires, a byproduct of the quake and aftershocks, burned in many northern communities. Buildings collapsed and landslides began. The coast guard was called to search for ships that were swept away from shipyards, and several trains were derailed or missing. It was difficult to comprehend the extent of the



### **March 11, 2011: A Fateful Day**

The devastation the Japanese feared came on Friday March 11, 2011, at 2:46 p.m. with a massive 9.0 earthquake that

destruction that had occurred—but more challenges awaited.

### **Search and Rescue Efforts**

Hundreds of aftershocks with a magnitude of 5.0 or more occurred in the days following the earthquake. The official death toll was 27 000 on April 1, but Japanese officials predicted that final numbers would be much higher. More than 2 000 shelters housed more than 400 000 people who faced extremely cold and dire conditions. Prime Minister Naoto Kan ordered military, police, and fire personnel to work in communities across the affected areas, sifting through

debris in search of survivors and the dead. More than 13 nations assisted in Japanese relief efforts, providing everything from bottled water, boil-in-the-bag rice to blankets and power generators.

The destruction was both personal and economic. A major fire broke out at the Cosmo Oil Company refinery in Ichihara. Automotive industries such as Toyota, Mitsubishi, and Honda ceased operations. A major steel plant also stopped operations, as did Sony, the giant electronics company. Property damage estimates alone ranged from \$35-billion to \$100-billion.

### **Activity: Eyewitness Accounts**

As you carefully read the following eyewitness accounts, think about the emotional and personal impact of the earthquake-tsunami on the Japanese people. Predict some of the short-term and long-term psychological effects of a natural disaster of this magnitude.

“The only thing left standing in this area is the plant—you don’t know where your family [is], you don’t know what’s happened, but you have a job to do and you have to stick on it.” — Mr. Hawthorne, worker at the Fukushima nuclear facility (BBC World News, [www.bbc.co.uk/news/world-asia-pacific-12711152](http://www.bbc.co.uk/news/world-asia-pacific-12711152))

“We were in our second floor office when the first shocks hit. They were relatively gentle, the kind of thing that I’ve already felt since my arrival and that seem pretty commonplace for Tokyoites. It didn’t take long to register that this was not the normal passing tremor though, and as the force gradually built, my colleagues’ looks of acknowledgement started to look a bit more like panic. Then there was what seems like a few seconds of stunned silence. At this point the thought of getting under the desk ran through my mind, this being the one piece of advice I remember from my wife giving me some

basic emergency drilling. It was when we were outside that the most powerful tremors began to hit. Seeing our relatively old building visibly shake from the outside, the external spiral staircase we had all just run down loudly rattling against its side, I was glad to be outside. It was at this point that panic started to turn to fear, as we looked around at the surrounding skyscrapers visibly swaying, like trees blowing in the wind. It was only talking to people later that I learnt that this bendiness is part of what makes them resistant to quakes. At the time I was genuinely scared that one of these 100-story buildings could come down on top of us.” — Nicolas Roberts (“Japan earthquake eyewitness,” *The Christian Science Monitor*, March 11, 2011)

“I have never felt such a strong quake in my life. My flat is on the fifth floor, and the building shook slowly at first, then more and more violently. It was really scary. TV is showing a fire in a tall

building in the Odaiba area in Tokyo, and also tsunami waves carrying lorries and cars. It looks like there are more fires breaking out in Sendai, a major city in northern Japan. Until a few minutes ago I was with neighbours who jumped out of the building and shared what little information we had and consoled each other. Lifts have stopped in our building, and I guess have in most buildings. There are still aftershocks every few minutes.” — Yukiko, resident of Tokyo (BBC World News, [www.bbc.co.uk/news/world-asia-pacific-12711152](http://www.bbc.co.uk/news/world-asia-pacific-12711152))

“We stood amid the silence of Otsuchi and looked from horizon to horizon. They were picking over the remains of a town that no longer exists. As if earthquake, then tsunami were not enough, no sooner had the water retreated than fire engulfed this town. Fuelled by kerosene from cooking stoves and the wooden remains of thousands of houses, it burnt for two days and left nothing. Walking through it now, the stench of smoke is still everywhere. On Friday morning of last week, this was home to 17 000 people. Only 5 000

have been accounted for. They’re now calling this town ‘the lost town.’ And it’s very easy to see why. Anything the water left behind, the fire has completely consumed. There is nothing that tells you how Otsuchi once looked. Where streets ran, where houses stood, it is a shattering sight. We found Taka Akigoto, a town counsellor here, clambering back over the ruins. He had been looking for his home. ‘It’s all gone,’ he told us. Then he said, with a wry smile: ‘It was supposed to be earthquake-proof. But my family is OK.’ Every few minutes, the rescue teams were pulling bodies out, four here left for collection, another covered with plastic sheeting and a simple note attached saying where and when it was found. They do their best to give dignity to the dead, but there are simply too many to stand on ceremony. Juniichi Sendate had been at work elsewhere, and that’s why he is alive today. He knew why this disaster had been so deadly. ‘After the earthquake, the waves began almost immediately,’ he told us. ‘It was only about 15 minutes, so there wasn’t enough time.’” — James Mates (PBS News Hour, March 15, 2011)

## Follow-up

There is a psychological phenomenon known as desensitization that often occurs when we hear of large-scale human suffering or tragedy. When a problem is very large—like poverty in Haiti or HIV/AIDS in Africa—we sometimes turn away because the news is depressing and because we feel that there is nothing we can do to help. One of the ways we can overcome this tendency to become desensitized is to consider the personal stories of those affected.

1. Indicate which one of the quotes that you just read had the most impact on you. What was it about that particular story, or the details in the quote, that stood out for you.
2. Surf the Internet to locate other first-person accounts of the earthquake-tsunami. Select one or two that you find to be the most powerful. Be prepared to share those stories within a small group or with the larger class.

# JAPAN AND THE NUCLEAR NIGHTMARE

## Nuclear Meltdown

### Further Research

Find out the causes and resulting impact of the nuclear disasters at Three Mile Island (1979, Pennsylvania), and Chernobyl (1986, Ukraine).

### Did you know . . .

Nuclear power provides about six per cent of the world's energy and 14 per cent of the world's electricity.

### Focus for Reading

If nuclear power plants have been proven to be unsafe, why do we use them? Read carefully to understand more about the science of nuclear power and radiation to decide if the risks of nuclear power outweigh the benefits.

Japan's nuclear crisis remains a serious global concern. What will be the extent of the damage caused by radiation leaking into the ground, water, and air to Japan and the world? Two previous nuclear plant accidents that panicked the world include Three Mile Island and Chernobyl. Three Mile Island was ranked by the International Nuclear and Radiological Event Scale as a Level 5 event, Chernobyl a Level 7, and the Fukushima reactors damaged by the earthquake-tsunami in Japan a Level 6.

### Why Nuclear Power?

The demand for power continues to rise worldwide. Even with significant conservation efforts it will be impossible to meet increased demands. The world's fossil fuels are running out, and our understanding of the adverse environmental effects of burning fossil fuels is increasing. Hydroelectric sources alone cannot meet the world's demand for energy. Alternative power sources are needed—and these include nuclear, solar, wind, and geothermal. To date, solar, wind, and geothermal provide only a very small part of the world's energy. Nuclear energy can, and does, provide a great deal more energy than these other sources combined.

Advocates of nuclear energy point to the fact that nuclear power plants cause little pollution and are reliable and safe. They also argue that there are no real alternatives to nuclear energy, pointing out that humans continue to consume staggering amounts of energy. Unless humans are willing to drastically change

the way they live, nuclear power will be required.

Those who oppose the use of nuclear power plants claim that they are not safe; they produce radiation, and there is risk of serious accidents, including the possibility of reactor meltdowns. Opponents also point to the production of toxic nuclear waste—the byproduct of nuclear processing—which must be safely disposed of. Current storage facilities are not large enough to store the world's nuclear waste, which limits the amount of nuclear fuel that can be used per year. The transportation of this waste on roads and waterways is very risky. Plus, there are questions about whether this toxic waste can be safely stored for any period of time.

### How Nuclear Power Works

Nuclear power is created when radioactive uranium bundles heat water into steam. The steam produced in a nuclear reactor turns giant turbines attached to generators that produce electricity for homes and businesses.

This process is not much different from a typical coal-burning power plant except for one important factor—the method of heating the water. While older plants burn fossil fuels to generate heat, nuclear plants depend on the heat released during nuclear fission, the process by which one atom splits into two, releasing heat and radiation. Uranium is used to induce the fission process.

Fuel rods are used to store uranium pellets; multiple rods are combined into a

**Did you know . . .**

The first time atoms were successfully split was during The Manhattan Project—the U.S. military program to develop an atomic weapon to be used during the Second World War.

**Did you know . . .**

The creators of comic-book heroes are fond of imagining that radiation exposure could cause mutations that create superhuman powers. Examples include Spider-Man, The Hulk, Doctor Manhattan, and the Japanese monster Godzilla.

bundle. Bundles are submerged in water. Control rods made of a material that absorbs neutrons are lowered and raised in the uranium bundles to control the temperature.

Since harmful levels of radiation are a concern, a nuclear power plant is lined with concrete that acts as a radiation shield. The concrete is surrounded by a steel containment vessel. This vessel contains the reactor core and acts as a barrier to prevent leakage of radioactive gases or fluids from the plant. An outer concrete building serves as the final protective layer, protecting the steel and the containment vessel. This concrete building is designed to withstand earthquakes and/or crashing planes. Many safety features go into the building of a nuclear power plant to reduce the danger of releasing harmful radiation into the environment. But at this point it

seems impossible to completely contain radiation leaks.

**Radiation: What is it?**

Radiation is part of the natural world and refers to the disintegration of atoms. Radiation arises from the Earth itself and from outside the Earth in the form of cosmic radiation. Radiation can also be created by humans as X-rays, treatments for cancer, fallout from nuclear testing, and materials released from coal and nuclear power plants.

Although we cannot see or feel the presence of radiation, it can be detected and measured in very small quantities. A radiation unit is called a sievert (Sv). One sievert is a large quantity, so radiation is typically expressed in millisieverts or microsieverts. For example, one chest X-ray is about 0.2 millisieverts of radiation.

**Comparing Radiation Doses**

Chest x-ray	0.2 millisieverts (mSv)
A yearly dose of exposure to radiation from natural sources (food, water, cosmic rays)	2.4 mSv
Exposure from a single coast-to-coast plane flight	0.01-0.6 mSv
Limit of exposure for those working in nuclear power plants over 5 years	100 mSv
Dose that would cause immediate illness and subsequent death	10 000 mSv

What happens when the human body gets a dose of radiation? There is still considerable uncertainty about the overall effects of low doses of radiation. Some scientists argue any additional amount of radiation beyond natural sources is harmful, while others contend that this hypothesis has not been conclusively proven.

The effects of radiation at high doses are better known. A very large dose of radiation will result in death within days. Much has been learned by studying the health records of the survivors of nuclear bombs dropped on the Japanese cities of Hiroshima and Nagasaki during the Second World War.

**Follow-up**

Review the notes you took while reading this section on the pros and cons of nuclear power. Write a two-paragraph summary that synthesizes your position and supporting points. Be prepared to share your summary with other students in a small group, or with the entire class.

# JAPAN AND THE NUCLEAR NIGHTMARE

## Focus on Fukushima

### Did you know . . .

Potassium iodine pills prevent or reduce the absorption of radioiodine, a byproduct of nuclear fission, through the thyroid gland. In British Columbia, the pills quickly sold out of pharmacies as people panicked about the possibility of airborne radiation from Japan reaching Canada.

As a result of the massive earthquake and tsunami that hit Japan on March 11, 2011, nuclear reactors located in Fukushima were critically damaged. Days and weeks after the disaster the situation continued to deteriorate, with cooling systems failing, explosions rocking several of the plants, and nuclear fuel rods being exposed to the air. The Nuclear Regulatory Agency evacuated people living within 30 kilometres of the plants, and further evacuations were planned if required.

Radioactive materials were detected beginning March 12. Detection of radiation prompted the nuclear safety agency to admit that the reactor had been melting, the first time such a dangerous situation has occurred in Japan. People, pets, food, water, and air were checked for radiation levels. The worst-case scenario was that multiple fuel rods would melt further and tonnes of melting uranium could get released, causing widespread damage to human health and the environment.

### The Chain of Events

Despite the multiple precautions that were in place at the Fukushima reactors, a series of disastrous events led to the nuclear disaster. Here are the events in chronological order:

1. The nuclear power plants structurally withstood the earthquake. However, electrical power to the plants—necessary for the cooling pumps—shut down.
2. The backup power grid became unstable and shut down as well.
3. Back-up generators were not located high enough off the ground to withstand the tsunami. The crisis might have been averted if the back-up

diesel generators had been designed to withstand submersion in water.

4. Batteries were the last line of power in this emergency. The batteries performed as expected but ran out of power after a few hours.
5. New generators were brought in but could not be hooked up in time.
6. The coolant pumps ran out of electricity. There was no longer a fresh supply of water in the boiler, and the fuel rods were exposed and overheated.

### Fixing the Damage

Teams of workers, heralded by Japanese people for their bravery in volunteering for this dangerous task, attempted to avert a reactor meltdown. Water was pumped from hoses and dropped from helicopters to keep the reactor fuel rods cool. At the same time, radioactive water had been discovered in numerous places around the Fukushima nuclear complex. Japanese workers at the plant faced the choice between continuing to douse the plant's stricken nuclear reactors with water to keep them cool and preventing the highly radioactive water that had flooded the reactors from spilling into the ocean.

### Impact

Japan lost a significant portion of its electrical generating capacity because of the tsunami. Approximately a third of Japan's electricity comes from nuclear power plants, and about half of that capacity had been lost (approximately 20 per cent of total generating capacity). This energy source will have to be replaced.

Radiation levels detected outside the plant were also found to be elevated. The seawater near Japan's Fukushima plant contained radioactive iodine at 3 355 times the legal limit, according to the Japanese nuclear safety agency. Officials found plutonium in the soil samples around the plant. Harmful radioactive steam prevented the workers at the plant from completing repairs.

The Japanese government announced that the four Fukushima reactors will be decommissioned and that safety procedures will be overhauled. Depending on the level of contamination, the land around the plants will not be inhabitable for years, or possibly decades. The events in Japan may stop

growth in nuclear power plants globally. Or they may spur research into other, possibly safer, nuclear technologies.

### **The Canadian Connection**

Health Canada issued a release on March 31, 2011, that stated "the amount of radiation reaching Canada is miniscule and does not pose a health risk to Canadians" ([www.cbc.ca](http://www.cbc.ca), April 2, 2011). Despite the fact that there was no imminent health risk for Canadians, it is clear that the Japanese and international community must work together to minimize the extent of this nuclear accident, to monitor its long-term effects, and to further debate and strategize on the safety of nuclear facilities.

### **Follow-up**

1. Research the first-ever accident at a nuclear reactor, which occurred in Chalk River, Canada, in 1952.
2. Find out the extent of other nuclear accidents in Canada as tracked by Greenpeace.
3. Summarize the most current research on the impacts of the Fukushima nuclear plant disaster on Japan, Canada, and the world.
4. Find out more about Japan's nuclear history, especially about the lives of the *Hibakusha* (survivors of Hiroshima and Nagasaki). You can read the testimonies of the *Hibakusha* at [www.inicom.com/hibakusha/](http://www.inicom.com/hibakusha/).
5. Research and analyze the disaster management plan for nuclear accidents in Canada.

# JAPAN AND THE NUCLEAR NIGHTMARE

## **Activity: In Canada: Is the risk acceptable?**

Your task is to send a letter or post a detailed comment to a news site or to a member of Parliament or to an environmental organization that defends your answer to the question: Is the use of nuclear power plants in Canada an acceptable risk? Use the chart below to gather your evidence, rank the criteria, and make your judgment.

### Background Information

In 2011, there were five nuclear power plants in Canada, located in Bécancour, Quebec; Lepreau, New Brunswick; Tiverton, Ontario; Bowmanville, Ontario; and Pickering, Ontario. Eighteen CANDU nuclear reactors throughout Canada account for 14.6 per cent of Canada's electricity generation, including 51 per cent of Ontario's power needs.

Is the use of nuclear power plants in Canada an acceptable risk?

Criteria	Source: detail the point of view of the source	Evidence presented in source	Acceptable or not acceptable risk?
Environmental benefits			
Environmental threats			
Economic benefits			
Economic threats			
Ability to withstand natural disaster			
Ability to withstand human error			
Ability to withstand acts of terrorism			

Some helpful sites for your research include:

- Industry Canada: [www.ic.gc.ca/ic\\_wp-pa.htm](http://www.ic.gc.ca/ic_wp-pa.htm)
- Greenpeace International: [www.greenpeace.org/international/en/](http://www.greenpeace.org/international/en/)
- CBC News: [www.cbc.ca](http://www.cbc.ca)
- Natural Resources Canada (for a calculator of earthquake hazard values): <http://earthquakescanada.nrcan.gc.ca/hazard-alea/zoning/haz-eng.php>
- Nuclear Safety – Government of Canada: <http://nuclearsafety.gc.ca/eng/about/index.cfm>