PowerPoint Talk Notes

Why We Should Support Nuclear Power

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1. Title slide - Thank you for inviting me to speak here today. I hope to dispel some myths and cure some phobias. It's likely no surprise to you that I will be making a PowerPoint presentation. Recently I came across a list of 'Warning Labels We'd Like To See" which included…
2. ||PAUSE|| ["Side effects include drowsiness, nausea, light-headedness, and, in rare instances, a diminished will to live."] I will do my best, but those of you who feel a diminished will to live, please exit the room and proceed quietly so as not to disturb those merely nauseated or snoozing.
3. In all seriousness, I believe that we should have a secure, reliable, abundant supply of electricity and clean air too. To that end, we should support nuclear power because…
4. … [Pause] Nuclear power is safe, clean, affordable, sustainable and proven technology.
5. In considering what to say today, I wondered where to start. Let's look at the situation here in Saskatchewan.
6. Across Canada, these were the relative per-capita CO_2 emissions in 2005. Saskatchewan has the highest emissions in large part because of the way we generate electricity.
7. SaskPower's website provides these data. Two-thirds comes from burning carbon.
8. So I think we should be looking for alternative energy that's cleaner energy, and by cleaner we mean lower CO_2 emissions.
9. Here's one option. [Pause] However, even this option is not CO_2-free, since the power source is still a carbon burner.
10. Since we are not living in Toontown, I suggest it would be prudent and judicious to derive our future energy production from largely carbon-free or carbon-neutral sources. While the so-called renewables will play a role in the world's energy mix, they cannot alone solve the environmental challenges of the energy industry, in particular the electricity sector. Renewables may be a welcome augmentation, but they cannot provide the reliable, sustained power that growing economies require.
11. Consider solar power. It is only available when the sun shines. Clouds reduce the output considerably, and after sundown the output is zero. The power density is low, so relatively large sites are required.
12. For example, an 800 megawatt solar-electric conversion plant would cover 100 to 200 square kilometres, and require 28,000 tonnes of aluminum, 1.6 million tonnes of

concrete, 6000 tonnes of copper, 480,000 tonnes of steel, 60,000 tonnes of glass, 1200 tonnes of specialty metals such as chromium and titanium - one thousand times the material needed to construct a comparable size nuclear plant.

13. Decentralizing by putting solar panels on everybody's roofs would not reduce the cost or the amount of materials used - in fact, both would increase. Then there are the safety hazards, such as having to repeatedly climb to the roof to keep your solar panels free of wet leaves and snow. And who would care for the banks of batteries, probably in your basement, that would be required to carry your genuinely all-solar house through a bad spell during the winter?
14. Despite the fact that we can wake up looking like a cooked lobster if we forget our sunscreen at the beach, energy in sunshine is relatively dilute. By the time it reaches us, the phenomenal energy of the sun is diluted by 93 million miles worth of the inverse square law. So how dilute is it? Here is a comparison.
15. This is a single uranium dioxide fuel pellet, in which its available energy is highly concentrated. Its shadow has an area of about 3 square centimetres. How long would, say, Arizona sunlight - nice and bright and hot and shining 12 hours per day - have to shine on that area to deposit the same amount of photovoltaic energy? The answer is 951,000 years. Compared to carbon fuels, the energy potential of one uranium fuel pellet is the equivalent of 17,000 cubic feet of natural gas, 1 tonne of coal, or 550 litres of oil.
16. Wind power is discontinuous - no wind, no power. Even in high wind areas, the wind blows strongly only about 25% of the time. Even the most optimally sited wind farm will only produce electricity about 35% of the time. Including inherently discontinuous and unpredictable wind power makes management of the electricity grid substantially more complex. Some attractive wind power sites are also flight paths for many birds, which has led to denial of installation or expansion of wind farms. And some people resist having their view cluttered by windmill towers and propellers. Again, wind power density is low, so relatively large sites are required. The 4700 MW Bruce Power nuclear site in Ontario has an area of 9 square kilometers. A 4700 MW wind power site would have an area of some 2800 square kilometers. The nuclear plant's power density is more than 300 times that for wind power.
17. Biomass has a land usage problem that is sobering when considering biomass as a potential large energy supplier.
18. To see why, we need to understand the concept of Net Primary Production, or NPP. NPP is the earth's net flux of carbon from the atmosphere into green plants per unit time. Although photosynthesis is an exquisitely efficient process, because energy in sunshine is relatively dilute, NPP is worryingly small.
19. For example, the fossil fuels burned in 1997 were ultimately derived from 400 years worth of primary production.
20. Estimates of the slice of global land NPP that humans now consume range from 10 to 55%, with 32% generally agreed as the best estimate. Replacing fossil fuels with biomass, even assuming the most efficient available use of biomass, would require us to increase our take of NPP by 50%. A dramatically larger increase would be needed if, for instance, biomass were to be converted to ethanol or other liquid fuels. Such

huge increases in human demands on the world's biomass resources are not feasible, particularly when our need for increased food production is taken into account.

21. To put this another way, let's say biomass will make a significant contribution and provide one third of the 30 Terawatt growth we expect in the next century.
22. This will use up 100% of the planet's agricultural land. We would be warm, but we would starve.
23. Hydro projects involve complex watershed management issues. Being as flat as it is, Saskatchewan will never be the thousand pound gorilla of hydropower. Even so, SaskPower does not plan any new hydro developments because they are not dependable - drier weather, less hydropower. World wide, locations for new large hydro dams, like the Hoover Dam on the left, are few and far between. Seen on the right, the huge Three Gorges Dam was indeed recently built in China, but it would almost certainly have been blocked in any non-totalitarian nation. The lack of acceptable sites for new large hydro dams limits hydro's future role. This will be made worse if, as some models predict, global warming gives us a drier terrestrial climate.
24. According to a recent analysis by ecologists at Cornell, even if implemented to the maximum, renewable energy sources could replace only about half of the US consumption of oil, natural gas and coal.
25. However, this full implementation of renewables would occupy one sixth of America's land area. This equals the whole land area now occupied by cropland. It's 6 times the land occupied by urbanization. Clearly, renewable energy systems alone would not do the job. The Cornell ecologists who did this study were avowed backers of renewables, but the professor who led the study team said, [QUOTE] "We wish this had turned out differently - we really do - but it's hard to argue with the facts." [END QUOTE]
26. Renewable energy systems are much higher cost, and will not be broadly competitive for many years, if ever.
27. For example, in Germany, fully 40% of the electricity price is simply to cover subsidies on renewables. Nuclear provides about 30% of Germany's electricity with no subsidy.
28. In Spain, solar electricity from concentrating solar power with mirrors is about 10 times as expensive as nuclear power.
29. For Australians, the consumer-paid extra increment of 4 cents per kilowatt hour for power from wind more than doubles the price relative to thermal sources.
30. In California, compared to power from a new base-load gas-fired plant, thermal solar electricity is 4 times as expensive and photovoltaic solar electricity is 9 times as expensive.
31. Currently in Ontario, compared to nuclear, wind power electricity is almost 3 times more expensive and solar power is more than 7 times as expensive.
32. Currently in Saskatchewan, purchasers of what SaskPower calls "GreenPower" pay an additional 27% over the regular electricity rate to cover the higher cost of generation. This on top of the federal government wind power subsidy of approximately 15% (1 cent per kilowatt hour).
33. In the UK, a recent study for the Royal Academy of Engineering looked at electricity generation costs from new plants. One aim was to develop a robust approach to

compare the costs of intermittent generation with more dependable sources of generation. This means, for example, adding the cost of standby capacity for wind. This table shows costs without standby capacity for renewables but including decommissioning costs for nuclear.

34. With standby costs added for the wind options, nuclear looks even better.
35. Renewables will play a role in the world's energy mix, but they cannot alone solve the environmental challenges of the energy industry, in particular the electricity sector. Renewables are a welcome augmentation, but they cannot provide the reliable, sustained power that growing economies require. Saskatchewan expects renewables to provide no more than 10 to 15 % of SaskPower's load.
36. Nuclear power is of fundamental importance because it is the only energy supply that already has a very large and diversified resource, does not emit green house gases, and has favourable economics. In combating climate change, nuclear is the only existing power technology which could replace fossil fuels in base load.
37. Consider CO2 emissions. These data are from a study by the Central Research Institute of the Electric Power Industry in Japan. They looked at fuel life cycle CO2 emissions for electricity generation. Note that these life cycle emissions for photovoltaic, or solar, take account of the considerable energy consumed in making the pure silicon for the photovoltaic cells. In evaluating the relative cleanliness of fuels, the life cycle approach must be used. As we can see, counting only the CO2 emissions of a solar panel soaking up the sun is misleading. On a life cycle basis, nuclear is the cleanest.
38. Here are the data from a 2000 International Atomic Energy Agency study.
39. And data from yet another study, this one by the International Energy Agency, again in 2000.
40. There is another beneficial role nuclear power can play in reducing CO2 emissions. Burning fossil fuels in car and truck engines makes a significant contribution to greenhouse gas emissions, 50% of the total in the United States. So let's look at the relative CO2 emissions for various engine/fuel combinations. IC means internal combustion. "Clean" gasoline is reformulated gasoline with reduced sulphur. We include natural gas, the so-called "clean fuel." We include hydrogen from biomass. Finally, we consider hydrogen generated using nuclear energy. These data are from a study by Princeton University, not likely a biased nuclear power advocate.
41. So for the green house gas emissions issue, nuclear has the lowest emission rate in electricity generation and huge potential benefits in providing hydrogen as a transportation fuel. Next, let's look at production costs.
42. Currently in Ontario, compared to nuclear, wind power electricity is almost 3 times more expensive and solar power is more than 7 times as expensive. In the United States, electricity production from nuclear plants consistently costs one half to one third the cost from gas-fired and oil-fired plants, and slightly less than the cost from coal-fired plants, and this with the gas, oil and coal-fired plants bearing no cost for their CO2 emissions.
43. This slide illustrates the important fact that the cost of nuclear electricity is stable. It is much less sensitive to changes in fuel costs, a major benefit for nuclear. A Finnish study in 2000 showed the doubling of fuel prices would result in electricity cost for nuclear rising 9%, for coal rising 31% and for natural gas rising by 66%. But, you

may say, what about the relatively high permitting and construction costs for nuclear. Don't the resultant higher capital costs make nuclear more expensive overall?

44. In the UK, the recent report for the Royal Academy of Engineering that I mentioned earlier also looked at electricity generation costs from new conventional plants. This table shows the results. I remind you, the nuclear cost **does** include the decommissioning cost. But the gas-fired and coal-fired costs shown here do **not** include any carbon tax.
45. These are the costs when a carbon tax of 30 pounds per tonne of CO2 is included. Nuclear has by far the lowest cost.
46. In August 2004 the University of Chicago published its study, "The Economic Future of Nuclear Power." This table shows the results considering the best case for coal and gas and the worst case for nuclear. First-of-a-kind engineering costs for new nuclear designs increase the capital cost by some 35%, and capital cost is the single most important factor determining the economic competitiveness of nuclear energy.
47. But on a more level playing field, with a series of similar nuclear plants built, nuclear again has by far the lowest cost.
48. Nuclear electricity costs are relatively stable. Considering the all-in costs, nuclear is competitive now and will likely become more so.
49. Uranium is created only in supernovas.
50. Here on earth uranium is ubiquitous. It is not a particularly rare element, with a mean abundance of just less than 2 ppm in the earth's continental crust.
51. Uranium is 500 times more abundant than gold, 25 times more abundant than mercury and about twice as common as tin. Naturally occurring traces of uranium can be found everywhere, contributing to the earth's natural background radiation.
52. Although the uranium concentration in seawater is relatively small at 3 mg/m3, because the oceans are very large seawater holds an enormous reserve of uranium. Nuclear power is thus the quintessential sustainable development technology.
53. Its fuel will be available for centuries.
54. Nuclear power is of fundamental importance because, as we have seen, for Saskatchewan it is the only energy supply that already has a very large and diversified resource, does not emit green house gases, and has favourable economics. It is also important to realize that in combating climate change, nuclear is the only **existing** power technology which could replace fossil fuels in base load.
55. So-called "clean" coal technology, known by the acronym CCS, with carbon dioxide sequestration, is a nice concept. But that's all it is right now, a concept. SaskPower abandoned its clean coal project last year, although the concept was recently talked up in political circles. The United States Department of Energy has started then abandoned its CCS project twice since 2003. So how clean is CCS?
56. These are the results of the most recent International Atomic Energy Agency study. It turns out CCS is not so clean after all. Good advertising, though.
57. In combating climate change, nuclear is the only existing power technology which could replace fossil fuels in base load.
58. In examining the safety record of nuclear power reactors, we are considering more than 10,000 reactor-years of commercial operation in 32 countries. There have been two significant accidents… Chernobyl and Three Mile Island. Let's look at Chernobyl first.

59. The April 1986 disaster at the Chernobyl nuclear power plant in Ukraine was the product of a flawed Soviet reactor design, minimal operator training, and a series of flagrant deliberate violations of safe operating procedures. It was a direct consequence of the lack of any safety culture in the USSR, that former workers' paradise. And further it occurred at a time when the Soviet Union no longer had control over its institutional structures. The reactor core overheated and caused a steam explosion. Power reactors cannot generate nuclear explosions. Hot pieces of the graphite core ignited the graphite moderator. With no containment structure, the resulting fire caused the main release of radioactivity. The immediate casualties were operators and firefighters. 28 immediate deaths were from acute radiation exposure, with doses up to 5,000 mSv, five times the threshold for the onset of radiation sickness. Many children in the surrounding area were exposed to radiation doses sufficient to lead to thyroid cancers (usually not fatal if diagnosed and treated early). Since the accident there have been up to ten deaths from thyroid cancer linked to the radiation release. Health effect studies since the accident covered over 1 million people possibly affected by radiation. There has been no substantiated increase attributable to Chernobyl in congenital abnormalities, adverse pregnancy outcomes or any other radiation-induced disease in the general population either in the contaminated areas or further afield. Lurid tales of thousands of deaths are the result of naïve or deliberate confounding of the effects of the accident with the generally poor health and medical services in Ukraine under the USSR. The Chernobyl disaster was a unique event: the only accident in the history of commercial nuclear power where radiation-related fatalities occurred.
60. This accident happened in the Three Mile Island Unit 2 reactor near Harrisburg, Pennsylvania. It was due to a combination of equipment failure, inadequately designed instrumentation, and the inability of plant operators to understand the reactor's condition. Water leaking from the cooling system passed into the reactor building, but was held within the containment structure. Although a small amount of radioactive steam was slowly released to the atmosphere, no injuries, deaths or discernable direct health effects were caused, according to over a dozen studies involving as many as 30,000 individuals. And that's because the radiation release was very very small. If you had somehow managed to suspend yourself immediately above the plant, in the middle of the steam release, for several days, the maximum radiation dose you would have received is less than one third the dose your routine dental X-ray delivers in a few seconds. Ironically, because of the local abundance of granite, the area around Three Mile Island is exceptionally high in radon emissions, 4 times the US average. Because of this, people in the area get more radiation from radon every day than they got from the Three Mile Island accident.
61. You would have to live near a nuclear power plant for more than 2,000 years to get the same amount of radiation exposure that you receive from a single diagnostic medical x-ray.
62. A sense of perspective can be gained by examining accident statistics for all the methods of primary electricity production. With this perspective, nuclear looks just fine. Coal mining in particular is still lethal. We regularly hear of coal mining disasters in which tens or hundreds of workers die. And note that, since 911, several studies of the vulnerability of industrial plants to terrorist attack have led to a broad-

based recognition that nuclear plant structural integrity and security set the standard for industrial facilities.

63. Radiation exposure is commonly regarded as a safety risk for nuclear power. Let's look at some typical radiation doses. On average we all receive 1 mSv per year of gamma radiation from cosmic rays. 2 mSv per year is the typical world average background dose from natural radioactivity. People everywhere are typically exposed to up to 3 mSv/year from inhaled radon without apparent ill effect. 9 mSv/year is the exposure to an airline crew flying the polar route, say from Calgary to Europe. 100 mSv/year is the lowest level at which any increase in cancer is evident. 1,000 mSv in a single dose causes temporary radiation sickness, but not death.
64. At 20% U3O8, Cameco's McArthur River mine has the world's highest uranium ore grade. What radiation doses do the workers there receive?
65. This is the average annual radiation dose for surface workers
66. ….the average for underground workers…
67. …the individual maximum for a surface worker…
68. and the individual maximum for an underground worker.
69. Our uranium operations in northern Saskatchewan meet strict environmental standards set out by both the federal and provincial governments. Twenty-four hours per day, 365 days per year, comprehensive sampling, monitoring and assessment programs are in operation to ensure that the physical environment is protected. All sites are subject to compliance-based monitoring - by which water and air emissions from mines and mills are tested on a regular basis to ensure that contaminants, if any, remain within regulatory limits. But we go further than just assuring emissions meet standards. Cumulative environmental effects monitoring, conducted by Saskatchewan Environment, samples the ecosystem near operating sites and further away to ensure that plants, animals and fish are not adversely affected. Environmental effects are prevented even if this means keeping the concentration of a contaminant below the regulatory limit.
70. And we go further still. Reverse osmosis, a membrane filtration technology, is a means of obtaining very pure water. As shown here, it is used at a large scale for desalinating seawater to obtain drinking water. We are deploying reverse osmosis and related membrane filtration technologies to obtain effluent well below regulatory limits for all dissolved species.
71. This is our water treatment reverse osmosis plant at Key Lake, operating since 1996 on feed from dewatering wells.
72. And this is our membrane technology pilot plant, which we are using to extend membrane filtration technology to the treatment of aqueous streams heretofore regarded as too saline for membrane filtration. To my knowledge, we are world leaders in this effort, which serves our commitment to move beyond regulatory compliance.
73. Our mill tailings are stored in carefully engineered and closely monitored pervious surround in-pit tailings management facilities. This is Cameco's tailings management facility at Rabbit Lake.
74. This is how the pervious surround works. The mined out pit is first lined with crushed rock. A sand liner is placed inside the rock liner. Tailings slurry is deposited inside the sand envelope, which retains the solids but lets the water pass through. The

water flows down to the bottom of the pit, from where it is pumped out through the tunnel, up the raise and into the mill for reuse or treatment. As the tailings settle and consolidate, the solids pack together more and more. The result is that the contained tailings become virtually impermeable to water flow. The crushed rock, however, lets water flow through it with no resistance. So ground water flows around the tailings, not through them. This isolates the tailings from the environment.

75. The Rabbit Lake in pit tailings management facility was the first anywhere to use the pervious surround method. You can see the rock lining, the sand lining inside the rock, tailings held within the pervious surround, the raise pump house, and the mill in the distance.
76. Exposure to radon emitted by and escaping from uranium operations is often touted as a public danger. Is it? Routine air monitoring around uranium mining and milling sites has shown that the radon concentrations at the property boundaries are indistinguishable from natural background levels. In Saskatchewan, measurements around our northern operations have shown that these radon concentrations are actually lower than they are in the southern agricultural regions of the province.
77. Construction of Canada's spent reactor fuel repository awaits the political decision to do so. The Nuclear Waste Management Organization (the NWMO) is moving Canada towards this decision. The NWMO was created to recommend to Parliament a long-term approach for managing Canada's used nuclear fuel. The NWMO assessment recommends a deep geological repository. There is no urgency to build the repository. Surface storage in concrete and steel casks at nuclear reactor sites can provide safe storage for many decades. And why can I say that? Because all of the high level waste, from the start of the nuclear age, from all the reactors in Canada, would roughly fill a soccer field to the height of only 1.3 metres. Nuclear power is the only energy industry that takes full responsibility for all its wastes, and costs this into the product. The relatively small amounts involved allow them to be effectively and economically isolated. This is a real advantage for nuclear.
78. Natural uranium has this mixture of isotopes. U-235 is fissile, which means that under certain conditions it can be split, yielding a lot of energy. Most power reactors require enriched fuel with 3 to 4% U-235. About 90% of the original feed to enrichment becomes a by-product known as depleted uranium, because it is depleted in U-235.
79. Depleted uranium has a number of uses. These civilian uses make use of its high density, about twice that of lead. As a radiation shield it is some five times more effective than lead.
80. The most contentious use is by the military. Depleted uranium is pyrophoric, so that upon impact about 30% of the projectile atomizes and burns to uranium oxide dust. These shells were used…
81. … in the Gulf War and in Kosovo. In 2001 the United Nations Environment Program examined the effects of virtually all (that is 9 out of 11 tonnes) of the depleted uranium munitions used in Kosovo, checking the sites targeted. It found no widespread contamination, no sign of contamination in water or the food chain, and no correlation with reported ill health in NATO peacekeepers. A two-year study by Sandia National Laboratories in the US reported in 2005 that consistent with earlier

studies, reports of serious health risks from depleted uranium exposure during and after the Gulf War are not supported by medical statistics or analysis.

82. Furthermore, extensive studies have concluded that no radiological health hazard **should** be expected from exposure to depleted uranium. The risk from external exposure is essentially zero. As for ingestion or inhalation, no detectable increases of cancer, leukemia, birth defects or other negative health effects have ever been observed from radiation exposure to inhaled or ingested **natural** uranium concentrates, at levels far exceeding those likely in areas where depleted uranium munitions have been used. This is mainly because the low radioactivity per unit mass of uranium means that the mass needed for significant internal exposure would be virtually impossible to accumulate in the body - and depleted uranium is less than half as radioactive as natural uranium. The health hazards associated with any uranium are much the same as those for lead. Thus depleted uranium munitions are **clearly** dangerous for military combatants in targeted vehicles, but for anyone else - even in a war zone - there is little hazard.
83. Although there was previously a nuclear industry based on producing radium, most people today think of the Manhattan Project and the atomic bomb dropped on Hiroshima as the dawn of the nuclear age.
84. In the 1960s it was widely assumed that there would be thirty to thirty-five nuclear weapon states by 2000. To forestall such a development, the Non-Proliferation Treaty, known as the NPT, was negotiated by 1968. There are now 8 nuclear weapon states - the United States, Russia, the United Kingdom, France and China under the NPT, and India, Pakistan and Israel outside the NPT. The fact that there are only 8 is a testament to the effectiveness of the NPT and its related treaties, conventions and arrangements.
85. Uranium processed for electricity generation is not useable for weapons. As described previously, uranium in reactor fuel is enriched to about 3 to 4% U-235, compared to weapons-grade which is over 90% U-235. Few countries possess the technical knowledge or the facilities to produce weapons-grade uranium.
86. Weapons-grade plutonium is not produced in commercial power reactors but in a specialized so-called production reactor. The mix of plutonium isotopes in spent power reactor fuel makes it useless for weapons. The only use for reactor grade plutonium is as a nuclear power fuel, after it is separated by reprocessing. Reactor grade plutonium is unsuitable for weapons, and is not and has never been used for weapons.
87. Civil nuclear power has not been the cause of or route to nuclear weapons in any country that has nuclear weapons, and no uranium traded for electricity production has ever been diverted for military use. All nuclear weapons programs have either preceded or risen independently of civil nuclear power, as shown recently by North Korea.
88. Perspective is relevant. As little as 5 tonnes of natural uranium is required to produce a nuclear weapon. Remember, uranium is ubiquitous. No country is without plenty of uranium in the small quantities needed for a few weapons. If cost is no object, it could be recovered from granite or from seawater - sources that would be uneconomic for commercial use. In contrast, world trade for electricity production is about 66,000 tonnes of uranium per year.

89. There is no chance that development of nuclear weapons will be prevented by turning away from civil nuclear power.
90. Lastly, the frosting on the cake. Civil nuclear power currently provides the route for nuclear weapon decommissioning. The so-called HEU agreement, a treaty between Russia and the United States, was signed in 1993. Cameco and Areva are two of three western companies on the commercial side of the agreement.
91. **HEU** stands for highly enriched uranium, which means weapons grade uranium. Using depleted uranium, we blend down HEU from dismantled Russian nuclear weapons into power reactor fuel. This is another use for depleted uranium, a most beneficial use.
92. To date under this agreement, more than 8000 nuclear warheads have been decommissioned. Over the life of the agreement - that is by 2013 - we will eliminate a total of 20,000. As a consequence, the world will be a safer place.
93. Nuclear power is safe.
94. So…
95. *******************