were shown to be either bounded by the three listed above or not affected by aging effects. In these cases the un-aged safety analysis remains valid until the end of life unless there is a discovery issue or a design change, in which case the analysis is updated.

These three design basis accidents are periodically reanalyzed. Based on inspection data obtained during plant outages as well as the knowledge of training of those parameters due to aging, the analysis is updated after extrapolation for three or more years of the key parameters values affected by aging. Should the effect of aging cause unacceptable reduction on safety -- on margins, sorry, for the period analyzed, mitigating measures which may include operational limitations such as reduction of trip point or D rating must be put in place.

Before the valid analysis expires new aged conditions data including data from inspections is centered in the next analysis cycle. By reviewing these periodic analyses CNSC staff ensure that the units are operated within analyzed states and the adequate safety margins are maintained.

In closing, I wish to present the conclusions:

OPG has met the regulatory requests of the Commission in the records of proceeding of the May 14th -- May 7, 2014 hearing on the Pickering hold point.

CNSC staff have modified the Licence Conditions Handbook to track the future annual reporting until end of life. In turn, this information will be provided to the Commission as part of the annual Integrated Safety Assessment of the Canadian Nuclear Power Plants.

CNSC staff find the Risk Improvement Plan to meet safety goals targets to be acceptable.

Staff finds OPG progress on the whole site PSA methodology to be acceptable and the timetable reasonable considering they are in the early stages of the development for multi-unit PSA and the complexity involved.

CNSC staff judged the status of OPG's enhanced Aging Management Program to be acceptable as they ensure adequate fitness for service of the plan and the maintenance of adequate safety margins.

This concludes my presentation. We are available to answer any questions the Commission may have.

THE PRESIDENT: Thank you.

So let's jump right into the question session and starting with Ms Velshi.

MEMBER VELSHI: Thank you.

If we can turn to page 8 of staff CMD, please, 14-M42, the Improvement Action Plan.

So other than all the Fukushima Action Plan related stuff and including the methodology -- I'm okay with that -- it was all the other physical changes and perhaps the other follow up analysis where the status is shown as "Further details to be provided in February 2015". Personally, I thought today's action plan would actually have got the timelines. This is now a plan for a plan.

And I understand how complex this is, but given the remaining life of the plant -- and this is a question for OPG -- given the remaining life of the plant and that you are focusing your priority improvement areas on fire and wind, what happens after you've done your analysis and you find out, well, there really isn't much benefit in making this kind of an investment?

Do you have lower priority improvement plans that you would then consider, or is it too late?

I'm just trying to understand with this short timeframe, this long time to do the planning and the analysis, are we going to be in a situation where the cost-benefit analysis just isn't there for this big improvement potential areas?

MR. McGEE: Brian McGee, for the record.

What I would say to you to start out, we're making significant improvement in the plant even today as we're sitting here on improvement programs, capital improvement programs to improve plant safety and plant reliability.

You know, to jump ahead to, you know, when would that point come where we'd say an investment isn't -- doesn't make sense, you know, is a bit hypothetical, to be frank.

At this point in time, that type of decision making is not entering into our thinking. Our focus right now is continued safe operation of the power plant and we continue to make the investment to make that happen.

MEMBER VELSHI: Sorry I wasn't clear with my question.

I meant the cost-benefit analysis of the improvement initiative, so on this particular action plan, it's item 16 that you talk about.

And I'm saying if that cost-benefit analysis is for these priority areas that you have identified, if those don't pan out, do you have lower-impact ones that may make more sense from a benefit -- cost-benefit perspective?

Maybe not so much from risk reduction perspective.

MR. McGEE: Brian McGee, for the record.

Thank you for the clarification of your question, Commissioner. I'll ask Mark Elliott to respond.

MR. ELLIOTT: Mark Elliott, Chief Nuclear Engineer for OPG, for the record.

We're confident that the actions that we have for the Fukushima will be significant, first of all, and we are going to carry on and finish those.

To give you an example of those, we're putting in one megawatt generators, temporary generators, that are going to come in and repower things like the emergency power system, so that's a huge electrical system that's going to be repowered after a serious accident.

We expect that to be significant in terms of the risk.

We are repowering the air conditioning units in the boiler room to cool containment so that -- and that helps to preserve containment.

So I think we're confident we're going to make significant gains in the plan we have. We will -- if we do get a situation where there's -- the next level of safety is very, very expensive, we will be looking for practical ways to do things.

Give you an example on the practical side. The tie-downs for the equipment that Mr. McGee showed, that was done over about a two-month period with design and installation, so we're going to look for those practical things that can add safety, and we'll be guided by the

PRA calculations to show us, yes, it does add real safety.

So I'm confident that even though we're entering the last stages of life that with what we've got planned with our practical approach, we can continue this.

MEMBER VELSHI: And I don't know if this is a fair question or not, but are you confident that -- as we sit today, that -- with what you're doing and planning on doing that you will be below the target number for safety codes?

MR. ELLIOTT: We don't know whether we will.

You know, one of the things that is the -- and why it takes till early next year to get it scoped out is what's the best interventions that'll add the most value.

And then when you design and -- I guess you could figure it out when you design them. You probably don't have to wait until you install them, but once you design them, you know exactly what they're going to do.

I think at that point we'll be able to see what's the -- what's the real benefit and see where we are.

We know we'll be better than we are now. We know it will be reduced, but whether it will be all the way on every -- you know, every -- you know, the internal events, the high winds, whether everyone will be below the target, we can't say at this moment.

MEMBER TOLGYESI: Okay. And in the --

THE PRESIDENT: Sorry. So I'm a bit surprised because, if memory serves, it wasn't even a target. We're talking about the actual limits. And I thought fire -- if memory serves, fire you were beyond the limits, not the target necessarily.

No?

So what I'm trying to understand is, some of those new mitigation, I thought you can really quickly do a quick and dirty analysis to find out where your PSA taking you because we didn't see any new estimates for the PSA numbers. And I thought that was the purpose of the update.

So you're saying we're not going to see it until February 2015? Is that what this is about?

I was looking for a new

calculation of the ALARA reference. That's what I was looking for.

MR. ELLIOTT: Mark Elliott, for the record.

Yeah, you're not going to see the calculations even in February. We'll tell -- we'll report on what are the things that we're going to do, the actual plan, what are the steps that we're going to take to improve.

Some time after that, we'll be able to quantify those and say where we're actually going to land.

In terms of the risk -- kind of the risk aggregation that we talked about in May you know, when you sum all the hazards, you know, there's something else happening there at the same time as we're doing these improvements. We're actually going to figure out how to aggregate.

So that method of aggregation so that we can -- that calculation method is outstanding right now. That's on the plan that Mr. McGee spoke about.

So in parallel with doing the improvements, we're going to figure out, basically, what's the best method of aggregation.

And it'll take both of those to be able to answer your question on exactly where we'll end up.

THE PRESIDENT: I don't want to belabour it, but I thought on fire -- on fire, you were off. I don't know if you were off limit or in between target and limits.

You were off -- over something. I think it was the target. And you had to, by your own procedures and requirement, you had to develop a plan.

I thought that, here, you were going to tell us how you're now back into below target.

MR. ELLIOTT: Well, I'll ask Dr. Jack Vecchiarelli to answer the specifics on fire.

DR. VECCHIARELLI: Jack Vecchiarelli, Ontario Power Generation, Manager of the Nuclear Safety and Technology Department.

So when we completed the S294, Pickering A and Pickering B PSAs, we followed their governance and looked at, are there hazards that are between the safety goal target and safety goal limit.

As part of the action plan to further reduce risk, as discussed in this action plan, the second hold point that was around including enhancements from Fukushima and other related activities were part of the plan, and we actually quantified, as part of that hold point, what the level of risk reduction was.

It was mentioned earlier today that it ranged from a factor of two to 10, so we already have an idea of what the risk reduction is from the S294 compliant PSAs.

What the plan lays out is what more will be implemented either physically or analytically that will be further reducing the risk, will -- once we have enough information to be able to requantify the risk, the cumulative risk reduction now from what was previously quantified and what further improvements are being incorporated.

At that point, we'll have an updated cumulative risk reduction that will feed in to a cost-benefit analysis to see whether there's even more that we should be doing.

And fire was one of those hazards that met the limit, the safety goal limit, but did exceed the safety goal target.

MEMBER VELSHI: Well, yes. So

because it was greater than the safety goal target, the requirement then is for you to analyze and see if there is a cost -- a practicable way of reducing that risk, which is what you're doing.

So for no hazard category did you exceed the limit; correct?

DR. VECCHIARELLI: Jack Vecchiarelli, for the record.

That is correct.

THE PRESIDENT: But again, I'm dense about this.

So if you actually can tell me now that the improvement is a factor of two to 10, then even if my memory is that your table that you had last time, you're there already. Why can't you say right now you are below target?

DR. VECCHIARELLI: For the record, Jack Vecchiarelli.

That table refers to a simple summation, a risk aggregation of sorts, which is still under investigation as to whether -- what is the most appropriate way to aggregate risks.

That table showed that we were slightly -- right on the edge of the limit for large release frequency. That is above the per unit based target on a per hazard basis.

Our governance is built around driving the per unit per hazard risk metric towards the safety goal target, not an aggregated total hazard value.

But that will be reduced in parallel as we implement the action plan. The summation will also drop.

MR. FRAPPIER: Gerry Frappier, for the -- sorry.

I'm just going to -- because we're having the same conversation as the President, which is perhaps a little bit different than OPG's.

So there was a point where we were not satisfied with the numbers coming out of the PSA, in particular for fire and for wind. And in particular, you had sort of pushed -- the Commission had pushed very hard to implement within the PSA what's the EME benefit going to be of these new EMEs.

And at the time, that was controversial with respect to nobody really knew how to do that very well.

And so what OPG did for Pickering

was they did -- I think they were calling it a Phase 1 sort of thing where they took some aspects of the EME that they could quantify or they felt comfortable that they could model and, from that, they -- that's where this two to 10 sort of number comes from.

And with some of -- and with those improvements, we then had the fire and wind falling just above target, but definitely below limit, and so that changes now the sort of next stage of what needs to be done, so they're going to be looking now from a planning perspective to see what can be done from a pragmatic perspective to bring below the target.

So that was -- a lot of that discussion was at the hold point removal piece.

THE PRESIDENT: Ms Velshi?

MEMBER VELSHI: My second question was on the work that's been done on the methodology and the pilot for the multi-unit. And it is multi-unit and multi-hazard that's going to happen in 2017, or is it multi-unit only?

MR. McGEE: Brian McGee, for the record.

I'll ask Jack Vecchiarelli to

answer that, please.

DR. VECCHIARELLI: Jack Vecchiarelli, for the record.

It's referred to as a whole site PSA, and whole site embodies all units, all hazards, all operating modes and all other sources of potential radioactivity releases like spent fuel base.

MEMBER VELSHI: So the pilot -- I think it's in the staff presentation -- says you're going to do it for Pickering.

Does it make more sense to do it for Darlington instead only because, you know, then you can actually build on it to move forward?

MR. ELLIOTT: Mark Elliott, for the record.

We've started down the Pickering path, and this came out of a Pickering hold point hearing, so we've stayed on that path.

We're on a slightly different path for Darlington where we're in transition from S294 to RD242, so there's a number of PRA -- PSA activities on that -- on Darlington that you'll hear about in the Darlington relicensing.

So we're kind of on two different

tracks, and the Pickering track is the one that leads, I guess, sooner to that whole site.

MEMBER VELSHI: Okay. Thank you.

THE PRESIDENT: But presumably, when you will be coming for a licence renewal for Darlington -- and we're not talking about Darlington here now, so that's an unfair question -- all those numbers and all those calculations will be available.

MR. ELLIOTT: Mark Elliott, for the record.

We found the hold point hearing instructive on that point. And to be honest, that's part of the extension so that we can provide the Commission -- we know what the Commission is looking for, and we can provide you with that for the relicensing, and we can provide it early enough that we can get it out on our web site so that the public can see it as well.

So that was all factored in.

We understand what you want to see in the Darlington licence.

THE PRESIDENT: Thank you.

Dr. McEwan?

MEMBER McEWAN: I guess this whole

package -- and I'm coming to this because I wasn't at the hearing, the hold point hearing.

It really all boils down to how confident you are in the degree to which you can put in the risk mitigation strategies and how you can get the whole site PSA methodology complete in the time frame.

What is the likelihood of being able to do that?

I still end up with certain uncertainties you describing what your actions are going to be.

MR. ELLIOTT: Mark Elliott, for the record.

There's a lot of work there.

I just would go back to what we've accomplished to kind of instruct on how we're going to do this. When we got the challenge, I think, in May of 2013 for the Pickering relicensing, we immediately went to work and we produced a lot in a short period of time.

And we have a report -- a COG Report that was submitted as part of the hold point, CANDU Owners' Group Report, that really had all the industry thinking up to that point, and we actually had a workshop in January of this year where we brought in people from around the world. Experts, IAEA, NRC were involved.

And we produced a product that -- in a fairly short period of time that laid out a road map.

So I think it's a lot of work, but we've shown that we can work together with the whole industry and get a lot of work done, so we're rolling up our sleeves and we're doing this.

Right now, the first phase of that, the joint project with the CANDU Owners' Group has been set, and the first purchase order to get work started is about to be issued. We've got the bids. We're evaluating them.

So we're starting, and we're not waiting. And we believe that that schedule is achievable, and we're going to drive to it.

MEMBER McEWAN: So I guess for starters, is there a sort of a checkpoint in the middle of this process where you would gain increasing confidence that the target is meetable?

MR. JAMMAL: Ramzi Jammal, for the record.

Your question is very valid. It's

-- we're breaking ground with respect to the methodology and, really, no one in the world has done it to the extent that the Commission has requested to have done.

So we will be reporting to you on an annual basis and we will highlight to you if there are any deviation or any indicators to say there is a slippage.

Falling short of that, there is nothing I can provide you with. Otherwise, I'll be misleading you because especially on the whole site PSA and the methodology of the PSA, so there is confidence internationally that methodology can be achieved on time.

Now, as with respect to the safety goals or regulatory requirements, that's going to be another discussion and challenge that will take place.

But all I can say is wait and see, and that we will report accordingly.

But the funds, the progress and the intent to move on with this project is in place, and we will see what obstacles we're going to face because, with all honesty, there are only very few contractors can do this work. And that's the challenge that's going to be faced.

So Ms Velshi's comment is, okay, I'm not putting words in her mouth, but are you going to be applying any lessons learned from Pickering to Darlington. The answer is yes, and put all these lessons learned in the PSA methodology with respect to Darlington.

And that's why the licence renewal was requested, in order to have a complete submission for the application.

THE PRESIDENT: Thank you.

Mr. Tolgyesi?

MEMBER TOLGYESI: Merci, monsieur le président.

Regarding steam generators, what you are saying in the staff presentation that there are hundreds of thousands of Model 400 tubes inside, and these tubes can be plugged or isolated without safety impact because considerable margin is built into original design.

What's a "considerable margin"? You could plug 50 percent of tubes or 10 percent, or, I don't know?

MR. McGEE: Brian McGee, for the record.

I'll ask Imtiaz Malek to address your question.

MR. MALEK: Imtiaz Malek, Director of Fuel Channel Life Management, OPG.

There are 2,570-something tubes in each SG, and one has to do a stress analysis and heat transfer capabilities to determine how many you can plug.

Normally, the number ends up around 500 per SG that you can actually plug.

In the beginning, we started to plug quite a few because there were some degradations, but since then, we've come back on that because we found the degradation is actually quite slow. But we have considerable room in these SGs, these 12 SGs per unit, and we believe that they will -- well, not believe. We know that they will last far longer than the period we plan to operate.

THE PRESIDENT: What is the life of a steam generator, normally?

MR. MALEK: In terms of -- I want to talk in terms of EFPH. It's around -- we can take them to around 261,000 hours of operation.

THE PRESIDENT: So the Pickering

steam generator will stay there till the end?

MR. MALEK: Absolutely.

MR. McGEE: Brian McGee, for the record.

Maybe I can just make a more general comment. There are a lot of things that factor into steam generator tube life, and it starts with the metal. They're not all made from the same alloys.

Chemistry is a factor over its life cycle. There are a number of things. And then contaminants as well, which is, I guess, a variation of chemistry.

But you know, we've learned a lot about steam generator tubes. We continue to. You know, there's a belief that some of the tubes that we've plugged in the past because some of the degradation mechanisms that we thought we were seeing could be actually unplugged now.

So I would say it's really more a matter of the specifics of the steam generators, the specifics of the chemistry, any, you know, unforeseen contaminants as well as a good inspection life cycle management program.

THE PRESIDENT: Thank you.

Mr. Tolgyesi.

MEMBER TOLGYESI: Go to page 27 of the OPG presentation.

They're talking about -- it's Table 311 about plugged units, latest outage, tubes plugged, unit previous outage and total number of tubes plugged in unit.

Now, how do you reconciliate(sic) this? It's the total number is 556, and the tubes plugged in the previous, it's 480.

You add the two ones, the actual and the last ones. That's the total number.

So -- yeah. When you look at tubes plugged ad unit latest outage is 76 and previous 480, which is 556.

MR. McGEE: So Brian McGee, for the record.

So Commissioner, I just want to make sure I understand your question. Are you asking why we're above 500 tubes?

MEMBER TOLGYESI: Well, what I'm driving to is what just you said, that it's -- you could plug 500 tubes in the SG to be safe. I mean, that's your safety margin.

So when you are looking, how do

you calculate that it's 500 at any point of time or is cumulative? Because here you have -- you mention 1950. What it means, 1950? Is it high or low, or...?

MR. McGEE: Brian McGee, for the record.

That number is across all 12 steam generators or boilers, as we sometimes call them. The number of 500, we can confirm -- I don't think that's an exact number. I think Mr. Malek put it as an approximation.

Steam generators, any heat exchanger is typically over-designed, so it gives you some margin for plugging.

If it's important, we can get you the exact number that we could -- that we could plug, but typically, plugging doesn't mean end of life for the steam generator. What it means is you may be confronted with heat removal issues, and so there are other compensatory actions that you'd take to keep the unit operating safely.

So you might, you know, de-rate the unit and reduce margins and some of the things that Mr. Santini talked about earlier.

But the number that you're looking

at is across all 12 steam generators.

MEMBER TOLGYESI: Because there is a percentage of tubes plugged in units, there's quite a variation from .17 to 6.32 percent, which is maybe not so high in absolute value, but it's quite a variation between, so what's the reason for this variation?

MR. ELLIOTT: Mark Elliott, for the record.

Each steam generator for each unit has had a little bit different in terms of its chemistry control during the 30 years of operation, and there was a time when we did not control the chemistry as well as we should have. And there was actually, in the late nineties, quite a number of tubes had to be plugged.

I know I was the outage manager then, so we were always running outages to do this. Very busy time.

But we got control of the chemistry and arrested that.

So on the various units, we were not as good on some as we are on others in controlling the chemistry, and -- but we've got that in shape now, and so that's why there's variation.

But as Mr. McGee said, those numbers are quite -- still -- we still have margin in all of our units.

THE PRESIDENT: Monsieur Harvey?

MEMBER HARVEY: Merci, monsieur le président.

Mr. Santini, you mentioned in your presentation that the CNSC's current oversight is adequate.

So as we are supposed to have more monitoring, more reports, more analysis, saying that is like you are saying things will go on as usual.

So could you try to make the equation between the -- that sentence and the -- what you're doing there?

MR. SANTINI: Miguel Santini, for the record.

So what I tried to reflect in the presentation was that our current level is adequate, but we have enhanced it since the -- we started with the continuous operation -- the continued operations process. That is why we have increased the number of inspections in the past.

We have -- the level of review of OPG plants and OPG inspections and OPG non-conformances acceptance request has been -- we believe it is acceptable because it's a very high level of oversight.

That is not to say that the inspections, they could not be augmented, but in our view, we would -- we have enhanced the level in the past few years and, in our view, the current level is adequate.

MEMBER HARVEY: You won't lead to other sources to the people inside and things like that.

MR. SANTINI: We believe that we need to add resources, but not specifically on this program. There are other areas that would need to -- the oversight would have to increase, and I think that I mentioned this in the previous discussion which is in the area of human performance in approaching end of life.

MEMBER HARVEY: You also mentioned that there will be periodic analysis to confirm the safety margins.

So is it something you and what will be the frequency, the -- you mentioned periodical. What is periodical?

MR. SANTINI: Miguel Santini, for the record.

I will answer that high level and then I would ask our colleagues to expand on it.

So this periodic analysis started a few years ago to account for the changes in the key parameters to the safety analysis due to aging. And as I mentioned in the presentation, depending on the type of analysis, these periodicities go from three to six years.

I would like to ask -- or more years, I will say.

I will ask Dr. Michel Couture to expand a little bit on that.

DR. COUTURE: Michel Couture, for the record.

So the way to ensure -- when you're in a condition of aging reactors or aging heat transport systems, that means that your condition of your core is changing as you're moving in time.

So to ensure that you have -- when you assess your safety margins, let's say for today, you actually -- what they do, the process they follow is they look at the aging conditions in, let's say, two years or four years' time.

A key one, key input parameter here, is the pressure tube diameter that tends to increase with time, so that's one of the key parameters that they have to monitor.

So you take the aging conditions for the -- let's say in three years' time, you do your analysis and you assess whether you have adequate safety margins today.

That means that if you -- if your analysis methodology and everything is fine, you can say that you'll maintain adequate margins for the next three years, let's say. However, that doesn't stop there.

You have to monitor the key parameters, so pressure tube diameter. One other one is also the temperature -- the inlet header temperature of the coolant. It tends to increase because of aging of the core.

So they monitor this, they monitor the pressure tube diameter and then they compare with the trending they had predicted for that three years.

If it's within the predictions,

you're fine. If it turns out to be aging faster than you thought, then corrective measures have to be made to bring it back to the margins you wanted to maintain.

So that is -- and all these safety analysis that we're mentioning here have the same approach, is to look in the future, make a prediction on your -- take these aging conditions for the future, do your analysis now and then you know that you're maintaining margins and then monitor -- constantly monitor these parameters.

MEMBER HARVEY: So those analysis, it's not something new. I mean, it has been implemented.

MR. SANTINI: No, this technique -- these techniques actually have been used even for G-2, for Point Lepreau before -- for instance, before Point Lepreau refurbished, they would monitor these -- the -- that's the standard approach.

MEMBER HARVEY: Okay. Thank you.

MR. FRAPPIER: Gerry Frappier, for the record.

Could I just add a little bit to that?

So as Michel is saying, so this idea of safety analyses that have to be regularly updated, that's been in place forever, ever since business started, if you like. So there's a term that we use often and you see it often in CMDs that they cannot operate in an unanalyzed state.

So it's very important for the operator always to know -- have all these safety analyses up to date with whatever changes might have been made to the plant design changes over the years.

That has been going on forever and they have to report that in to us on a regular basis around five years.

What's different -- a little bit different now and where there's been an awful lot of activity the past few years is to better quantify, analyze the effects of aging. And so that's what Michel was just talking about there as to some of the particular things that, because we're now getting aged reactors, we want to ensure the safety analysis can handle those things, those situations, but we're looking further down the road already.

We're always looking -- looking

down, five years down the road, not just for today.

MEMBER HARVEY: I thought that because we were going over 200,000 hours that the frequency will be increased, so it's not the case.

MR. SANTINI: Miguel Santini, for the record.

No, this was done even before getting closer to 210,000 equivalent full power hours.

THE PRESIDENT: And that's where you're confusing us.

So we're looking end of life and aging, and I'm looking for the increment.

What's the difference between plant that's going toward a closure than a plant that recently got refurbished like, I don't know, Point Lepreau?

Are there frequency change, are there measurement change? What is different over time as between a normal operation of a relatively young plant and an aging plant?

Can you summarize it for 10 seconds?

MR. ELLIOTT: Mark Elliott, for

the record.

One example is the hydrogen pick-ups.

So as we get closer to the end of life, we want to make sure that we know exactly how much hydrogen because that affects the brittleness of the pressure tube, as we've talked about.

So there's extra hydrogen sampling as we get closer to the end of the life.

Point Lepreau has just retubed, and they'll be doing it in the first few years on a, you know, lesser frequency, certainly, than Pickering.

THE PRESIDENT: That's exactly the kind of -- you know, it would be useful for us, you know, to understand what is different about the last chapter of the life, if you like.

MR. FRAPPIER: Gerry Frappier, for the record.

So just to be clear, so what we were talking about before was what we call safety analysis, so the periodicity of the safety analysis is doing about the same as it was before.

The emphasis we put on it now for

an aged reactor versus a newer reactor, if you like, is some of the parameters that have to be taken into consideration.

Separate from safety analysis is the whole periodic inspection program that we're talking about, and that's where we do things like actually going out and measuring aspects of the pressure tubes, doing the non-destructive testing of feeders at the -- inspection of feeders that we were talking about earlier. And those sort of timings increase with the -- as the reactor ages.

THE PRESIDENT: Monsieur Harvey?

MEMBER HARVEY: So what I'd like to conclude, what you do in Pickering is not so far of what is the -- your team does in Darlington.

MR. JAMMAL: Ramzi Jammal, for the record.

From a regulatory perspective, I just want to make sure that licensees doesn't get away that the review of safety analysis will be reduced.

The review for the safety analysis will be maintained with respect to the frequency. But you are correct, the periodicity of -- as Mr.

Frappier mentioned, the periodicity or the inspection program frequency will increase, depending on the results that are coming from the field and the review of the safety analysis.

So, the safety analysis review is constant, consistent for the reactor itself, but the inspection program will defer according to the results arising from the review of the safety analysis.

MEMBER HARVEY: Those results could modify the periodicity, too, yeah. I mean, if you find things that you thought you wouldn't find, so you will have to do something.

MR. JAMMAL: Thank you for that. You're correct, it's actually -- it's a feedback, too, so depending on if you are -- if your projection is adequate and your inspection is proving what you are projecting is adequate, then you maintain status quo. But, if there are worse degradation and so on and so forth, then you will have to give the feedback into the safety analysis, increase both frequencies and so on and so forth.

MEMBER HARVEY: But, the day to day business for the staff in Pickering is almost the same -- you’ve got the same duty and the same load of work than in Darlington and Point Lepreau. Well, there is the size of the station, but it will not be so different in the future despite the fact that we are just -- on allonge la période.

MR. SANTINI: I guess you are concerned about the level of regulatory oversight on the licensees programs to maintain the -- for instance, on the life cycle management program.

MEMBER HARVEY: Every thing, every thing.

MR. SANTINI: Yeah. So, yes, we have increased the number of inspections. As I said, that was done previously at the onset of the continued operations plan. So, our oversight is already enhanced, which doesn’t mean that we won’t increase in the future if we see some performance issues of the licensee program. So far, we haven’t seen that, so that gives us confidence that we can keep with the current level of oversight at least when it comes to this particular issues which is the life cycle of the -- of the major components.

MEMBER HARVEY: Merci.

THE PRESIDENT: Just to close on

that one, so on page 17 you have a list of the fuel channel aging mechanism. And the aging mechanism here, I -- so coming back to what is the increment that you need to do, I assume that you will have to monitor a little bit and measure a little bit closer some of these pressure tubes, elongation, tube thinning. Those will not be issues in Point Lepreau right now. So, is that not correct?

So you'll have to do a little bit more frequent measurement, I assume, of some of those aging mechanisms.

MR. SANTINI: Miguel Santini, for the record.

I let licensee respond about how to comply with the standards because effectively the frequency of inspections increased. But the periods you were talking about, our inspections -- so there were inspections. What confuses everybody, we inspect what they inspect, to put it in a layman's language.

Our regulatory oversight is that at the current level we believe it gives us confidence. Their level of inspection has to increase with age.

THE PRESIDENT: Well, that's a good answer. That's what we're looking at, the kind of increment that goes on here.

MR. ELLIOTT: Mark Elliott, for the record.

You know, one of the things that's worth noting is that Pickering is the first reactor to go past 2010 in Canada and to go to where, you know, 2047, as we've discussed. So, you know, the second, third and fourth -- we'll have that information from Pickering so we'll know exactly how the hydrogen builds up, how the pressure tubes expand, how they elongate, so we're going to get a lot of information for the rest of CANDU by being the first. And, so that will be instructive in how we manage this -- the pressure tubes for the whole CANDU fleet.

THE PRESIDENT: Okay, thank you.

Any other questions?

Ms Velshi?

MEMBER VELSHI: Since we haven't talked about feeders, I have some fairly basic questions to ask of OPG. So, have all the feeders been inspected for wall thickness at Pickering?

MR. ELLIOTT: Mark Elliott, for

the record.

Yes, they have at least once. Once -- so there's a base line been done. And then you do another set to kind of see the rate of thinning, and then you take the lead feeders after that and monitor. So, the number isn't going to be one hundred percent in every outage. We're now tracking those lead feeders that are thinning the fastest.

MEMBER VELSHI: And so I noticed in your inspection scope you do more than just the -- well, more than the three lead, there are a bunch of them. So, do you even try to predict what thickness you expect to see when you inspect them as opposed to just checking that they are fit for service? Does your model include a prediction side?

MR. ELLIOTT: It does. And because we are predicting, kind of for business purposes, when we'll have to actually change a feeder, an elbow, cut it out, and so if the rate changes somehow that would affect -- that could affect any number of feeders. So, we're always looking for that rate of thinning.

MEMBER VELSHI: And what's the

track record been now? Is it kind of thinning as you expect? Or, was your estimate more conservative, faster?

MR. ELLIOTT: One other part has changed. It’s as expected and it’s actually not causing us to have to change any feeders. So, we haven’t actually cut out and changed a feeder in quite a long time. But, not only has the -- we’ve got a good handle on the thinning, and it hasn’t changed, we actually have good methods for assessing the fitness for service of the feeders. And that actually has, through technology, improved over the years and so we can actually take a feeder down thinner than we thought in the past we would be able to. So, we’ve kind of improved our analysis, and they’re not thinning at any extreme rate.

MEMBER VELSHI: And if they get thinner then whatever the acceptable rate is, is replacement the only option? Can you like plug them?

MR. ELLIOTT: Replacement is the option we’ve chosen. Plugging, you would have to -- obviously you would stop the flow in that channel. You would have to take the fuel out. I guess it is possible, there's been channels run without fuel in them. But, replacing the elbow is the -- is the tried and true method.

MEMBER VELSHI: Okay, thank you.

THE PRESIDENT: Thank you.

Anybody else?

Mr. Tolgyesi?

MEMBER TOLGYESI: Inspection. When you're talking about -- do you have a specific criteria for inspection frequency? Say, that if you lose 10 percent -- 10 percent loss, it means that it's 15 percent loss in the period between inspections, or if it's another 10 percent, or it's pre-determinated, or you go according to what you observe?

MR. ELLIOTT: I'm not really sure I understand. We certainly wouldn't --

MEMBER TOLGYESI: Say you have a specific dimension, say diameter. If it's a loss of 10 percent, now you were doing -- originally you were doing inspections every -- every six months. That means that if you lose 10 percent you will do every four months an inspection? It's something like this, or it's in function of some other criteria?

MR. ELLIOTT: The results actually do inform what we're going to do. My best example is that the cracking of feeders was found at Point Lepreau, and they ended up having to inspect every year as opposed to like an every two-year outage frequency.

So, yes, what we find, the actual results, will guide us on what we should be doing in terms of increased inspections, or maybe the same frequency but more -- more feeders to make sure there's nothing untoward.

MEMBER TOLGYESI: M'hmm.

MR. ELLIOTT: So, yes, there's a feedback loop from the inspections, the results back to the plant.

MEMBER TOLGYESI: And my last is, on page 14 you are talking about authorized inspection agency. And, what's the role, responsibilities and involvement of an authorized inspection agency? Do they develop a plan? Do they ensure oversight? Are they involved in the execution, or what?

MR. JAMMAL: Ramzi Jammal, for the record.

Are you asking staff to start, or

you want OPG to start?

We can start. I'll pass it on to Mr. Gerry Frappier with respect to TSSA and their inspections on behalf of CNSC.

MR. FRAPPIER: Gerry Frappier, for the record.

So, we're talking about pressure boundary in particular where any time there's any changes, a design change, for instance, or particular inspections that are done, the licensee would be doing those inspections and we require them to have what's called an authorized inspection agency. In this case it's TSSA, so it's a provincial entity that does this kind of inspection for all kinds of different -- different industries. They have a special group of inspectors that are certified to do nuclear type pressure boundaries inspections.

They would come and then review what has been done, either review in a sense of looking at the actual inspection results, whether it be an x-ray inspection or whatever the case might have been, or from the -- if they changed the design, to review the design changes that were made and ensure that they meet all the codes. So, that’s a third part that’s completely independent from the licensees.

MR. JAMMAL: Ramzi Jammal, for the record.

I would like to add that even though TSSA, it’s not a one-off inspection, they have staff on site, TSSA staff, who are permanent on site resident inspectors that they do the verifications, and they are in close collaboration with our staff and our inspectors.

MEMBER TOLGYESI: And who gives authorization, it’s CNSC or another regulatory body, to these authorized inspection agencies?

MR. FRAPPIER: Gerry Frappier, for the record.

So, the inspection agency has to be authorized by ourselves, by CNSC. We decide that this is an inspection agency that is acceptable to the -- to the Commission to be playing the role of authorized inspection agency. It’s different ones for different licensees.

MEMBER TOLGYESI: But this particular one is used by all industry for anything to do with pressure boundaries, boilers, etcetera? It’s a well-known and credible organization?

MR. FRAPPIER: Gerry Frappier, for the record.

Yes, it's been around for a long -- it used to be part of the province. It also does inspections on elevators and everything else. TSSA is a big inspection organization.

But, like I said, they do have a special group that are associated with nuclear facilities.

MEMBER TOLGYESI: Are they involved -- this is for OPG -- are they involved in the planification of frequency of inspections, you know when you are talking about aging? How are they involved in this?

MR. ELLIOTT: The TSSA is involved in -- when we do maintenance work and repair work, and we do -- we have to have a pressure boundary package in terms of how we're going to do the welding. They would approve that package. They would look at the results. They would witness hydrostatic tests. They're not so much involved in the analysis of pressure tubes, that's our own people and the CNSC experts.

THE PRESIDENT: Okay, anything

else?

Okay, thank you. Thank you very much.

We are slightly behind schedule, but we will continue ahead, I think, with the last item for today which is a presentation by CNSC entitled Cradle to Grave Fuel Management Story in Canada, as outlined in CMD 14-M51. And, I understand that Mr. Frappier, you will make the presentation?

CMD 14-M51

Oral presentation by CNSC staff

MR. FRAPPIER: Yes.

THE PRESIDENT: Whenever you're ready.

MR. FRAPPIER: Thank you, Mr. President and Commission.

For the record, my name is Gerry Frappier, I'm the Director General of the Assessment Analysis Directorate at the CNSC.

With me today are Dr. Michel Couture, Director of Physics and Fuel Division, Mr. Mike Rinker who is the Director of Fuel

Processing Division, Mr. Don Howard, who is the Director of Waste and Decommissioning Division.

And this presentation is -- you can relax a little bit, it's -- it's not for decision, it's really information about -- we've titled it Cradle to Grave Fuel Management Story, but basically think of it as Fuel Management 101, which will be, I think, of use to both the public and everybody else.

So, this briefing to the Commission on the Cradle to Grave Management of Fuel including used nuclear fuel, and with the main focus being on CANDU fuel, this presentation is intended to provide a background information on basic concepts, processes and technical and safety aspects of nuclear fuel from the beginning, that is the cradle, which is uranium mining, to the interim management of used fuel.

We will also touch on plans for the long-term management of used nuclear fuel within Canada, that is the grave.

I think it would be useful to first cover some basic notions that are important to understanding the changes that happen to uranium as it goes from being a rock in the ground into being fuel for a reactor and then into being used fuel.

So a couple of -- I'm bringing you back to your physics, your high school physics, if you like.

So, nuclear fission is the splitting of an atomic nucleus and is the main process by which energy is produced in nuclear reactors.

Atoms with nuclei containing the same number of protons but a different number of neutrons are called isotopes.

Uranium has several isotopes, but two of them in particular, uranium-238(U^{238}) and uranium-235(U^{235}), with 92 protons each and 146 and 143 neutrons respectively, make up almost 100 percent of the naturally occurring uranium.

Fast neutrons, another word, are generated during nuclear fission, and they move at a very high velocity of approximately 14000 km/sec.

Fast neutrons generated from fission in CANDU and light water reactors are slowed down through collisions with the atoms of a moderator material (usually light water, heavy water or graphite). This slows the neutrons and these slower neutrons are known as thermal neutrons and they have a velocity that's still quick, but much, much less than the others, at 2.2 km/sec.

The thermal neutrons have a greater probability of causing fission and therefore they are the key to a sustainable chain reaction in a reactor.

Fissile material is a different type of material, it's a nuclide that is capable of undergoing fission after capturing a thermal neutron. The three primary fissile materials are uranium-233(U^{233}), uranium-235(U^{235}), and plutonium-239(Pu^{239}).

CANDU reactors use heavy water as a moderator, and light water reactors use light water, or H_2O) as a moderator, as we've talked earlier today.

Another piece of definition that's important is what's called fertile material. So, fertile material is a material, which is not itself fissile, but that can be converted into a fissile material by irradiation in a reactor. And there are two naturally occurring fertile materials: uranium-238(U^{238}) and thorium-232(Th^{232}), and when these fertile materials capture neutrons, they are converted into fissile plutonium-239(Pu^{239}) and uranium-233(U^{233}), respectively.

Now, let's talk radioactive decay itself. So, radioactive decay refers to the phenomena by which a nucleus transforms into another nucleus, or to a lower energy state by emitting energy (radiation). The chain of decays will take place until a stable nucleus is reached, so it might go through many transitions.

The radiation emitted by an unstable nucleus takes the form of a tiny fast-moving particle, either an alpha particle, beta particle, or a neutron, or as gamma rays.

Gamma rays are very similar to x-rays, are very penetrating and are best stopped or shielded by very dense materials.

Fission fragments resulting from a fission -- from a decay -- resulting from the nuclear fission are mostly radioactive nuclei which decay through emission of radiation.

Continuing on radioactive decay, the concept of half-life is very important. And the half-life of any radioactive material is the length of time necessary for half the number of the nuclei of that material to decay to whatever the next material is it's decaying to.

And, they come in quite a different variety of half-lives, and that's very important as we move forward to think about long-term what do we have to do with the nuclear waste.

So, the half-life of uranium-235(U^{235}) and U^{238} are 0.7 billion and 4.5 billion years. So, as you can see, they're going to be here forever, or for a long, long time.

Other items that you will find within fission products that are within a reactor have much different half-lives, so Krypton-90, for example, 30 seconds. We're not going to worry about it for very long, it's going to be gone.

Krypton-85 for 10 years.

Cesium-137 for 30 years.

These are things that are going to be around and have to be considered.

To put it in perspective, Mo^{99}, which we've talked about often at the Commission, here, has a half-life of about 66 hours, which is why it's good for medical purposes, it's not going to be in your body for very long.

Iodine-131, another one that we talk about often, has an eight day half-life.

And, Tritium half-life is about 12 years.

So, just to show that there is quite a range, and that's a very important parameter when talking about radioisotopes.

So, now talking about uranium as a fuel, natural uranium which is found in the earth's crust is a mixture largely of two uranium isotopes, uranium-238(U^{238}) and U^{235} which accounts, as you see there, for about 100 percent of the uranium.

CANDU reactors can operate with natural uranium fuel. It is very different than other reactor technologies.

Uranium fuel enrichment is another definition that's important and it's the ratio of mass of fissile material to the total mass of fissile and fertile material.

Research reactors in Canada, unlike CANDU reactors, do operate with enriched uranium fuel. So that is something that there is in Canada.

Light water reactors can only operate with enriched fuel, typically 3 percent to 5 percent enrichment.

I would now like to give a quick Overview of the Nuclear Fuel Cycle before I pass it over to Michel and the others.

First off, Three Categories of Activities associated with fuel.

The nuclear fuel cycle refers to all activities related to the use of fissile material as fuel in fission reactors. There are uranium and thorium based fuel cycles.

In general, all those activities fall into three categories:

The front-end fuel management, which is mining, milling, refining, conversion, enrichment if there’s enrichment, and fuel fabrication and assembly.

Then we have in-core fuel management which is the fuel assembly design itself and then in-core depletion, running it through a reactor and getting your energy out of it.

And then the back-end fuel management, which is the spent fuel cooling, storage, reprocessing if you’re doing reprocessing, and waste disposal.

It is important to realize that the CNSC regulates all activities within the nuclear fuel cycle, from mining to the interim to long-term management of used nuclear fuel.

Types of Nuclear Fuel Cycles.

There are two types of nuclear fuel cycles that are important to talk about.

One, is open cycle, which is used fuel is considered as a waste. There is no fuel reprocessing, you basically run your fuel through your reactor once and now you have a waste.

There's also closed fuel cycles where the used fuel is reprocessed to produce new fuel to be used in fission reactors. So you can take the fuel, reprocess it and use it over again.

The type of nuclear fuel cycle chosen by a country and the activities it will need to perform within that fuel cycle depends on the reactor type it operates, resources available, technology status and national policy.

Canada has an open uranium fuel cycle; that is, we do no reprocessing in the country and no enrichment facility since we can use natural uranium.

Very quickly here is the Canadian uranium fuel cycle. We'll talk a bit more about it in a minute, but I just briefly want to describe how the fuel progresses.

Our fuel cycle begins in mining. Canada has a large uranium mining sector that produces extremely high grade uranium deposits which supply a significant portion of global uranium needs.

Most of the ore mined in Canada is processed in Canada. We have a uranium refinery and conversion facility both in the Province of Ontario, these have very large throughputs. For instance, in Blind River is licensed to have 24,000 tonnes of uranium per year and most of the material that goes through these facilities is exported either as UO_3 or UF_6.

Our conversion facilities also produce natural uranium oxide powder to supply three fuel fabrication facilities, chiefly producing natural uranium fuel bundles for use in CANDU reactors.

There are 19 CANDU-type reactors operating in Canada spread over five sites and two provinces and the CANDU design is a pressurized heavy water reactor with on-load refueling and fueled by natural uranium.

As mentioned earlier, we have an open fuel cycle; that is to say, there is no reprocessing of spent fuel in Canada. All spent fuel is currently stored at the reactor site where it was produced, although the Nuclear Waste Management Organization, which is a government body, is actively planning a long-term facility management for spent fuel.

Outside of the natural uranium fuel cycle associated with the power plants, we also have the Chalk River laboratories and the NRU reactor which is fueled with lightly enriched uranium.

The Chalk River site also includes facilities for the manufacture of enriched fuel and the production of Moly-99 and extensive waste management areas due to Chalk River's long operating history.

Finally, we have various other small establishments, including research reactors in locations and decommissioned facilities and these are all spread through the country, some of which have enriched uranium -- enriched fuel.

A safety issue that is very specific to the nuclear industry is what is known as criticality safety. Fuel handling, storage and transportation of fresh and used enriched nuclear fuel introduces the issue of an inadvertent criticality accident; that is, a nuclear chain reaction that would start outside of a nuclear reactor. This is a very serious safety concern, however, criticality safety is not a concern for CANDU reactors since it uses natural uranium.

We have there a little chart just showing the different sort of groupings of enriched fuel and the potential for inadvertent criticality going from insignificant with one percent enriched to very high if you have 90 percent enriched.

In Canada the regulatory document Reg Doc 327 and Reg Doc 364 specify requirements for prevention of criticality accidents during fuel handling, storage and transportation.

Another important aspect of nuclear fuel cycle is ensuring it is only used for peaceful applications and this comes under the term of safeguards, which is a system of international inspections and other verification activities undertaken by the International Atomic Energy Agency in order to evaluate a state's compliance with its safeguards agreements with the IAEA.

The IAEA conducts activities across the Canadian fuel cycle to verify that all nuclear material remains in peaceful applications.

The CNSC performs inspections to ensure that relevant Canadian licensees are implementing safeguards programs. The fuel cycle facilities are required to report to the CNSC on all inventories and transfer of nuclear materials in accordance with Regulatory Document 336.

The General Nuclear Safety and Control Regulations require that licensees take all necessary measures to facilitate compliance with any applicable safeguard agreements.

Finally, on the CANDU fuel and fuel cycle options, the CANDU design itself can use natural uranium, but it's actually a very flexible reactor technology that allows multiple fuels to be used. The uranium fuel cycle, which is where we use natural uranium, is what all current CANDUs use.

The use of low enriched uranium is a possibility and was the basis for the advance CANDU reactor design, the ACR design that we were reviewing over the past few years.

And the use of reprocessed fuel from light water reactors is a possibility, not likely to happen in this country since we don't have light water reactors, but many other countries, led probably by China, very interested in this because then you can take your fuel waste from your light water reactor and use it as fuel in your CANDU reactor.

There's also the possibility of thorium fuel cycle, again not so much of an interest here in Canada, but very much of an interest in other countries in the world where you use a plutonium thorium basis to run your reactor, or you can use a uranium thorium base as a fuel for your reactor.

So the CANDU reactor offers many options for exploiting the CANDU light water reactor synergism, but in Canada all CANDU reactors use natural uranium, as you know.

I would now like to ask Dr. Michel Couture to provide more details on the front-end and in-core fuel management.

MR. COUTURE: Thank you, Gerry.

Having provided you with some basic notions and an overview of the nuclear fuel cycle, we would now want to provide more detailed information about the three categories of activities within the uranium nuclear fuel cycle; namely, what is called a front-end fuel management, the in-core fuel management and the interim and long-term used nuclear fuel management.

The focus will be on CANDU uranium fuel cycle. I will be covering the front-end and the in-core part and Don Howard will then complete the presentation by discussing the back-end.

As mentioned earlier, the activities of the front-end fuel management are comprised of mining and milling, refining, conversion enrichment, in the case of Canada for the CANDU we do not do enrichment as was mentioned by Jerry, and fuel fabrication and assembly.

In the case of CANDU, front-end fuel management in Canada there are, like I just said, no enrichment activities.

The above diagram shows the

process of how uranium is mined and processed to be used in a CANDU reactor. It also shows the facilities that the CNSC regulates where manufacturing occurs.

So, for example, uranium is mined at the Cigar Lake Mine in Saskatchewan. The ore is then transported to McClean Lake in Saskatchewan who mills it into what is known as yellowcake which is a -- you take uranium ore and you refine it and you get -- it's separated chemically and you end up with this, what they call yellowcake.

The yellowcake is shipped to Blind River where it is refined. The refined, or if you want the purified uranium which is referred to as oxide UO_3 is shipped to a uranium conversion facility, for instance, Cameco in Port Hope where the chemical form of uranium is converted to UO_2 for CANDU reactor fuel.

The Port Hope conversion facility also converts UO_2 into uranium hexafluoride gas, UF_6, and then shipped to the U.S. or elsewhere for enrichment.

So this potential path is not done in Canada, of course, and it's done elsewhere. So

Cameco does actually serve the community, the nuclear community outside Canada for enrichment facilities.

The UO_2 powder is then shipped. Once you have the UO_2 powder, it's then shipped to a CANDU fuel fabrication facility such as Cameco or GE Hitachi where the UO_2 powder is pressed into pellets. Those pellets are then inserted in a CANDU reactor fuel bundle.

For example, GE Hitachi fabricates the tubes of your bundle in Arnprior, fabricates the pellets in Toronto and assembles the fuel bundles in Peterborough.

Once assembled, the fuel bundles are then transported to a CANDU reactor site where they are to be loaded into the reactor in order to produce electricity.

Overall the radiation hazards associated with the front-end fuel management of the Canadian natural uranium fuel cycle are much lower than those associated with handling of irradiated fuel which occurs during activities related to in-core or back-end fuel management.

Radiological hazards related to the activities related to the front-end fuel management are very low, and unlike the other components of the fuel cycle, there are no hazards related to heat generation because, like we just mentioned in our basic notions, the heat generations come from decay and at the time you're just using the pellets you're just manufacturing the fuel, there's no decay going on, everything is very stable. It's composed essentially of U^{238} and U^{235} which have very long half-lifes.

Furthermore, unless fresh fuel bundles with enriched fuel pellets are being assembled and/or stored, there are no hazards related to inadvertent criticality accidents.

I would like to conclude this very short description of the front-end fuel management by providing a brief description of the CANDU reactor core and of how the fuel is loaded into the reactor core because that's the last part.

You have manufactured your bundles and then you will load them in the reactor.

The core of a CANDU reactor is contained in a large, horizontal, cylindrical tank called calandria which contains the heavy water moderator. Several hundred horizontal fuel channels run from one end of the calandria to the other.

Each channel has two concentric tubes. The outer one, called the calandria tube, forms the inside boundary of the calandria. The inner one, called the pressure tube, holds the fuel and the pressurized heavy water coolant. Pressure tubes are approximately six metres long and have a diameter of approximately 10 centimetres.

The number of fuel channels is reactor design dependent and varies between 380 and 480 channels. For example, CANDU 6 is 380.

Each fuel channel is loaded with 12 and in some cases 13 fuel bundles. The total number of fuel bundles in a CANDU core is design dependent and ranges from approximately 4,500 to 6,000 bundles.

Fresh fuel bundles are inserted into the fuel channels by remotely operated fueling machines. The fueling machines can function while the reactor is operating and is referred to as on power fueling.

To refuel a channel, a pair of fueling machines are latched onto the ends of the channel. A number of fresh fuel bundles are inserted into the channel by the machine at one end and an equal number of irradiated fuel bundles are discharged into the machine at the other end of the channel.

Light water reactors, like pressure water reactors, need to shut down before refueling and refueling is done during plant outages.

So now we're going to the in-core fuel management. As mentioned earlier in the presentation, nuclear fission is the main process by which energy is produced in nuclear reactors and eventually transformed into electricity.

In order to ensure that this is done efficiently and safely, there are many activities that need to be performed before loading the fuel in the reactor and once it is loaded in the core.

Those activities are part of what is referred to as in-core fuel management and include the fuel design activities and activities related to in-core depletion which is the decrease in time of the fissile material such as U^{235}.

In-core fuel management activities are very complex. This presentation will be limited to only mentioning some key notions.

Proper in-core fuel management requires a detailed understanding of how energy is being released from nuclear fission. We will cover in a few slides the various forms of energy release during the fission.

Fuel design and qualification are important activities related to in-core fuel management and we will briefly discuss them in this section.

In CANDU reactors, refueling is carried out with the reactor at power. This feature makes the in-core fuel management substantially different from that in reactors that must be refueled while shut down.

For CANDU reactors, fuel-loading and fuel-replacement strategies are required in order to operate the reactor in a safe and reliable fashion while keeping the total unit energy cost low.

Those strategies cover fuel channel selection, its timing and the number of bundles that need to be removed and replaced by fresh fuel.

And at the end of our presentation in this section we will cover some of the objectives of these fuel-loading and fuel-replacement strategies.

As mentioned earlier, nuclear fission is the main process by which energy is produced in a nuclear reactor.

Over 80 percent of the energy of fission appears as kinetic energies of the fission fragments and this immediately manifests itself as heat. Essentially your fission fragments -- your nucleus is split and your fragments are flying within the pellets and they'll be slowed down and just by the slowing down of it, the friction, that creates heat. So that's 80 percent of that energy is due to the kinetic energy of the fission fragments and they're slowing down into the fuel and the fuel pellet.

The rest of the fission energy is liberated in the form of instantaneous gamma rays from excited fission fragments and as kinetic energy of the fission neutrons. Essentially when you have a split of the nucleus, you will have, like we just mentioned, kinetic energy of your fragments and also fission neutrons that are emitted. So that's part of the energy produced during the fission.

About seven percent of that total heat generated in the reactor is obtained from the decay of radioactive fission products. This decay heat must be safely removed after the reactor shutdown. And that's of great interest, like Jerry mentioned, when you're starting to talk about the waste and how to -- when you're unloading the fuel from the reactor and putting them either in a pool or storing them on dry storage, you have to worry about decay heat and then the decay heat will depend also on the half-lifes of your fission products which are in the fuel.

Fuel burnup is the energy generated in the fuel during its residency in the reactor core per unit mass of fuel. So the amount of energy you're extracting essentially per unit mass of fuel is called fuel burnup and that turns out to be a key parameter, in fact, when you're either -- when you're planning your in-core management, so how much burnup do you want to achieve.

The energy of fission is generated at the expense of fissile nuclei. Their amount in the fuel material decreases in time, which is called fuel depletion; certain other fissile isotopes build up such as plutonium and U-233 and contributes to the total energy generated in the fuel. I'll come back to this.

So actually as you are proceeding you start with U^{235} and U^{238} and U^{235} being the fissile material, but as you're progressing in your depletion in the core through fission chain reaction you start producing other fissile materials like Plutonium-239 or U^{233}.

Onto next one. Here's the example of the production of energy due to Plutonium-239. Although you do not start with Plutonium-239 in your fuel, plutonium is a fissile material which is normally created in the nuclear reactor by transmutation, meaning actually by -- through absorption of a neutron.

Here we have basically a small equation explaining how this is done. The neutron -- your U^{238} will absorb a neutron, it creates a U^{239} and then there will be decay, it

For instance, the length. As was mentioned, the bundle for a CANDU fuel .5 m; a fuel assembly for a light water reactor is 4 m.

If you looked at the weights, 25 kg roughly for CANDU fuel, 450 kg for a light water reactor or a PWR, pressurized water reactor.

The elements, 260 in one for the light water reactor, 28 or 37 for CANDUs.

So what one notices in this is that the complexity of one fuel assembly compared to the other, the weights, so this could have impact. If you thought about it, you would realize that first on the design side it is more complicate.

And also if you are thinking about waste management afterwards, once you unload the fuel, the challenges are slightly different. They can be handled safely, there's no question about that, it's done by the light water reactor, but perhaps it's slightly different, you just can think about having to carry 450 kg instead of 25 kg. And the issue of -- since it's enriched fuel you have criticality safety that adds to perhaps the hazard but, again, it can be handled safely.

Should Canada end up having a light water reactor, we would be facing this type of design instead of CANDU fuel or maybe combined.

That was essentially the purpose, it just gives you an idea of the differences.

Here what I wanted to emphasize on the CANDU fuel bundle design qualification is that given the importance of fuel from a safety perspective, not only from a production perspective, the introduction of a new fuel design requires close regulatory scrutiny.

Prior to loading in a power reactor a fuel bundle -- and here I'm focusing on the CANDU -- a fuel bundle of a new design is subjected to very complex and rigorous fuel qualification process, which includes in-reactor and out-reactor tests.

So this qualification process, starting with the design and eventually the testing in test reactors and reactors such as NRU, you have to do all of that before you conclude at the end. There is some analysis on top of that that your fuel is qualified and can be loaded in a reactor -- in a power reactor.

CNSC authorizes the loading of a

new fuel design into a power reactor only after completion of a thorough review of all fuel qualification results.

CNSC staff review of fuel qualification results is multidisciplinary, represents a major effort and requires a high level of expertise. The most recent one of course was the 37M. Modifications were small, nevertheless we went through a very thorough process of review before authorizing the loading of the fuel in the reactor.

Finally, worth mentioning that since it's on-power refuelling in the CANDU reactor, there is obviously -- it may not be obvious just thinking about it, but you have to decide at one point since you want to maintain the chain reaction all the time and you have depletion, then you have to have a strategy as to which channels you will be replacing the fuel and how many bundles will you remove. Will you remove two bundles, four bundles and then replace them by new fuel? You have to make sure that you avoid distortion in your fluxes while you are doing this refuelling.

So the primary objective of the

fuel management, in-core fuel managing, loading and fuel replacement strategies to operate the reactor in a safe and reliable fashion while keeping -- so that is the main objective of in-core fuel management, it is to determine fuel loading and fuel replacement strategies.

Specific objectives include adjust a fuelling rate to maintain reactor critical and at full power. If you don't do your replacement of the fuel as it's depleting, so you have less and less U35, you may have the Plutonium 239, but at one point you will end up having -- you will not make -- you will have difficulties maintaining your chain reaction, the steady state, so you have to start loading new fuel in there.

So one of your objectives is to adjust the refuelling rate to maintain reactor critical and at full power.

Control the core power to satisfy safety and operational limits on fuel power.

You certainly don't want to -- there are always limits on the fuel power you can achieve in the channels, so you have to make sure you take this into account when you are fuelling.

Maximize burn up with operational

constraints to minimize fuelling costs.

I mentioned that earlier. You want to maximize the energy extraction from your fuel. If you do a poor fuel management and you actually remove the fuel before the maximum amount of energy was taken out of it, you are actually increasing the costs of your fuel.

Avoid fuel defects to minimize replacement fuel costs and radiological occupational hazards.

Here what happens is, when you are actually fuelling, changing the fuel, your fuel actually, since it's a fresh fuel, you will go through some form of power ramp. There will be an increase in power in that channel, so you have to be careful that you do not fail the fuel for that.

This has been planned. This is part of fuel qualification, they go through power ramping and making sure that your fuelling strategy takes into account the maximum power ramps that you can tolerate, otherwise you may actually start failing your fuel.

So on-power refuelling is a key feature of CANDU reactors which requires the development of fuel loading and fuel replacement strategies.

So that concludes my part of the presentation.

MR. HOWARD: Okay. This section of the presentation will focus on what is termed as the back-end of the fuel cycle, the exciting part, looking at the characteristics of CANDU fuel once discharged from the rector, the interim storage of the used nuclear fuel in either water-filled bays or dry storage facilities, and then I will briefly touch on Canada's plans for the long-term management of used nuclear fuel.

So let's start off with some key messages.

Basically there are three main hazards associated with used nuclear fuel: criticality, radiation dose and heat generation. All used nuclear fuel is managed safely in either wet or dry facilities that are safe, secure and environmentally sound.

These facilities are under close CNSC regulatory oversight and CNSC staff routinely perform compliance verification activities. The types of barriers used range from water in the water-filled bays, to the bay liner, to reinforced concrete structures.

First, I will start by explaining the hazards associated with a used nuclear fuel bundle and the multi-barriers that are in place to ensure that these hazards are managed in the interim, meaning less than 100 years, and the long-term, great than 100 years.

So criticality, as mentioned earlier in this presentation, is not an issue for CANDU fuel. However, criticality needs to be considered by the Nuclear Waste Management Organization for the long-term management of used nuclear fuel as there currently exists a very small quantity of non-CANDU fuel currently in storage at the Chalk River laboratories.

Next, radiation is the key hazard as the used nuclear fuels exits a reactor and throughout its interim and long-term management. However, as shown on the slide, radioactive doses decreases over time to less than one mSv per hour at year 500. Therefore, due to the penetrating radiation shielding is required.

The third main hazard is heat. At the time of discharge from the reactor a CANDU bundle is hot and needs to be cooled. As shown on this slide, a CANDU fuel bundle at the time of discharge from the reactor emits 27,600 W of decay heat, which is almost equivalent to 460 60-watt light bulbs.

So the used fuel bundle is initially stored in water-filled storage bays, because the water helps to shield the workers from the radiation, but it also helps to cool the used fuel bundle. However, because of the long-lived radio isotopes being present in the used nuclear fuel, significant decay heat continues to be produced once removed from the reactor for a number of years, as illustrated on the figure.

After a residence time of about 10 years in the water filled storage bay, the decay heat reduces significantly, down to 6 W per bundle, almost equivalent to a nightlight. So we have gone from 460 60-W light bulbs, to a nightlight in 10 years.

Now I will discuss interim or short-term management of used fuel.

Interim storage of used nuclear fuel occurs at each of the nuclear reactor sites in Ontario, Québec and New Brunswick. Also, used nuclear fuel is also stored at AECL sites in

Ontario and Manitoba.

The initial interim storage method is wet storage. Each reactor site has wet storage bays within the reactor buildings for this purpose.

As previously indicated, the water cools the fuel and acts as a shielding for the radiation. The storage capacity at the bays are typically designed for 15 to 20 years of spent fuel.

Once the used nuclear fuel has reached a storage age of between 7 to 10 years -- this will be dependent on the design of the dry storage container -- it can then be transferred to dry storage. Each reactor site currently has a dry storage facility which is routinely monitored and has no impact on the public or the environment.

Canada's nuclear program has produced over 2 million used fuel bundles over the past half century. If these bundles were stacked end-to-end, they would fit into a space the size of six hockey rinks, stacked to the top of the boards.

As previously indicated, the used

nuclear fuel is initially discharged into the wet fuel bays. I will now outline some information on the wet fuel bays.

The wet fuel bays are all at or in ground level, they are double-walled reinforced concrete with steel or epoxy liner. The bays are seismically qualified. There are approximately 12 to 16 used fuel bundles discharged per unit per day and each emitting, as previously indicated, 27,600 W of decay heat. Therefore, 2 to 10 MW of cooling is required to keep the water below 30 degrees Celsius.

A new CSA standard for wet storage of used nuclear fuel is currently under development.

This slide outlines the many accident scenarios considered in the applicant's safety report and review by CNSC staff.

As requested by the CNSC, licensees conducted a post-Fukushima analysis to determine the robustness of the safety analysis. It was determined that the ability to easily replace or add water to fuel bays in the event of an accident scenario is essential.

Therefore, on this slide multiple

sources were identified, station water, fire water, emergency water, water gravity feed and transferring water from the lake. This all formed part of the Fukushima Action Plan.

The slide shows the initial filling of the storage pool.

Within Canada dry storage forms part of the interim management of used nuclear fuel. It is standard practice that the used nuclear fuel bundles are transferred to a dry storage facility after a cool-off period and the wet storage bays. Dry storage containers are designed to reduce radiation exposure and manage the decay heat.

There are basically three designs currently in use in Canada: the OPG dry storage container, or DSC; the AECL CANSTOR module and the AECL Canister or silo.

As with wet storage bays, they use reinforced concrete with a steel or epoxy inner liner. The dry storage containers are seismically qualified.

This slide provides one example of dry storage which is OPG's Dry Storage Container or DSC. Each OPG dry storage container holds

384 used fuel bundles that have been cooled in the storage pool for 10 years or more. The bottom right picture is the dry storage facility at the Western Waste Management Facility at the Bruce Nuclear Power Development site.

The top left corner in this slide is of the AECL CANSTOR module which is currently in use at the Gentilly 2 Nuclear Generating Station. Each CANSTOR module contains a total of 12,000 used fuel bundles.

The bottom right picture is the AECL canister or silo design which is currently in use at the Point Lepreau Generating Station. Each canister or silo holds approximately 60 used fuel bundles. This canister design is also used at Whiteshell, Douglas Point, and Gentilly 1.

Regardless of the type of storage structure used, they all utilize the same principles of defence in depth, using multiple barriers. The dry storage system essentially produces no solid, liquid or gaseous effluents.

In response to CNSC requests following the accident at Fukushima, OPG assessed the impact of Beyond Design Basis Accidents and consequential event sequences on the existing safety envelope of the waste management facilities including dry storage facilities. In all scenarios assessed for each waste management facility and dry storage facility, the consequence of the resulting events were found to be within the existing safety envelope for each facility.

No significant issues requiring immediate corrective or compensatory measures were identified. Potential improvement opportunities were identified and are being implemented by Ontario Power Generation.

For example, OPG is considering and assessing reducing the resistance time of used nuclear fuel in the wet storage bay from 10 years to around 7 years. This would then be in line with the practice currently used by Hydro-Québec and New Brunswick Power.

Due to the characteristics of used nuclear fuel, it needs to be contained and isolated for long periods of time.

The Nuclear Waste Management Organization has been mandated to implement the long-term management strategy, namely the Adaptive Phased Management approach, or commonly known as the APM approach, for Canada’s used nuclear fuel.

This approach must include consideration of any new reactors, meaning any new types of fuel.

A site selection process to find a willing host community was launched in May 2010. A total of 22 communities initially stepped forward as potential candidate sites. This has been reduced to the current 14 communities, with a further reduction expected in early 2015. Although there are no fixed timelines, the Nuclear Waste Management Organization is working towards an operational date of 2035.

It should be noted that presently there is no licence application. However, the CNSC is conducting pre-licensing activities in such areas as:

Conceptual safety case reviews for a hypothetical repository in a sedimentary crystalline rock formation;

Conducting independent research in areas such as bentonite seals, copper containers; and

Conducting outreach activities in the various communities.

I will now pass the presentation back to Mr. Frappier to summarize.

MR. FRAPPIER: Thank you.

In summary, the type of nuclear fuel cycle chosen by a country, and the activities it will need to perform within that fuel cycle, depend on the reactor types it operates, resource availability, technology status, and its national policy.

In Canada, the power reactors being operated are of the CANDU type; they are heavy-water cooled, moderated, and utilize natural uranium.

Research reactors being operated in Canada use enriched fuel.

Canada has an "open" uranium fuel cycle, that is there is no reprocessing, and has no enrichment facility.

Fuel, including used nuclear fuel, is under CNSC regulatory oversight and is safely managed throughout the nuclear fuel cycle in facilities that are safe, secure and environmentally sound.

The CNSC is responsible for licensing facilities for the interim and the long-term management of used nuclear fuel, including deep geological repositories.

We are now available for any questions you might have.

THE PRESIDENT: Thank you. There's an interesting story here. Why don't we get some comments questions starting with Monsieur Harvey, s'il vous plaît.

MEMBER HARVEY: You mentioned that China was interested and maybe some other countries to use the reprocessed. It is not yet done anywhere in the world, I mean to use reprocessed fuel -- used fuel?

MR. FRAPPIER: I will start and I will ask Michel to add a bit to it.

So China has indicated an arrangement with CANDU Energy whereby they are investigating to use various types of fuel in the CANDU reactors that they have in China and in particular to be looking at taking fuel from their light water reactors, the waste fuel if you like, or the used fuel, and then reprocessing it so that it is available for use in the CANDU reactors. That's what we were making reference to in our discussion.

The reprocessing of fuel is quite complicated and obviously because it's highly radioactive there is a lot of heat and depending on what configuration you are trying to get to, from and to, can be quite difficult, but it has been done in different places and maybe Michel can give us a little bit more on that.

MR. COUTURE: Michel Couture, for the record.

I think, like Gerry mentioned, that was the Chinese decided to go with this reprocessing and they have actually gone through some tests and, as far as I know, they are going ahead with this reprocessing from the light water reactor to the CANDU.

MEMBER HARVEY: What is the purpose doing that? It just takes you to take care of the --

MR. COUTURE: Well, it is to -- essentially they figure they can actually -- you want to extract as much as possible the energy that is left in the fuel that you just unloaded, so one way of doing this is, if you can and you have the technology needed for it, if you go from a light water reactor, when it comes out of the light water reactor it's still enriched enough to actually be used in a CANDU reactor.

The CANDU reactor can operate with actually natural uranium on unriched. So even if you do have a bit of enrichment, the CANDU reactor can operate. So you start producing electricity using the waste of another reactor and therefore you are reducing your cost per I guess kilowatt hours you are producing.

MEMBER HARVEY: What is the percentage of energy taken out from the fuel when you extract it from the reactor when it goes in the bay?

MR. COUTURE: You mean what's remaining in terms of what's still remaining?

MEMBER HARVEY: Well, when you take it out from there reactor it's because there's not enough energy in it to produce I suppose?

MR. COUTURE: You decide, especially in the CANDU fuel, let's say CANDU natural uranium, after a while you will not have enough fissile material in there to maintain your chain reaction, a steady-state chain reaction, so you have to remove it. You start losing your -- you will not be able to maintain a steady state of neutrons being absorbed and being created because you don't have enough.

When you actually have enriched fuel, it allows you to stay there longer.

MEMBER HARVEY: Further.

MR. COUTURE: You can stay longer and extract more energy.

So the strategy, I think for the CANDU, the CANDU can use both enriched and natural, so you take some waste from the light water reactor and you reprocess it in the CANDU.

It's an integral process, however, and in Canada of course we don't have the light water reactors to provide us the -- and at the moment it's not economical to do that in Canada.

MEMBER HARVEY: It won't be cheaper than using that --

MR. COUTURE: No, it would not be cheaper to --

MEMBER HARVEY: Okay. Okay, just one other question.

There is a different configuration of the fuel bundle, but does the flow remain the same in the pressure tube depending on the nature of the different bundle?

MR. COUTURE: Well, what will

happen with different designs, you will end up having the flows within the sub channels between the elements will be different.

MEMBER HARVEY: Will be different.

MR. COUTURE: Will be different, but the --

THE PRESIDENT: But the bundle itself, the actual pellets, the fuel pellet --

MR. COUTURE: Oh yes.

THE PRESIDENT: -- it's the same?

MR. COUTURE: Oh, the pellets are the same, yes.

For instance, if you have a certain pressure tube size, you know, you can -- what you can do is, if you start decreasing, like if you go from 37 to -- let's say 28 to 37, you will end up with smaller elements, so your pellets would have to reflect that.

You have to adjust to the tube, the size of the tubes you have. The more tubes -- and if you have the fixed pressure tube diameter, so more tubes in it, you will end up smaller diameter and therefore you have to --

MEMBER HARVEY: Change the flow.

MR. COUTURE: Yes. Well, it will

affect the flow. And in some cases you will improve your heat transfer.

That's why for instance in the 37M, in the modified fuel they have a smaller central element. The claim there is that they are modifying the flows within the bundle and that is enough to improve their heat transfer and give them additional margins.

But it has to be demonstrated of course, you know, tested, and so on. And it was tested at Stern Labs outside the core and they do all these testings.

MEMBER HARVEY: Okay, that's it. Thank you.

THE PRESIDENT: So just on the same concept, I was always fascinated, who came up with those numbers, 24, 37, 43? Are they by calculations? Why not 47? Is there a limit? Why not 50?

MR. COUTURE: Well, I can tell you that I have heard, but this I would have to -- but I heard about 66 or 65. It's a matter of what you are trying to achieve.

Now, at one point you also have to worry about the mechanical properties, you know, if you end up having 100 elements let's say -- let's exaggerate -- in the same, mechanically they may not be strong enough, so there is a combination of mechanical.

It has to be when you're qualifying the fuel and you're looking at whether or not that design is proper, you also have mechanical tests because your bundles for instance will be loaded in the core and the flows are something like 26 kg per second of water coming, so a bundle will be accelerated and hit the other bundles in the core had a speed of about -- I think it's 2.2 m/s.

So I have seen some tests being done and they take pictures of it in very, you know, fractions of seconds and you can see the bundle being compressed a bit.

So there is some -- so this has to be tested before so there will be a combination of things that will determine the number of elements that you could put in and some of that will be the mechanical aspects.

THE PRESIDENT: But are their computer simulations?

MR. COUTURE: Oh yes.

THE PRESIDENT: I mean who came up with this 37M?

MR. COUTURE: The 37M was OPG.

THE PRESIDENT: I mean was it an in-house design?

MR. COUTURE: Well, they used codes, computer codes, and they started analyzing the flows and they said, okay, let's reduce the central element diameter and they made some assessments about what would be the heat transfer properties, and so on.

So they do this at the design stage, but eventually they have to design it and they will take a few bundles and do some tests. What they do is they put these bundles at Stern Labs and they start increasing the power.

So the bundles are subjected to some flow and they are given flow, they will start increasing the bundles power and they will see when the heat transfer starts deteriorating at one point and they will notice that actually -- what they want is to be able to reach higher powers and still maintain good heat transfer.

So by playing around with the element sizes, and so on, they figured that -- and then they verified it in Stern Labs and confirmed that they had certain gains.

On our side of the CNSC we are now discussing how much gain and that of course for them it's important to have the maximum that they think they should have. We are looking at it and we have some issues, but we accepted a certain amount of gain and now we're discussing about the remaining part that they claim they want to have as a credited gain.

THE PRESIDENT: Mr. Tolgyesi...?

MEMBER TOLGYESI: Merci, Monsieur le Président.

You know, when I look at this graph when you are talking about mining, milling, refining, you are saying in the milling you remove 98 percent of uranium which is put in yellowcake. What's the uranium which is remaining in the tailings at the mine sites?

MR. RINKER: Mike Rinker, for the record.

I guess as a percentage of the uranium that was in the rock how much is going out in the stream as waste, it's a tough question. I think it depends on the mine and mill. But I think it's in the order of less than 1 percent.

Certainly, as a contaminant of concern from an environmental protection perspective, it's low enough that it's not an element that we are concerned about in terms of regulation. We are more worried about nickel and cobalt and arsenic and less so with uranium.

MEMBER TOLGYESI: Because I remember two or three years ago when we were in Saskatoon up in the north there, some intervenors were talking that most of uranium remains in the tailings.

MR. RINKER: Mike Rinker, for the record.

That's certainly not true. What they may be referring to is since uranium is being separated from all of its daughter products you may say most of the radiation, sources of radiation remain in the tailings, and that would be true because all of the other radioactive elements in that uranium decay chain are not being sent as or are not in the yellowcake. It's only uranium in the yellowcake.

So they may be referring to the sources of radiation remaining in the tailings which would be true, but not uranium.

THE PRESIDENT: But they all are still controlled in terms of the -- if memory serves -- a pair -- a kilogram there is a limit for uranium in any of the other possible contaminations, right?

MR. RINKER: Mike Rinker, for the record.

That's correct. It's just that the uranium is in such a low quantity in the tailings that it's generally not approaching the limit. In fact, you know, the mills are continually being updated and designed to make sure that uranium is not released as a waste.

MEMBER TOLGYESI: So uranium is not released as a waste or it's very little. But when you're looking at the global radiation capacity of the ore or uranium and all other products in situ, and after when you process it, part is going in the yellowcake. I mean uranium, 98 percent of uranium is going to yellowcake. That means maybe 2 percent is left.

But in all other products, radiation capacity stays in the tailings. So when you compare that in situ capacity of radiation and in situ -- and the capacity of radiation of tailings, how much is going out and how much stays there?

MR. RINKER: Mike Rinker, for the record.

I guess I would say almost all of the radiation stays in the tailings and the yellowcake on its own is not much of a radiological hazard. The half-life is very long. It decays at a very low rate.

So the majority if not -- like all of the radiation associated with the ore stays as the waste.

THE PRESIDENT: Okay. But we've got to be really careful. But it's a minute quantity. It is almost below measurement. If you are going to a tailing pond you do not register much of radiation. Correct me if I'm wrong.

MR. RINKER: Mike Rinker, for the record.

There's a number of -- the mines in northern Saskatchewan are fairly rich deposits but it only takes a bit of a water cover to reduce that hazard to nil to safe levels.

THE PRESIDENT: Okay. That's the

essence of that.

MEMBER TOLGYESI: When you are talking about on your slide 35 you are saying that:

> "After a period in wet storage (7 to 10 yrs), used nuclear fuel can be transferred to dry storage."

Gentilly-2 was talking about six years. Is it -- what's the reason that it could be shortened to that time?

MR. HOWARD: Don Howard, for the record.

When dry storage first started in Canada they used a -- when they started their analysis they used a reference timeframe of six years. And basically the analysis demonstrated that six year old fuel or older can be safely stored into dry storage.

Hydro Quebec and New Brunswick Power have adopted, for conservatism, seven year fuel or older but essentially the analysis has demonstrated that six year old fuel can be safely stored in dry storage.

MEMBER TOLGYESI: And my last --

THE PRESIDENT: But I guess they are moving because it's probably easier to manage in a dry storage. You can empty the pool and don't have to worry about cooling it. Is that not the economic reason?

MR. HOWARD: Don Howard, for the record.

A number of reasons, yeah, economics is one. But when you're dealing with a liquid, a liquid is very mobile. Whereas if you put it into dry storage it's solid. It's in a stable form. It's contained. Even under adverse conditions, you know, liquid moves.

THE PRESIDENT: But that's what I mean. That's why you would --

MR. HOWARD: Yeah.

THE PRESIDENT: -- want to get it out of the pool and just leave it in storage probably for 100 years or so.

MR. HOWARD: For as long as it's required until a repository for long term management is --

THE PRESIDENT: That was a better answer. Right.

MEMBER TOLGYESI: My last is when

I talk -- we are talking about dry storage. It's always kind of a concrete shell which contains the fuel. And what about aging of this concrete because this storage, dry storage is there, as you said, for maybe hundreds of years?

What about concrete aging because we were -- we observed that there's a problem after so many, 35-40 years? We are talking about power plants. You know, the concrete could have some problems.

MR. HOWARD: Don Howard, for the record.

And I think that's the beauty of dry storage in that you can reverse the process, is that there is an aging management on dry storage concrete containers. The design life is anywhere between 50 to 100 years.

But as the concrete starts degrading and it no longer can provide for containment of the material, you can retrieve the spent fuel under controlled conditions and move it into a brand new container which then is good for another 50 to 100 years. So that's the beauty. You can reverse the process and repackage it into a new container. You can't do that with a reactor.

THE PRESIDENT: Dr. McEwan...?

MEMBER McEWAN: So thank you for the presentation. I enjoyed it.

What we've heard a couple of times at these meetings of thorium as sort of the new idea in reactor fuel, what are the advantages? What is unknown? What has to be done before it becomes realistic?

MR. FRAPPIER: Gerry Frappier, for the record.

So there has been talk about thorium for a long time, actually. But it's more popular now again, if you like, but really primarily because two very major countries, China and India, find themselves with a lot of thorium but no uranium. So from their perspective they are very interested in seeing whether this thorium fuel, exactly what the economics of it might be and whether it's plausible because they have a lot of it.

So the CANDU reactor can use it as a fuel. It's a little bit more complicated. As far as the economics, the economics are not there. It's certainly better to use uranium right now.

But if you're in India and especially in China and you have a lot of thorium it's there for free almost sort of thing, is one of the things that are of interest.

Michel, you might want to add to that.

MR. COUTURE: Well, first, the thorium that we're talking about here is 232. And as we mentioned in our basic notions, the 232-thorium is not a fissile material. So in order to kick start the process you need U235 or you may want to use other types of fuel that actually have fissile to start the process.

Once the process is started the thorium-232 will be transferred -- will be transformed in U233. This one is fissile so then you can continue your chain reaction like this. But that's not necessarily a disadvantage. It's just that you have to have something to kick start it.

And in Canada and I think some countries are rich in thorium. So for them it's very attractive to go there.

MEMBER McEWAN: Are there any sort of energy production advantages or storage, waste storage issues by moving to it?

MR. COUTURE: Well, maybe I can get some more details from -- I don't know if, Vladimir, you can --

THE PRESIDENT: I think there is a certain VP that has long views about thorium so why don't you join us and share them with us, please.

MR. HOWARD: One of our senior technical specialists will help us on this one.

--- Laughter / Rires

MR. JAMIESON: And they don't like it when I get technical. Terry Jamieson, Vice President, Technical of the Support Branch.

So one of the considerations with the thorium fuel cycle is that there is associated radiation with the thorium. When it comes out of the core it's a little bit, perhaps stronger than a uranium based fuel bundle.

That's both a plus and a minus. You can view it as a plus in the sense that it is maybe a little more proliferation resistant because it's more difficult to handle. And of course the minus would be it does have higher radiation fields.

THE PRESIDENT: And it's really not as much -- it doesn't have a track record the way uranium plants have to date. All this technology has been building for many, many years.

But there's some very vocal advocates for thorium. So we'll see. Somebody has got to build one and see how it works.

Thank you.

MEMBER McEWAN: So just one other question on long term solid storage. I remember hearing in a presentation by the Australians who were saying that they developed some new -- I think it might have been a resin-based solid storage state for waste that was going to significantly reduce volumes.

Am I remembering that right? Is it likely to be practical and retrofittable to reduce volumes that have to go into long term storage?

MR. HOWARD: Don Howard, for the record.

I'm not familiar with this Australian -- it's always desirable to reduce your overall amount that has to go into a repository, yes. I'm not familiar with that one, but I'll certainly look it up.

MEMBER McEWAN: It was about a year and a half ago that I heard the presentation.

THE PRESIDENT: Ms Velshi...?

MEMBER VELSHI: Thank you.

What fraction of a nuclear power plant's energy cost is as a result of the fuel cost?

THE PRESIDENT: You mean as compared to capital in other operations. I don't know if we have --

MR. FRAPPIER: The only thing I would say is that certainly that -- it's Gerry Frappier, for the record -- the fuel costs are very, very small compared to the overall costs which is one of the key advantages of using nuclear power, if you like, as opposed to gas or something else where your capital costs are low but your operating costs of fuel is very, very high.

I think if our licensees were still here they would really know the answer to that very closely.

MEMBER VELSHI: Yeah. And I don't mean just the fuel but the whole life cycle management of the fuel. I just wondered how significant it was.

And the frequency of fuel -- fail fuel incidents, like that does that happen a couple of times a year or does it even happen nowadays?

MR. COUTURE: I'd say on the average we had one fuel failed, I mean near failed fuel per unit per year. That's the -- actually, it's a very good performance. So that's on the average. Sometimes there could be increases in defect rates but normally that's about the reference, one failure per year per unit.

And maybe to add to this, because we are power fueling we can remove the failed fuel, identify it and remove it eventually. And there are some limits from the safety perspective.

When you fail the fuel usually you'll have iodine-139 -- 131 getting into the coolant. But there's limits on that. As soon as you reach that limit something has to be done. You have to either shut down the reactor. But most of the time there is no problems meeting the limits and the fuel in general of CANDU performance is good.

MEMBER VELSHI: I remember at one time hearing that being able to do online fueling in a CANDU reactor was a great competitive advantage and you didn't have to shut down the reactor to refuel.

Is that still the case, though, the online fueling? Is that something you can comment on?

MR. FRAPPIER: Gerry Frappier.

So yes, I mean, it's still an advantage. There's no doubt about it.

I think what has changed a little bit over the past few decades is on the flip side on the light water reactors the time they have to shut down to refuel during that whole outage which of course was a big penalty on them, has been reduced. They have become more and more efficient at trying to minimize the length of time of an outage for fuel change. So the differences in those are not as -- it's not as great as it used to be.

But there are other aspects that are advantageous. As Michel was saying just now, so if you have failed fuel you can get it out of a CANDU reactor, whereas you cannot do that easily until the next major outage for a light water reactor.

And also, with respect to ensuring you're always at optimum power levels from a cost of per unit for -- cost per kilowatt of power made because you can very much manage your reactor much more easily by moving fuel around.

THE PRESIDENT: But you know, that's why it was so strange that they haven't fixed the reliability of the fuelling machine because it's so crucial for maintaining ongoing operation. So I'm always struck by this deficiency here that they are having trouble with the reliability here.

MEMBRE HARVEY : Est-ce que dans le long terme, dans la gestion à long terme des déchets, il y a toujours dans l'idée de les déposer dans ces grottes profondes là, en gardant la possibilité d'aller récupérer le matériel plus tard si des techniques de réutilisation sont découvertes ou développées ou si on les dépose là, c'est vraiment de façon terminale?

MR. HOWARD: Don Howard for the record.

Est-ce que vous voulez que je

réponde en français ou en anglais?

I'll respond in English.

During the operational life of a repository as you're emplacing spent fuel into a repository there's always that possibility of retrieval during that time. But once you get to the end of life and then you have sealed the shaft to that repository, basically there is no intent on retrieval at that point.

And would it be economical to retrieve in order to reuse it again because over time, depending on how much time has passed by the time the spent fuel has been emplaced in the repository and, say, you want to retrieve you know, 10,000 years into the future, degradation of the spent fuel bundle itself and everything else may not warrant -- may not lend to reprocessing or reutilizing.

So basically the approach that we're using in Canada is that once the retrievability is part of the system during the operational phase of the repository, but once the shaft is sealed there's no intent on retrieval.

THE PRESIDENT: But that operational -- it's going to be quite a long time.

MR. HOWARD: Don Howard, for the record.

Yes, operational phase will be somewhere up around the 100 year mark.

THE PRESIDENT: If they can't find a solution, I mean, in 100 years I don't think they'll continue to pursue that.

Mr. Tolgyesi...?

MEMBER TOLGYESI: You know, we are hearing about all those advantages of CANDUs. How come they are not sold in those new projects, you know, across the world because they are -- the plants are reliable?

MR. FRAPPIER: Gerry Frappier, for the record.

That would be better directed to CANDU Energy. It could be a whole bunch of different things.

But some of the aspects that have been put forward is cost, is one of the things that has to be considered. There are -- there are other things that just have to do with marketing and sales and the success of other companies.

However, in the past few weeks there has been some announcements with CANDU

Energy about potential sales into Romania. We talked earlier about the joint venture with China with respect to doing things in China.

But as far as the overall, technically CANDU has some advantages and others have advantages of CANDU. I mean, it really becomes much more of other aspects of the project than just the technical design that determines the sales, I believe.

MEMBRE HARVEY : Je pourrais essayer d'avoir une réponse en français.

Monsieur Howard a mentionné « when the shaft will be plugged. » Je pensais qu'il y aurait une sorte de monitoring à long terme du site même, du dépôt même, puis c'est important pour voir s'il n'y a pas d'écoulement, de changement dans le site même. Ça fait que de cette façon-là, si tout est bouché, qu'est-ce qui va advenir du monitoring?

M. HOWARD : Don Howard.

Le programme présentement, c'est que, après l'exploitation de l'installation, on va boucher le ventilation shaft, puis après ça, il va y avoir une période de surveillance pour alentour de 300 années. Comme ça, il va avoir des instruments qu'on va... bien, le plan, c'est d'emplacer des instruments dans l'installation, et puis il va avoir de la surveillance en haut sur la terre, et puis ça, ça va durer à peu près 300 années.

THE PRESIDENT: So is it the intention to publish this?

By the way, I really like this deck. The question is, what's the best use of this deck? You know, are you talking about if somebody says it was fuel life 101? You know do we take it -- you put it on the web, you take it to school? Maybe it's beyond grade nine. Maybe this is university first year.

I don't know. What's the intention?

MR. FRAPPIER: Gerry Frappier, for the record.

Well, we certainly would take your direction or your advice on that. Right now it's available publicly because it's at this meeting, shall we say. But we'd be looking to work with communications to, as a minimum, put it on our website as part of this sort of ongoing area of technical papers and technical presentations.

We haven't talked about sort of putting it into the CNSC outreach program with respect to going with the kiosks for instance or going to schools and that, but it's something that would be worth discussing, I guess.

THE PRESIDENT: So if you're going to do it, by the way, it's in a meeting but it's not really available unless somebody asks for it. So you have to translate it and put on the web.

But I've got to tell you, on slides 33 and 34, your presentation, your verbal description was better than the actual slide itself. So you know, going from a full 66 light bulb to one nightlight is a lot more illustrative than going to something like 3.5 0E to the 07. I don't know how many people understand that.

So somewhere along the line it will be nice if we are going to, for the public, to -- I don't want to say dummy down but explain in layman's language.

And on slide 33 for sure there is a lack of understanding where people talk about this thing staying radioactive for a billion years. They don't understand what happened to the dose and the radiation. You know, it's one milliSievert per hour. They can actually hold it. It's not going to kill you. How many people know that? Now, you don't want to keep it forever in your hand but the idea of how dangerous the material is, I don't think really is explained. You explained it but it's not really in here in a layman kind of language.

So I think it doesn't need much more to do but there is a lot of useful information. And I think you should post it on the web.

MR. FRAPPIER: Well, then that's obviously what we will do.

--- Laughter / Rires

MR. FRAPPIER: But we can certainly add some storylines around slides 33 and 34. That's the first time I heard the light bulb one actually and that's, I think, is pretty good.

But clearly, most people do not have the concept of geometric increases or geometric decreases and how it's very powerful to reduce things quickly.

MEMBER TOLGYESI: Just to say that I'd be interested -- I will be interested in that when we are talking about radioactivity in the tailings, how much stays there because that will be of some interest probably to those around when --

THE PRESIDENT: Every time we go to -- every time we deal with a mine.

MEMBER TOLGYESI: Yes.

THE PRESIDENT: I think we have this data, but maybe a refresher will give us a little update on that.

MR. FRAPPIER: Yeah, we can add a slide with some data with respect to tailings and radioactivity and amount of uranium left. Like I say, I know it's around. I've heard it many times. I just don't want to take a chance on putting it out here now.

MEMBER McEWAN: So again, I think slide 33 if you are going to use it for public, I would actually take it out to 1,000 years. A millennium is a nice round figure. But also then put it in the context at 500 and 1,000 years of what it is in terms of background radiation that we're exposed to on a daily basis. And then I think there is a context there as well.

But again, I thought that was a great presentation. Thank you very much.

THE PRESIDENT: Okay, thank you. Thank you very much. I think this is it for today. We will reconvene tomorrow at nine o'clock for all those who are listening on the web.

Thank you.

--- Whereupon the hearing adjourned at 7:40 p.m., to resume on Thursday, August 21, 2014 at 9:00 a.m. / l'audience est ajournée à 19 h 40 pour reprendre le jeudi 21 août 2014 à 9 h 00