

NUCLEAR FUEL COSTS

1.0 PURPOSE

This evidence presents the forecast of nuclear fuel costs including the key cost drivers and assumptions. It also discusses the results of the Uranium Procurement Program Assessment Study (Ex F5-2-1) conducted by Longenecker and Associates and presents OPG's response to that study.

2.0 OVERVIEW

OPG is requesting approval of nuclear fuel costs of \$280.6M in 2014 and \$267.5M in 2015. Nuclear fuel costs for 2010 - 2015 is provided in Ex. F2-5-1 Table 1.

Nuclear fuel costs consist of:

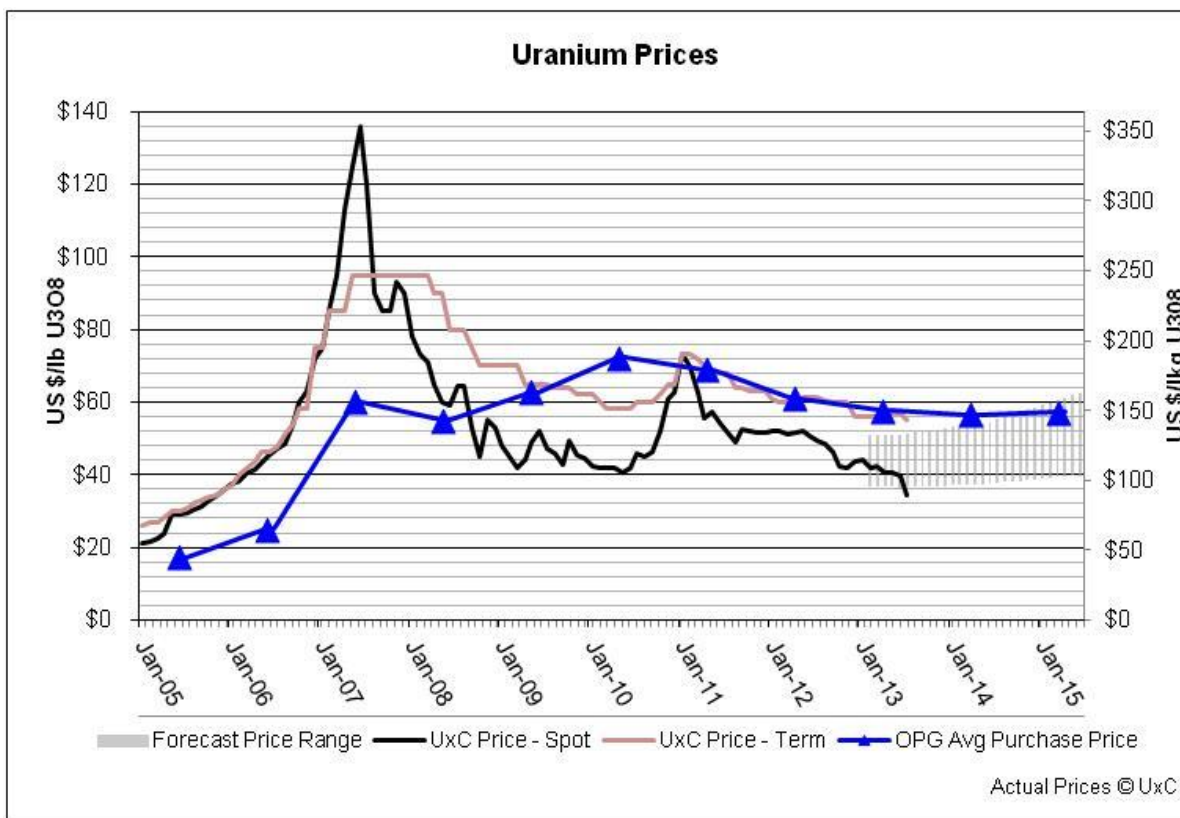
- the cost of manufactured uranium fuel bundles loaded into a reactor ("nuclear fuel bundle cost") of \$220.3M in 2014 and \$207.1M in 2015.
- used nuclear fuel storage and disposal costs of \$56.3M in 2014 and \$56.3M in 2015.
- fuel oil which is used to run nuclear stand-by generators of \$4.1M in 2014 and \$4.2M in 2015.

The cost of nuclear fuel bundles is forecast to decrease by \$3.1M from 2012 to 2015, reflecting changes in the individual component costs that make up the cost of a fuel bundle (e.g. uranium concentrate, uranium conversion and fuel bundle manufacturing costs) along with the impact of changes in production on fuel usage. Specifically:

- Uranium Concentrate: OPG's average cost of uranium concentrate in a fuel bundle loaded into a reactor is forecast to decline to CDN \$58.3 \$/lb U308 (CDN\$151.5/KgU) by the end of the test period, as shown in Chart 1 below.
- Conversion Services and Nuclear Fuel Bundle Manufacturing Costs: OPG is forecasting an increase in the contract prices paid for uranium conversion services. Under recently renegotiated contracts, the conversion cost will increase from \$27.49KgU CDN in 2012 to a forecast cost in 2015 of CDN \$29.07/KgU. The Nuclear Fuel bundle manufacturing cost is also forecast to increase from CDN \$68.66 / KgU in 2012 to CDN \$71.13/KgU in 2015.

- Production impact: Nuclear fuel usage decreases due to lower generation in 2015 (48.0TWh) as compared to 2012 (49.0 TWh). The lower generation results in an approximately \$0.8M decrease in the cost of fuel bundles loaded into a reactor.

Chart 1
Uranium Concentrate Prices



OPG's use of weighted average cost accounting delays and smooths out the impact on nuclear fuel bundle costs of changes in the costs of uranium concentrate, uranium conversion services and fuel bundle manufacturing.

As directed by the OEB, OPG engaged an independent consultant, Longenecker and Associates, to conduct a review of OPG's uranium procurement program (Longenecker Report). Longenecker and Associates found that OPG's uranium procurements have been undertaken in a professional manner, using evaluation criteria that gives appropriate consideration to diversity of supply, the relative capabilities and performance risks of

1 suppliers, and includes an appropriate mix of contracts (spot versus long-term, fixed price
2 versus market-related, etc). They also found that OPG's procurement strategy is prudent in
3 today's market. Longenecker and Associates concluded that OPG's uranium procurement
4 program is appropriate and fully inclusive of the various factors that should be considered.
5 Further discussion of the Longenecker Report and its recommendations can be found at
6 Section 5.

8 **3.0 NUCLEAR FUEL SUPPLY**

9 **3.1 General**

10 OPG's nuclear fuel supply strategies and procurement plans are reviewed and approved by
11 OPG's senior management, including consideration of nuclear fuel quality because it is an
12 extremely important aspect of maintaining nuclear safety.

13
14 To ensure high quality, OPG requires its fuel bundle manufacturer to maintain a quality
15 program which conforms to a rigorous Canadian quality standard (CAN3-Z299.1). This
16 ensures that all phases, including design, procurement, manufacturing and inspection, are
17 appropriately controlled. OPG performs surveillance of all manufacturing processes to
18 monitor conformance to design requirements and to verify conformance to OPG's quality
19 standard requirements. Potential vulnerabilities in the supply chain need to be carefully
20 managed by OPG as only two vendors have been qualified by OPG and licensed by the
21 CNSC to manufacture the fuel bundle designs required by OPG units.

22
23 The OPG nuclear fuel supply objectives are to:

- 24 • Ensure security of supply: OPG must reduce the risk of its reactors being shut down
25 due to lack of fuel bundles, including the risk that any step in the supply chain is
26 substantially delayed due to lack of materials from an earlier step.
- 27 • Minimise cost: OPG seeks to obtain its fuel supply at the lowest cost, consistent with
28 is fuel quality requirements.

29
30 OPG's nuclear fuel procurement supply chain is made up of the following three stages:

- 31 • The purchase of uranium concentrates.

- 1 • The purchase of services for the conversion of uranium concentrate to uranium
- 2 dioxide pellets
- 3 • The purchase of services for the manufacture of nuclear fuel bundles containing the
- 4 uranium dioxide pellets.

5
6 OPG's fuel procurement planning for the test period begins with a three-year forecast of the
7 required number of manufactured fuel bundles to be loaded into OPG's reactors. OPG's
8 production forecast from the approved Nuclear Generation Plan (see Ex. E2-1-1)
9 determines the forecast of fuel bundles required for fueling, adjusted by forecasts of fuel
10 burn-up and reactor thermal efficiency rates. From this forecast and considering existing
11 inventories, OPG determines its need for purchasing additional manufactured fuel bundles.
12 This determines the need for uranium dioxide conversion services and the need to procure
13 and deliver new supplies of uranium concentrates.

14
15 OPG currently purchases each of these components separately and maintains ownership of
16 the uranium at each stage of the nuclear supply chain. OPG does this because its fuel
17 bundle manufacturing service providers are not willing to accept the supply risk associated
18 with the uranium concentrates and uranium conversion services portion of the supply chain.
19 OPG therefore arranges each stage to protect itself from possible supply disruptions.

20
21 OPG maintains a 12 month supply of fuel bundles to allow continued fueling in the event of a
22 disruption in the supply of fuel bundles or uranium conversion due to labour unrest or
23 production issues. A 3 month supply of uranium dioxide is targeted to feed the fuel bundle
24 manufacturing process. In addition, the uranium conversion supplier is also contractually
25 required to maintain an inventory of certified uranium dioxide for OPG's use in the event of a
26 supply interruption at the supplier's facilities. OPG has recently adopted a minimum uranium
27 concentrate inventory of 288,000 KgU, representing a 4 month supply to feed the production
28 of uranium dioxide. OPG's prior inventory target of 385,000 KgU, or approximately 5.5
29 months supply, was put into place at a time when there was more uncertainty with respect to
30 the supply of uranium. The target inventory level for uranium concentrate has been reduced
31 based on recommendations from the Longenecker Report. OPG expects to reach the new
32 target level of 288,000 KgU by end of 2015. Nuclear fuel inventories are included in Ex. B1-
33 T1-S1, section 3.2.3.

3.2 Uranium Concentrate Procurement

OPG plans to purchase additional uranium concentrate equal to 40 per cent of OPG's requirements during 2014-2015, with the balance being provided from existing contracts or inventory.

3.2.1 Objectives

The primary objectives of OPG's uranium concentrate procurement program are to ensure an adequate supply of uranium is available to meet the operational requirements of OPG's nuclear units, while minimizing the price, market and credit risks associated with this supply. In addition, OPG also must ensure quality standards are met.

The procurement program has the following requirements:

- **Purchase within pre-established physical coverage limits.** OPG uses a quantitative risk management model to establish long-term physical coverage limits. These limits establish the maximum and minimum percentages of future uranium requirements that can be under contract. The minimum limit ensures security of supply by requiring a certain amount of OPG's future requirements be under contract or in inventory. The maximum limit ensures more regular entry by OPG into the market, thereby encouraging a diversity of suppliers which reduces the impact of individual supply source disruptions
- **Purchase within pre-established financial coverage limits.** OPG's risk management methodology also establishes financial coverage limits. Financial coverage limits specify the maximum and minimum portion of supply to be under "fixed" price arrangements, expressed as a percentage of OPG's aggregate amount under contract. This mitigates near term cost uncertainty and encourages a diversity of contract pricing mechanisms.
- **Maintain, as market conditions dictate, a strategic target inventory of uranium.** This further mitigates the impact of supply disruptions and ensures continuous reactor operations.
- **Employ competitive and fair procurement practices.** The use of these practices provides value for money. OPG's standard procurement practice is to employ

competitive processes where available, using pre-determined evaluation criteria that include quality, security of supply and costs.

3.2.2 Uranium concentrate pricing provisions and fuel contracts

OPG's existing long term contracts for the supply of uranium concentrates contain a mix of pricing provisions, as shown in Chart 2 below. Under contracts with market-related pricing terms, quantities are priced at a market price established at or near the time of delivery. Contracts with fixed or indexed pricing include base prices, set at the time of contract signing, which escalate to the time of delivery by formula or by published, inflation-related, indexes. Combination, or hybrid contracts, provide for a combination of market-related pricing and fixed/indexed pricing. For spot market purchases, OPG generally enters into contracts priced for delivery within 3 months of contracting.

A summary of OPG's existing and projected (2013) fuel contracts are shown in Chart 2 below:

Chart 2
Summary of Fuel Contracts

Contract	Contract Negotiation	Date of First Delivery	Delivery Period	Total Quantity (000 kgU)	Pricing: MR = Market related HYB = combination of MR and Indexed
A	2006 1 st half	2007	7 years	1,462	MR
B	2006 1 st half	2010	6 years	1,154	HYB
C	2006 1 st half	2011	5 years	385	HYB
D	2007 2 nd half	2009	9 years	1,154	HYB
E	2009 2 nd Q	2009	Spot	154	Fixed
F	2010 2 nd Q	2012	3 years	317	Fixed
G	2010 2 nd Q	2015	6 years	577	HYB
H	2011 3 rd Q	2011	Spot	77	Fixed

Contract	Contract Negotiation	Date of First Delivery	Delivery Period	Total Quantity (000 kgU)	Pricing: MR = Market related HYB = combination of MR and Indexed
I	2011 4 th Q	2011	Spot	106	Fixed
J	2012 4 th Q	2013	4 years	385	Fixed
K	2013 3 rd Q	2015	4 years	336	MR
L	2013 3 rd Q	2015	4 years	432	Fixed
M	2013 4 th Q Anticipated	2013	Spot	105	Fixed

New purchases by OPG will be made under new long-term contracts, short-term spot market contracts, or a combination of both. OPG was not active in the market in 2012 while the Longenecker review of its procurement program was underway. In the 4th quarter 2012, OPG began to implement procurement changes as recommended by the Longenecker Report. These changes, including new spot purchase contracts will be reflected in future contracts.

In forecasting nuclear fuel costs, OPG models its existing contracts using forecasts of escalators, foreign exchange, and market price indicators. For its uncontracted uranium requirements, OPG uses a forecast based on the annual average of the Ux Consulting Company's spot forecast (US\$54 per pound in 2014 (\$140.4/KG) and US\$59 per pound in 2015 (153.4/KG)) as shown in Chart 2 above.

Uncertainty in the start up of new uranium production, the possible liquidation of additional inventories, the uncertainty of worldwide nuclear expansion, fluctuations in exchange rates, and political developments in uranium producing regions are expected to result in price volatility over the test period and account for the wide range of forecast market prices

3.3 Uranium Conversion Services Procurement

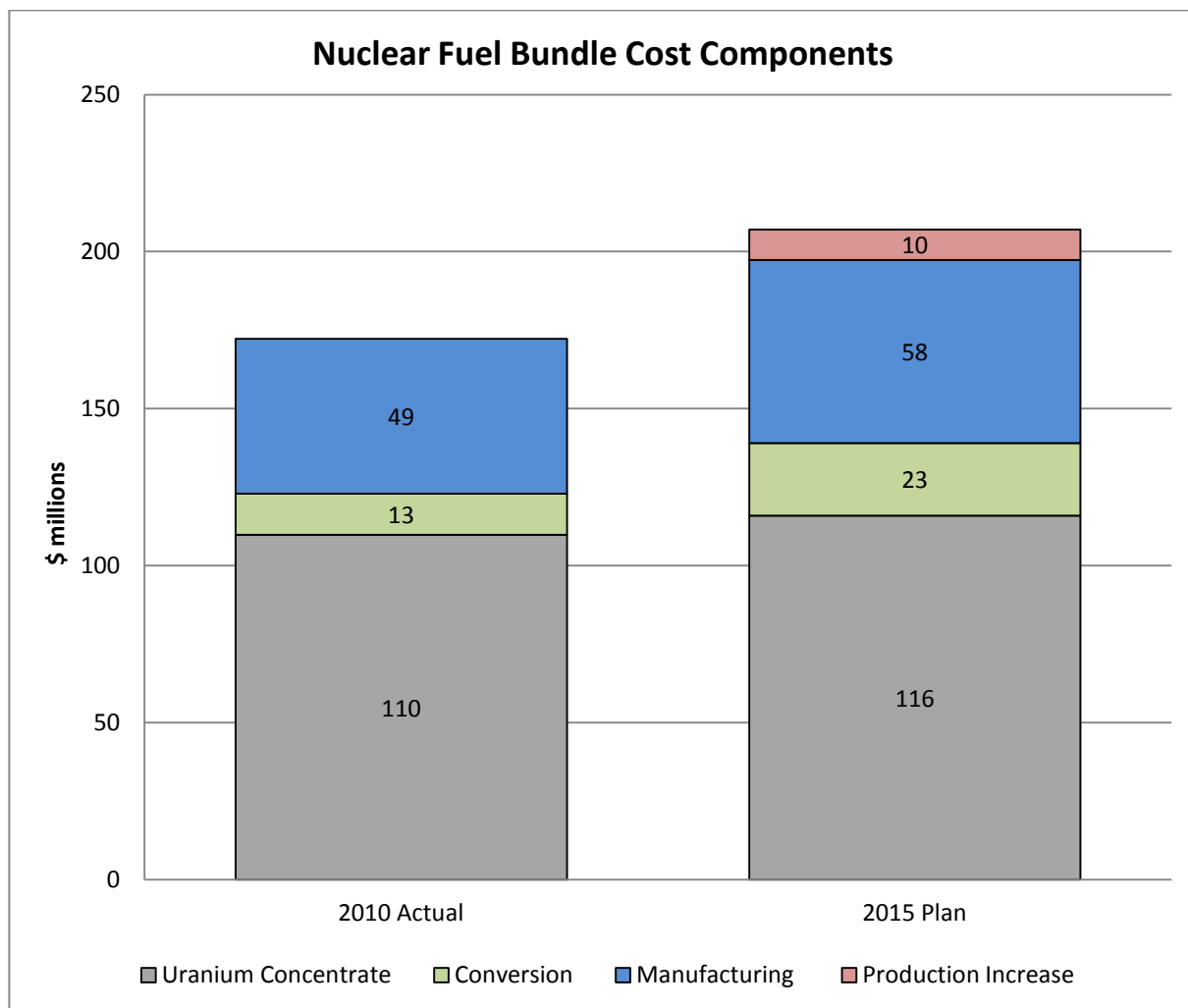
To meet fuel quality requirements, OPG's uranium conversion suppliers must conform to CSA standard CAN3Z299.2-85, Quality Assurance Program. This standard ensures that all phases of production, including procurement, manufacturing, and inspection, are

1 appropriately controlled. OPG performs audit and surveillance of the conversion supplier
2 and verifies conformance to the quality standard.

3
4 OPG's 10 year supply contract with the sole domestic supplier of uranium conversion
5 services expired at the end of 2011. OPG negotiated a new agreement for uranium
6 conversion services for the period 2012 - 2021 inclusive.

7
8 The new agreement will result in higher costs for uranium conversion services from \$13.0M
9 in 2010 to \$23.0M in 2015 as shown in Chart 3 below. However, as part of its due diligence
10 around this new contract, OPG conducted an independent examination of the supplier's
11 costs and satisfied itself that the higher cost for uranium conversion services was justified.
12 Under the new agreement, the price is indexed to inflation and is subject to adjustment for
13 cost (or benefit) sharing if actual cost changes are beyond a threshold. OPG's test period
14 forecast assumes no adjustment for cost or benefit sharing. The new uranium conversion
15 services agreement is a contributor to the forecast increase in nuclear fuel costs over the
16 period 2010 - 2015 resulting in a 3.6 per cent impact to the overall increase in fuel costs
17 over the 2010 to 2015 period (see Chart 3).

Chart 3



3.4 Manufactured Fuel Bundles Procurement

OPG currently has a supply contract with General Electric (one of the two domestic CANDU fuel bundle manufacturers) to supply OPG's requirements through the test period. In 2011, OPG negotiated an extension to the fuel bundle supply contract through to 2018 in order to secure the supply of the modified fuel design for Darlington station. Darlington is moving to implement a modified fuel design (37M) which provides better flow distribution within the fuel elements, increasing the margin of safety and improving fuel cooling. The base price under this contract extension was improved over previous pricing. The base price is subject to

future adjustments for inflation and changes in zirconium costs, a key component in fuel bundles.

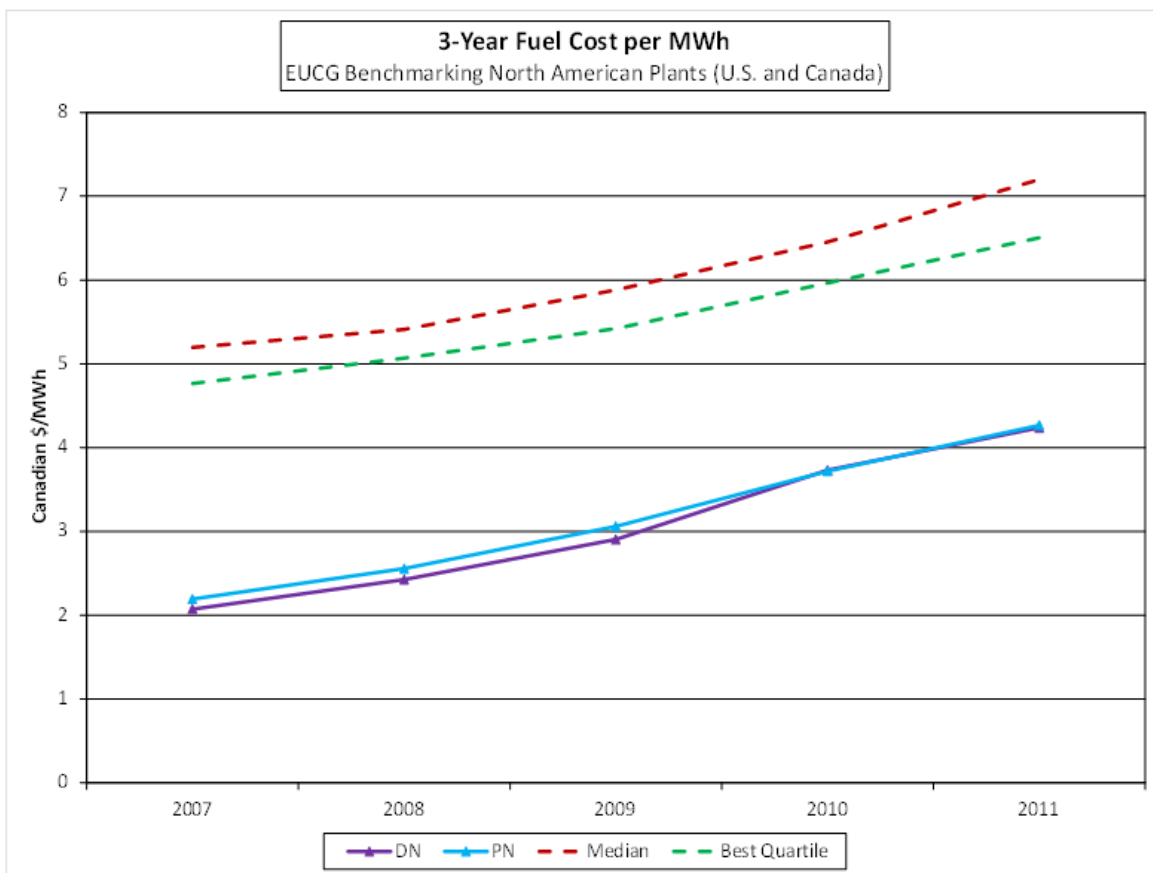
4.0 NUCLEAR FUEL COST FORECAST

The nuclear fuel cost forecast for 2014 and 2015 is shown in Ex. F2-5-1 Table 1 along with comparable figures for 2010 - 2013.

The escalation trends in OPG's fuel bundle costs are consistent with other North American nuclear operators, based on EUCG data (which includes CANDU, PWR and BWR units) as per the 2012 Benchmark Report (Ex. F2-1-1 Att. 2, p. 69) and per Chart 4 below.

Darlington and Pickering continue to rank among the top North American EUCG plants in terms of fuel costs mainly due to the CANDU requirement of natural uranium.

Chart 4



1 More detailed explanations of nuclear fuel cost variances over the period 2010 - 2015 are
2 provided at Ex. F2-T5-S2.

3 4 **5.0 URANIUM PROCUREMENT PROGRAM ASSESSMENT**

5 In its Decision with Reasons in EB-2010-0008, the Board directed OPG to engage an
6 external consultant to conduct a review of OPG's procurement program to determine whether
7 the company is optimizing its contracting in order to minimize costs to ratepayers.

8
9 The review was undertaken by Longenecker & Associates ("Longenecker"), external
10 consultants with extensive experience in uranium procurement. OPG selected Longenecker
11 through a competitive RFP process.

12
13 OPG asked Longenecker to:

- 14 • Review and assess OPG's physical and financial coverage limits for uranium
15 concentrate procurement, and provide recommendations on potential changes.
- 16 • Review and assess OPG's supply risk mitigation strategies and provide
17 recommendations for improvement.
- 18 • Review and assess recent OPG's price risk mitigation strategies and provide
19 recommendations on contract improvements.
- 20 • Review and assess OPG's inventory targets and provide recommendations on
21 alternative inventory targets, and
- 22 • Provide an overall assessment of OPG's uranium procurement program in achieving
23 low cost and meeting OPG's objectives.

24
25 The main conclusions of the Longenecker report are:

- 26 • OPG's uranium procurement objectives are appropriate and fully inclusive of the
27 various factors which should be considered. In reaching that conclusion, Longenecker
28 noted that uranium procurement decisions must balance the risk related to security
29 of supply and price-related risk. Longenecker concludes that "OPG has optimized its
30 contract portfolio with respect to protecting itself from supply and price disruptions"
31 and that OPG's procurement objectives are "appropriate and fully inclusive of the
32 various factors which should be considered in a uranium procurement program"
33 (page 35 of Ex. F5-2-x).

- 1 • OPG's uranium procurements have been undertaken in a professional manner, using
2 evaluation criteria which give appropriate consideration as to diversity of supply,
3 relative capabilities and performance risk of suppliers, and an appropriate mix of
4 contracts (spot versus long-term, fixed price versus market-related, etc.).
- 5 • OPG's uranium purchasing activities are consistent with those of other utilities
6 surveyed.
- 7 • OPG's uranium contract coverage (i.e. maximum and minimum physical and financial
8 coverage limits) is consistent with the aggregated contract coverage of U.S. utilities
9 as published by the U.S. Energy Information Administration.
- 10 • OPG's target inventory policy for uranium concentrate is consistent with other utilities'
11 inventory policies. They recommended that OPG conduct an ongoing evaluation of its
12 target inventory levels based on an assessment of the potential risk of its reactors
13 being shut down due to uranium concentrates supply shortfalls.

14
15 Longenecker also provided several recommendations to OPG's uranium procurement
16 program (see summary Ex. F5-2-1 page 51). These recommendations, along with OPG's
17 response, are provided below:

18
19 *Longenecker recommended that OPG maintain, consistent with the physical coverage*
20 *limits, a continuing presence in the uranium market by frequent market contracting in*
21 *order to maximize opportunities to achieve attractive contract terms and encourage*
22 *potential suppliers to solicit OPG's business .(Ex. F5-2-1 page 40).*

23
24 OPG accepts this recommendation. Following the completion of the Longenecker report,
25 OPG awarded a proposal contract for the supply of 1,000,000 pounds uranium over the 2013
26 to 2016 period per Chart 2. OPG has also been active in the market in 2013, with two term
27 contracts awarded and an anticipated spot market procurement exercise in Q3 2013.

28
29 *Longenecker recommended that OPG explore "off-market" negotiated transactions that*
30 *may provide value by lowering its costs and providing terms and conditions that are not*
31 *offered in open market transactions. (Ex. F5-2-1 page 43)*

1
2 OPG does not accept this recommendation as it is inconsistent with OPG's and the Province
3 of Ontario's procurement guidelines to which it is subject. These guidelines require that OPG
4 provide access for qualified vendors to compete in a fair and transparent procurement
5 process.

6
7 *Longenecker recommended that OPG re-assess its Physical and Financial Coverage Limits*
8 *on a more regular basis. Longenecker also recommended that OPG ensure that its*
9 *Financial Coverage Limits continue to enable effective monitoring of the degree of price*
10 *certainty as new pricing determinants emerge (Ex.F5-2-1 page 45-46).*

11
12 OPG accepts these recommendations. An internal review of the Physical and Financial
13 Coverage Limits was undertaken after the completion of the Longenecker Report. This
14 review resulted in changes to the limits and these changes were approved by the Nuclear
15 Executive Committee ("NEC") in September 2012.

16
17 OPG's Physical Coverage Limits ensure security of supply in future years by requiring OPG to
18 contract within prescribed ranges in each year. The ranges establish maximum/minimum targets
19 on the total quantity of committed uranium supply to be under contract (including inventory in
20 excess of OPG's targeted inventory levels) and are defined in terms of percentages of expected
21 future needs. The NEC approved a reduction in the lower band (i.e. minimum target) on the
22 Physical Coverage limits in all years but more pronounced in the in the outer years¹. Reducing
23 the quantity of targeted uranium under contract provides increased flexibility to OPG to
24 accommodate a range of future market conditions as well as the potential for reduced OPG
25 uranium requirements.

26 Financial Coverage Limits provide maximum/minimum targets for the portion of contracted
27 supply to be under "fixed" price arrangements. The NEC approved a change in the derivation
28 of the Financial Coverage Limits which is now calculated to be a maximum and minimum
29 percentage of OPG's actual purchased uranium contracts. For example, if OPG has a
30 quantity of supply under contract in 2018, the Financial Coverage limits provide targets

¹ The maximum length of time into the future that OPG will contract for uranium supply is 10 years.

1 setting out the maximum and minimum percentage of the 2018 supply that can be under a
2 fixed price. Previously, OPG's Financial Coverage Limits provided maximum and minimum
3 targets, but these were calculated as a declining percentage of OPG's forecast total yearly
4 uranium requirements.

5
6 OPG intends to re-assess its Physical and Financial coverage limits regularly to
7 accommodate changes in the future supply/demand outlook for uranium, future market price
8 trends and new pricing determinants, and substantial changes to OPG's uranium
9 requirements.

10
11 ***Longenecker recommended an ongoing evaluation of uranium concentrate inventory levels***
12 ***based on an assessment of potential physical supply disruption risks. (Ex.F5-2-1 pag 48).***

13
14 OPG accepted this recommendation and undertook a review of its target uranium
15 concentrate inventory level of 385,000 Kilograms. This target was put into place at a time
16 when the market price for uranium was increasing and supply situation was tight. As a result
17 of the review, OPG lowered its target inventory level to 288,000 Kilograms. This inventory
18 level reflects current improved market conditions for uranium given the near term reduced
19 demand and the fact that additional new production has come on line. Going forward,
20 inventory target levels will be reviewed on a regular basis and as market conditions change.
21 OPG does not anticipate any further changes in the test period.