

700 University Avenue Toronto, ON M5G 1X6

OPG Confidential

August 15, 2016

File No: 08502-12-21 T06

Shawn-Patrick Stencil
Greenpeace
33 Cecil Street
Toronto, ON
M5T 1N1

Dear Shawn-Patrick:

**Request for Access to Information - Reference Number: IPC File PA12-394 OPG
File12-21**

As per the Adjudicator's ORDER PO-3629 please find enclosed the unredacted record related to this file.

Sincerely,



Steven Troup
FIPPA Coordinator
H18 G11
Tel: 416-592-4542 Toll: 1-877-592-2555 Fax: 416-592-3621
E-mail: steven.troup@opg.com

Enc

Sent by: Overnight Courier

cc. Justine Wai – Adjudicator (IPC)

Ontario Power Generation Inc.

Explanation of Calculation of Levelized Unit Energy Costs

At the November 2009 Board of Director's meeting, additional details were requested with respect to the Levelized Unit Energy Cost (LUEC) for the Darlington refurbishment project. The following documents provide:

1. A brief explanation of Levelized Unit Energy Costs.
2. A printout of a simplified version of the spreadsheet used to develop the estimated LUEC forecast for the Darlington refurbishment project.
3. Charts showing the LUEC probability distribution curve and a sensitivity analysis.

Explanation of Levelized Unit Energy Cost

The following is a brief explanation of LUEC:

- LUEC is an economic measure, often used as a screening tool to facilitate consistent cost comparison across generation options with different lives and cost characteristics.
- LUEC is generally expressed in today's dollars, and is a constant number that changes over time at the rate of inflation.
- LUEC is the electricity price (in ¢/kWh or \$/MWh) that is required for an option to achieve the target rate of return (Weighted Average Cost of Capital) given the assumed option service life, operating pattern and incremental cost profile.
- For the purposes of economic comparisons, "Going Forward" (excluding sunk costs) LUECs are typically used.

$$\text{Price (LUEC)} \times \text{Volume (ENERGY)} = \text{ALL COSTS OF AN OPTION ON A PRESENT VALUE BASIS}$$

LUEC Calculation for Darlington Refurbishment

The attached spreadsheet that provides summary level information underlying the calculation of LUEC for the Darlington refurbishment project. The spreadsheet is populated with a very high level summary of the cost flows for the refurbishment project, as well as the operational costs in the post-refurbishment period. The cost flows begin at the start of the refurbishment project and continue to the end of Darlington's service life post-refurbishment in 2054, when the last unit is expected to be removed from service. The LUEC represented here is a measure of the LUEC of the "second life" of Darlington. For readability, the cost flows are shown only to 2026. The actual model used to calculate the LUECs for OPG's various generation projects, including the Darlington refurbishment, are much more detailed than the one provided.

The example provided shows only the "point estimate" of the LUEC. In order to generate a probability distribution of the LUEC outcomes, OPG utilizes range estimates and probability distributions for all inputs and apply Monte Carlo simulation techniques to develop the overall probability distribution for LUEC. Also attached to this document, is a probability distribution curve which resulted from the Monte Carlo simulation analysis, as well as the "Tornado" diagram, which is used to provide information on the sensitivity of the LUEC results to uncertainty of inputs or groups of inputs.

ONTARIO POWER GENERATION

INPUT

Capacity MW/unit	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Outage Start																		
u1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.00	1.00	1.00	1.00
Return to Service																		
u1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	1.00	1.00	1.00	1.00	1.00
u3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.00	1.00	1.00	1.00
u4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.00
Out-of-Service Date																		
u1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Operational Unit-Years																		
u1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	1.00	1.00	1.00	1.00	1.00
u3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.00	1.00	1.00	1.00
u4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.00
Total Operational Unit-Years	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.84	2.17	3.00	3.75	4.00	4.00
Lifetime Unit-Years																		
u1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00
u4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.00	1.00	1.00	1.00	1.00
Total Lifetime Unit-Years	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.00	1.84	2.17	3.00	3.75	4.00	4.00	4.00	4.00	4.00
Perfect production GWh	0	0	0	0	0	0	0	0	0	0	1939	7691	14139	16668	23074	28869	30765	30765
Annual Capacity Factor	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
Energy GWh	0	0	0	0	0	0	0	0	0	0	1687	6691	12301	14501	20074	25116	26766	26766

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Economic Indices

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Discount Rate																		
Interest Capitalization Rate																		
Capital Escalation																		
Escalation rate																		
Escalation factor																		
Operations, Maintenance & Admin Escalation																		
Escalation rate																		
Escalation factor																		
Fuel Escalation																		
Escalation rate																		
Escalation factor																		
Used Fuel Management Escalation																		
Escalation rate																		
Escalation factor																		
Inflation (CPI)																		
Escalation rate																		
Inflation factor																		

Option Costs

Project Expenditures (2009 \$M)

u1	2350	0	66	99	201	218	262	192	238	507	398	161	9	0	0	0	0	0
u2	1296	0	0	0	0	0	0	0	0	16	406	540	299	34	1	0	0	0
u3	1272	1	0	0	0	0	0	0	0	0	4	99	489	468	192	21	0	0
u4	1294	0	0	0	0	0	0	0	0	0	0	0	13	318	565	344	51	3
Total Project Cost Flow	6213	1	66	99	201	218	262	192	238	522	808	799	810	820	758	365	51	3

Project Expenditures (esc \$M)

u1	2679	0	67	103	214	236	290	217	273	595	476	196	11	0	0	0	0	0
u2	1581	0	0	0	0	0	0	0	0	18	486	659	372	43	2	0	0	0
u3	1605	1	0	0	0	0	0	0	0	0	5	120	609	594	249	28	0	0
u4	1680	0	0	0	0	0	0	0	0	0	0	0	17	404	732	454	68	4
Total Project Cost Flow	7543	1	67	103	214	236	290	217	273	613	967	976	1008	1042	982	482	68	4

Interest During Construction (esc \$M)

u1	675	0	2	7	17	32	49	68	86	118	173	194	112	93	125	87	26	0
u2	169	0	0	0	0	0	0	0	0	1	16	51	85	17	0	0	0	0
u3	172	0	0	0	0	0	0	0	0	0	0	4	26	64	77	0	0	0
u4	175	0	0	0	0	0	0	0	0	0	0	0	1	13	48	87	26	0
Total Interest During Constr	1191	0	2	7	17	32	49	68	86	118	173	194	112	93	125	87	26	0

Annual Operating Costs

Annual Costs (2009 \$M)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Base Operations, Maintenance & Admin (OM&A)	305	305	305	305	305	305	305	282	282	282	282	282	282	282	282	282	324	324
Outage OM&A & OM&A Projects	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143
Nuclear & Corp Overhead	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190
Sustaining Capital	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Total Annual Costs	689	689	689	689	689	689	689	666	666	666	666	666	666	666	666	666	708	708
Fuel Costs (2009\$/MWh)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Used Fuel Management Costs (2009\$/MWh)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Annual Costs (esc \$M)																		
Base Operations, Maintenance & Admin (OM&A)	0	0	0	0	0	0	0	20	83	155	186	263	336	365	373	380	445	454
Outage OM&A & OM&A Projects	0	0	0	0	0	0	0	0	0	0	11	45	83	100	142	181	197	201
Nuclear & Corp Overhead	0	0	0	0	0	0	14	56	105	126	126	177	226	246	251	256	261	266
Sustaining Capital	0	0	0	0	0	0	0	0	0	0	4	16	30	36	51	64	70	72
Fuel & Used Fuel Management	0	0	0	0	0	0	0	0	0	0	9	37	69	83	117	149	162	165
Total Annual Costs	0	0	0	0	0	0	0	34	138	260	336	538	744	830	933	1030	1135	1158

Total Lifetime Annual Cost

Total Costs (\$ million)

Project Expenditures	1	67	103	214	236	290	217	273	613	967	976	1008	1042	982	482	68	4	0
Interest During Construction	0	2	7	17	32	49	68	86	118	173	194	112	93	125	87	26	0	0
Base Operations, Maintenance & Admin (OM&A)	0	0	0	0	0	0	0	20	83	155	186	263	336	365	373	380	445	454
Outage OM&A & OM&A Projects	0	0	0	0	0	0	0	0	0	0	11	45	83	100	142	181	197	201
Nuclear & Corp Overhead	0	0	0	0	0	0	0	14	56	105	126	177	226	246	251	256	261	266
Sustaining Capital	0	0	0	0	0	0	0	0	0	0	4	16	30	36	51	64	70	72
Fuel & Used Fuel Management	0	0	0	0	0	0	0	0	0	0	9	37	69	83	117	149	162	165
TOTAL	1	70	111	231	268	339	285	394	869	1399	1506	1657	1879	1938	1501	1125	1139	1158

Capital Cost Allowance and Tax

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Tax Depreciation Schedule	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Undepreciated Capital Cost opening	0	0	0	0	0	0	0	0	0	0	0	3220	2962	4403	5754	5292	6646	6112
In-Service additions- Project	0	0	0	0	0	0	0	0	0	0	3354	1749	1776	1776	1854	1854	1854	1854
In-Service additions- Sustaining	0	0	0	0	0	0	0	0	0	0	4	16	30	36	51	64	70	72
Capital Cost Allowance (CCA)	0	0	0	0	0	0	0	0	0	0	134	258	308	425	462	500	534	492
Undepreciated Capital Cost closing	0	0	0	0	0	0	0	0	0	0	3220	2962	4403	5754	5292	6646	6112	5620
Tax Schedule																		
Current provincial + federal	31.0%	29.0%	28.5%	25.0%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%

Simplified Levelized Unit Energy Cost (LUEC)

Costs (including tax impact)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base Operations, Maintenance & Admin (OM&A)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outage OM&A & OM&A Projects	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear & Corp Overhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel & Used Fuel Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Capital	1	67	103	214	236	290	217	273	613	967	976	1008	1042	982	482	68	4	0
Sustaining Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCA tax shield	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PV = 53.43																		
LUEC denominator	1	67	103	214	236	290	217	299	717	1161	1195	1351	1530	1508	1079	732	739	763
FV = 135.35																		
LUEC 2009 \$/MWh	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LUEC 2009 \$/kWh	54																	
	5.4																	

NOTICE

The attached model and information contained in the model is confidential, a trade secret and otherwise proprietary to Ontario Power Generation Inc. (OPG) and is, at all times, the exclusive property of OPG.

Users of this model will treat the model and the information contained therein as confidential information and take such measures to protect such information as it uses to protect its own confidential and proprietary information. Unauthorized disclosure of this information could reasonably be expected to prejudice significantly its competitive position or interfere significantly with the contractual or other negotiations of OPG.

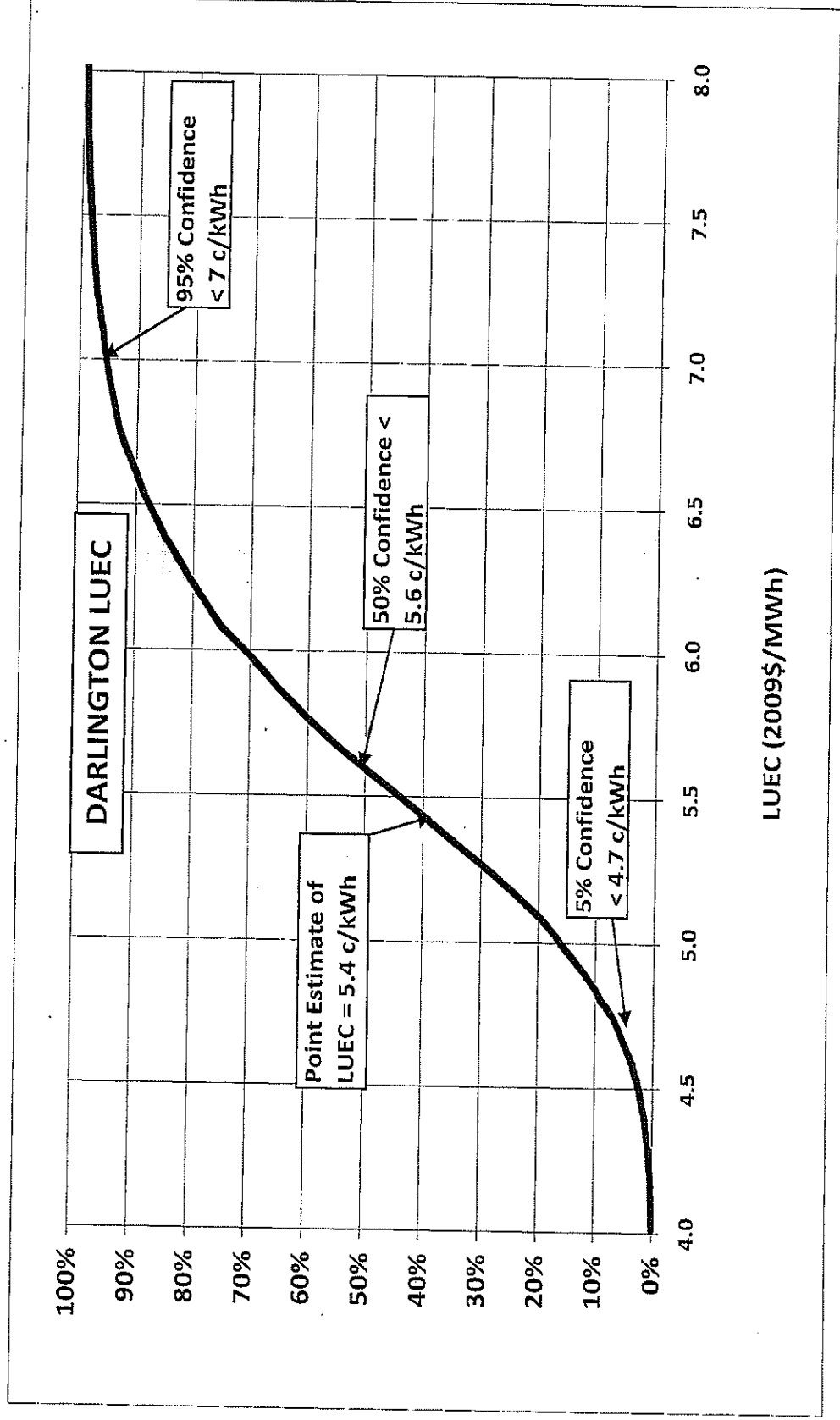
Simplifications:

1. Simplified tax calculation
2. No calculation of working capital
3. Simplified Operations, Maintenance & Admin allocation during partial station operation
4. Standby generator fuel cost included with Base Operations, Maintenance & Admin
5. Base OM&A is lower during project execution due to some staff being assigned to the project.

Darlington Refurbishment Levelized Unit Energy Costs

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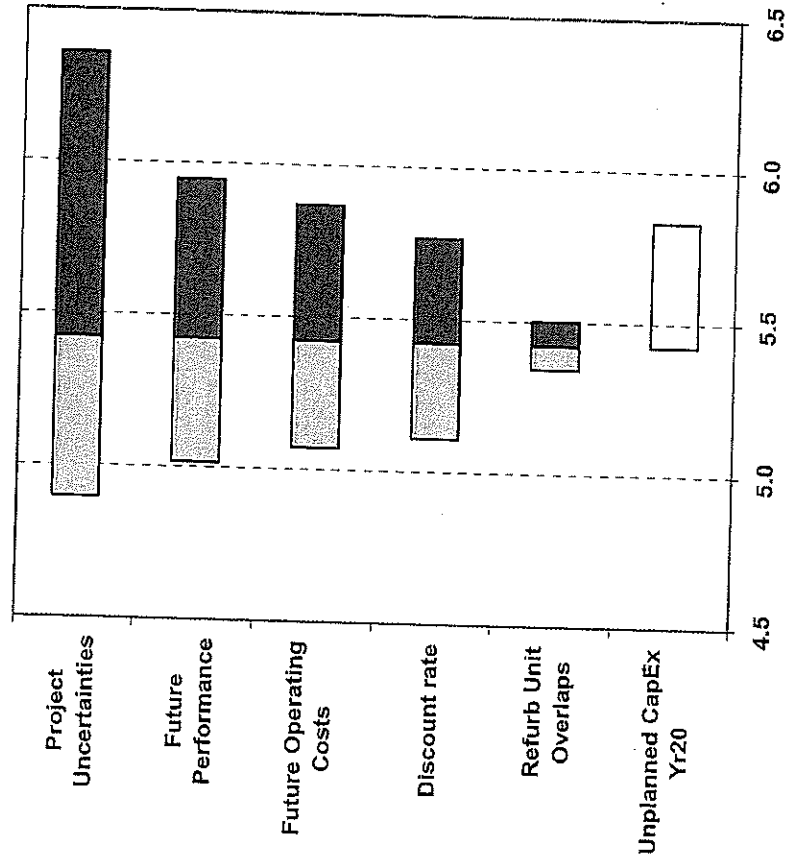
- The analysis indicates a LUEC for Darlington of < 7 ¢/kWh (2009\$); management is very confident that the LUEC will be < 8 ¢/kWh (2009\$); on an incremental basis.
- The “point estimate” LUEC of 5.4 ¢/kWh (2009\$) lies at approximately the 40% confidence level on the probability distribution.



Sensitivity of LUEC to Input Variables & Potential Scope Changes

- ☐ LUEC is very sensitive to refurbishment project costs and duration.
- ☐ LUEC is also quite sensitive to future performance (Life and Annual Capacity Factor assumptions and to future operating costs (Direct Station and Nuclear & Corporate Support).
- ☐ If Steam Generators needed to be replaced it would add approx. 1/2 ¢/kWh to the LUEC.

Darlington Life Extension
LUEC Sensitivities - ¢/kWh (2009\$)



Assumptions	Lower	Base	Upper
Project Uncertainties			
Refurb Cost (2009\$)	-15%	\$6.2B	20%
Refurb Duration (months)	-6 mths	36 mths	+12 mths
Future Performance			
ACF (%)	-5%	87%	5%
Life of Refurb Units (yrs)	+5 yrs	30 yrs	-5 yrs
Future Operating Costs			
Base OM&A (\$M)	-5%	295	5%
Outage OM&A (\$M)	-5%	95	10%
Sustaining Projects (\$M)	-20%	100	20%
Nuclear Support (\$M)	-5%	150	15%
Corporate Support (\$M)	-10%	40	15%
Fuel (\$/MWh)	-30%	5	30%
Discount Rate			
	-1%	7%	+1%
Refurb Unit Overlaps	+4 mths	19/16 mths	-4 mths
Unplanned CapEx Yr20			\$1B/unit

