Q. **Reference: Schedule 6, Program 3 Replace Diesel Gensets (2024-2028), Page 6, line 3**

Please provide the sizing study.

A. Please refer to PUB-NLH-035, Attachment 1 for the sizing study completed for the Makkovik Unit 3033 Replacement and PUB-NLH-035, Attachment 2 for the sizing study completed for the Nain Unit 2085 Replacement.

Doc #: RP-TN-085
Issue Date: 2023/03/15
Document Type: Technical Note

RP-TN-085
Makkovik Genset Unit 3033 - Replacement Recommendation

1 Purpose

As requested by Engineering Services, this study contains a cost benefit analysis and recommendation for the size of a new genset that should replace Makkovik Genset Unit 3033.

2 Equipment

Table 1 shows the existing unit information.

Table 1: Existing Unit Information

Unit ID	Unit Rating	Engine Speed	Total Hours At The End of 2022	Hours Since Last Overhaul
Unit 3033 (To be replaced)	565 kW	1800 rpm	102,442	5,119
Unit 2029	565 kW	1800 rpm	89,272	3,301
Unit 593	945 kW	1200 rpm	15,707	0
Plant Installed Capacity	2,075 kW	-	-	-
Plant Firm Capacity	1,130 kW	-	-	-

The load forecast used for this analysis is the 2023 long term load forecast for Makkovik and is presented in Table 2. No additional firm capacity will be needed to meet the long term load forecast.

Table 1: Makkovik Long Term Load Forecast

Year	Gross Peak (kW)
2023	879
2024	890
2025	900
2026	910
2027	920
2028	922
2029	927
2030	935
2031	941
2032	946
2033	951
2034	957
2035	962
2036	967
2037	970
2038	973
2039	975
2040	978
2041	981
2042	984
2043	984

3 Simulation and Alternatives

A diesel plant simulator was used to estimate the overhaul and replacement frequencies and total unit operating hours over a 20 year period for different plant configurations. The simulation inputs included the system load forecast, existing genset information, and alternative genset information. A summary of the simulation results can be found in Table 3.

Table 3: Simulation Summary

Alternatives	Total Unit Operating Hours	# of Unit Replacements	# of Overhauls
Alt 1. 545kW, 1800RPM	157,687	2	4
Alt 2. 725kW, 1800RPM	157,687	3	5
Alt 3. 945kW, 1800RPM	157,687	3	4
Alt 4. 945kW, 1200RPM	157,687	3	4

Four different unit configurations alternatives were considered. All sizes considered allow the systems firm capacity criteria to be maintained.

A cost benefit analysis was completed to compare the alternatives to replace Unit 3033 in the year 2023. The following were the assumptions made for this analysis:

1. Unit replacement costs:
    a. $1.8507M for a 545kW, 1800RPM unit
    b. $1.9507M for a 725kW, 1800RPM unit
    c. $2.2411M for a 945kW, 1800RPM unit
    d. $2.6208M for a 945kW, 1200RPM unit

2. Unit overhaul costs:
    a. $180k for a 545kW, 1800RPM unit
    b. $240k for a 725kW, 1800RPM unit
    c. $375k for a 945kW, 1800RPM unit
    d. $400k for a 945kW, 1200RPM unit

3. The overhaul and replacement frequencies:
    a. 545kW, 1800RPM unit
       Overhaul every 20,000 hours, Replacement every 100,000 hours
    b. 725kW, 1800RPM unit
       Overhaul every 20,000 hours, Replacement every 100,000 hours
    c. 945kW, 1800RPM unit
       Overhaul every 20,000 hours, Replacement every 100,000 hours
    d. 945kW, 1200RPM unit
       Overhaul every 60,000 hours, Replacement every 120,000 hours

4. Timing of unit replacements and overhauls were based on simulation results unless a unit reaches 35 years of operation in which it will be assumed to be replaced.

The summary of the CPW analysis results are presented in Table 4. These results do not include the fuel consumption of the alternatives. The fuel was excluded from the analysis because the fuel efficiency of the genset is used during tendering process and the simulator results can be very different depending on the specific fuel efficiency curves used during the simulation. The lowest cost option is Alternative 1.

Table 4: CPW Analysis Results

Alternative Comparison *Cumulative Net Present Value To The Year* **2023**		
Alternatives	**Cumulative Net Present Value (CPW)**	**CPW Difference between Alternative and the Least Cost Alternative**
Alt 1. 545kW, 1800RPM	3,417,411	
Alt 2. 725kW, 1800RPM	4,039,072	621,662
Alt 3. 945kW, 1800RPM	4,189,363	771,952
Alt 4. 945kW, 1200RPM	4,358,355	940,945

4 Recommendations

Based on the analysis above, it is recommended to replace Makkovik Genset Unit 3033 with a 545 kW 1,800 rpm unit.

Document Summary

Document Owner:	Rural Planning
Document Distribution:	

Revision History

Revision	Prepared by	Reason for change	Effective Date
0	P. Ji	Initial Release	2023/03/15
1	P. Ji	Edited to include a range of recommended unit sizes.	2023/05/26

Document Control

Regarding Rural Planning documents: The electronic version of this document is the CONTROLLED version. Please check the Rural Planning Document Management System SharePoint site for the official copy of this document. This document, when downloaded or printed, becomes UNCONTROLLED.

RP-TN-086
Nain Genset Unit 2085 - Replacement Recommendation

1 Purpose

As requested by Engineering Services, this study contains a cost benefit analysis and recommendation for the size of a new genset that should replace Nain Genset Unit 2085.

2 Existing Equipment

Table 1 shows the existing unit information.

Table 1: Existing Unit Information

Unit ID	Unit Rating	Engine Speed	Total Hours At The End of 2022	Hours Since Last Overhaul
Unit 2085 (To be replaced)	1275 kW	1800 rpm	87,843	736
Unit 595	1050 kW	1200 rpm	5,265	0
Unit 576	865 kW	1800 rpm	67,576	8,197
Unit 591	860 kW	1200 rpm	44,794	0
Plant Installed Capacity	4,050 kW	-	-	-
Plant Firm Capacity	2,775 kW	-	-	-

3 Analysis

Four alternative unit sizes were considered for the replacement of Unit 2085 within this analysis. They were:

- Alternative 1: 945kW, 1200RPM
- Alternative 2: 945kW, 1800RPM
- Alternative 3: 1275kW, 1800RPM
- Alternative 4. 1600kW, 1800RPM

3.1 Load Growth Considerations

The load forecast used for this analysis was the 2023 long term load forecast for Nain. This forecast as well as the plant firm capacity, existing capacity deficit, and capacity deficit for each

alternative are presented in Table 2. This table does not take into consideration future unit replacements as described below.

Table 1: Nain Long Term Load Forecast

Year	Forecast Gross Peak (kW)	Existing Firm Capacity (kW)	Existing Excess Capacity (kW)	Alt. 1 & 2 Excess Capacity[1] (kW)	Alt. 3 & 4 Excess Capacity[2,3] (kW)
2023	2,279	2,775	496	391	496
2024	2,309	2,775	466	361	466
2025	2,337	2,775	438	333	438
2026	2,364	2,775	411	306	411
2027	2,385	2,775	390	285	390
2028	2,385	2,775	390	285	390
2029	2,421	2,775	354	249	354
2030	2,456	2,775	319	214	319
2031	2,492	2,775	283	178	283
2032	2,528	2,775	247	142	247
2033	2,565	2,775	210	105	210
2034	2,602	2,775	173	68	173
2035	2,640	2,775	135	30	135
2036	2,679	2,775	96	-9	96
2037	2,718	2,775	57	-48	57
2038	2,757	2,775	18	-87	18
2039	2,798	2,775	-23	-128	-23
2040	2,839	2,775	-64	-169	-64
2041	2,880	2,775	-105	-210	-105
2042	2,922	2,775	-147	-252	-147
2043	2,922	2,775	-147	-252	-147

If Alternatives 1 and 2 were implemented, a violation of the planning firm capacity would begin to occur in the year 2036. To prevent this, both of the small Units 576 and 591 would need to be replaced with larger diesel gensets within the next 20 years.

[1] The installed capacity of Alternative 1 and Alternative 2 would be 3,720 kW (945 kW+1,050 kW+865 kW+860 kW) and the firm capacity would be 2,670 kW (945 kW+ 865 kW+ 860 kW).

[2] The installed capacity of Alternative 3 would be 4,050 kW (1,275 kW+1,050 kW+865 kW+860kW) and the firm capacity would be 2,775kW (1,050 kW+ 865 kW+ 860 kW).

[3] The installed capacity of Alternative 4 would be 4,375 kW (1,600 kW+1,050 kW+865 kW+860 kW) and the firm capacity would be 2,775kW (1,050 kW+ 865 kW+ 860 kW).

Within Alternative 1, two different options for avoiding the future planning criteria violations were considered:

- Option 1 (Alternative 1-1):
    - Unit 576 is assumed to be replaced with a 1,275 kW, 1,800 rpm when it reaches its end of life (estimated as 2029)
    - Unit 591 is assumed to be replaced with a 945 kW, **1,200 rpm** unit when it reaches its end of life (estimated as 2036)
- Option 2 (Alternative 1-2)
    - Unit 576 is assumed to be replaced with a 1,275 kW, 1,800 rpm when it reaches its end of life (estimated as 2029)
    - Unit 591 is assumed to be replaced with a 945 kW, **1,800 rpm** unit when it reaches its end of life (estimated as 2036)

Within Alternative 2, two different options for avoiding the future planning criteria violations were considered:

- Option 1 (Alternative 2-1):
    - Unit 576 is assumed to be replaced with a 1,275 kW, 1,800 rpm when it reaches its end of life (estimated as 2029)
    - Unit 591 is assumed to be replaced with a 945 kW, **1,200 rpm** unit when it reaches its end of life (estimated as 2036)
- Option 2 (Alternative 2-2)
    - Unit 576 is assumed to be replaced with a 1,275 kW, 1,800 rpm when it reaches its end of life (estimated as 2029)
    - Unit 591 is assumed to be replaced with a 945 kW, **1,800 rpm** unit when it reaches its end of life (estimated as 2036)

If Alternative 3 or 4 were implemented, a violation of the planning firm capacity would occur in 2039. To prevent this, only one of the small Units 576 and 591 would need to be replaced with a larger diesel gensets within the next 20 years. In Alternative 3, it was assumed that Unit 576 would be replaced with a similarly sized unit when it reaches its estimated end of life in 2030 and Unit 591 would be replaced with a 1,275 kW, 1,800 rpm unit when it reaches its estimated end of life in 2039. In Alternative 4, it was assumed that Unit 576 would be replaced with 1,275 kW, 1,800 rpm unit when it reaches its estimated end of life in 2034. In this alternative, the replacement of unit 591 is not expected to be required within the study duration.

3.2 Simulation and Alternatives

A diesel plant simulator was used to estimate the overhaul and replacement frequencies and total unit operating hours over a 20 year period for different plant configurations. The simulation inputs included the system load forecast, existing genset information, and alternative genset information. A summary of the simulation results can be found in Table 3.

Table 3: Simulation Summary

Alternatives	Total Unit Operating Hours	# of Unit Replacements	# of Overhauls
Alt 1-1. 945kW, 1200RPM	293,735	3	4
Alt 1-2. 945kW, 1200RPM	293,735	3	5
Alt 2-1. 945kW, 1800RPM	293,735	3	6
Alt 2-2. 945kW, 1800RPM	293,735	3	7
Alt 3. 1275kW, 1800RPM	280,509	3	8
Alt 4. 1600kW, 1800RPM	230,119	2	7

A cost benefit analysis was completed to compare the alternatives to replace Unit 2085 in the year 2023. The following were the assumptions made for this analysis:

1. Unit replacement costs:
    a. $2.9105M for a 945kW, 1200RPM unit
    b. $2.3105M for a 945kW, 1800RPM unit
    c. $2.8105M for a 1275kW, 1800RPM unit
    d. $2.9105M for a 1600kW, 1800RPM unit

2. Unit overhaul costs:
    a. $400k for a 945kW, 1200RPM unit
    b. $375k for a 945kW, 1800RPM unit
    c. $540k for a 1275kW, 1800RPM unit
    d. $720k for a 1600kW, 1800RPM unit

3. The overhaul and replacement frequencies:
    a. 945kW, 1200RPM unit
    Overhaul every 60,000 hours, Replacement every 120,000 hours
    b. 945kW, 1800RPM unit
    Overhaul every 20,000 hours, Replacement every 100,000 hours
    c. 1275kW, 1800RPM unit
    Overhaul every 20,000 hours, Replacement every 100,000 hours
    d. 1600kW, 1800RPM
    Overhaul every 20,000 hours, Replacement every 100,000 hours

4. Timing of unit replacements and overhauls were based on simulation results unless a unit reaches 35 years of operation in which it will be assumed to be replaced due to obsolescence and potential lack of parts availability.

The summary of the CPW analysis results are presented in Table 4. Alternative 4 is the least cost option. These results do not include the fuel consumption of the alternatives because

the fuel efficiency of the genset is used during tendering process and the simulation results can be very different depending on the specific unit make and model used during the simulation.

Table 4: CPW Analysis Results

Alternative Comparison *Cumulative Net Present Value To The Year* **2023**		
Alternatives	**Cumulative Net Present Value (CPW)**	**CPW Difference between Alternative and the Least Cost Alternative**
Alt 4. 1600kW, 1800RPM	5,673,543	
Alt 3. 1275kW, 1800RPM	5,846,337	172,794
Alt 1-1. 945kW, 1200RPM	6,048,454	374,911
Alt 1-2. 945kW, 1200RPM	6,091,725	418,182
Alt 2-1. 945kW, 1800RPM	6,225,680	552,137
Alt 2-2. 945kW, 1800RPM	6,268,951	595,408

4 Recommendations

Based on the analysis above, it is recommended to replace Nain Genset Unit 2085 with a 1,600 kW, 1800RPM genset.

Document Summary

Document Owner:	Rural Planning
Document Distribution:	

Revision History

Revision	Prepared by	Reason for change	Effective Date
0	P. Ji	Initial Release	2023/03/15

Document Control

Regarding Rural Planning documents: The electronic version of this document is the CONTROLLED version. Please check the Rural Planning Document Management System SharePoint site for the official copy of this document. This document, when downloaded or printed, becomes UNCONTROLLED.