

Renewable Energy Deployment in Canadian Arctic: Pre-Feasibility Studies for Nunavut



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SUMMARY

- Pre-selection of 13 out of total 25 communities in Nunavut based on high level data.
- RE integration simulations performed in HOMER on these 13 communities to select 5 communities for detailed feasibility studies.

STUDY PROCEDURES

- **Pre-selection** made based on high level data on solar and wind profiles, costs, demand, and size of the communities.
- HOMER is used to determine the **optimal generation plan**:
 - ✓ With and without RE.
 - ✓ Varying the energy storage (battery) capacity.
 - ✓ Optimal plan selected based on minimum net present (NP) costs while satisfying HOMER's in-built stability criteria.

- Community **rankings** based on the following **criteria**:

1. Replacement of new required diesel generators.
2. Maximum savings on fuel and O&M costs.
3. O&M savings equal to RE installation costs.
4. Maximum reduction in CO₂ emissions.
5. Maximum RE penetration (as a percentage of total energy).

- Input considerations and assumptions:

- ✓ Capital and O&M costs for all new equipment considers transportation and installation costs for each community.
- ✓ Solar and wind data from NASA SSE (Surface meteorology and Solar Energy) or Environment Canada.
- ✓ Operating reserves of 25% and 50% of solar and wind energy generation, respectively.
- ✓ Project life of 25 years.
- ✓ Discount rate of 8%.

PRE-SELECTION RESULTS

COMMUNITIES	OVERALL RANK	WIND SPEED	SOLAR ENERGY	Tr. COST SEA	Tr. COST AIR	COMM. SIZE	ENERGY DEMAND	GHG EMISSION	ELECTR. RATE	REGION
Rankin Inlet	1	H	H	ML	L	H	H	ML	L	Kivalliq
Iqaluit	2	MH	MH	L	ML	H	H	MH	L	Qikiqtaaluk
Arviat	3	H	H	ML	L	H	H	ML	L	Kivalliq
Cape Dorset	4	H	MH	L	H	ML	ML	L	L	Qikiqtaaluk
Baker Lake	5	H	MH	ML	L	H	ML	L	L	Kivalliq
Repulse Bay	6	H	MH	ML	L	H	ML	L	ML	Kivalliq
Sanikiluaq	7	H	H	ML	L	MH	ML	L	ML	Qikiqtaaluk
Chesterfield Inlet	8	H	H	ML	L	L	MH	ML	MH	Kivalliq
Coral Harbour	9	MH	H	ML	L	MH	ML	L	MH	Kivalliq
Whale Cove	10	MH	MH	L	ML	H	ML	L	H	Kivalliq
Pangnirtung	11	MH	MH	L	ML	H	ML	L	L	Qikiqtaaluk
Igloolik	12	H	MH	ML	L	H	ML	MH	L	Qikiqtaaluk
Qikiqtaaluk	13	H	MH	MH	ML	ML	MH	ML	L	Kivalliq
Hall Beach	14	H	MH	ML	L	MH	ML	L	MH	Qikiqtaaluk
Clyde River	15	H	ML	MH	H	H	ML	ML	ML	Qikiqtaaluk
Cambridge Bay	16	H	MH	H	H	H	MH	ML	ML	Kivalliq
Kugaaruk	17	H	MH	MH	H	MH	ML	L	L	Kivalliq
Gjoa Haven	18	MH	MH	H	MH	H	ML	L	MH	Kivalliq
Kimmirut	19	MH	MH	L	H	L	ML	ML	H	Qikiqtaaluk
Grise Fiord	20	MH	L	MH	H	L	H	H	H	Qikiqtaaluk
Resolute Bay	21	MH	L	MH	H	L	H	H	H	Qikiqtaaluk
Kugluktuk	22	ML	ML	H	MH	H	ML	L	MH	Kivalliq
Pond Inlet	23	ML	ML	MH	H	H	ML	L	MH	Qikiqtaaluk
Taloyoak	24	MH	ML	H	H	MH	ML	L	H	Kivalliq
Arctic Bay	25	ML	ML	MH	H	MH	ML	L	MH	Qikiqtaaluk

RANKING RESULTS

- First ranking criterion:

Community (Alphabetical)	Gen. Cap. Removed [kW]	Installation Costs (NPV) [M\$]	O&M Savings [%]	RE and Associated CAPACITIES				RE Penetration [%]	CO ₂ Reduction [%]	Rankings based on	
				Battery [kWh]	PV [kW]	Wind [kW]	Converter [kW]			Gen. Cap. Removed (Descend)	Installation Costs of RE (Ascend)
Arviat	1,400	15,058	-0.32	3,500	500	1,100	1,000	35.1	34.99	2	6
Baker Lake	1,200	2,989	7.94	0	500	0	500	7.1	7.31	5	2
Cambridge Bay	780	19,931	20.62	4,300	1,200	1,000	1,600	28.8	29.63	7	7
Cape Dorset	1,400	34,635	18.56	21,600	1,100	600	1,100	37.0	37.32	3	10
Clyde River	520	7,691	21.71	1,460	500	300	600	28.7	29.62	9	3
Igloolik	940	8,771	12.91	2,400	1,000	0	1,100	17.0	18.54	6	5
Kugaaruk	1,300	29,220	28.24	18,600	600	600	600	42.7	42.83	4	8
Pangnirtung	550	7,946	9.94	2,500	900	0	1,000	13.6	15.57	8	4
Qikiqtaaluk	400	43,103	-151.84	37,000	700	0	500	20.6	21.89	11	11
Rankin Inlet	2,300	32,524	27.79	7,000	1,300	2,000	2,200	39.2	39.06	1	9
Sanikiluaq	460	1,402	10.53	300	100	100	100	11.5	11.37	10	1

- Second ranking criterion:

RANK	Max. O&M Savings [%]	Community	RE and Associated CAPACITIES				RE Penetration [%]	CO ₂ Reduction [%]	Installation Costs (NPV) [M\$]
			Battery [kWh]	PV [kW]	Wind [kW]	Converter [kW]			
1	44.92	Sanikiluaq	2,500	400	600	700	51.7	52.99	7.795
2	27.82	Hall Beach	1,300	400	400	500	36.0	37.03	7.726
3	27.79	Rankin Inlet	7,000	1,300	2,000	2,200	39.2	39.06	32.524
4	25.21	Iqaluit	21,500	2,000	6,000	5,500	39.3	40.08	84.715
5	24.87	Baker Lake	3,500	600	900	1,000	36.4	36.04	15.873
6	21.94	Kugaaruk	1,500	500	300	600	31.5	31.55	7.573
7	21.71	Clyde River	1,460	500	300	600	28.8	29.82	7.691
8	21.33	Cambridge Bay	4,500	1,200	1,100	1,600	30.1	30.96	20.978
9	20.29	Arviat	3,500	500	1,100	900	34.6	34.25	15.058
10	17.03	Cape Dorset	3,500	500	700	900	31.0	31.17	13.160
11	12.91	Igloolik	2,400	1,000	0	1,100	17.0	18.54	8.771
12	10.96	Qikiqtaaluk	1,100	400	0	500	13.3	15.56	3.620
13	9.94	Pangnirtung	2,500	900	0	1,000	13.6	15.57	7.946

- Third ranking criterion:

Community (Alphabetical)	NPV/O&M Savings [%]	Installation Costs (NPV) [M\$]	O&M Savings [%]	RE and Associated CAPACITIES				RE Penetration [%]	CO ₂ Reduction [%]	Rankings based on	
				Battery [kWh]	PV [kW]	Wind [kW]	Converter [kW]			Gen. Cap. Removed (Descend)	Installation Costs of RE (Ascend)
Arviat	837,705	907,600	1.70	0	0	100	0	2.6	2.46	16	3
Baker Lake	3,648,351	4,047,500	6.73	1,000	500	0	500	7.1	7.36	14	8
Cambridge Bay	6,198,906	5,879,400	7.39	1,500	600	100	700	8.3	9.07	13	9
Cape Dorset	580,989	591,400	1.21	0	100	0	100	0.6	1.41	18	1
Clyde River	3,053,834	3,087,000	9.92	800	200	100	200	11.3	13.49	8	7
Hall Beach	2,429,447	2,374,200	1.95	700	100	100	200	9.8	11.27	11	6
Igloolik	8,832,737	7,940,400	27.25	1,500	400	400	500	36.2	37.25	3	12
Kugaaruk	735,488	721,800	1.50	100	100	0	100	1.7	1.66	17	2
Iqaluit	36,739,335	37,081,000	9.62	12,500	2,000	1,500	3,000	13.5	14.99	9	16
Iqaluit	96,285,121	84,714,992	25.21	21,500	2,000	6,000	5,500	39.3	40.08	4	17
Iqaluit	93,116,687	90,651,504	24.28	25,000	0	7,500	5,500	41.4	42.25	5	18
Kugaaruk	6,285,116	6,138,500	18.45	1,100	500	200	500	25.9	25.64	7	10
Kugaaruk	7,471,944	7,572,300	21.94	1,500	300	600	600	31.5	31.55	6	11
Pangnirtung	1,944,607	1,863,800	3.85	100	300	0	300	4.7	4.57	15	5
Qikiqtaaluk	11,898,300	1,730,400	7.41	500	200	0	200	6.7	9.22	12	4
Rankin Inlet	11,197,390	12,392,600	9.43	4,000	500	600	800	13.8	14.79	10	14
Rankin Inlet	33,006,219	32,523,800	27.79	7,000	1,300	2,000	2,200	39.2	39.06	2	15
Sanikiluaq	11,292,466	11,537,900	33.99	10,000	400	600	700	52.1	53.06	1	13

- Fourth ranking criterion:

RANK	Max. CO ₂ Reduction [%]	Community	RE and Associated CAPACITIES				RE Penetration [%]	O&M Savings [%]	Installation Costs (NPV) [M\$]
			Battery [kWh]	PV [kW]	Wind [kW]	Converter [kW]			
1	53.06	Sanikiluaq	7,500	400	600	700	52.1	37.79	10.290
2	42.83	Kugaaruk	18,600	600	600	600	42.7	-28.24	29.220
3	42.29	Iqaluit	30,000	0	7,500	6,000	41.5	22.88	95.806
4	40.50	Rankin Inlet	15,000	1,300	2,100	2,200	40.6	20.97	41.737
5	39.50	Baker Lake	12,500	600	1,000	1,300	40.3	7.62	26.495
6	37.32	Cape Dorset	21,600	1,100	600	1,100	37.0	-18.56	34.635
7	37.31	Hall Beach	2,000	400	400	500	36.2	37.21	8.476
8	34.99	Arviat	12,500	500	1,100	1,000	35.1	-0.32	19.945
9	30.98	Cambridge Bay	10,000	1,200	1,100	1,600	30.1	13.59	26.671
10	30.08	Clyde River	2,000	500	300	700	28.9	19.87	8.324
11	21.89	Qikiqtaaluk	37,000	700	0	500	20.6	-151.84	43.103
12	18.54	Igloolik	2,400	1,000	0	1,100	17.0	12.91	8.771
13	15.64	Pangnirtung	5,000	900	0	1,000	13.6	4.10	10.561

- Fifth ranking criterion:

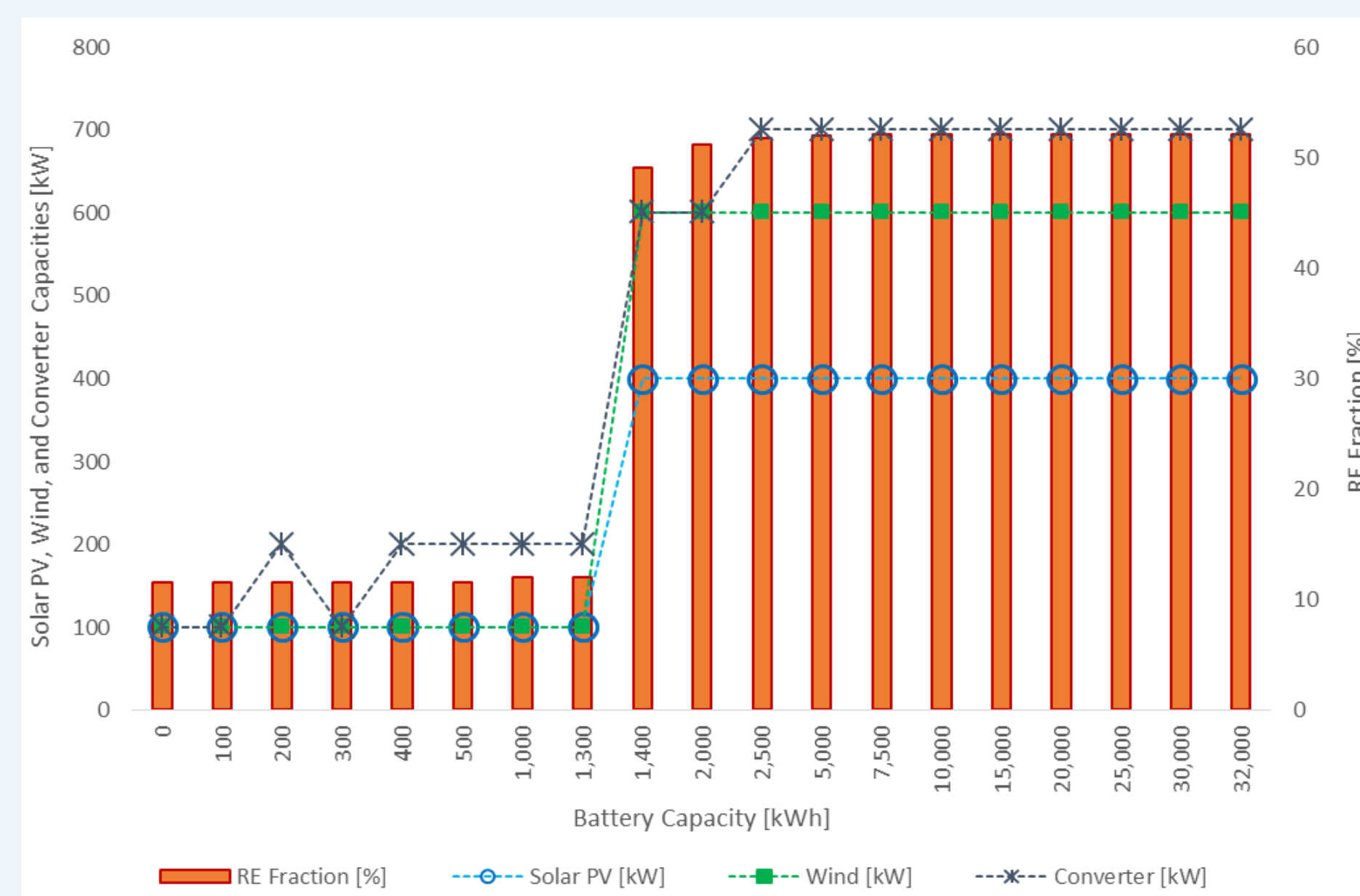
RANK	Max. RE Penetration [%]	Community	RE and Associated CAPACITIES				CO ₂ Reduction [%]	O&M Savings [%]	Installation Costs (NPV) [M\$]
			Battery [kWh]	PV [kW]	Wind [kW]	Converter [kW]			
1	52.1	Sanikiluaq	7,500	400	600	700	53.06	37.79	10.290
2	42.7	Kugaaruk	18,600	600	600	600	42.83	-28.24	29.220
3	41.5	Iqaluit	30,000	0	7,500	6,000	42.29	22.88	95.806
4	40.6	Rankin Inlet	10,000	1,300	2,100	2,200	40.49	25.99	36.517
5	40.3	Baker Lake	12,500	600	1,000	1,300	39.50	7.62	26.495
6	37.0	Cape Dorset	21,600	1,100	600	1,100	37.32	-18.56	34.635
7	36.2	Hall Beach	1,500	400	400	500	37.25	27.25	7.940
8	35.1	Arviat	12,500	500	1,100	1,000	34.99	-0.32	19.945
9	30.1	Cambridge Bay	10,000	1,200	1,100	1,600	30.98	13.59	26.671
10	28.9	Clyde River	2,000	500	300	700	30.08	19.87	8.324
11	20.6	Qikiqtaaluk	37,000	700	0	500	21.89	-151.84	43.103
12	17.0	Igloolik	2,400	1,000	0	1,100	18.54	12.91	8.771
13	13.6	Pangnirtung	5,000	900	0	1,000	15.64	4.10	10.561

FINAL RANKING

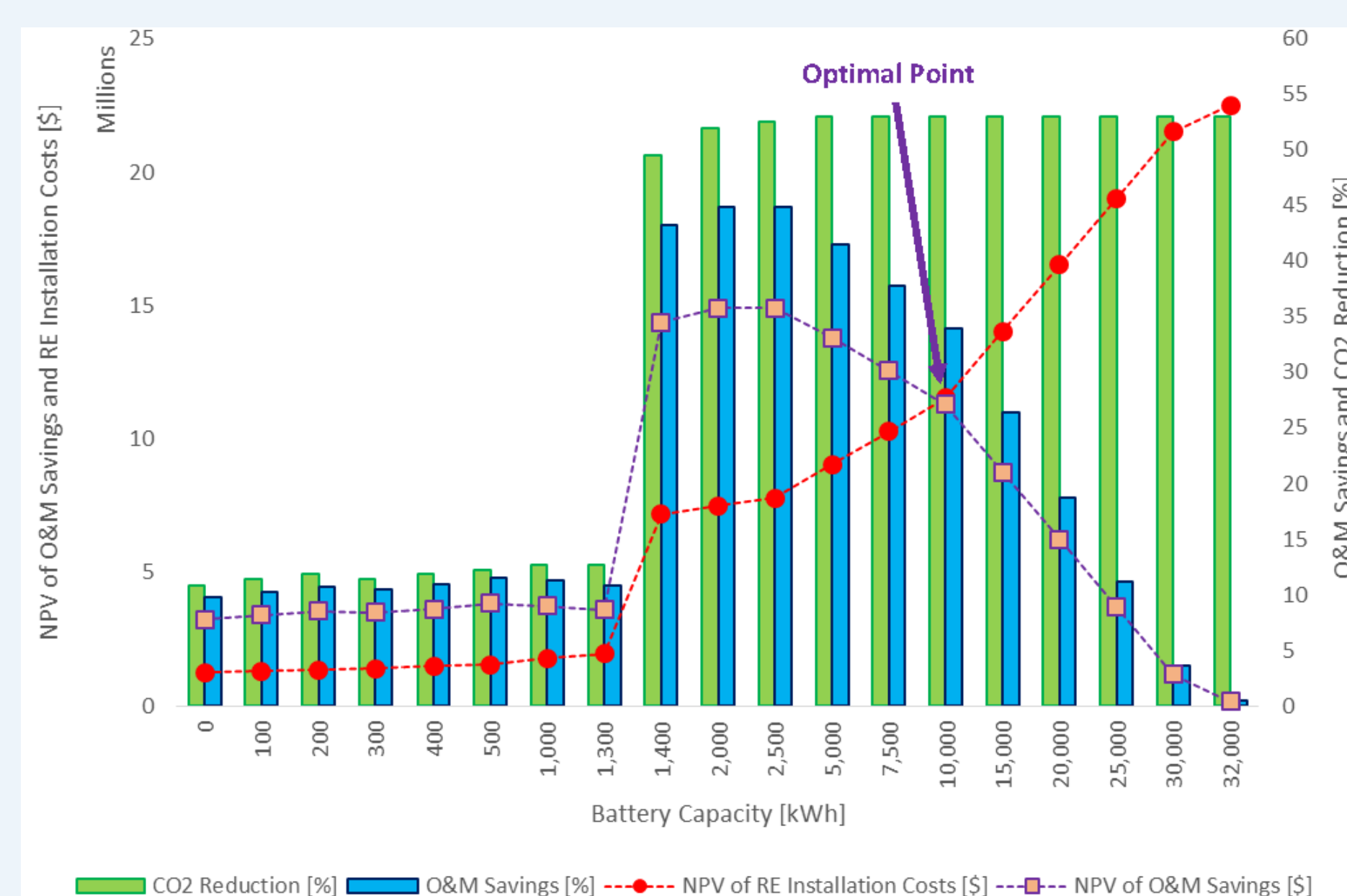
- The Nunavut Communities selected for feasibility studies are:
 1. Sanikiluaq
 2. Iqaluit
 3. Rankin Inlet
 4. Baker Lake
 5. Arviat

SAMPLE RESULTS FOR SANIKILUAQ

- New capacity additions and RE penetration:



- O&M and fuel savings, RE capital costs, and emissions:



- Percentage share of energy generation:

