Manitoba Hydro
Electric Infrastructure Condition Assessment Summary

December 2014

Manitoba Hydro

1. Executive Summary

Manitoba Hydro is one of the largest integrated electricity and natural gas distribution utilities in Canada, serving over 555,000 customers across nearly 650,000 square kilometres. Meeting the needs of its customers requires a vast complex of diverse assets. Though assets are being continually maintained to extend asset life, a significant portion requires reinvestment over the next 20 years due to the current health and age of the assets.

This Electric Infrastructure Condition Assessment Summary report provides an overview of the most significant Manitoba Hydro generation, transmission, high voltage direct current (HVDC) and distribution assets. It consists of current asset conditions, demographics and a 20-year forecast of equipment condition based on current replacement rates and projected replacement or refurbishment work included in the Capital Expenditure Forecast 2013 (CEF13).

Some of these assets are in poorer condition than what is considered acceptable with ages well beyond industry standards and present a significant risk of failure while in-service. In-service failures generally represent a greater risk of customer outages and/or load shedding and are a potential hazard to individuals working in and around these assets as well as to public safety. Some of these assets, such as breakers, generators, wood poles and valve groups, also require significant effort, lead time and capital investment to address their present condition.

The 20-year outlook based on current replacement rates and the CEF13 current capital expenditure forecast indicates a trend toward less asset reliability as more assets slip into the very poor and poor condition categories. This trend is something that must be addressed with additional capital asset sustainment programs or an equivalent means to address this predicted scenario. The 20-year outlook indicates the following items are of most concern:

- Generators
- Generation breakers
- Generation governors
- HVDC smoothing reactors
- HVDC valve groups
- Transmission protection relays
- Distribution wood poles
- Distribution underground cables

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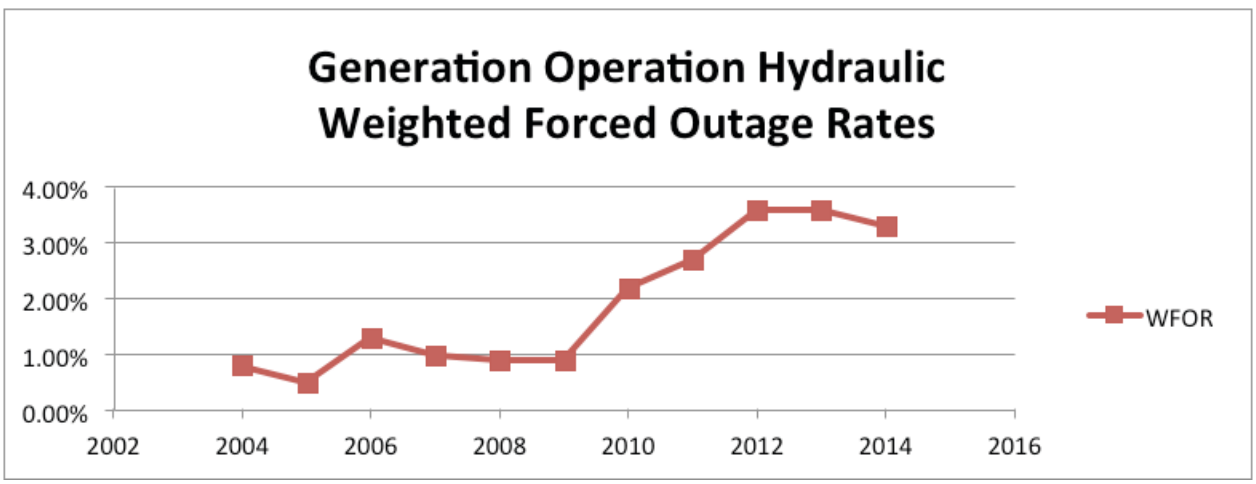
2. Introduction/Background

Manitoba Hydro owns and maintains several million assets throughout Manitoba. This complex electrical system has been developed in key stages over more than 100 years. The assets stretch to all corners of the province with some being in very remote locations without traditional road access.

A considerable amount of Manitoba Hydro's assets were installed prior to 1960 when many of the first generating stations and transmissions systems were built (1911-1950) and when a large portion of the province was electrified (1940-1960). Many of these assets have been well maintained or overhauled and are still in service, providing decades of valuable service to the corporation and its ratepayers. The next mass installation of assets was from 1960 through to 1990 when generating stations were developed on northern Manitoba river systems along with the supporting HVDC system to transport the electricity to customers in the south. Many of these assets are now at or near the end of their design lives and require replacement in the near future to maintain reliability.

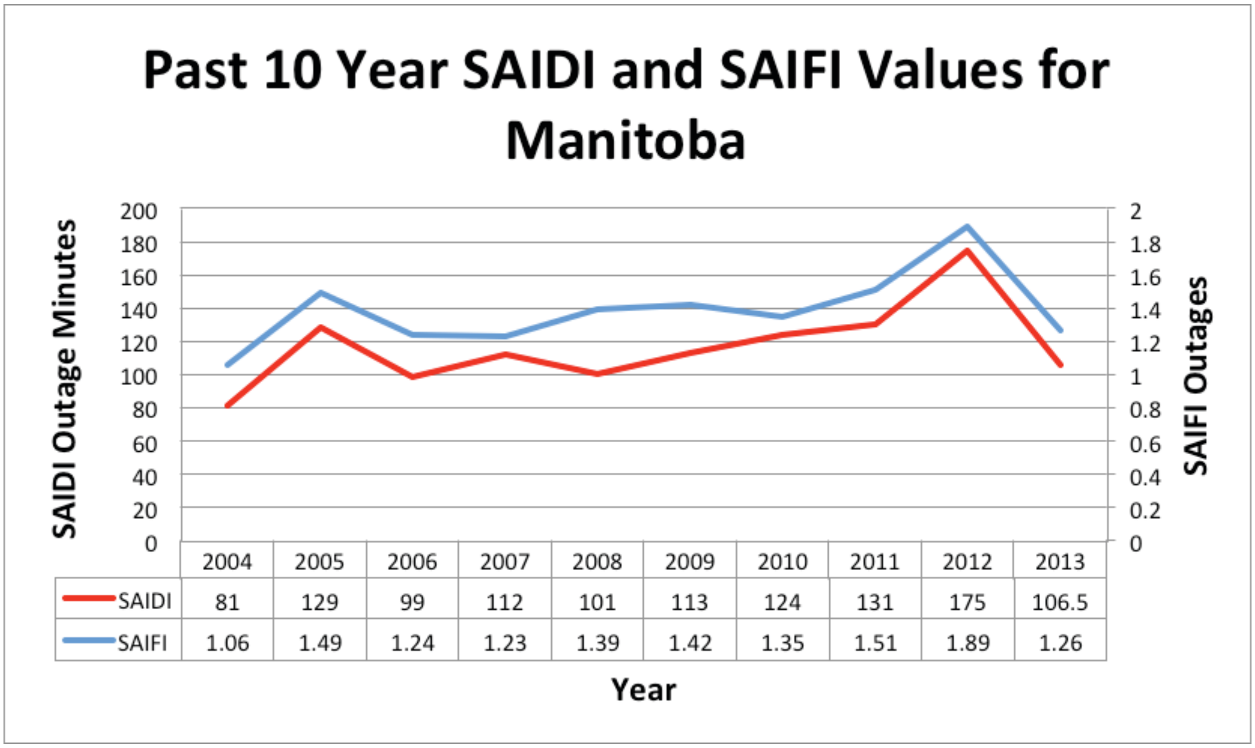
Manitoba Hydro reliability has historically been amongst the best in Canada. However, system reliability performance is beginning to degrade and asset condition is a contributing factor. The following charts are a few key reliability indicators that Manitoba Hydro uses to gauge infrastructure performance.

Generation forced outage rates indicate the amount of time that generation is unavailable due to equipment failures.



***The percentage of service hours that a generating unit is not available due to forced outages as a function of the MCR. MCR is the unit maximum continuous MW rating.**
Weighted Forced Outage Rate (WFOR) = Sum of all units ((Forced Outage Hours Per Unit * MCR Per Unit)) / Sum of all units ((Forced Outage Hours Per Unit + Operating Hours Per Unit) * MCR Per Unit))

SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) values are used throughout the utility industry as a standard for comparison purposes across jurisdictions and is the average outage time and frequency that a customer would experience.



Equipment at the end of its life tends to experience increased failure rates. Many of Manitoba Hydro's assets have been in service since the original system developments. As a result, significant changes to current replacement rates will be required in the future to mitigate the negative impacts of aging infrastructure on our electrical system.

The original cost of these assets is approximately $15 billion with an estimated replacement value that would be many multiples higher due to inflation, increases in commodity prices and other factors. An asset portfolio of this size requires significant reinvestment to ensure that performance and safety standards are achieved.

Objectives of the Electric Asset Health Index Summary Report

This Electric Infrastructure Condition Assessment Summary presents a view of some of the major electrical asset conditions and their demographics. It was completed using industry accepted methodologies for each asset type presented. Asset condition is an important input into the risk management process and the prioritization of capital funding used to maintain a sustainable and reliable electric system for Manitoba.

The 20-year asset condition outlook based on the current capital expenditure forecast indicates a trend toward less asset reliability as more assets slip into the very poor and poor condition. This trend must be addressed with additional capital asset sustainment programs or an equivalent means to address this expected scenario.

3. Methodology

An Asset Health Index (AHI) quantifies equipment condition based on numerous condition parameters that are related to the long-term degradation factors that cumulatively lead to an asset's end of life. An AHI should provide a measure of long-term degradation, which is an indicator of the asset's overall health, and should reflect the likelihood that an asset will fail and necessitate a forced replacement or refurbishment. For some asset types, forced replacements can result in substantial costs and extended outages due to delays associated with procuring a replacement asset and with the engineering required to install the replacement (e.g. replacing older breaker or protection relay technologies with newer technologies). Therefore, the AHI provides an important input to the assessment of asset related risks.
Manitoba Hydro used available asset data (such as age, lab tests, equipment vibration and temperature, etc), maintenance and operating experience, and engineering assessments to calculate a condition index for each asset. Availability of various input parameters and data quality differed from asset to asset.

The asset health index methodologies:

- are used to calculate the various ratings for each asset to arrive at the "Asset Health Index" (AHI).
- provide a consistent means of evaluating the condition of individual assets,
- tracks and categorizes the health of a class of equipment,
- assists with asset decision making,
- facilitates planning for future maintenance, replacement and refurbishment.

Across the three business units (Generation Operations, Transmission and Customer Service & Distribution) there are similar asset types, such as breakers, poles, and batteries that are used for the same basic functions. Other asset types, like transformers, seem similar but are utilized in very different operating contexts by each business unit. As a result these assets have different maintenance requirements and life expectancies, and require somewhat different AHI methodologies.

Asset Health Index Summary Graphs

Asset Health Index (AHI) summary graphs show the summary of AHI results in a single picture. The asset class members for each condition rating are charted in colored bar percentages that extend across the grid. The final scoring breakdown provides consistent comparisons across all the various Manitoba Hydro assets.

Scoring breakdown

- **Very poor** = Beyond acceptable level of risk; Action is required over the short term. Asset should be replaced, refurbished or decommissioned soon (Condition Index 0 -1.49)
- **Poor** = Managing risk; Assets may require replacement (approaching or past expected end of life) (Condition Index 1.5- 3.49)
- **Fair** = Long term service without notable measures of degradation (still in its useful part of its life) (Condition Index 3.5 – 4.99)
- **Good** = Midterm service without notable measures of degradation (in the prime of its useful life) (Condition Index 5 – 8.49)
- **Very Good** = Like new operating at expected measure of performance (early in its life) (Condition Index 8.5 -10)

Some assets are replaced based on risk informed economic end of life assessments in conjunction with asset condition score.

4. Individual Asset Condition Assessment and Demographics by Business Unit

The following sections outline, by business unit, the details surrounding each individual asset so that the reader can relate to how the asset is used, how it will degrade, how long it is expected to be in service, and its age and condition demographics at the time this report was prepared.
Asset health indexes continually change based on new asset data as it become available over time and the findings in this report are based on the asset data available prior to reporting.

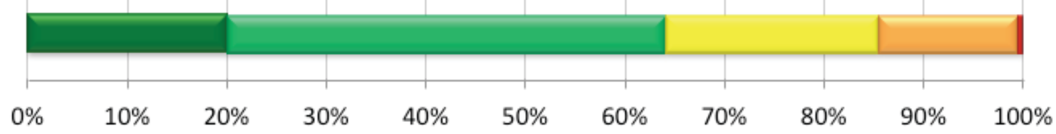
GENERATION OPERATIONS

Generation Operations is responsible for 15 hydroelectric generating stations and two small thermal generating stations with a total combined capacity of approximately 5400 MW.

Generators:

Description: A generator is a rotating electrical machine. It is used to convert the mechanical energy of a prime mover to electrical energy. Generators are the source of electrical energy for the bulk electric system. The majority of Manitoba Hydro's electricity is generated in northern Manitoba.		
Degradation: • Insulation break down • Thermal fatigue • Wear of moving parts	**Expected Life:** **(as defined in Appendix A)** 60 years	**Turnover based on Current Replacement Rate:** Approximately every 117 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	32	27.35%
10 to 20	8	6.84%
20 to 30	20	17.09%
30 to 40	16	13.68%
40 to 50	9	7.69%
50 to 60	18	15.38%
60 to 70	0	0.00%
70 to 80	8	6.84%
80 to 90	4	3.42%
> 90	2	1.71%
Grand Total	117	100.00%
Replacement Value	$2 300 M	



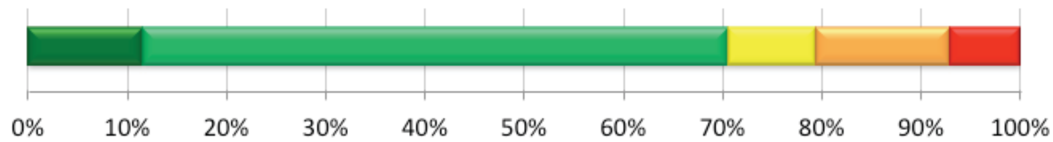
	Asset Quantity	Population Breakdown
Very Good	24	20%
Good	52	44%
Fair	25	21%
Poor	17	14%
Very Poor	1	0%

Very Good Good Fair Poor Very Poor

Hydraulic Turbines:

Description: A hydraulic turbine is a rotating device connected to an electrical generator. It is used to convert the potential energy of stored water to rotating mechanical energy. The expected life of a turbine is long due to the fact that there are many opportunities to refurbish and add years to the life of this asset.		
Degradation: • Cavitation • Wear of moving parts	**Expected Life:** 90-100 years	**Turnover based on Current Replacement Rate:** 84 years Assets are replaced due to end of life as well as economically justified increases to unit output.

Demographics		
AGE (Yrs)	Qty	%
0 to 10	11	9.82%
10 to 20	7	6.25%
20 to 30	16	14.29%
30 to 40	17	15.18%
40 to 50	17	15.18%
50 to 60	8	7.14%
60 to 70	16	14.29%
70 to 80	2	1.79%
80 to 90	8	7.14%
> 90	10	8.93%
Grand Total	112	100.00%
Replacement Value	$2 010M	



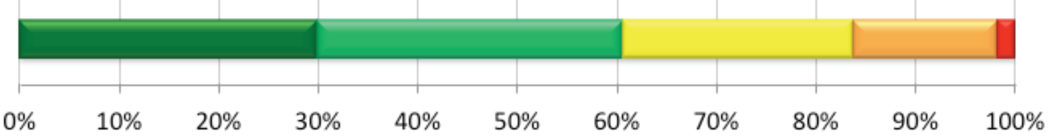
	Asset Quantity	Population Breakdown
Very Good	13	12%
Good	66	59%
Fair	10	9%
Poor	15	13%
Very Poor	8	7%

Very Good Good Fair Poor Very Poor

Exciters:

Description: An exciter is a device used to control the voltage output of an electrical generator. There are different types of exciters used in a utility environment. Older types are typically rotating exciters with many moving parts requiring additional maintenance but increased overall asset longevity compared to the new types which are static analog/digital exciters with fewer repair options and shorter life expectancies.		
Degradation: • Wear of moving parts • Obsolescence	**Expected Life:** 25-90 years[1]	**Turnover based on Current Replacement Rate:** Approximately 117 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	17	14.41%
10 to 20	13	11.02%
20 to 30	18	15.25%
30 to 40	19	16.10%
40 to 50	12	10.17%
50 to 60	6	5.08%
60 to 70	12	10.17%
70 to 80	10	8.47%
80 to 90	8	6.78%
> 90	3	2.54%
Grand Total	117	100.00%
Replacement Value	$220M	



	Asset Quantity	Population Breakdown
Very Good	35	30%
Good	36	31%
Fair	27	23%
Poor	17	15%
Very Poor	2	2%

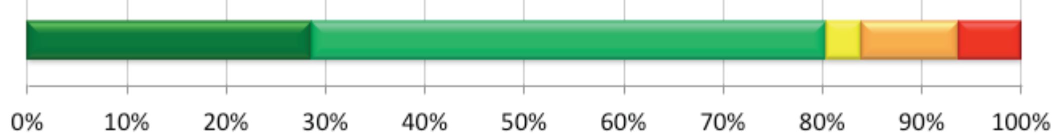
Very Good Good Fair Poor Very Poor

Governor:

Description:
The governor is the machine that controls the mechanical speed of the turbine and ultimately the frequency of the AC power generated. Manitoba Hydro has three types of governors: mechanical, analog and digital. Maintaining the mechanical governors present many opportunities to refurbish and reverse engineer worn parts which extend their life. Newer governors are digital and have much shorter expected lives because of their nature to fail without warning and lack of replacement parts due to obsolescence.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Wear of moving parts • Obsolescence	25-125 years[2]	Due to a replacement program for electronic governor the turnover has recently been accelerated to approximately 50 years. Previous to that Governors have little history of replacement.

Demographics		
AGE (Yrs)	Qty	%
0 to 10	5	4.46%
10 to 20	15	13.39%
20 to 30	17	15.18%
30 to 40	18	16.07%
40 to 50	7	6.25%
50 to 60	17	15.18%
60 to 70	0	0.00%
70 to 80	21	18.75%
80 to 90	8	7.14%
> 90	4	3.57%
Grand Total	112	100.00%
Replacement Value	$58M	



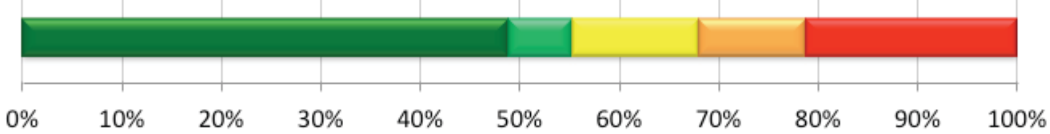
	Asset Quantity	Population Breakdown
Very Good	32	29%
Good	58	52%
Fair	4	4%
Poor	11	10%
Very Poor	7	6%

Very Good Good Fair Poor Very Poor

Battery Banks:

Description: Battery banks are used to provide a source of control power and a back up or emergency source of control power to operate key equipment in the event of a loss of generation or power supply. The battery banks can be used to start a unit and play a key role in allowing the utility to bring the system back online after a serious event or emergency. Battery banks are typically of the lead-acid type similar to car batteries but different voltage level and better quality to allow a longer life span. Generation Operations battery bank condition is not displayed in the forecasted condition as they are replaced to maintain reliability at the end of their expected life.		
Degradation: • Cracks, and physical damage • Cell oxidation • Number and depth of discharges	**Expected Life:** 20 years	**Turnover based on Current Replacement Rate:** Approximately 20 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	16	34.04%
10 to 20	17	36.17%
20 to 30	14	29.79%
Grand Total	47	100.00%
Replacement Value	$6M	



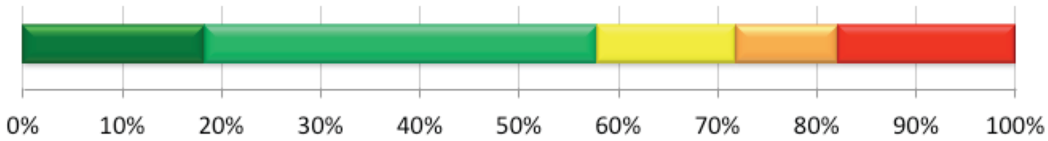
	Asset Quantity	Population Breakdown
Very Good	23	49%
Good	3	6%
Fair	6	13%
Poor	5	11%
Very Poor	10	21%

Very Good Good Fair Poor Very Poor

Breakers:

Description: Breakers are located throughout the generating stations and their corresponding switchyards to allow operators to control the flow of power by opening and closing breakers either locally or remotely from the System Control Center. There are several different types of breaker technology used including sulfur hexafluoride (SF6) (or a mix of gases), air blast and vacuum units.		
Degradation: • Insulation degradation • Mechanical Wear due to normal and fault operations • Obsolescence and depletion of spares • Poor connections	**Expected Life:** 60-65 years	**Turnover based on Current Replacement Rate:** Approximately 129 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	57	14.73%
10 to 20	51	13.18%
20 to 30	53	13.70%
30 to 40	73	18.86%
40 to 50	51	13.18%
50 to 60	72	18.60%
60 to 70	29	7.49%
70 to 80	1	0.26%
Grand Total	387	100.00%
Replacement Value	$220M	



	Asset Quantity	Population Breakdown
Very Good	71	18%
Good	153	40%
Fair	54	14%
Poor	40	10%
Very Poor	69	18%

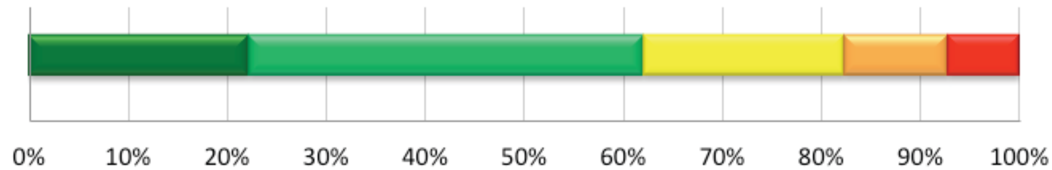
Very Good Good Fair Poor Very Poor

Transformers:

Description:
Power transformers in Generation Operations are typically very large, high value, long lead time, key components that are necessary to convert electrical energy from one voltage to another for the purposes of the delivering bulk electric power from the generators to the transmission system or the generating station for facility use. High voltages are used to minimize line losses over long distances, therefore these types of transformers typically increase the voltage level where power is being generated, move it long distances to areas where the power is to be utilized. Power transformers are oil filled for electrical insulation and cooling purposes.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Insulation degradation or contamination due to heating (loading) or moisture • Corrosion • Mechanical deterioration of tap changer due to operations • Mechanical damage due to through faults or physical impact	40-70 years[3]	Approximately 150 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	23	15.03%
10 to 20	12	7.84%
20 to 30	16	10.46%
30 to 40	16	10.46%
40 to 50	14	9.15%
50 to 60	21	13.73%
60 to 70	28	18.30%
70 to 80	7	4.58%
80 to 90	14	9.15%
> 90	2	1.31%
Grand Total	153	100.00%
Replacement Value	$250M	



	Asset Quantity	Population Breakdown
Very Good	34	22%
Good	61	40%
Fair	31	20%
Poor	16	10%
Very Poor	11	7%

TRANSMISSION

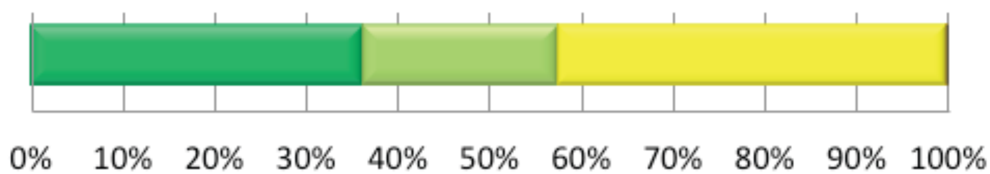
The Transmission Business Unit provides a reliable and safe transmission system for the delivery of electricity to domestic and out-of-province customers; this also includes the High Voltage Direct Current (HVDC) system used to delivery bulk electric power from the large generation base in northern Manitoba to the large load center in southern Manitoba. The AC system and the DC system are significantly different systems maintained by different groups within Manitoba Hydro and therefore the condition assessments were also completed by the appropriate group responsible for each system.

The Manitoba bulk electric system is an interconnected system that is impacted by system expansion as a result of load growth and the need for increased reliability. Asset failures on the transmission system have the potential to dramatically effect reliability, capacity and service but often times are mitigated due to the redundancy built into the bulk electric system. Certain assets are often replaced based not only on condition but other factors such as safety, system development, regulation, obsolescence or economic reasons.

Transmission System Breakers:

Description: Breakers are strategically located throughout the bulk electric transmission system at voltages ranging from 115 kV to 230 kV and allow utility operators to control the flow of power by opening and closing breakers either locally or remotely from the System Control Center. There are several different types of breaker technology used including SF6 (or a mix of gases), air blast and oil filled units.		
Degradation: • Insulation degradation • Mechanical Wear due to normal and fault operations • Obsolescence & depletion of spares • Poor connections	**Expected Life:** 60-65 years	**Turnover based on Current Replacement Rate:** 149 years[4]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	52	15.16%
10 to 20	43	12.54%
20 to 30	57	16.62%
30 to 40	31	9.04%
40 to 50	97	28.28%
50 to 60	52	15.16%
60 to 70	11	3.21%
Grand Total	343	100.00%
Replacement Value	$176M	

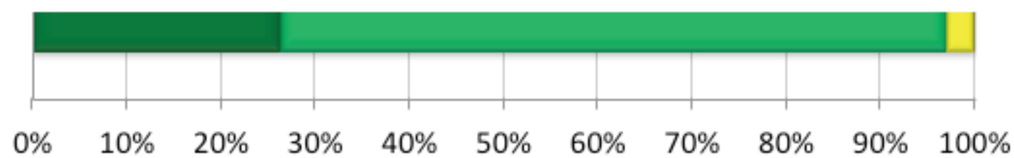


	Asset Quantity	Population Breakdown
Very Good	124	36.15%
Good	73	21.28%
Fair	145	42.27%
Poor	1	0.29%
Very Poor	0	0%

HVDC System Breakers:

Description: Breakers are strategically located throughout the HVDC substation, and 500 yard at voltages ranging from 4kV to 500kV and allow utility operators to control the flow of power by opening and closing breakers either locally or remotely from the System Control Center. There are several different types of breaker technology used including SF6 (or a mix of gases), vacuum, air blast and minimum oil filled units.		
Degradation: • Insulation degradation • Mechanical Wear due to normal and fault operations • Obsolescence & depletion of spares • Poor connections	**Expected Life:** 60-65 years	**Turnover based on Current Replacement Rate:** 58 years[5]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	9	3.49%
10 to 20	133	51.55%
20 to 30	47	18.22%
30 to 40	41	15.89%
40 to 50	28	10.85%
Grand Total	258	100.00%
Replacement Value	$91M[6]	

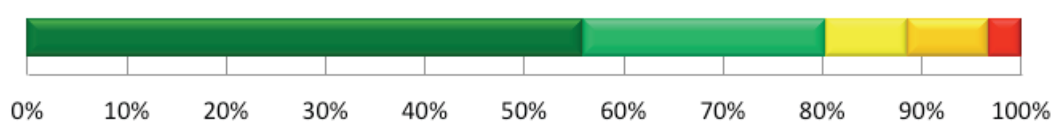


	Asset Quantity	Population Breakdown
Very Good	68	26.36%
Good	183	70.93%
Fair	7	2.71%
Poor	-	0.00%
Very Poor	-	0.00%

Transmission System Battery Banks:

Description:		
Battery banks are used to provide a back up or emergency source of control power to operate key substation equipment in the event of a situation where the bulk electric system is not available. Battery banks play a key role in allowing the utility to bring the system back online after a serious event or emergency. Battery banks are typically of the lead-acid type similar to car batteries but different voltage level and better quality to allow a longer life span.		
Degradation: • Cracks, and physical damage • Cell oxidation • Number & depth of discharges	**Expected Life:** 20 years	**Turnover based on Current Replacement Rate:** 15 years[7]

Demographics		
AGE (Yrs)	125 Vdc	%
0 to 10	183	83.18%
10 to 20	31	14.09%
20 to 30	6	2.73%
> 30	0	0.00%
Grand Total	220	100.00%
Replacement Value	$19M	

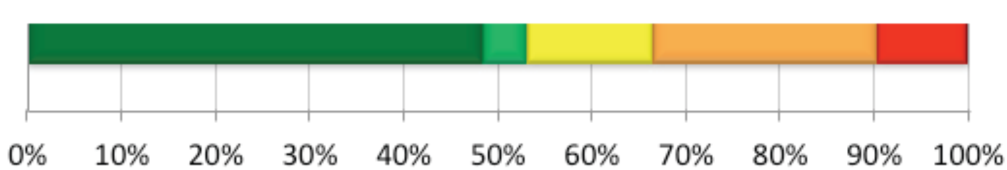


	Asset Quantity	Population Breakdown
Very Good	123	55.9%
Good	54	24.5%
Fair	18	8.2%
Poor	18	8.2%
Very Poor	7	3.2%

HVDC System Battery Banks:

Description: Battery banks are used to provide a back up or emergency source of control power to operate key conversion control equipment and substation equipment in the event of a situation where the bulk electric system is not available. HVDC has various control, and protection battery banks, not just the 125V found in other areas. Battery banks play a key role in allowing the utility to bring the system back online after a serious event or emergency. Battery banks are typically of the lead-acid type similar to car batteries but different voltage level and better quality to allow a longer life span.		
Degradation: • Cracks, and physical damage • Cell oxidation • Number & depth of discharges	**Expected Life:** 20 years	**Turnover based on Current Replacement Rate:** 33 years

Demographics		
AGE (Yrs)	Qty	%
0 to 10	44	41.90%
10 to 20	34	32.38%
20 to 30	27	25.72%
Grand Total	105	100.00%
Replacement Value	$9M	

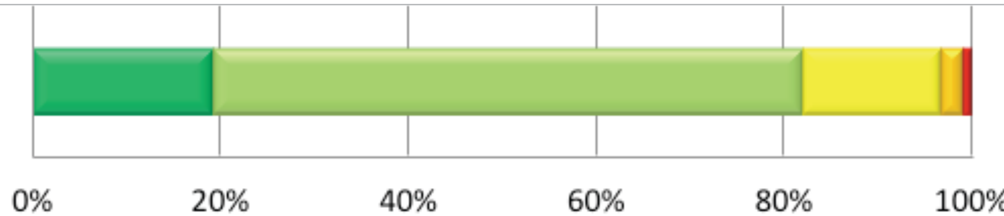


	Asset Quantity	Population Breakdown
Very Good	51	48.57%
Good	5	4.76%
Fair	14	13.33%
Poor	25	23.81%
Very Poor	10	9.52%

Transmission System Transformers:

Description: Station Class transformers are necessary to convert electrical energy from one voltage to another for the purposes of delivering bulk electric power over long distances. Tap changers are a component that can be added to a transformer to allow small incremental changes to the voltage ratio based on changing positions of the tap changer. This functionality is used for voltage regulation purposes.		
Degradation: • Insulation degradation or contamination due to heating (loading) or moisture • Corrosion • Mechanical deterioration of tap changer due to operations • Mechanical damage due to through faults or physical impact	**Expected Life:** 40-70 years[8]	**Turnover based on Current Replacement Rate:** 152 years[9]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	18	6.95%
10 to 20	41	15.83%
20 to 30	41	15.83%
30 to 40	38	14.67%
40 to 50	69	26.64%
50 to 60	32	12.36%
60 to 70	20	7.72%
Grand Total	259	100.00%
Replacement Value	$400M	

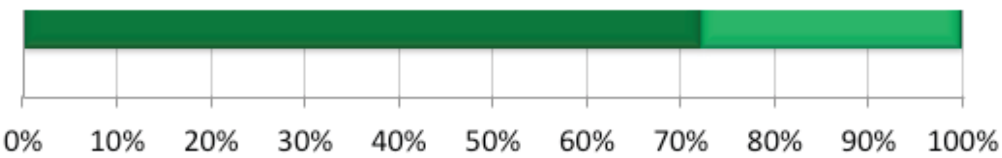


	Asset Quantity	Population Breakdown
Very Good	50	19.31%
Good	163	62.93%
Fair	38	14.67%
Poor	6	2.32%
Very Poor	2	0.77%

HVDC System Transformers:

Description: Transformers are typically very large, high value, long lead time (2-3 years), necessary for exporting power to the U.S., and keeping the HVDC system stable. High voltages are used to minimize line losses over long distances, therefore these types of transformers typically increase the voltage level for transmission and move it long distances to areas where the power is to be utilized. Tap changers are used to make small incremental changes to the voltage ratio. This functionality is used for voltage regulation purposes.		
Degradation: • Insulation degradation or contamination due to heating (loading) or moisture • Corrosion • Mechanical deterioration of tap changer due to operations • Mechanical damage due to through faults or physical impact	**Expected Life:** 40-70 years[10]	**Turnover based on Current Replacement Rate:** 70 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	5	17.24%
10 to 20	1	3.45%
20 to 30	6	20.69%
30 to 40	10	34.48%
40 to 50	7	24.14%
Grand Total	29	100.00%
Replacement Value	$96M	



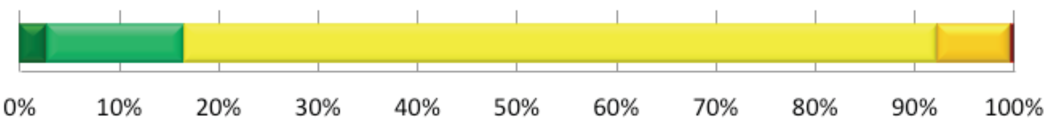
	Asset Quantity	Population Breakdown
Very Good	21	72.41%
Good	8	27.59%
Fair	-	0.00%
Poor	-	0.00%
Very Poor	-	0.00%

Protection Relays:

Description:
Protection relays are critical components used to protect utility assets and ultimately the safety of the public. Protection relays work hand in hand with breakers and are used throughout the utilities electrical system to isolate faults or other inappropriate parameters on the transmission system. Protection relays continuously monitor the electrical system and operate the appropriate breakers to avoid having parts of, or the entire system become unstable and collapse, and to avoid damaging expensive equipment or worse, fires and explosions. Sample represents 80% of total relays on the system.

Degradation:	**Expected Life:**	**Turnover based on Current Replacement Rate:**
• Obsolescence • Mechanical wear • Electrical component failure	20-50 years[11]	N/A[12]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	155	1.31%
10 to 20	1109	9.40%
20 to 30	1360	11.53%
30 to 40	2649	22.46%
40 to 50	3538	30.00%
50 to 60	2982	25.29%
Grand Total	11793	100.00%
Replacement Value	$312M	

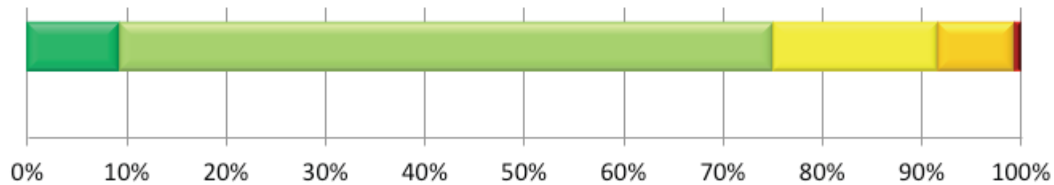


	Population Breakdown	Asset Quantity
Very Good	2.7%	315
Good	13.9%	1634
Fair	75.8%	8940
Poor	7.4%	876
Very Poor	0.2%	28

Transmission System Structures/Grillage:

Description: Structures, grillage and foundations are the means of providing ground clearance for electrical conductors, safely away from the normal activities carried on by people, animals, etc. These structures are typically constructed of steel and form the "backbone" of the bulk electric system.		
Degradation: • Environmental (extreme ice, wind, and fire) • Corrosion (minimal)	**Expected Life:** Minimum 85 years	**Turnover based on Current Replacement Rate:** 285 years[13]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	1050	5.30%
10 to 20	2288	11.56%
20 to 30	990	5.00%
30 to 40	1478	7.47%
40 to 50	6881	34.76%
50 to 60	3178	16.05%
60 to 70	553	2.79%
70 to 80	8	0.04%
80 to 90	2361	11.93%
> 90	1009	5.10%
Grand Total	19796	100.00%
Replacement Value	$4,600M	

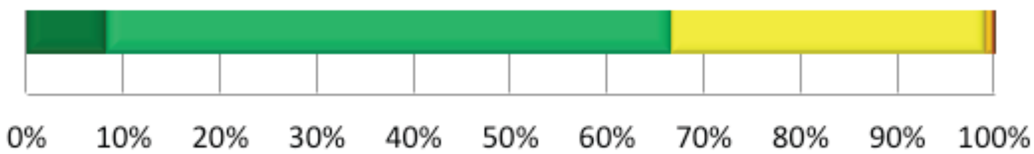


	Asset Quantity	Population Breakdown
Very Good	1846	9.33%
Good	13021	65.78%
Fair	3260	16.47%
Poor	1543	7.79%
Very Poor	126	0.64%

Transmission System Wood Pole Structures:

Description: Similar in function to steel structures/grillage, wood poles are also used for a variety of reasons including ground clearance for electrical conductors. Transmission wood poles are typically larger in diameter and taller than distribution wood poles. Condition assessment and demographics based on 2012 study.		
Degradation: • Environmental (moisture causing shell rot, wood destroying fungi, insect infestation) • Mechanical Damage (contact with snow plows and vehicular traffic)	**Expected Life:** 75 years	**Turnover based on Current Replacement Rate:** 255 years[14]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	663	3.63%
10 to 20	1360	7.44%
20 to 30	2032	11.11%
30 to 40	1889	10.33%
40 to 50	7412	40.54%
50 to 60	3293	18.01%
60 to 70	1619	8.85%
70 to 80	0	0.00%
> 80	17	0.09%
Grand Total	18285	100.00%
Replacement Value	$740M	



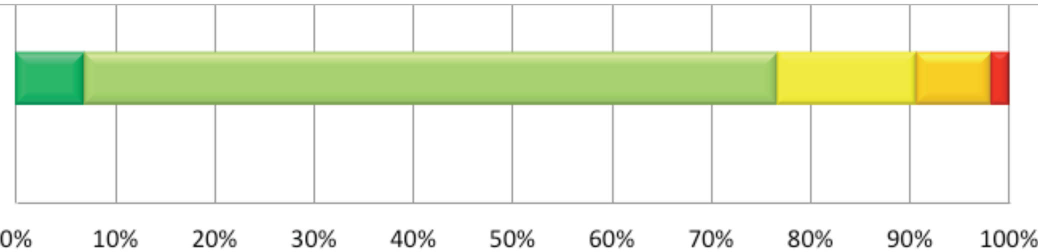
Very Good	1487	8.13%
Good	10700	58.52%
Fair	5904	32.29%
Poor	185	1.01%
Very Poor	9	0.05%

Transmission System Overhead Primary Conductor:

Description:
The overhead primary conductor is the main high voltage, current carrying wire that transmits power from source to load. This wire is usually "ACSR" or Aluminum Conductor Steel Reinforced which consists of a steel core for strength and an outer aluminum current carrying conductor, however there are other types of conductor used as well and it comes in a variety of sizes depending on many factors.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Thermal loading • Vibration • Environmental (extreme ice, wind, and fire) • Corrosion (minimal)	85 years	410 years[15]

Demographics		
AGE (Yrs)	Conductor (km)	%
0 to 10	645	4.51%
10 to 20	1073	7.50%
20 to 30	791	5.53%
30 to 40	1208	8.45%
40 to 50	6289	43.98%
50 to 60	2047	14.31%
60 to 70	898	6.28%
70 to 80	9	0.06%
80 to 90	1094	7.65%
> 90	247	1.73%
Grand Total	14301	100.00%
Replacement Value	1,073M	

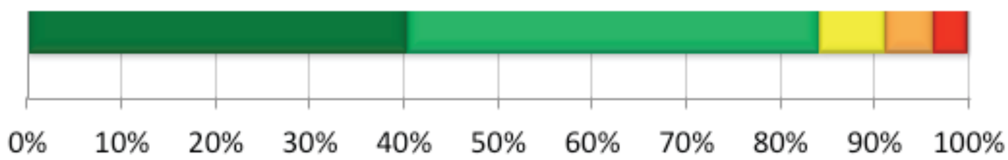


	Conductor (km)	Overall Population
Very Good	984	6.88%
Good	9996	69.89%
Fair	1981	13.85%
Poor	1094	7.65%
Very Poor	247	1.73%

HVDC System Converter Transformers:

<table>
<tr><td colspan="3">Description:
Converter transformers are typically very large, high value, long lead time (3-5 years), key components that are necessary to an HVDC system. The converter transformers step the voltage up or down. The on load tap changer is an essential part of the valve groups' ability to control the voltage and current levels on the DC system. The transformer has much higher insulating values than normal transformers to be able to withstand the stresses from both the AC and DC systems.</td></tr>
<tr><td>Degradation:
Short circuit
Poor connections
Corrosion
Tap changer deterioration
Insulation deterioration
Oil breakdown</td><td>Expected Life:
40-50 years</td><td>Turnover based on Current Replacement Rate:
73 years</td></tr>
</table>

Demographics		
Age (Yrs)	Qty	%
0 to 10	8	14.04%
10 to 20	18	31.57%
20 to 30	2	3.51%
30 to 40	9	15.79%
40 to 50	20	35.09%
Grand Total	57	100.00%
Replacement Value	$349M	



	Asset Quantity	Population Breakdown
Very Good	23	40.35%
Good	25	43.86%
Fair	4	7.02%
Poor	3	5.26%
Very Poor	2	3.51%

HVDC System Valve Groups:

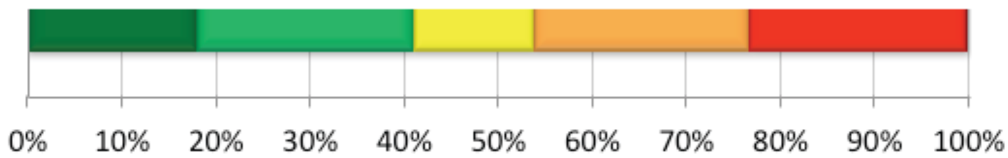
Description:

The valve groups are located in the converter buildings. The converter valve is used to convert AC energy to DC energy at the generation end for less expensive transmission over long distances. High voltages are used to minimize line losses over long distances. HVDC uses only two conductors, and shorter less expensive transmission towers for increased savings. Once power reaches its destination the energy is converted to AC for transmission to customers.

Large cooling systems keep the thyristors used in the conversion process from overheating and failing to a short circuit. This cooling system has detailed monitoring, and protection to ensure the valve group is maintained below the critical temperatures for thermal runaway of the thyristors.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Short circuit • Poor connections • Valve cooling deterioration • Controls failure • Thyristor valve control	25 years	48 years

Demographics		
Age (Yrs)	Qty	%
10 to 20	12	30.77%
20 to 30	12	30.77%
30 to 40	15	38.46%
Grand Total	39	100.00%
Replacement Value	$608M	



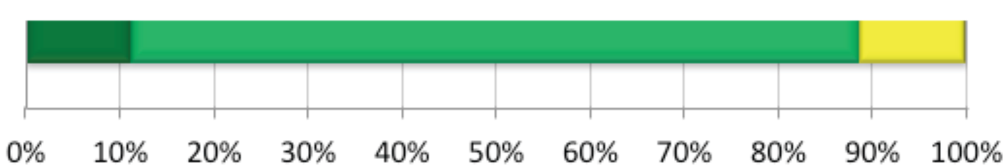
	Asset Quantity	Population Breakdown
Very Good	7	17.95%
Good	9	23.08%
Fair	5	12.82%
Poor	9	23.08%
Very Poor	9	23.08%

HVDC System Synchronous Condensers:

Description:
The synchronous condenser is located on the AC side of the southern DC station. All the synchronous condensers are electrically driven. The reactive power generated by the synchronous condenser improves system regulation of voltage and the inertia aids in stabilizing frequency. The synchronous condenser is constantly reacting to system conditions either consuming, or adding reactive power to stabilize the power system.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Short circuit • Unable to supply load • Controls failure • Cooling degradation • Excessive vibration	65 years	65 years[16]

Demographics		
Age (Yrs)	Qty	%
20 to 30	3	33.33%
30 to 40	3	33.33%
40 to 50	3	33.33%
Grand Total	9	100.00%
Replacement Value	$510M	

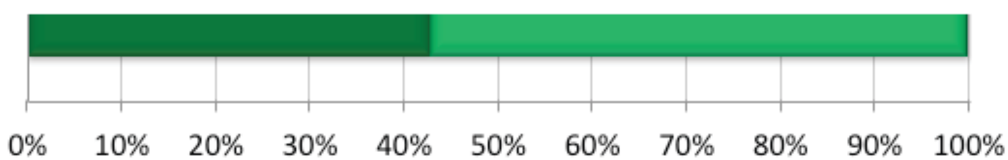


	Asset Quantity	Population Breakdown
Very Good	1	11.11%
Good	7	77.78%
Fair	1	11.11%
Poor	-	0.00%
Very Poor	-	0.00%

HVDC System Shunt Reactors:

Description: The shunt reactors are oil filled devices and are located in the 500KV AC transmission yards. Shunt Reactors are used for extra-high-voltage (EHV) transmission lines to prevent excessive terminal voltage.		
Degradation: • Overheating/Overloads • Insulation deterioration	**Expected Life:** 35 years	**Turnover based on Current Replacement Rate:** 55 years[17]

Demographics		
Age (Yrs)	Qty	%
0 to 10	3	42.86%
30 to 40	4	57.14%
Grand Total	7	42.86%
Replacement Value	$14M	

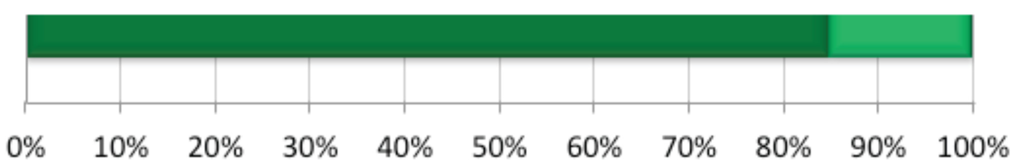


	Asset Quantity	Population Breakdown
Very Good	3	42.86%
Good	4	57.14%
Fair	-	0.00%
Poor	-	0.00%
Very Poor	-	0.00%

HVDC System Smoothing Reactors:

Description: This asset is located on the DC side of the system. It is used to minimize harmonics (electrical noise), and help prevent rapid changes in current and excessive electrical current. All smoothing reactors have been changed to air core, from oil filled, to reduce environmental impact, maintenance and repair costs.		
Degradation: • Overheating/Overloads • Insulation deterioration	**Expected Life:** 25 years	**Turnover based on Current Replacement Rate:** 30 years[18]

Demographics		
Age (Yrs)	Qty	%
0 to 10	20	42.86%
Grand Total	20	42.86%
Replacement Value	$60M	



	Asset Quantity	Population Breakdown
Very Good	17	85.00%
Good	3	15.00%
Fair	-	0.00%
Poor	-	0.00%
Very Poor	-	0.00%

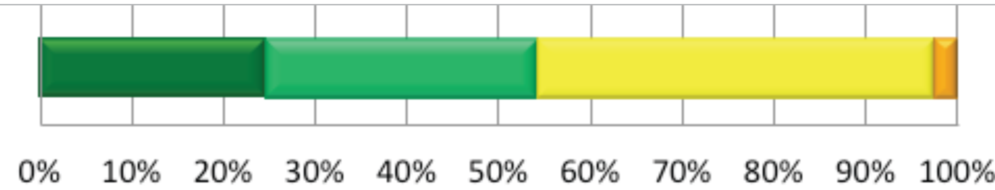
DISTRIBUTION

Distribution is responsible for the delivery of electricity from local sub-stations to the customer throughout the province of Manitoba. Methods of delivery are done by both overhead and underground methods using voltage levels that range from 4kV to 66kV.

Breakers:

Description:		
Breakers are strategically located throughout the bulk electric transmission system at voltages ranging from 4-kV to 66-kV and allow utility operators to control the flow of power by opening and closing breakers either locally or remotely from the System Control Center. There are several different types of breaker technology used including SF6 (or a mix of gases), air blast, vacuum and oil filled units.		
Degradation: • Insulation degradation • Mechanical Wear due to normal and fault operations • Obsolescence & depletion of spares • Poor connections	**Expected Life:** 60-65 years	**Turnover based on Current Replacement Rate:** 180 years[19]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	290	16.19%
10 to 20	170	9.49%
20 to 30	206	11.50%
30 to 40	94	5.25%
40 to 50	415	23.17%
50 to 60	473	26.41%
60 to 70	93	5.19%
70 to 80	9	0.50%
80 to 90	22	1.23%
> 90	0	0.00%
Not Available	19	1.06%
Grand Total	1791	100.00%
Replacement Value	$359M	



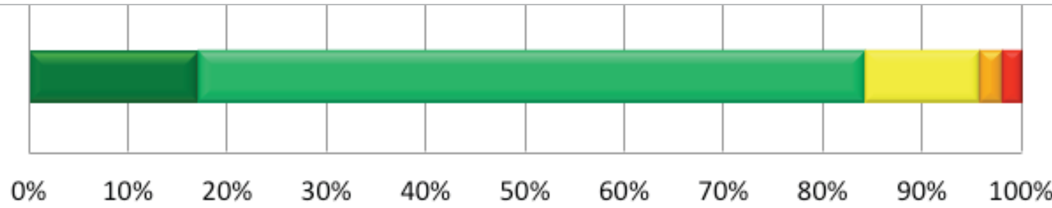
	Asset Quantity	Population Breakdown
Very Good	441	24.6%
Good	532	29.7%
Fair	774	43.2%
Poor	44	2.5%
Very Poor	0	0.0%

Station Transformers:

Description:
Station Class transformers are necessary to convert electrical energy from one voltage to another for the purposes of delivering bulk electric power over long distances. Tap changers are a component that can be added to a transformer to allow small incremental changes to the voltage ratio based on changing positions of the tap changer. This functionality is used for voltage regulation purposes.

Degradation:	**Expected Life:**	**Turnover based on Current Replacement Rate:**
• Insulation degradation or contamination due to heating (loading) or moisture • Corrosion • Mechanical deterioration of tap changer due to operations • Mechanical damage due to through faults or physical impact	40-70 years[20]	370 years[21]

Demographics		
AGE (Yrs)	Qty	%
0 to 10	21	2.84%
10 to 20	49	6.63%
20 to 30	74	10.01%
30 to 40	66	8.93%
40 to 50	294	39.78%
50 to 60	151	20.43%
60 to 70	55	7.44%
70 to 80	13	1.76%
80 to 90	13	1.76%
> 90	3	0.41%
Grand Total	739	100.00%
Replacement Value	$700M	

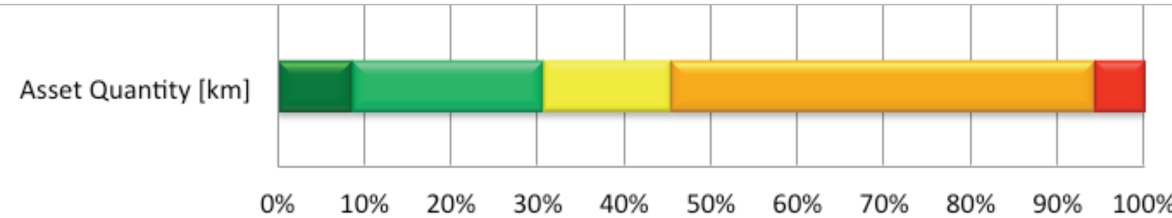


	Asset Quantity	Population Breakdown
Very Good	126	17.05%
Good	497	67.25%
Fair	85	11.50%
Poor	16	2.17%
Very Poor	15	2.03%

Underground Cable:

Description: Underground cables are heavily insulated conductors, installed below grade, that are used to distribute electricity from a source (Distribution Stations) to padmount transformers. The insulating medium is a requirement not found on overhead conductors and allows the cables to be installed directly in the ground. The majority of these conductors are aluminum; however, some are copper. The insulation surrounding the cable can vary, from oil impregnated paper (PILC) to rubber (RINJ/RIPVCJ) to cross link polyethylene (XLPE/TRXLPE).		
Degradation: • Mechanical Damage (contact by construction crews, loss of oil due to leaks) • Electrical (heat from overloading decays cable insulation) • Environmental (moisture from surrounding soil permeates the insulation)	**Expected Life:** 30-70 years[22]	**Turnover based on Current Replacement Rate:** 328 years

Demographics		
Age (Yrs)	Total (km)	%
0 to 10	949.9	15.7%
10 to 20	867.4	14.3%
20 to 30	1,398.7	23.0%
30 to 40	2,026.3	33.4%
40 to 50	570.8	9.4%
50 to 60	66.2	1.1%
60 to 70	67.7	1.1%
70 to 80	67.7	1.1%
> 80	54.1	0.9%
Grand Total	6,069.0	100.0%
Replacement Value	$1,500M	

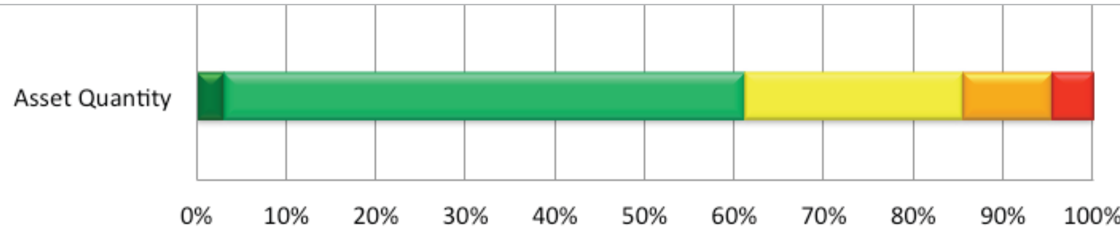


	Asset Quantity [km]	Population Breakdown
Very Good	518.09	8.5%
Good	1,340.07	22.1%
Fair	899.54	14.8%
Poor	2,970.17	48.9%
Very Poor	340.87	5.6%

Manholes:

Description: Manholes are concrete vaults that are built below grade and used to install and splice underground cables in heavily congested underground urban areas. The majority of the manholes are located in the downtown core of Winnipeg, with the remainder found in suburban areas of Winnipeg and Brandon.		
Degradation: • Mechanical (ground movement, vibration due to vehicular traffic) • Environmental (soil condition, tree roots)	**Expected Life:** 80 years	**Turnover based on Current Replacement Rate:** 500 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	67	2.8%
10 to 20	472	19.6%
20 to 30	517	21.5%
30 to 40	458	19.0%
40 to 50	218	9.0%
50 to 60	218	9.0%
60 to 70	156	6.4%
70 to 80	93	3.9%
80 to 90	93	3.9%
90 to 100	60	2.5%
>100	57	2.4%
Grand Total	2,409	100.0%
Replacement Value	$301M	

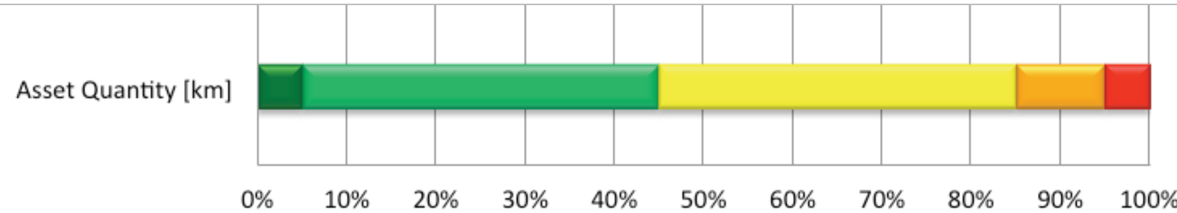


	Asset Quantity	Population Breakdown
Very Good	74	3.1%
Good	1,397	58.0%
Fair	587	24.4%
Poor	243	10.1%
Very Poor	108	4.5%

Duct Lines:

Description: Ductlines are made up of bundled PVC pipes that are encased in an envelope of concrete. They are installed below grade between manholes and are used to provide an underground path for high voltage cables in heavily congested areas. They are most commonly found in the downtown core of Winnipeg, but are also used in suburban areas of Winnipeg and Brandon.		
Degradation: • Mechanical (ground movement, vibration due to vehicular traffic) • Environmental (soil condition, tree roots) • Age of construction material	**Expected Life:** 100 years	**Turnover based on Current Replacement Rate:** 378 years[23]

Demographics		
Age (Yrs)	Total (km)	%
0 to 10	12.0	4.5%
10 to 20	36.5	13.8%
20 to 30	39.3	14.8%
30 to 40	39.3	14.8%
40 to 50	39.3	14.8%
50 to 60	39.3	14.8%
60 to 70	24.7	9.3%
70 to 80	10.2	3.8%
80 to 90	10.2	3.8%
90 to 100	7.3	2.8%
>100	7.0	2.6%
Grand Total	265.0	100.0%
Replacement Value	$795M	

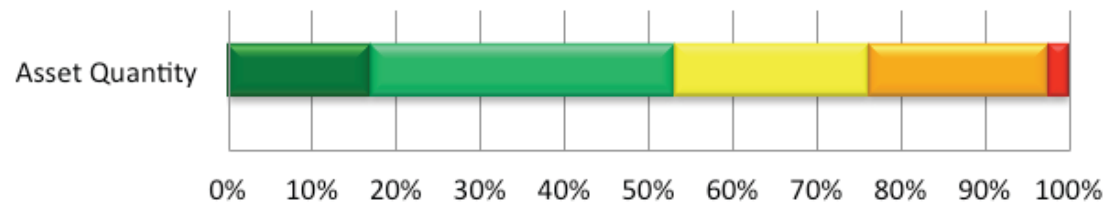


	Asset Quantity [km]	Population Breakdown
Very Good	13.2	5.0%
Good	106.0	40.0%
Fair	106.0	40.0%
Poor	26.5	10.0%
Very Poor	13.3	5.0%

Padmount Transformers:

Description: These transformers are used to step high voltage power (24kV and below) down to a voltage that is usable by customers (600V and below). The service point between Manitoba Hydro and the customer is generally located immediately downstream of the secondary side of these units. These transformers, both single phase and three phase, are located at ground level on top of fiberglass or concrete pads.		
Degradation: • Ambient Temperature • Wind • Loading • Corrosion due to exposure to environment (contact with moist soil, road salt, limited air flow)	**Expected Life:** 50 years	**Turnover based on Current Replacement Rate:** 70 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	7,296	38.6%
10 to 20	3,557	18.8%
20 to 30	3,453	18.3%
30 to 40	3,440	18.2%
40 to 50	1,140	6.0%
Total	20,435	100.0%
Replacement Value	$273M	

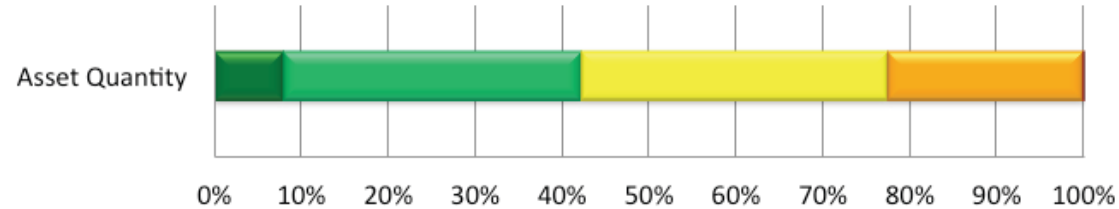


	Asset Quantity	Population Breakdown
Very Good	3,190	16.9%
Good	6,839	36.2%
Fair	4,363	23.1%
Poor	4,056	21.5%
Very Poor	437	2.3%

Wood Poles:

Description: Wood poles are used to provide ground clearance and to support conductors and energized equipment installations on the pole. In addition to holding up overhead lines, the pole can also support equipment installations, such as overhead distribution transformers and transition structures between overhead conductors and underground cables.		
Degradation: • Environmental (moisture causing shell rot, wood destroying fungi, insect infestation) • Mechanical Damage (contact with snow plows and vehicular traffic)	**Expected Life:** 75 years	**Turnover based on Current Replacement Rate:** 200 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	143,873	13.3%
10 to 20	157,792	14.6%
20 to 30	170,517	15.7%
30 to 40	173,802	16.1%
40 to 50	174,556	16.1%
50 to 60	144,486	13.3%
60 to 70	113,771	10.5%
70 to 80	3,313	0.3%
> 80	762	0.1%
Grand Total	1,082,873	100.0%
Replacement Value	$3,500M	

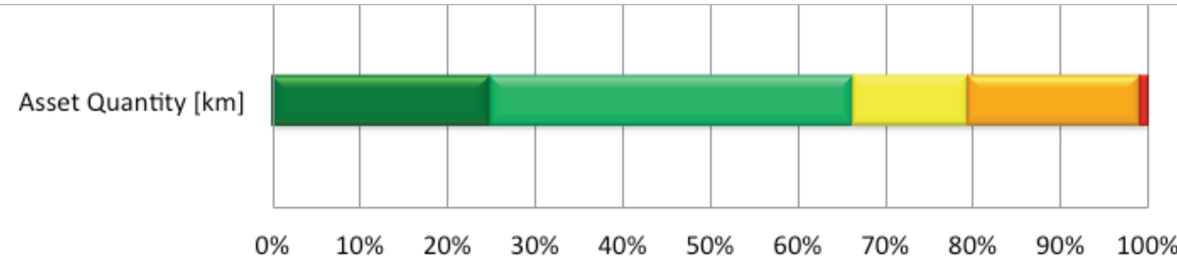


	Asset Quantity	Population Breakdown
Very Good	85,192	7.9%
Good	371,713	34.3%
Fair	380,387	35.1%
Poor	243,768	22.5%
Very Poor	1,813	0.2%

Overhead Primary Conductor:

Description: Like the Transmission overhead conductor, these are the main high voltage, current carrying wire that distributes power from source (distribution stations) to load (the customer). These wires are generally made of bare aluminum alloy; however, some copper lines are still in operation. Some of these lines are covered by a polyurethane sheet; however, most are not.		
Degradation: • Mechanical (ice build-up, tree strikes) • Electrical (capacity overloading due to general load growth, high fault levels)	**Expected Life:** 100 years	**Turnover based on Current Replacement Rate:** 200 years[24]

Demographics		
Age (Yrs)	km	%
0 to 10	38,073.5	33.2%
10 to 20	23,373.8	20.4%
20 to 30	14,349.5	12.5%
30 to 40	8,809.4	7.7%
40 to 50	5,408.2	4.7%
50 to 60	16,142.7	14.1%
60 to 70	7,302.0	6.4%
70 to 80	543.6	0.5%
80 to 90	333.7	0.3%
90 to 100	204.9	0.2%
>100	125.8	0.1%
Grand Total	114,882.0	100.0%
Replacement Value	$700M	



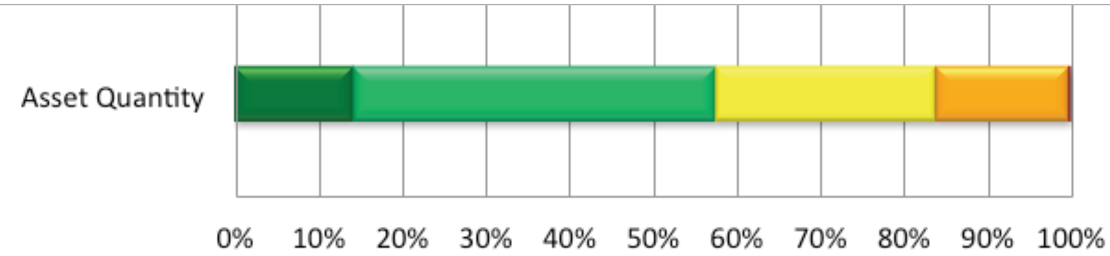
	Asset Quantity [km]	Population Breakdown
Very Good	28,530.8	24.9%
Good	47,266.0	41.2%
Fair	15,017.0	13.1%
Poor	22,500.9	19.6%
Very Poor	1,352.3	1.2%

Overhead Transformers:

Description:
These transformers are used to step high voltage power (24kV and below) down to a voltage that is usable by customers (600V and below). The service point between Manitoba Hydro and the customer is generally located immediately downstream of the secondary side of these units. These transformers, both single phase and three phase, are attached to wood poles just below the primary overhead lines.

Degradation:	**Expected Life:**	**Turnover based on Current Replacement Rate:**
• Ambient Temperature • Wind • Loading • Exposure to environment (wildlife, lightning strike, tree strike)	75 years	70 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	40,139	27.7%
10 to 20	29,935	20.7%
20 to 30	21,172	14.6%
30 to 40	17,192	11.9%
40 to 50	15,731	10.9%
50 to 60	12,153	8.4%
60 to 70	7,923	5.5%
70 to 80	255	0.2%
80 to 90	207	0.1%
> 90	53	0.0%
Grand Total	145,798	100.0%
Replacement Value	$494M	



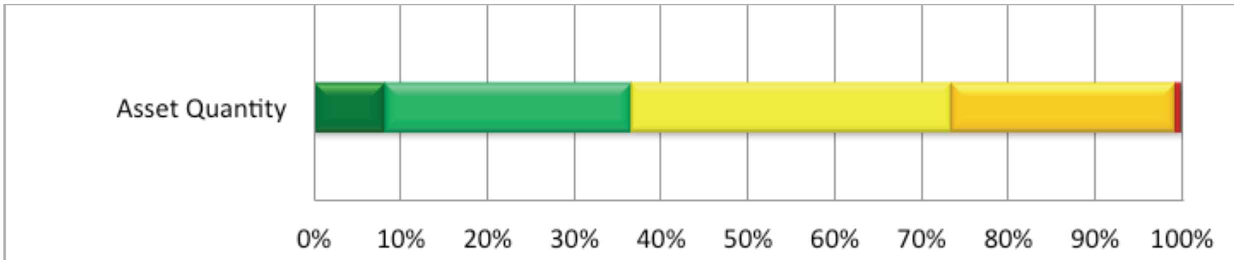
	Asset Quantity	Population Breakdown
Very Good	20,381	14.1%
Good	62,797	43.4%
Fair	38,148	26.4%
Poor	22,919	15.8%
Very Poor	515	0.4%

Street Lights:

Description:
Streetlight standards typically consist of a tubular steel or aluminum. This supports the lights and is used to provide roadway lighting in urban and high traffic locations. The majority of Manitoba Hydro street lights are concentrated within the City of Winnipeg and to a lesser extent in other large urban centers in the province. Street lights are generally installed on a pre-formed concrete base; however, can also be installed directly into the ground.

Degradation:	Expected Life:	Turnover based on Current Replacement Rate:
• Corrosion due to exposure to environment (contact with moist soil, road salt) • Mechanical Damage (contact with snow plows and vehicular traffic) • Installation methods • Material	50-70 years[25]	100 years

Demographics		
Age (Yrs)	Qty	%
0 to 10	11,107	19.1%
10 to 20	7,267	12.5%
20 to 30	9,789	16.8%
30 to 40	10,815	18.6%
40 to 50	9,884	17.0%
50 to 60	7,558	13.0%
60 to 70	1,474	2.5%
70 to 80	27	0.0%
80 to 90	58	0.1%
90 to 100	50	0.1%
> 100	196	0.3%
Grand Total	58,225	100.0%
Replacement Value	$282M	



	Asset Quantity	Population Breakdown
Very Good	4,685	8.0%
Good	16,498	28.3%
Fair	21,696	37.3%
Poor	14,991	25.7%
Very Poor	355	0.6%

5. Current vs. 20 year Forecast of Asset Condition

The following condition assessment demographic charts estimates the impact on the condition of the assets if Manitoba Hydro implements the currently approved Capital Expenditure Forecast 2013 (CEF 13). CEF 13 includes approved spending for projects to refurbish and replace assets as well as asset sustainment programs. In some cases the CEF 13 does not capture the spending requirements surrounding program renewals and projects for assets that had not begun to show signs of significant deterioration at the time it was put together and there is no remaining funds to address these replacements.

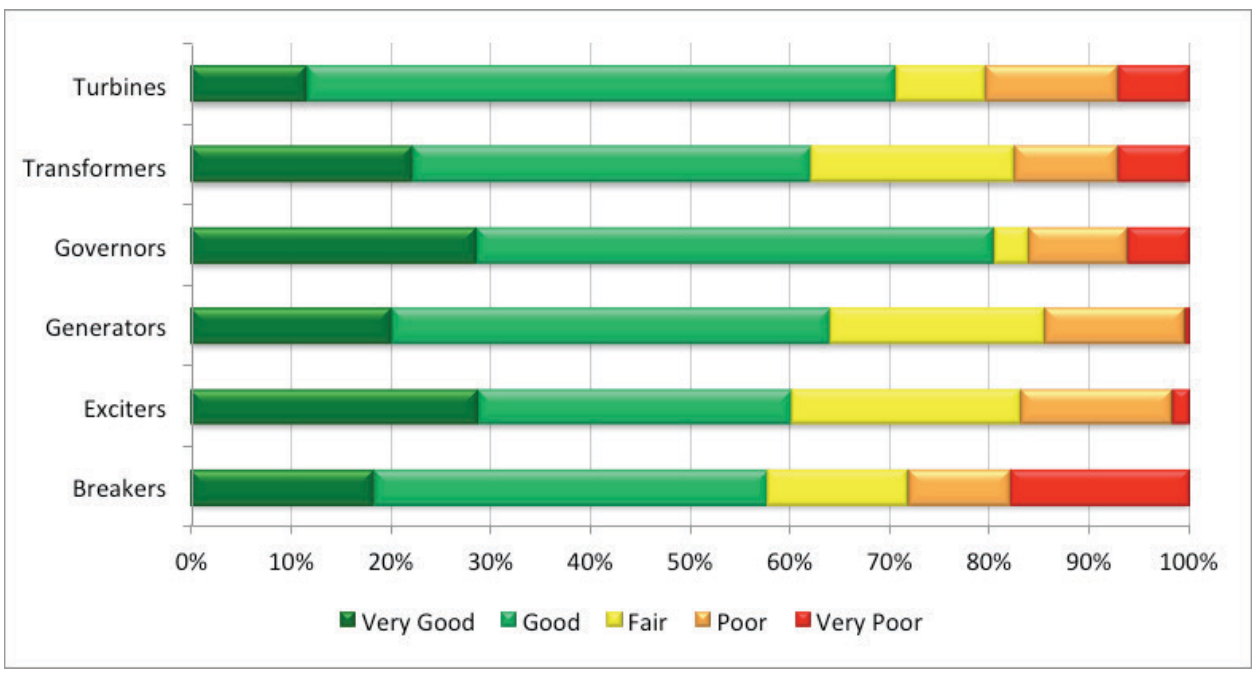
The charts are arranged so the reader can compare the current condition of all assets in each business unit to the forecasted condition 20 years from now.

The 20-year asset outlook for Generation Operations, Transmission and Distribution indicates significantly poorer asset health compared to current day conditions. Generation Operations, HVDC and transmission battery bank condition is not displayed in the forecast as they are replaced to maintain reliability at the end of their expected life.

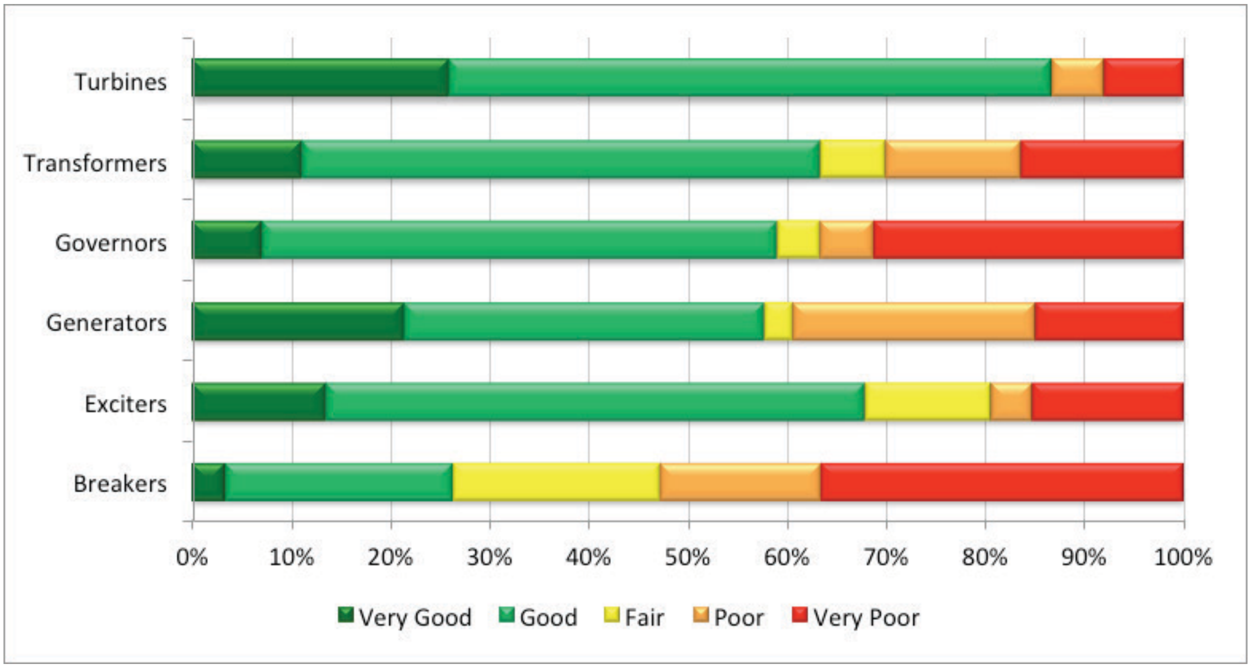
An alternative funding and resource plan will be required over the next 20 years to maintain or improve the overall condition of the Generation Operations, Transmission and Distribution Assets. This is based on the current asset condition and the effective remaining life that may dictate asset replacement.

GENERATION OPERATIONS

Current Asset Condition Assessment



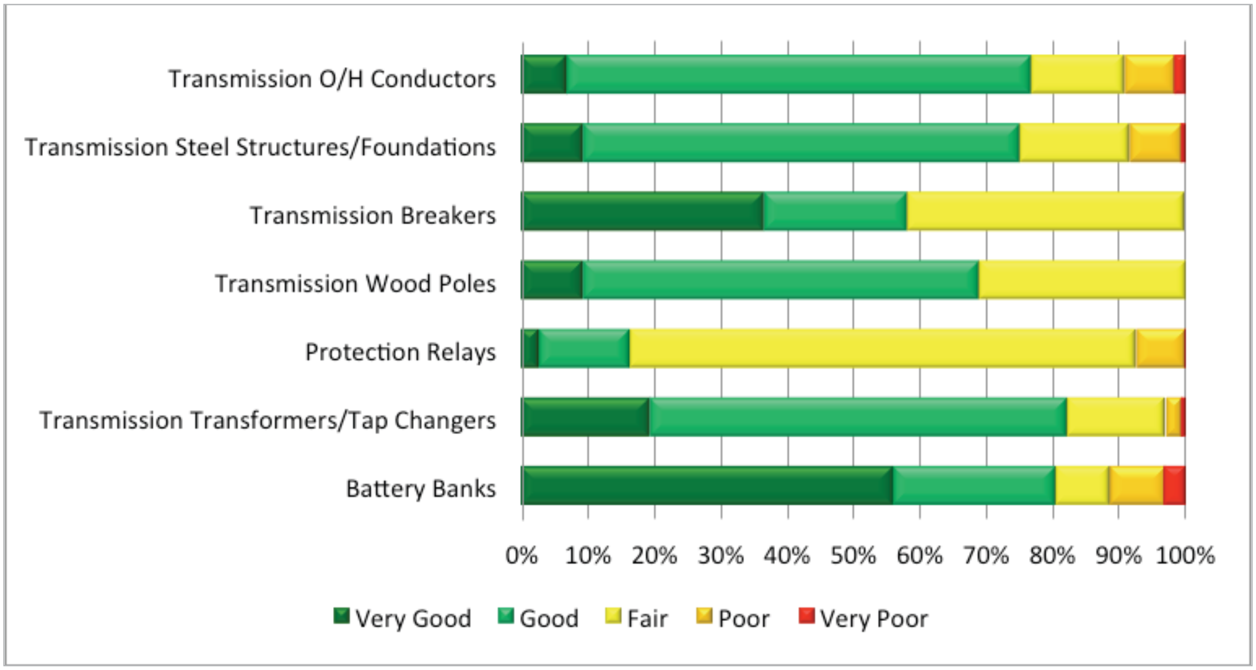
20 year Asset Condition Assessment Forecast



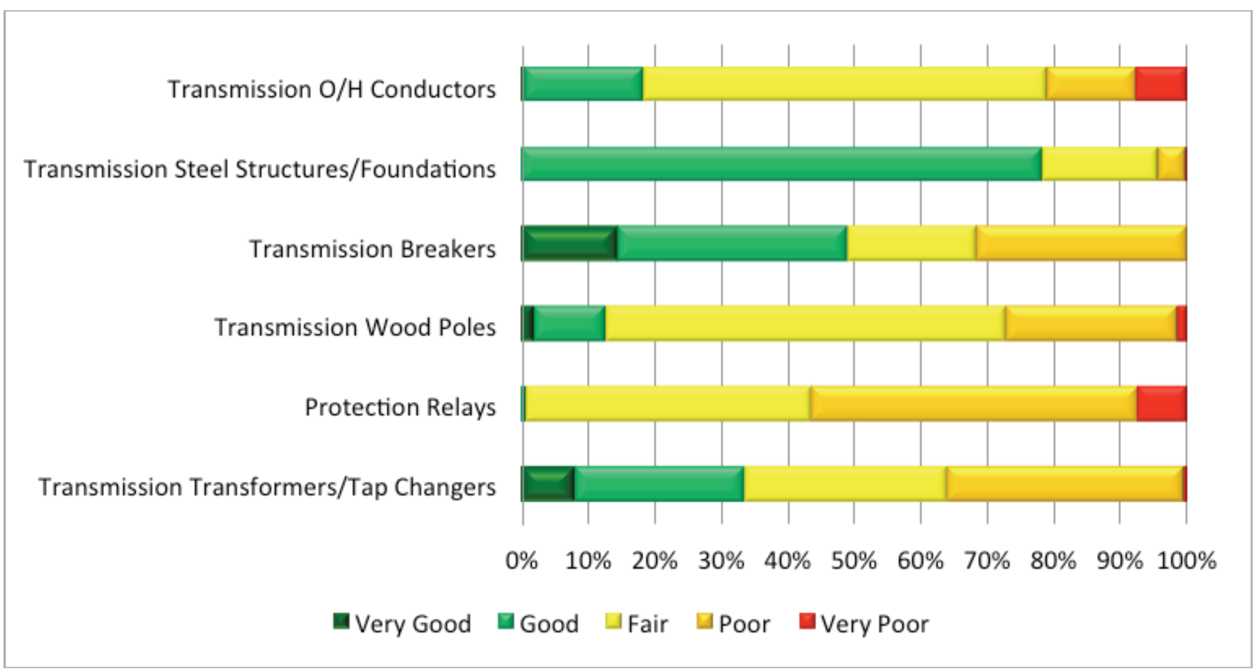
In the case of generators, the increased count of “poor” and “very poor” is due to having limited funds presently in place for their replacement. A generator replacement can cost up to $30,000,000 and in the event of limited funds it is often favorable to defer this work and address more less costly assets. The deferral of a generator replacement increases the risks of in-service failures. Many of the digital governors have an end of life which occurs within the 20-year forecast period. If there is not a project in place to address these assets, the funding may not be available and the assets will be run to the poorest condition. The transformer and breaker conditions will continue to drop as the funded work on these assets is currently not sufficient to address their excessive age.

TRANSMISSION

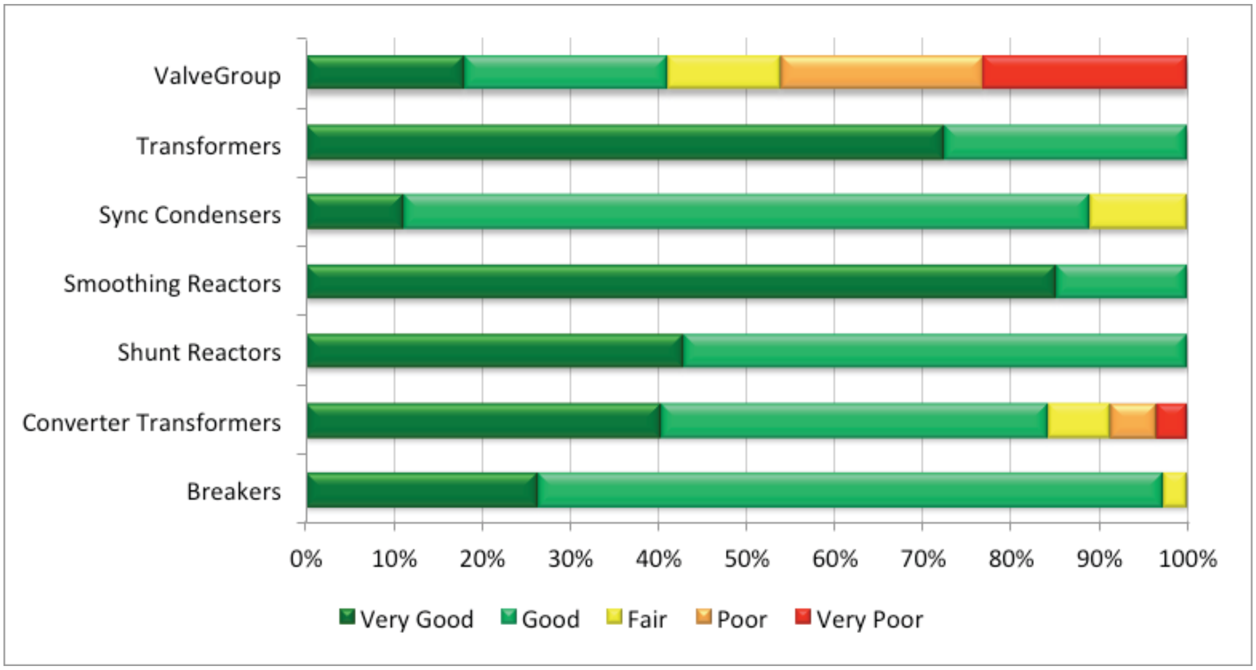
Transmission Summary of Assets



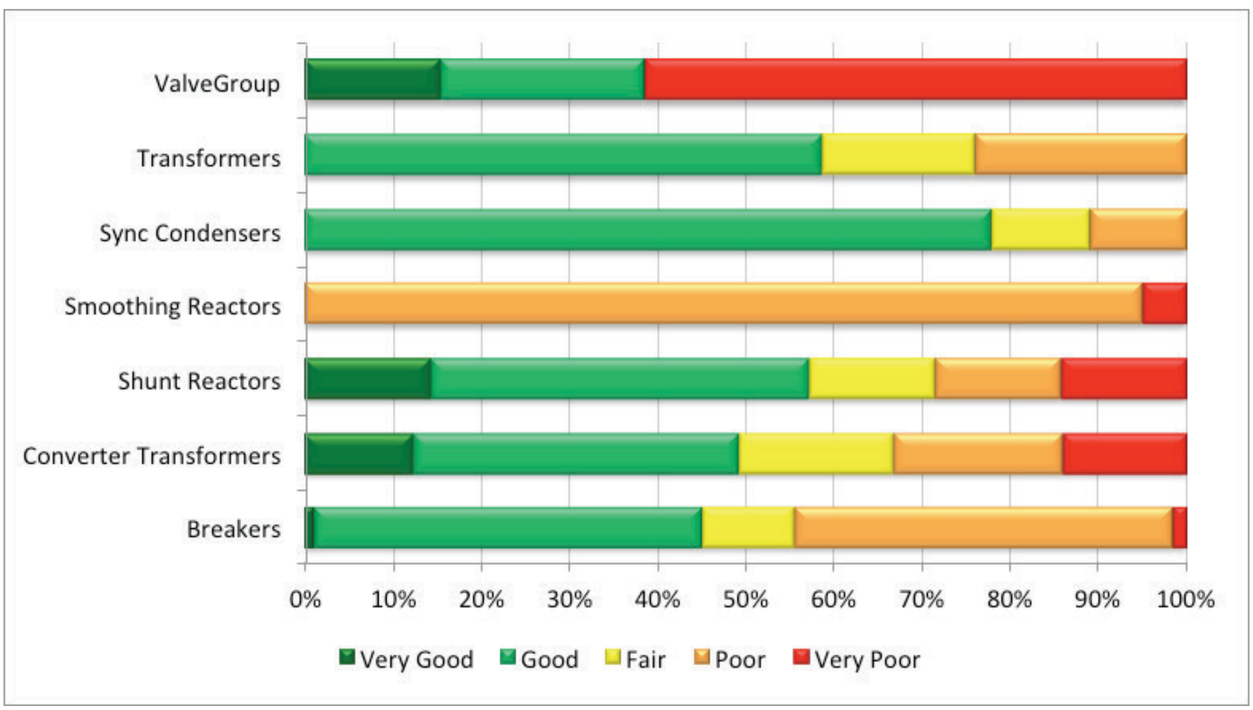
Transmission 20 Year Asset Forecast



HVDC Summary of Assets



HVDC 20 Year Asset Forecast



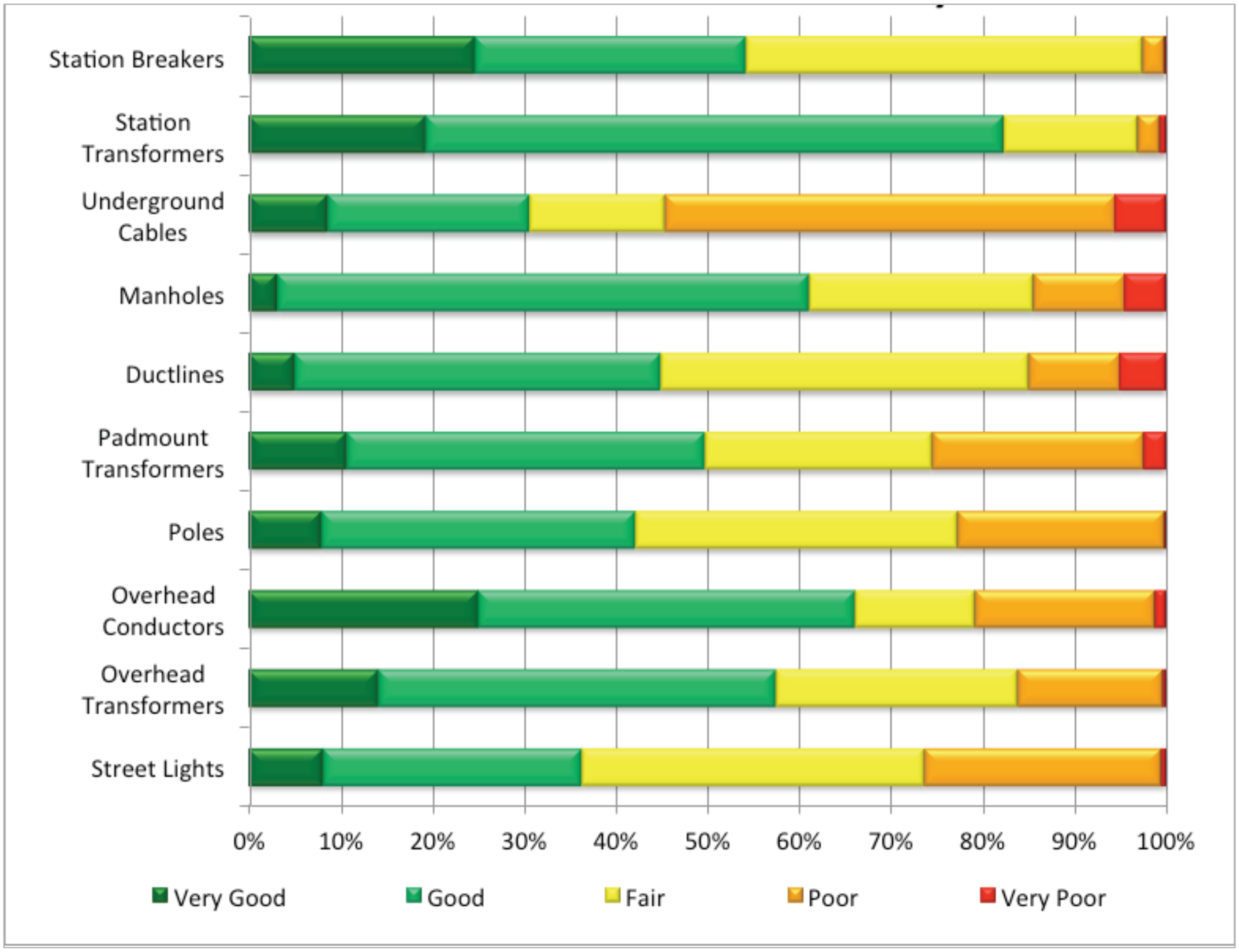
The Transmission 20 year forecast includes approved capital sustainment programs for breakers, transformers and transmission line wood pole structures. It should also be noted that capital projects/programs currently being executed will address Transmission O/H Conductor assets that are currently in "Very Poor" condition. There are also currently foundations associated with steel structures that are scheduled for repair due to condition.

In the case of breakers and protection relays, the increase in assets of "poor" and "very poor" condition is due in part to the effects of age and our declining ability to support the existing assets with obsolescence issues and/or a dwindling supply of spare parts, which limits the ability to extend "useful life". For protection relays, it should be noted that the outlook does not include the impact of all future replacements associated with capacity enhancement projects. This is expected to impact less than 5% of the protection relays considered in this report. Wood poles, steel structures, conductors and transformers deteriorate into the "poor" category due mainly to the effects of aging and continued utilization. The transmission line asset forecasts do not include the impact of the Transmission Line Upgrades for NERC Alert project. These impacts will be incorporated into future forecasts as additional project details become available.

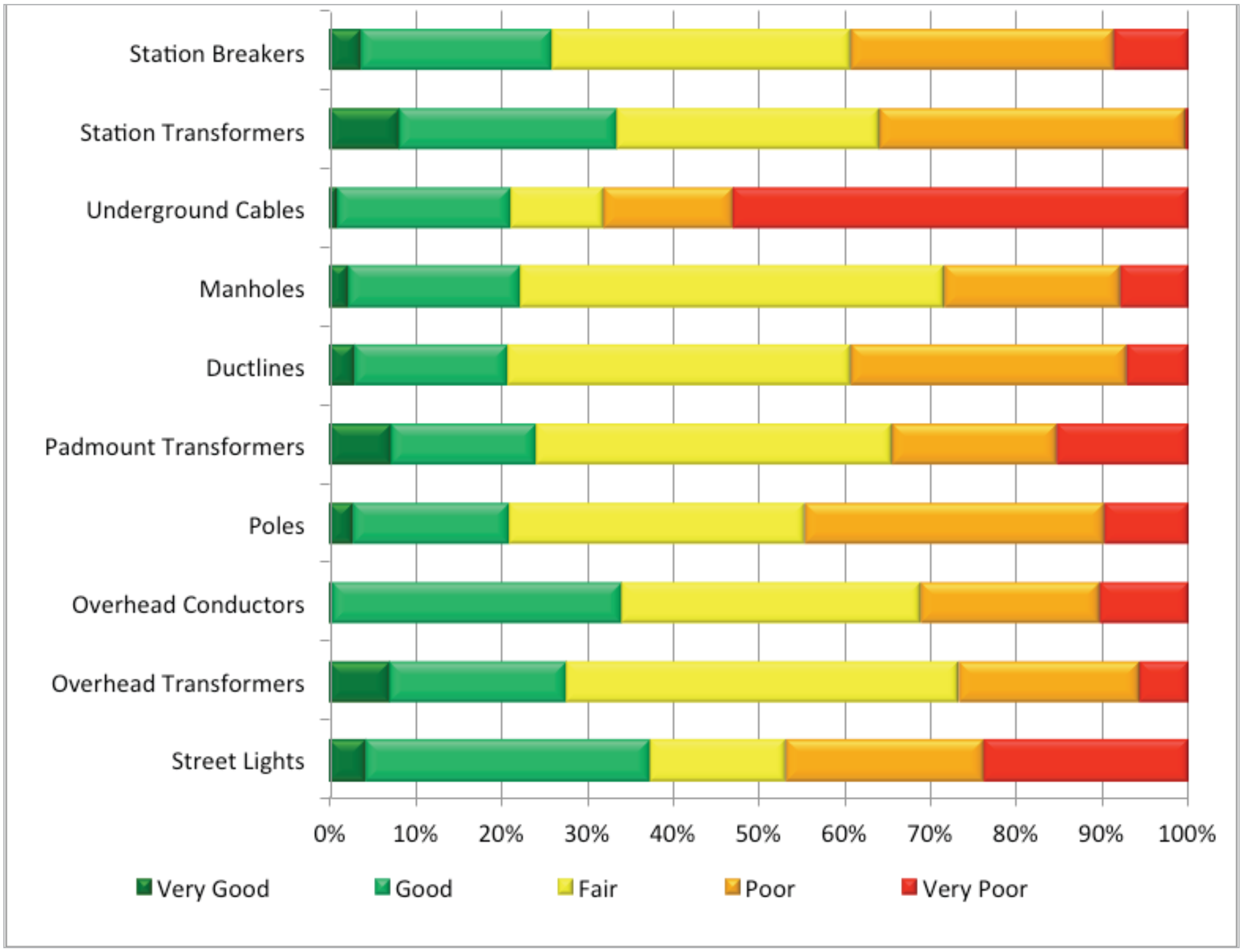
The HVDC 20 year forecast includes approved capital sustainment programs for breakers, transformers, synchronous condensers and valve groups. In the case of smoothing reactors, and valve groups, the increase in assets of "poor" and "very poor" is due to these assets reaching expected end of life prior to the 20 years occurring. Air core smoothing reactors deteriorate into the "poor" category in the last few years of the 20 year outlook due mainly to expected life. Since this is a new type of smoothing reactor, this forecast is based on industry guidelines for replacement. As Manitoba Hydro gains experience with this type of smoothing reactor, the condition forecast will be updated accordingly. It should also be noted that the Pole 2 Valve Group does not move into the Very Poor condition category until the last two years of the 20-year outlook period. HVDC Engineering is currently performing assessments of options to extend the life of the Bipole 1 Valve Group. The outcome of this work may modify the Valve Group condition forecast.

DISTRIBUTION

Current Distribution Summary of Assets



Distribution 20 Year Asset Forecast



As poles installed during the rural electrification program approach end of life, a dramatic increase in pole replacements is anticipated. Current resources will not be able to meet this demand and as a result, a significant increase in the number of assets transitioning from “poor” to “very poor” condition is expected. This is also anticipated for underground cables, as the majority of XLPE lines installed in the early 1980’s are also approaching end of life. It is forecasted that current cable replacement rates will not be able to meet the demand for this asset replacement. A similar trend will see a dramatic increase in street lights transitioning from “fair” to “poor” as a large segment of the direct installed assets will reach end of life within the next 20 years. The condition of these assets will continue to drop as the funded programs are currently not sufficient to address their excessive age.

Appendix A: Definitions and Acronyms

Definitions:

i. Asset Age = This criterion identifies how many years the asset has been in service or the date of manufacture (depending on data availability). For some asset classes, asset age remains a key criterion for evaluating asset health because it is more cost-effective and efficient to have a maintenance program that allows assets to run to failure with no condition assessments. For example, overhead transformers on the distribution system are run to failure.

ii. Expected life = The typical life span of an asset, provided it is not replaced sooner for other reasons such as government regulations, economic justification, system development, performance, safety issues, obsolescence/lack of spare parts, and/or unusual condition degradation. Under favorable operating environments, the asset may exceed its typical life span.

iii. In service = Equipment that is installed and energized, and seeing active commercial duty.

Acronyms:

ACSR= Aluminum Conductor	ACA= Asset Condition Assessment
Steel Reinforced	ASC= Armor Sheathed Cable
AHI= Asset Health Index	AH= Asset Health
AMPS= Applied Maintenance Planning System	ASTM= American Society for Testing and Materials
CB= Circuit Breaker	CEF= Capital Expenditure Forecast
CEATI= Center for Energy Advancement through Technological Innovation	CH4= Methane
C2H6= Ethane	C2H4= Ethylene
C2H2= Acetylene	CO= Carbon Monoxide
CO2= Carbon Dioxide	CO2/CO= Carbon Dioxide/Carbon Monoxide
CPF= Sub-Condition Parameter Score	CPS= Condition Parameter Score
CSC= Customer Service Center	DC= Direct Current
DGA= Dissolved Gas Analysis	DMPS= Distribution Maintenance Planning System

DR= De-Rating Multiplier	eGIS= electronic Geographic Information System
EPRI= Electrical Power Research Institute	H2= Hydrogen
HI= Health Index	HMI= Human Machine Interface
HVDC= High Voltage Direct Current	IFT= Interfacial Tension
IR= Infrared	LMA= Loss of Metallic Area
LTC= Load Tap Changer	MCC= Motor Control Center
PILC= Paper Insulated Lead Covered Cables	RINJ= Rubber Insulated Neoprene Jacket
RIPVCJ= Rubber Insulated Poly Vinyl Chloride Jacket Cables	RTS= Rated Tensile Strength
SF6= sulfur hexafluoride	SFC= Stat Frequency Converter
SFRA= Swept Frequency Response Analysis	TRXLPE= Tree Retardant Cross Linked Poly Ethylene
WCP= Weight of Condition Parameter	WCPF= Weight of Sub-Condition Parameter
XLPE= Cross Linked Poly Ethylene Cables	

Appendix B: Generation Operations Detailed Methodology

GENERATION OPERATIONS

Asset Condition Assessment Methodology

Manitoba Hydro's methodology determines Asset Health (AH) by performing standardized equipment condition assessments as part of the maintenance program. Technical experts take the condition assessment and factor in the field feedback and their judgment in conjunction with the engineers, the asset's age, life curve, and performance to calculate the AHI. This provides a more accurate and reliable index of asset health that aligns better with asset management.

The general breakdown of each assets health index methodology includes:

- Providing general descriptions of each asset class
- Showing the demographics of each type of asset
- Describing condition assessment techniques for each asset class
- Determining end-of-life criteria based on condition assessments of each asset class
- Formulating the Asset Health Index using data from asset health, age, performance and life curve.
- Calculating a numerical condition score for each equipment asset class to indicate the reliable service life remaining.
- Ensuring repeatability, by documenting the methodology and data sources used.

The results are used to help decide acceptable risk and clarify the consequences of an asset's criticality issues, determine acceptable reliability goals, ensure compliance requirements are met, and meet performance expectations.

Transformers:

The following tests/inspections were considered in calculating a condition index score:

- Furan levels in oil
- Dissolved Gas Analysis
- Capacitance Bridge and Dissipation Factor
- Operations & Mtce History (see Hydro AMP guide for more details on this)
- Age
- DC Winding Resistance Test
- Turns Ratio Test

In select cases, the following test results were considered (where available):

- Core-to-Ground Resistance (Megger)
- Swept Frequency Response Analysis (SFRA)
- Internal Inspections
- Degree of Polymerization (based on internal inspections and furan levels in oil)

Generators:

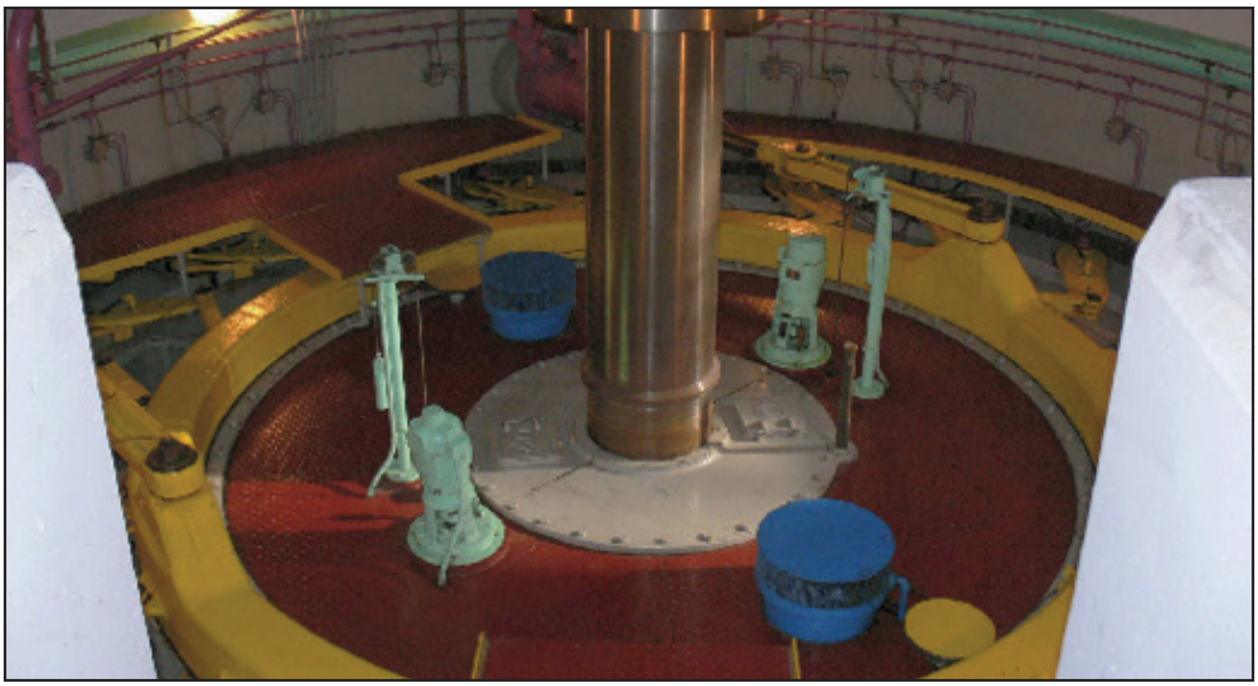
The generators were reviewed using routine historical testing data (high direct voltage ramp). In addition factors such as age, neighboring unit condition, and overhaul history were used to create the condition scores and replacement dates.

Turbines:

For determining the condition score of the Turbines, a combination of the following methods was used:

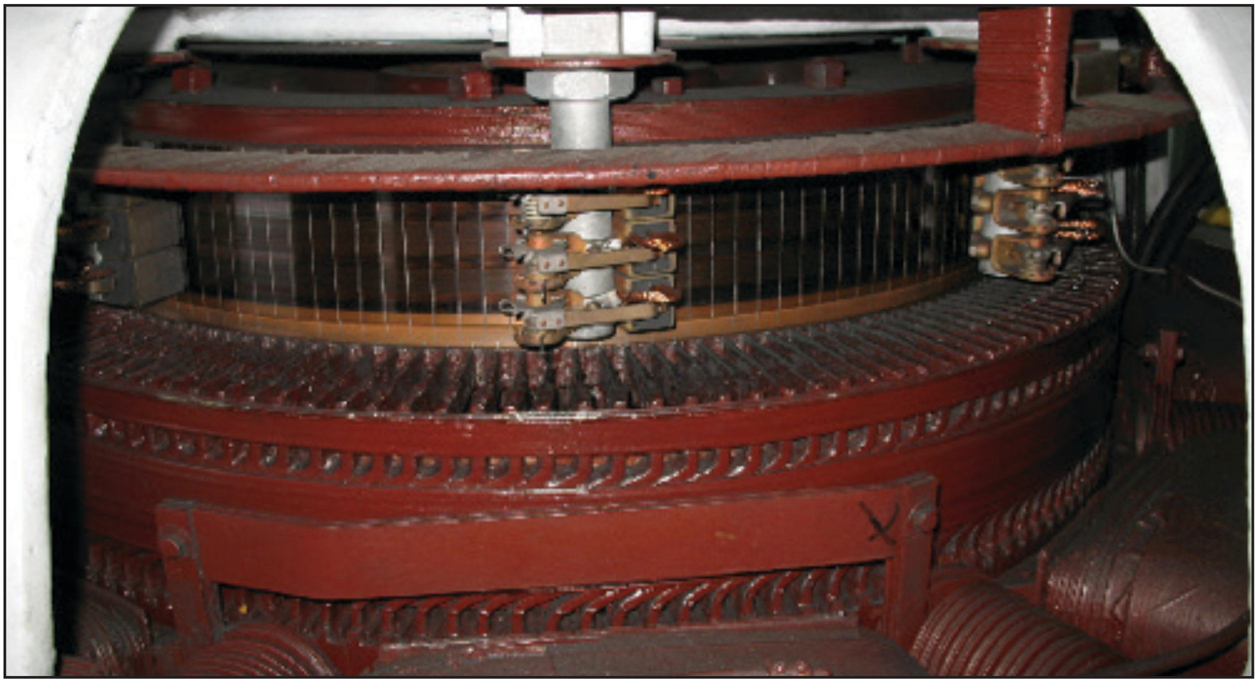
- Interviews with site maintenance staff to determine any known issues on each turbine based on existing maintenance record and staff experience.
- Review of available past maintenance records, engineering drawings, and relevant reports.
- Scheduled outage-based Non-Destructive Examination of major turbine components, including the runner, shaft, visible embedments, headcovers, and control system components.

The above information gathering and inspection process is currently ongoing, and largely dependent on scheduled unit maintenance outages. The initial pre-inspection scoring is based on the interview and information research phases, which prioritizes the inspection sequence.



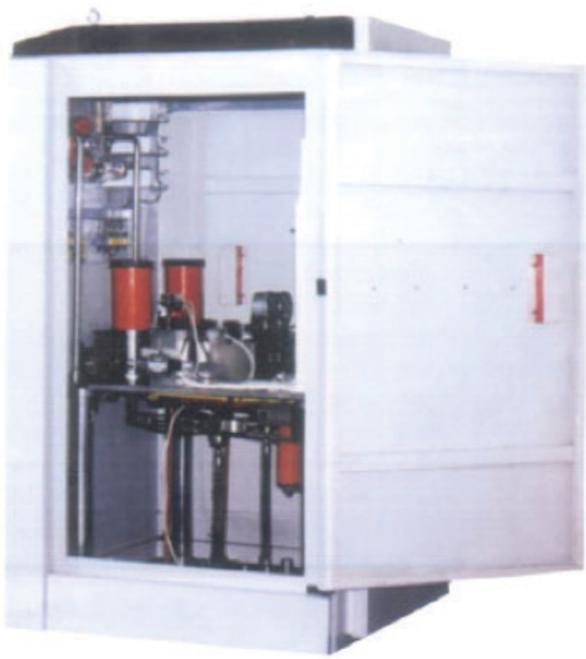
Exciters:

The excitation systems were reviewed on a family of exciters basis versus an individual basis. The approach was appropriate due to the short equipment life of the products. Individual performance deviations were treated as resolvable issues through routine maintenance.



Governors:

Condition scores were generated by applying an age and performance based score to each type of governor. Most governors in our system do not have performance issues so the majority of the scores are based on age. This score was combined with empirical knowledge to generate an adjusted value which was agreed to under consensus by hydro maintenance engineers to best represent actual condition and expected life.



Breakers:

The equipment condition evaluation involved the review and assessment of the following criteria:

- Equipment performance information from the following sources:
  - Electronic defective work order information and notes contained within Applied Maintenance Planning System- AMPS
  - Reliability information from Apparatus Maintenance Reliability Reports, Center for Energy Advancement through Technological Innovation (CEATI), Electrical Power Research Institute (EPRI) and others
  - Paper maintenance documentation from site

- Maintenance records from the following sources:
  - Electronic maintenance work order information and notes contained within AMPS
  - Paper maintenance documentation from site
  - Electronic circuit breaker analysis results if available
  - Insulation test results in electronic and paper form

- Evaluation of Equipment Obsolescence
  - Equipment age
  - Spare parts availability from the following sources:
    - AMPS stores inventory
    - Apparatus Maintenance Stores inventory
    - Salvaged parts inventory
    - Original equipment manufacturer
  - Technical Support availability from the following sources:
    - Internal staff
    - Original equipment manufacturer
    - Other equipment support companies

Battery Banks:

- Visual inspections
- Past test data (if available) (resistance(now)/conductance(before), specific gravities, and voltages)
- Previous performance of batteries if they have been put to use (i.e. AC power loss and batteries were called upon to carry the DC load)
- Past maintenance records

Appendix C: Transmission Detailed Methodology

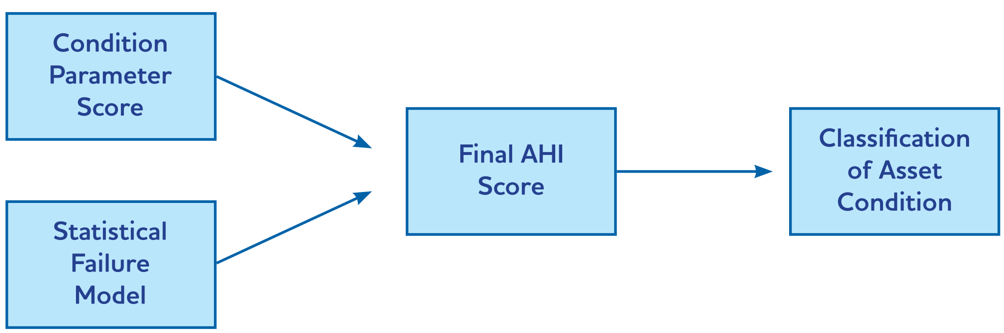
TRANSMISSION

Asset Condition Assessment (ACA) Methodology

Background:

The Transmission Business Unit (BU) began its asset condition assessments in 2012 by hiring a third party consultant with expertise in the development of condition assessment methodologies for utility grade high voltage (HV) equipment. This third party consultant worked with Transmission's subject matter experts to provide asset condition assessment methodologies and statistical failure models for transmission system station transformers, tap changers, breakers and transmission wood poles structures. The remaining Transmission asset condition assessment methodologies presented in this report, while similar in approach, were developed by the Transmission Asset Strategies group in consultation with subject matter experts across the Business Unit. This section describes these methodologies.

Where an asset has a statistical failure model available, the model has been incorporated into the AHI scoring methodology. The purpose of this is to increase the extent to which the AHI reflects the likelihood of failure. Statistical failure models were available for breakers, transformers and transmission line wood pole structures. These models were provided by the above mentioned consultant and were based on the consultant's industry failure curves, on subject matter expert input and limited failure data provided by Manitoba Hydro and on the consultant's proprietary methodology to link condition parameter scores to probability of failure.



Transmission will continue to evolve its existing condition assessment methodologies as it gains experience with these models and to develop and implement new condition assessment models for asset classes such as instrument transformers and equipment bushings, to the extent that there's a positive business case to do so.

The boundaries between the different classifications of the AHI Score (i.e. Very Good, Good, Fair, Poor and Very Poor) were determined using the classification definitions provided in Section 4 of the report.

Transmission System Substation Transformers

Health Index Formulation

This report presents a transformer/tap changer AHI score distribution that, where applicable, reflects the combined AHI scores of the transformer (main tank) and tap changer. The combined AHI score is intended to reflect the likelihood that either the transformer or the tap changer will fail and need to be replaced or refurbished. It should be noted that the remedial action for a main tank failure may be very different from the remedial action required for a tap changer failure.

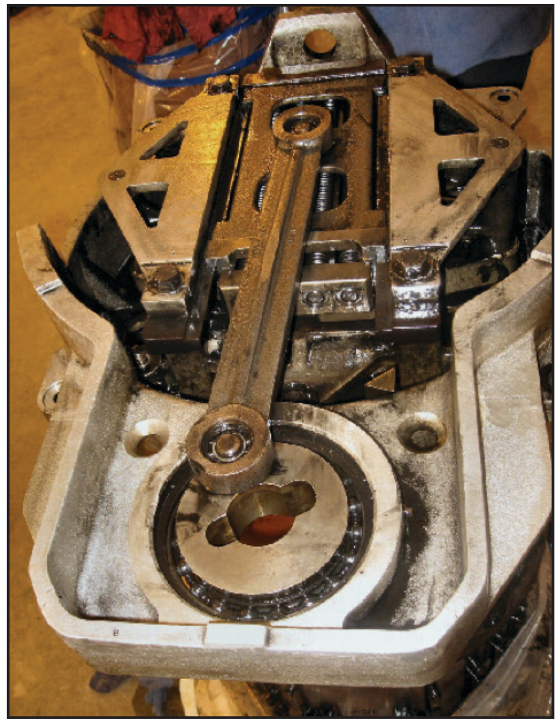
The health index formulation for the transformer main tank uses condition parameters that significantly contribute to the long-term degradation of the transformer. For substation transformers the condition parameters and sub-condition parameters were selected as follows:

- Insulation
  - Oil Quality
  - Oil DGA
  - Power dissipation*
  - Insulation Issues
- Cooling
  - Cooling system
- Sealing and connection
  - Insulation containment
  - Tank condition
  - Grounding
  - Oil conservator
  - Connections
- Service record
  - Loading*
  - Age

*When available in electronic format.
Where available, source data used for calculating Asset Health Index scores was taken from various Transmission electronic database systems as well as actual test results. Additional factors such as known design flaws or performance issues were also accounted for in the AHI.

Transmission System Load Tap Changers

Health Index Formulation



For transformer tap changers the condition parameters and sub-condition parameters have been selected as follows:

- Operating mechanism
  - Switch/contact
  - Tap selector head
  - Diverter
  - Control – Electrical
  - Control – Mechanical
  - Cabinet
  - Pressure relief
- Arc extinction
  - Diverter vacuum
  - Contacts
- Sealing and connection
  - Gasket or sealant
  - Oil level
  - Breather
- Insulation
  - Oil DGA
  - Oil quality
  - Insulation
- Service record
  - Operations
  - Failure to operate
  - Age

For transformer tap changers, the operating mechanism, sealing & connection, arc extinction and service record sub-condition parameter inputs were supplied by data and/or corrective maintenance records obtained from an electronic maintenance database(s) whereas much of the insulation sub-condition parameter inputs were supplied by actual test data. Additional factors such as obsolescence, known design flaws or performance issues were also accounted for in the AHI.

HVDC System Transformers:

The following tests/inspections were considered in calculating a condition index score:

- Furan levels in oil
- Dissolved Gas Analysis
- Capacitance Bridge and Dissipation Factor
- Operations & Mtce History
- Age
- On Load Tap Changer condition
- DC Winding Resistance Test
- Turns Ratio Test
- Core-to-Ground Resistance (Megger)
- Swept Frequency Response Analysis (SFRA)
- Internal Inspections
- Degree of Polymerization (based on internal inspections and furan levels in oil)
  The transformers have a useful life expectancy of 40-70 years.

Transmission System Circuit Breakers

Health Index Formulation

For circuit breakers the condition parameters and sub-condition parameters have been selected as follows:

- Operating mechanism
  - Lubrication
  - Linkage
  - Cabinet
  - Operating type (as a multiplier)
- Contact performance
  - Closing timing
  - Trip timing
  - Contact resistance
  - Contact over-travel
  - Arcing contact
- Arc Extinction
  - Heater
  - Leakage
  - Interrupter
  - Oil DGA
- Insulation
  - Power factor
  - Oil quality (applicable to oil breakers only)
  - Insulation
- Service record
  - Operating counter
  - Age

For circuit breakers, the operating mechanism, contact performance, arc extinction and service record sub-condition parameter inputs were supplied by data and/or corrective maintenance records obtained from an electronic maintenance database(s) whereas much of the insulation sub-condition parameter inputs were supplied by actual test data. Additional factors such as obsolescence, known design flaws or performance issues were also accounted for in the AHI.

HVDC System Breakers:

The equipment condition evaluation involved the review and assessment of the following criteria:

- Equipment performance information from the following sources:
  - Electronic defective work order information and notes contained within AMPS
  - Reliability information from Electrical Power Research Institute (EPRI) and others
  - Paper maintenance documentation from site
- Maintenance records from the following sources:
  - Electronic maintenance work order information and notes contained within AMPS
  - Paper maintenance documentation from site
  - Insulation test results in electronic and paper form
- Evaluation of Equipment Obsolescence
  - Equipment age
  - Spare parts availability from the following sources:
    - AMPS stores inventory
    - Original equipment manufacturer
  - Technical Support availability from the following sources:
    - Internal staff
    - Original equipment manufacturer
    - Other equipment support companies

The breakers have a useful life expectancy of 40-65 years

Protection Relays

Health Index Formulation

The methodology for protection relays, be it electromechanical or solid state, was completed in a very similar manner to the approach taken by the third party consultant with the exception that the model was simplified given probability of failure curves were not developed or readily available.
For protection relays the condition parameters and sub-condition parameters have been selected as follows:

- Age
- Manufacturer support
- Spare parts
- Maintenance performance

For protection relays, the condition parameter inputs were supplied by data and/or corrective maintenance records obtained from an electronic maintenance database(s). Additional factors such as known obsolescence and performance issues were also accounted for in the AHI.

Transmission System Battery Banks

Health Index Formulation

Batteries are an asset that are quite different from most other electrical assets and need to be treated as such. The methodology for battery banks differs somewhat from other assets in that a formula using age, potential failures, functional failures along with appropriate weighting factors is used to establish an AHI. The difference between potential and functional failures is normally a matter of degree; a potential failure requires corrective maintenance but was an issue that, due to regular inspection(s), would have become a functional failure had it not been caught in time. Functional failures can be described as events such as "Fails to regulate voltage" or other such conditions that impact the actual performance of the battery bank should they be called upon for service.

For battery banks the condition parameters and sub-condition parameters have been selected as follows:

- Age
- Past maintenance history including potential and functional failures

For battery banks, the condition parameter inputs were supplied by data and/or corrective maintenance records obtained from an electronic maintenance database(s).

HVDC System Battery Banks:

The equipment condition evaluation involved the review and assessment of the following criteria:

- Visual inspections
- Past test data (if available) (resistance(now)/conductance(before), specific gravities, and voltages)
- Previous performance of batteries if they have been put to use (i.e. AC power loss and batteries were called upon to carry the DC load)
- Past maintenance records

The battery banks have a useful life expectancy of 20 years

Transmission System Steel Structures/Grillage

Due to the nature of steel structures/grillage, their associated foundations combined with available asset data, the methodology differs from that used by the third party consultant. Age was one of two characteristics used for condition assessment of transmission structures, excluding wood structures, and accounts for 20 percent of the condition index. Actual asset condition obtained from Manitoba Hydro's transmission line patrol database was the second characteristic used and accounts for 80 percent of the condition index. Reports reviewed for each line summarize annual visual inspections and note problems such as bent/broken/cracked footings, submerged/sinking/heaving footings, tilted footings, spreads, and bent tower steel.

Transmission System Overhead Conductors

Health Index Formulation

Due to the nature of overhead conductors, the methodology differs from that used by the third party consultant. Age was the primary qualifier used for condition assessment of transmission conductors. Reports from Manitoba Hydro's transmission line patrol database were reviewed for each line and used to validate the condition assigned based on age. These reports summarize annual visual inspections and note problems such as broken strands, bird caging, nicks/scars, and burn marks. For several lines the condition was adjusted to more accurately reflect the maintenance patrol reports.

HVDC System Synchronous Condenser:

The criteria used in evaluating the condition of the synchronous condenser are as follows:

- Age of the asset
- Maintenance history -repairs, leaking, increased tolerances, or additional maintenance impact the score. Discussion with the project manager to determine what additional work was carried out between overhauls.
- Operation performance - review of outages to see if there have been additional outages, or vibration issues.
- Physical Condition- Visual of the exterior for signs of deterioration, review of notes on internal inspection, plus assessments from engineering make up this score.

The synchronous condensers have a useful life expectancy of 65 years. The refurbishment programs, every 15 years, address the major issues found through maintenance, failures and obsolescence. The refurbishment of the unit substantially affects the life expectancy of these units.

HVDC System Shunt Reactor:

The criteria used in evaluating the condition of the shunt reactor are as follows:

- Age of the asset
- Maintenance history – oil byproduct evaluations, repairs, or additional maintenance would reduce the score.
- Operation performance - review of outages and a corresponding reduction in score corresponding with the seriousness of the failures.
- Physical condition- visual of the interior and exterior for signs of deterioration, score is combined from two items. Greater emphasis is placed on the findings during an internal inspection of the unit by the engineers.

The shunt reactors have a useful life of 35 years.

HVDC System Smoothing Reactor:

The criteria used in evaluating the condition of the smoothing reactor are as follows:

- Age of the asset
- Maintenance history - repairs, or additional maintenance would reduce the score.
- Operation performance - review of outages and a corresponding reduction in score for failures.
- Physical condition - visual of the exterior for signs of deterioration

The smoothing reactors have a useful life of 25 years.

HVDC System Converter Transformer:

The criteria used in evaluating the condition of the converter transformer are as follows:

- Oil Samples - review of dielectric strength, moisture and combustible gas generation.
- Power Factor - review of capacitance bridge tests and excitation current
- Winding DC Resistance - considers the test results from resistance tests, turn to turn ratio test and SFRA tests
- Operation and maintenance - review of outages, maintenance history, and a corresponding reduction in score for failures.
- Internal inspections of units looking for core shifting, missing blocks. External inspections looking for weld cracks, leaks, and cracked porcelain. The engineer's internal inspection is more heavily weighted than the exterior inspection.
- Age of the unit

The converter transformer has a useful life of 40-50 years.

HVDC System Valve Group

The criteria used in evaluating the condition of the valve group are as follows:

- Age of unit
- Maintenance history - repairs, unavailability of parts or additional maintenance would reduce the score
- Operational performance - review of outages to see if there have been additional outages, and a corresponding reduction in score for failures
- Physical Condition - visual of the exterior for signs of deterioration, broken fasteners, leaks in piping, loss of support for cooling pipes, and optical fibres.

The valve group has a useful life of 25 years.

Valve groups in Bipole 2 are all of the same generation and are all showing similar wear characteristics. Bipole 1 has two different valve group types in Pole 1 and Pole 2 and are showing different issues. Within Pole 1 there are differences in the issues found, which makes direct comparisons of the valve groups difficult. This therefore requires individual assessments of the valve groups to determine their respective conditions.

The failure of a valve group is a gradual process as various components wear out, or fail and require custom made solutions to restore to service. Manufacturers only continue supporting a valve group design for a limited time. Eventually there are too many items to have custom designed, and built causing the replacement of the valve group.

HVDC System Valve Group Cooling:

The criteria used in evaluating the condition of the valve group cooling are as follows:

- Age of the asset
- Maintenance history – repairs, or additional maintenance would reduce the score
- Operation performance – review of outages, reduced cooling capacity, interventions for repair and clearing of fins with custom cleaners are considered and a corresponding reduction in score applied.
- Physical condition – visual inspection of the exterior for signs of deterioration (fins bent, deposits on coolers that can no longer be cleaned, rust, leaks, etc.)

The valve cooling has a useful life of 20 years.

The coolers seldom fail in a destructive manner. They usually slowly deteriorate losing capacity due to blockages, fin damage and buildup on the fins that no longer comes off. At some point this results in a reduction of power output, and loss of revenue. When this point is imminent the coolers are specified for replacement.

The failure of a valve group is a gradual process as various components wear out, or fail and require custom made solutions to restore to service. Manufacturers only continue supporting a valve group design for a limited time. Eventually there are too many items to have custom designed, and built causing the replacement of the valve group.

Appendix D: Distribution Detailed Methodology

Asset Condition Assessment Methodology

Distribution Asset Maintenance has performed a thorough review of the eight key assets to gain a better understanding of the current demands on the system and how they will impact performance over the next 20 years. This study took into account asset demographics, degradation mechanisms, inspection and maintenance, asset health, risk and valuation so that potential investment gaps could be identified and addressed.

The health indexes of the eight key assets were based upon the following:

- Asset Age
- Asset Type
- Inspection Programs
- Maintenance Programs
- Historical Data

These values are used to determine an overall asset health index, which is as follows:

- Very poor = Beyond acceptable level of risk and replacement is required (Condition Index 0 -1.49)
- Poor = Manageable level of risk; May replace asset(s) at this level if criticality assessment indicates risk needs to be mitigated or if a business case provides justification (approaching or past expected end of life) (Condition Index 1.5- 3.49)
- Fair = Long term service without notable measures of degradation (still in its useful part of its life) (Condition Index 3.5 – 4.99)
- Good = Midterm service without notable measures of degradation (in the prime of its useful life) (Condition Index 5 – 8.49)
- Very Good = Like new operating at expected measure of performance (early in its life) (Condition Index 8.5 -10)

Circuit Breakers:

Please refer to the Circuit Breaker Health Index Formulation description, which can be found in Appendix D: Transmission Detailed Methodology.

Station Transformers:

Please refer to the Station Transformer Health Index Formulation description, which can be found in Appendix D: Transmission Detailed Methodology.

Overhead Transformers:

The assessment of overhead transformers is based on the following criteria:

- Age
- Regularly Scheduled Visual Inspections
- Regularly Scheduled Grounding System Inspection

Overhead transformers consistently outlast the pole structures that support them. Generally, they are replaced before the end of the expected useful life due to various system improvement projects (e.g. voltage conversions, transformer capacity upgrades, line refurbishments). As a result of this, the AHI is based primarily on age.

Visual inspections are required to be completed once every six years for every overhead distribution circuit. As part of these inspections, operational staff examines the transformer installation and note any signs of potential problems, such as oil leakage, overloading, corrosion and tree contacts.

Overhead transformers have a useful life expectancy of 75 years.

Padmounted Transformers:

The assessment of padmounted transformers is based on the following criteria:

- Age
- Regularly Scheduled Visual Security Assessment
- Regularly Scheduled Maintenance Inspection

Padmounted transformers are replaced at the end of the expected useful life resulting from regularly scheduled condition assessments. As a result of this, the AHI is based primarily on age.

Underground transformers have a yearly security check to ensure they are locked, not leaning severely, accessible, and no large oil leaks are visible externally. They also have a maintenance inspection done on a 6 year cycle where they are opened, cleaned, and thoroughly inspected.

Padmounted transformers have a useful life expectancy of 50 years.

Overhead Primary Conductor:

The assessment of overhead primary conductor is based on the following criteria:

- Age
- Conductor Type
- Regularly Scheduled Visual Inspections

Overhead primary conductors have a very low rate of failure and consistently outlive the structures that support them. Replacement of these assets generally take place before the end of the expected useful life due to performance related issues (e.g. demand exceeds conductor current carrying capacity, conductor impedance caused poor voltage profiles). As a result of this, the AHI is based primarily on the capacity of the conductor type; however, the age of the line is also taken into consideration.

Although specific testing is not performed on distribution conductors, visual inspections do occur on a regular basis. Visual inspections are required to be completed once every six years for every overhead circuit.

Overhead primary conductors have a useful life expectancy of 100 years.

Manholes:

The assessment of manholes is based on the following criteria:

- Age
- Construction Method (built in place, pre-fabricated)
- Construction Material (concrete, brick, clay tile)
- Regularly Scheduled Visual Inspections

The AHI of the manhole population is based upon a 2012 survey of 850 manholes within the downtown region of Winnipeg. The results of the study were then extrapolated over the entire population of manholes in Manitoba to determine the overall AHI.

Manhole inspections are completed on a three year cycle by operational staff. A visual check on the structural integrity of the manhole structure is performed, as well as an infra-red inspection of all electrical connections within the vault. The visual check includes the manhole cover, cover ring, collar, walls, ceiling, and floor.

Manholes have a useful life expectancy of approximately 80 years.

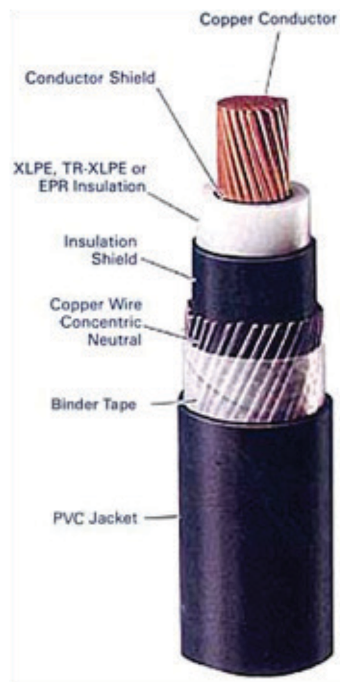
Underground Cables::

The assessment of underground cables is based on the following criteria:

- Age
- Cable Type (PILC, RINJ/RIPVCJ, XLPE/TRXLPE)
- Cable Manufacturer

Due to the extreme difficulty in inspecting buried cables, there is currently no regularly scheduled inspection program in place that is used to evaluate the health of these assets. As a result, the AHI of the underground cables are determined by the age of each cable type.

Underground cables have a useful life expectancy of approximately 30 – 70 years, depending on the cable type.



Ductlines:

The assessment of ductlines is based on the following criteria:

- Age
- Construction Material (PVC pipe, cast iron pipe, ceramic pipe)
- Visual Inspections

Ductlines have a very low rate of failure and consistently outlive the manholes and structures which they are connected to. Replacement or refurbishment of these assets generally take place only when associated work (i.e. manhole or station rebuilds) is scheduled within the area in order to take advantage of reduced construction costs.

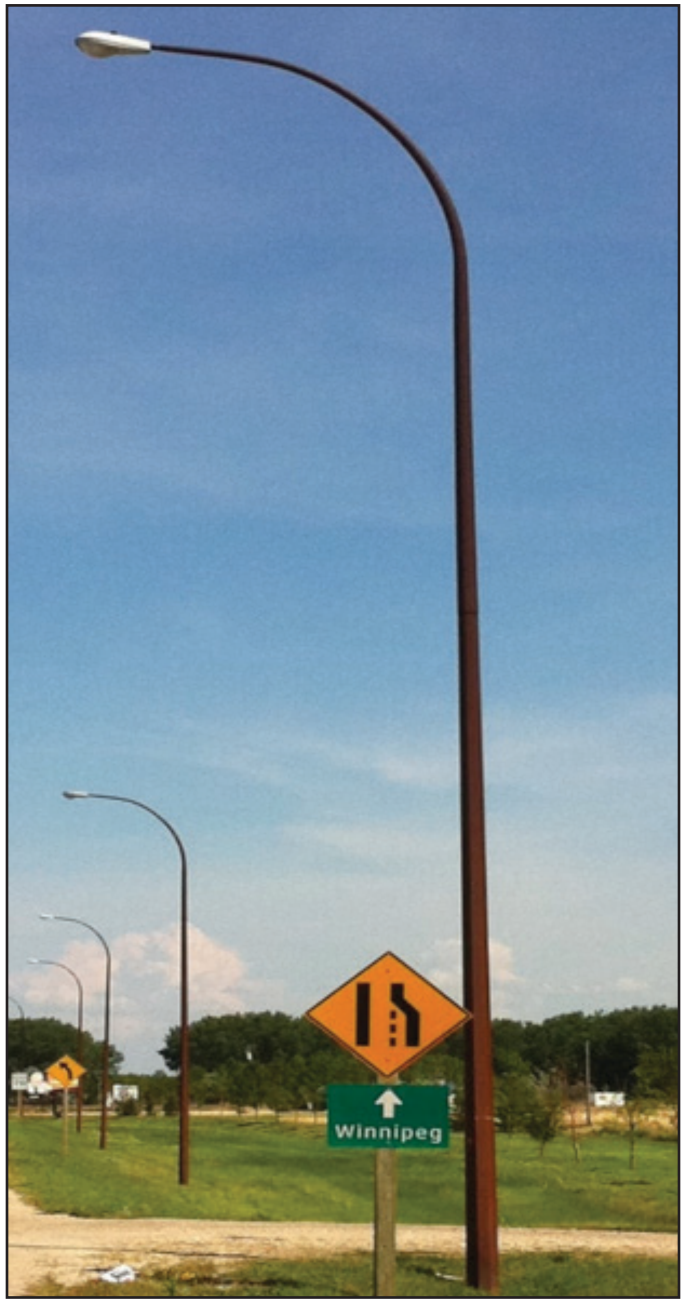
Although specific testing is not performed on duct lines, visual inspections do occur as part of regularly scheduled manhole inspections. As part of these inspections, operational staff will note if the duct line is exhibiting any visible signs of shifting or individual duct segments are collapsing or crumbling.

Manholes have a useful life expectancy of approximately 100 years.

Street Lights:

The assessment of street lights is based on the following criteria:

- Age
- Regularly Scheduled Visual Inspections
- Installation method (concrete pile, direct bury, power screw)



The AHI is based upon the DMPS reports of the previous four years and extrapolated over the entire street light population.

City of Winnipeg streetlights are scheduled for inspection once every four years. Standards are inspected by the Streetlight Maintenance and Underground Inspection Section. Outside the City of Winnipeg inspections are organized by the local CSC.

Street lights have a useful life expectancy of approximately 50 – 70 years, depending on the street light installation type.

Wood Poles:

The assessment of wood pole is based on the following criteria:

- Age
- Integrated Pole Maintenance Program (Regularly Scheduled Inspection/ Evaluation)
- Regularly Scheduled Visual Inspections

The AHI of wood poles is based upon the summary of the IPM program, as well as age.

In 1989, Manitoba Hydro implemented the Integrated Pole Maintenance program (IPM). The program is a designed to provide an accurate assessment of our wood poles on a 15 year cycle. Each pole receives a thorough inspection, strength evaluation, remedial treatments as required and attribute information is collected electronically. These remedial treatments are designed to provide the poles with added protection internally and externally to extend their service life.

Wood poles have a useful life expectancy of 75 years.

Appendix E: Endnotes

[1] Expected life is dependent on asset type: Mechanical (80-90 years), Analog/Digital (50/25 years).

[2] Expected life is dependent on asset type: Mechanical (100-125 years), Analog (45-55 years) and Digital (20-25 years).

[3] The expected life is dependent on loading and service type.

[4] Four (4) transmission system breakers have been replaced over the last ten years due to in service failures and nineteen (19) have been replaced or retired for system development or economic reasons.

[5] Reasons for replacement:

- 107 - 4kV and 12kV breakers were replaced due to safety and reliability concerns in early 2000s.
- All 46kV breakers were replaced.
- 43 of Dorsey's breakers upgraded in the early 90s due to insufficient capacity.
- One 500kV breaker replaced in 2010 due to condition,
- 15 of Dorsey's 230kV breakers are to be replaced by 2017 due to insufficient capacity.
- 31- 138kV breakers at Radisson are to be replaced around 2025 due to insufficient capacity.

[6] Costing of the breakers appears low because these numbers include 4, 12 and 46KV breakers.

[7] Station Battery Capacity & System Reliability Increase Program included 138 battery replacement projects since 2005. This program is expected to conclude in 2017.

[8] The expected life is dependent on loading and service type.

[9] Seven (7) transmission system transformers have been replaced over the last ten years due to in service failures and ten (10) have been removed from service as part of the Pointe Du Bois Transmission Redevelopment and Transcona East Station Projects.

[10] The expected life is dependent on loading and service type.

[11] Expected life is very dependent on device technology. Electromechanical devices have longer expected service performance than electronic devices. A key factor in end of life expectancy is obsolescence. Expected end of life is extended by ensuring adequate spare relays are retained after protection system upgrades.

[12] Three major programs have replaced 52 obsolete line teleprotection systems since 2005. The number of additional protection relay replacements or retirements completed as part of system improvement capital projects was not determined for this report.

[13] Close to 700 steel structures have been removed from service and/or replaced with new transmission infrastructure over the last 10 years. Additional partial structure replacements (e.g. footing replacements) are not reflected in this number.

[14] Slightly over 700 wood pole structures have been removed from service and/or replaced with new transmission infrastructure over the last 10 years. Additional partial structure replacements (e.g. individual poles or cross arms) are not reflected in this number.

[15] Approximately 350 km of three phase conductor has been removed from service and/or replaced with new transmission infrastructure over the last 10 years.

[16] Refurbishments to date have kept all original units in service.

[17] Refurbished one unit after failure, and it is retained as a spare.

[18] All units replaced in last four years when condition of old units dictated. New units are air core. This style has performed well in the filter positions, but has not been used in the smoothing reactor role before. Expected life and turn over are an estimate at present.

[19] The existing turnover rate is based upon the past 10 years of station breaker replacements. Due to a recognized need to increase system capacity as a result of customer demand, it is expected that station upgrade and replacement rates will dramatically increase in the near future which may result in reduced turnover rates.

[20] The expected life is dependent on loading and service type.

[21] The existing turnover rate is based upon the past 10 years of station transformers replacements. Due to a recognized need to increase system capacity as a result of customer demand, it is expected that station upgrade and replacement rates will dramatically increase in the near future which may result in reduced turnover rates.

[22] Expected life is dependent upon cable type: PILC (60-70 years), RINJ/RIPVCJ (30-40 years), XLPE/TRXLPE (40-50 years).

[23] Currently, no ductline replacement program exists as the life of the asset consistently outlasts that of the manholes they are connected to. Ductlines are rehabilitated or replaced when associated work in performed within the area in order to take advantage of the reduced costs of construction.

[24] Currently, no conductor replacement program exists as the life of the asset consistently outlasts that of the pole structure supporting it. Due to an increase in system capacity resulting from customer demand, overhead conductors are replaced as a result of capacity upgrades.

[25] Expected life is dependent upon installation method: direct install/power screw (50-60 years), concrete base (60-70 years).