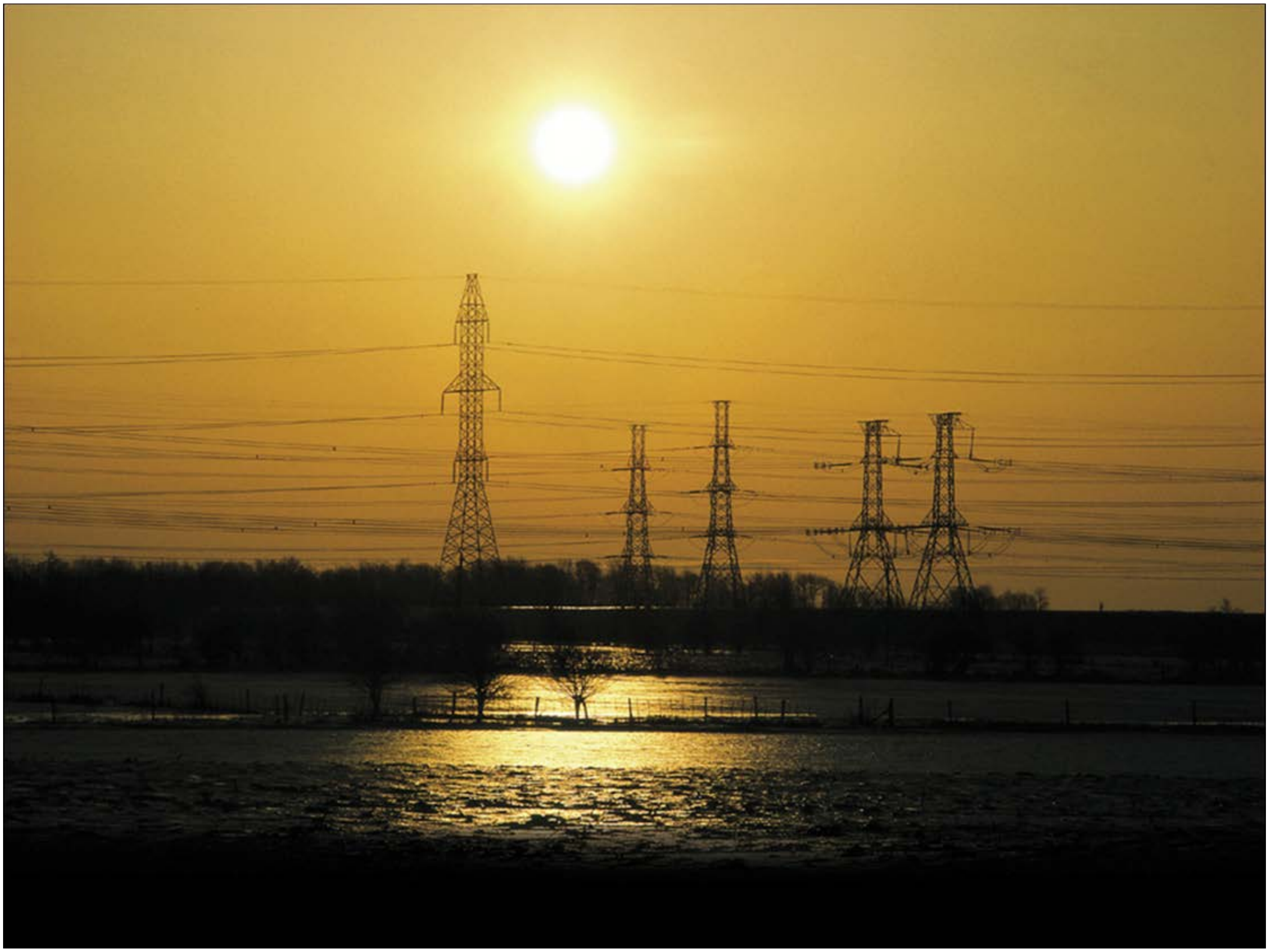

Kitchener-Waterloo-Cambridge-Guelph Regional Infrastructure Plan

December 10, 2021

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Prepared and supported by:

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Kitchener-Wilmot Hydro Inc.
Milton Hydro Distribution Inc.
Waterloo North Hydro Inc.
Wellington North Power Inc.

Disclaimer

This Regional Infrastructure Plan ("RIP") report was prepared for the purpose of developing an electricity infrastructure plan to address all near and mid-term needs identified in previous planning phases and any additional needs identified based on new and/or updated information provided by the RIP Study Team.

The preferred solution(s) that have been identified in this report may be reevaluated based on the findings of further analysis. The load forecast and results reported in this RIP report are based on the information provided and assumptions made by the participants of the RIP Study Team.

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Executive Summary

THIS REGIONAL INFRASTRUCTURE PLAN ("RIP") WAS PREPARED BY HYDRO ONE WITH SUPPORT FROM THE RIP STUDY TEAM IN ACCORDANCE TO THE ONTARIO TRANSMISSION SYSTEM CODE REQUIREMENTS. IT IDENTIFIES INVESTMENTS IN TRANSMISSION FACILITIES, DISTRIBUTION FACILITIES, OR BOTH, THAT SHOULD BE DEVELOPED AND IMPLEMENTED TO MEET THE ELECTRICITY INFRASTRUCTURE NEEDS WITHIN THE KITCHENER WATERLOO CAMBRIDGE GUELPH REGION.

The participants of the Regional Infrastructure Plan ("RIP") Study Team included members from the following organizations:

- Alectra Utilities Corporation ("Alectra")
- Centre Wellington Hydro Ltd. ("CWH")
- Energy + Inc. ("Energy+")
- Halton Hills Hydro Inc. ("HHH")
- Hydro One Networks Inc. (Distribution)
- Hydro One Networks Inc. (Transmission)
- Independent Electricity System Operator ("IESO")
- Kitchener Wilmot Hydro Inc.("KWH")
- Milton Hydro Distribution Inc. ("MHD")
- Waterloo North Hydro Inc. ("WNH")
- Wellington North Power Inc. ("WNP")

In the first cycle of the Regional Planning (RP) process for the KWCG Region, an Integrated Regional Resource Plan ("IRRP") was published in April 2015. The first cycle of RP process was completed in December 2015 [1] with the publication of the Regional Infrastructure Plan ("RIP") which provided a description of needs and recommendations of preferred wires plans to address near-term needs.

In accordance with the Regional Planning process, the Regional Planning cycle should be triggered at least every five years. In light of the timing of the needs identified in the previous IRRP and RIP reports as well as new replacement/ refurbishment needs identified in the KWCG Region, the 2nd Regional Planning cycle was triggered for the KWCG region in Q4 2018.

This RIP is the final phase of the second cycle of Kitchener Waterloo Cambridge Guelph (KWCG) regional planning process, which follows the completion of the KWCG Integrated Regional Resource Plan ("IRRP") in April 2021 [2][3] and the KWCG Region Needs Assessment ("NA") in December 2018 [4]. This RIP provides a consolidated summary of the needs and recommended plans for KWCG Region over the planning horizon (1 – 20 years) based on available information.

It discusses needs identified in the previous regional planning cycle, the Needs Assessment and IRRP reports for this cycle, and wires solutions recommended to address these needs. Implementation plans to address some of these needs are already completed or are underway.

The following needs identified in the first regional planning cycle have been addressed:

Needs	Needs Details
115kV System Supply Capacity	GATR Project Two new 230/115kV autotransformers at Cedar TS to reinforce supply to both 115kV sub-systems in the region.
230kV Load Restoration Needs	GATR Project Two new 230 kV in-line switches on D6V/D7V circuits to improve restoration capability of Waterloo-Guelph 230 kV sub-system.
	Galt Junction Two new 230kV in-line switches on M20D/M21D circuits to improve restoration capability of the Cambridge-Kitchener 230 kV sub-system.
Station Short Circuit Capacity	Arlen MTS Install 13.8 kV series reactors to mitigate LV bus short circuit levels.

Other projects completed in the region since the completion of first regional planning cycle are listed below:

Stations Refurbishment Project	
Campbell TS	Transformers T1 and T2 Replacement
Detweiler TS	AC Station Service and Component Replacement
Detweiler TS	230 /115 kV Auto Transformers T2 and T4 Replacement
D7F / D9F	115 kV Tower Refurbishment – Tower 157 near Freeport SS
D6V / D7V	230 kV Lines Refurbishment between Fergus TS and Campbell TS

The major infrastructure investments recommended for the KWCG Region over the near and mid-term planning horizon are provided in the Table 1 below, are all end of life needs along with their planned in-service date and budgetary estimates for planning purpose.

Table 1. Recommended Plans in KWCG Region over the Next 10 Years

Stations / Lines Project	Details	Timeframe	High Level Cost ($M)[1]
Hanlon TS	Transformers T1 and T2 Replacement	2022-2023	17.8
Kitchener MTS #5	Transformers T9 and T10 Replacement	2023-2024	7.5
Scheifele MTS	Transformers T1 and T2 Replacement	2025-2026	-
B5C/B6C	115KV Lines Refurbishment, refurbishing section from Burlington TS to a CTS	2025-2026	16.8
Preston TS	Transformers T3 and T4 Replacement	2026-2027	22.9
Cedar TS	Transformers T7 and T8 Replacement	2026-2027	23.7
Fergus TS	Transformers T3 and T4 Replacement	2028-2029	30.0
Galt TS	Breakers and Component Replacement	2028-2029	12.0
Campbell TS	Breakers and Component Replacement	2028-2029	18.1

The Study Team recommends that:

- Hydro One and LDCs to continue with the implementation of infrastructure investments listed in Table 1 above while keeping the Study Team apprised of project status;
- All the other identified needs/options in the long-term will be further reviewed by the Study Team in the next regional planning cycle.

[1] Budgetary estimates

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1. Introduction

THIS REPORT PRESENTS THE REGIONAL INFRASTRUCTURE PLAN ("RIP") TO ADDRESS THE ELECTRICITY NEEDS OF THE KITCHENER WATERLOO CAMBRIDGE GUELPH (KWCG) REGION BETWEEN 2021 AND 2041.

The report was prepared by Hydro One Networks Inc. (Transmission) ("Hydro One") on behalf of the Study Team that consists of Hydro One, Alectra Utilities ("Alectra"), Centre Wellington Hydro Ltd., Energy+ Inc., Halton Hills Hydro Inc., Hydro One Networks Inc. (Distribution), the Independent Electricity System Operator ("IESO"), Kitchener-Wilmot Hydro Inc., Milton Hydro Distribution Inc., Waterloo North Hydro Inc. and Wellington North Power Inc., in accordance with the new Regional Planning process established by the Ontario Energy Board in 2013 [5].

The Kitchener, Waterloo, Cambridge and Guelph (KWCG) region is located to the west of the Greater Toronto area in southwestern Ontario. The KWCG Region includes the cities of Kitchener, Waterloo, Cambridge and Guelph, portions of Oxford and Wellington counties and the townships of North Dumfries, Puslinch, Woolwich, Wellesley and Wilmot. Electrical supply to the Region is provided from eleven 230 kV and thirteen 115 kV step-down transformer stations. The approximate boundaries of the KWCG Region are shown below in Figure 1-1.

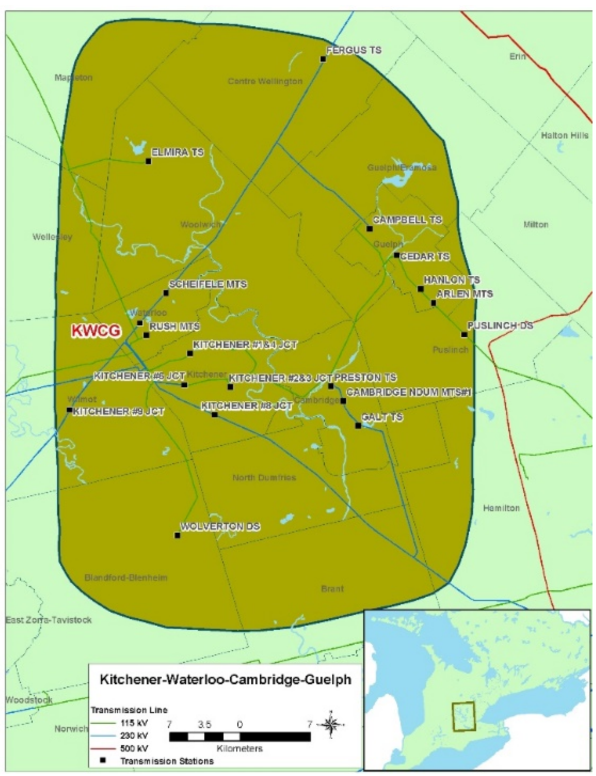

FIGURE 1-1: KWCG REGION MAP

1.1. Objectives and Scope

The RIP report examines the needs in the KWCG Region. Its objectives are to:

- Provide a comprehensive summary of needs and wires plans to address the needs;
- Identify any new needs that may have emerged since previous planning phases e.g., Needs Assessment ("NA"), Scoping Assessment ("SA"), and/or Integrated Regional Resource Plan ("IRRP");
- Assess and develop a wires plan to address these needs; and
- Identify investments in transmission and distribution facilities or both that should be developed and implemented on a coordinated basis to meet the electricity infrastructure needs within the region.

The RIP reviewed factors such as the load forecast, major high voltage sustainment issues emerging over the near, mid- and long-term horizon, transmission and distribution system capability along with any updates to local plans, conservation and demand management ("CDM") forecasts, renewable and non-renewable generation development, and other electricity system and local drivers that may impact the need and alternatives under consideration.

The scope of this RIP is as follows:

- A consolidated report of the relevant wires plans to address near and medium-term needs identified in previous planning phases (Needs Assessment, Scoping Assessment, and/or Integrated Regional Resource Plan);
- Discussion of any other major transmission infrastructure investment plans over the planning horizon;
- Identification of any new needs and a wires plan to address these needs based on new and/or updated information;
- Develop a plan to address any longer term needs identified by the Study Team.

1.2. Structure

The rest of the report is organized as follows:

- Section 2 provides an overview of the regional planning process.
- Section 3 describes the regional characteristics.
- Section 4 describes the transmission work completed over the last ten years.
- Section 5 describes the load forecast and study assumptions used in this assessment.
- Section 6 describes the adequacy of the transmission facilities in the region over the study period.
- Section 7 discusses the needs and provides the alternatives and preferred solutions.
- Section 8 provides the conclusion and next steps.

2. Regional Planning Process

2.1. Overview

Planning for the electricity system in Ontario is done at three levels: bulk system planning, regional system planning, and distribution system planning. These levels differ in the facilities that are considered and the scope of impact on the electricity system. Planning at the bulk system level typically looks at issues that impact the system on a provincial level, while planning at the regional and distribution levels looks at issues on a more regional or localized level.

Regional planning looks at supply and reliability issues at a regional or local area level. Therefore, it largely considers the 115 kV and 230 kV portions of the power system that supply various parts of the province.

2.2. Regional Planning Process

A structured regional planning process was established by the Ontario Energy Board ("OEB") in 2013 through amendments to the Transmission System Code ("TSC") and Distribution System Code ("DSC"). The process consists of four phases: the Needs Assessment[2] ("NA"), the Scoping Assessment ("SA"), the Integrated Regional Resource Plan ("IRRP"), and the Regional Infrastructure Plan ("RIP").

The regional planning process begins with the NA phase, which is led by the transmitter to determine if there are regional needs. The NA phase identifies the needs and the Study Team determines whether further regional coordination is necessary to address them. If no further regional coordination is required, further planning is undertaken by the transmitter and the impacted local distribution company ("LDC") or customer and develops a Local Plan ("LP") to address them.

In situations where identified needs require coordination at the regional or sub-regional levels, the IESO initiates the SA phase. During this phase, the IESO, in collaboration with the transmitter and impacted LDCs, reviews the information collected as part of the NA phase, along with additional information on potential non-wires alternatives, and makes a decision on the most appropriate regional planning approach. The approach is either a RIP, which is led by the transmitter, or an IRRP, which is led by the IESO. If more than one sub-region was identified in the NA phase, it is possible that a different approach could be taken for different sub-regions.

The IRRP phase will generally assess infrastructure (wires) versus resource (non-wires alternatives) options at a higher or more macro level, but sufficient to permit a comparison of options. If the IRRP phase identifies that infrastructure options may be most appropriate to meet a need, the RIP phase will conduct detailed planning to identify and assess the specific wires alternatives and recommend a preferred wires solution. Similarly, resource options that the IRRP identifies as best suited to meet a need are then further planned in greater detail by the IESO.

[2] Also referred to as Needs Screening

The IRRP phase also includes IESO led stakeholder engagement with municipalities, Indigenous communities, business sectors and other interested stakeholders in the region.

The RIP phase is the fourth and final phase of the regional planning process and involves discussion of previously identified needs and plans, identification of any new needs that may have emerged since the start of the planning cycle, and development of a wires plan to address the needs where a wires solution would be the best overall approach. This phase is led and coordinated by the transmitter and the deliverable is a comprehensive report of a wires plan for the region. Once completed, this report is also referenced in transmitter's rate filing submissions and as part of LDC rate applications with a planning status letter provided by the transmitter.

To efficiently manage the regional planning process, Hydro One has been undertaking wires planning activities in collaboration with the IESO and/or LDCs for the region as part of and/or in parallel with:

- Planning activities that were already underway in the region prior to the new regional planning process taking effect;
- The NA, SA, and LP phases of regional planning;
- Participating in and conducting wires planning as part of the IRRP for the region or sub-region;
- Working and planning for connection capacity requirements with the LDCs and transmission connected customers.

Figure 2-1 illustrates the various phases of the regional planning process (NA, SA, IRRP, and RIP) and their respective phase trigger, lead, and outcome.

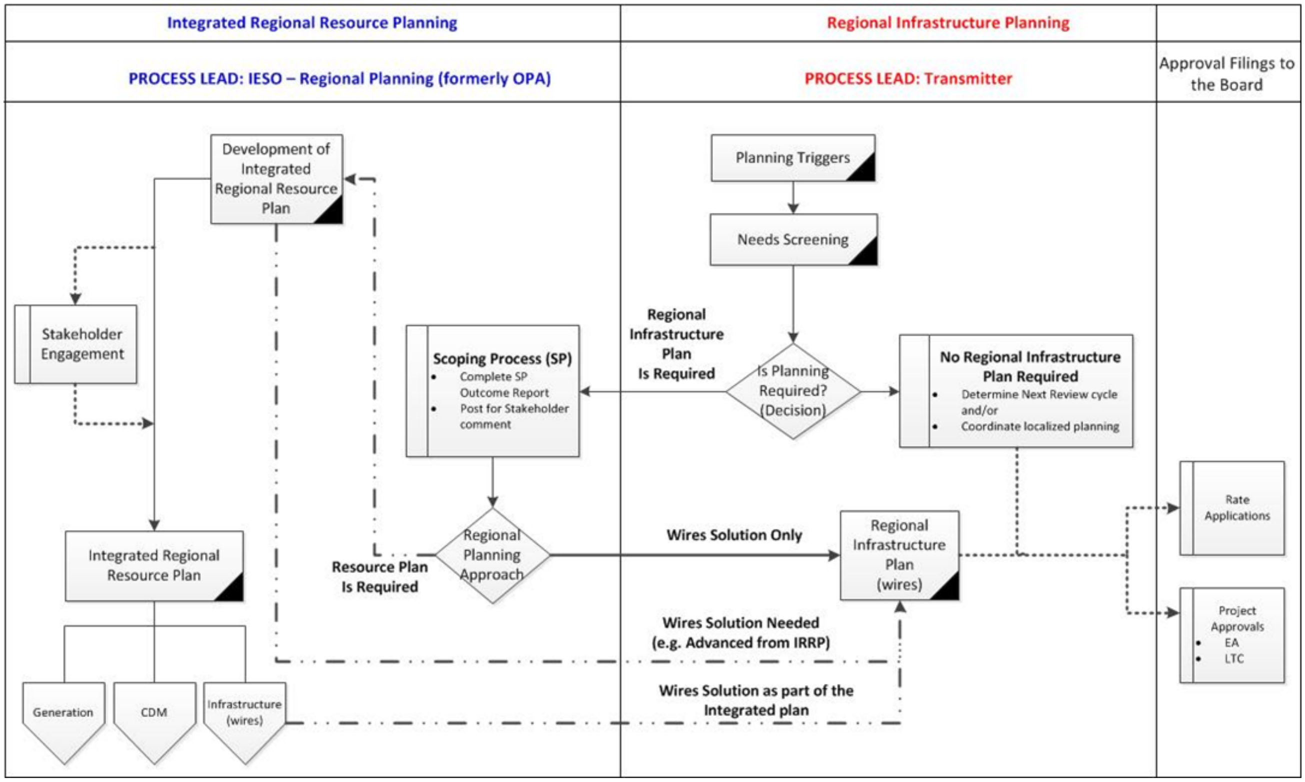

FIGURE 2-2: REGIONAL PLANNING PROCESS FLOWCHART

2.3. RIP Methodology

The RIP phase consists of a four step process (see Figure 2-2) as follows:

1) Data Gathering: The first step of the process is the review of planning assessment data collected in the previous phase of the regional planning process. Hydro One collects this information and reviews it with the Study Team to reconfirm or update the information as required. The data collected includes:

   - Net peak demand forecast at the transformer station level. This includes the effect of any distributed generation or conservation and demand management programs.
   - Existing area network and capabilities including any bulk system power flow assumptions.
   - Other data and assumptions as applicable such as asset conditions; load transfer capabilities, and previously committed transmission and distribution system plans.

2) Technical Assessment: The second step is a technical assessment to review the adequacy of the regional system including any previously identified needs. Depending upon the changes to load forecast or other relevant information, regional technical assessment may or may not be required or be limited to specific issue only. Additional near and mid-term needs may be identified in this phase.

3) Alternative Development: The third step is the development of wires options to address the needs and to come up with a preferred alternative based on an assessment of technical considerations, feasibility, environmental impact and costs.
4) Implementation Plan: The fourth and last step is the development of the implementation plan for the preferred alternative.

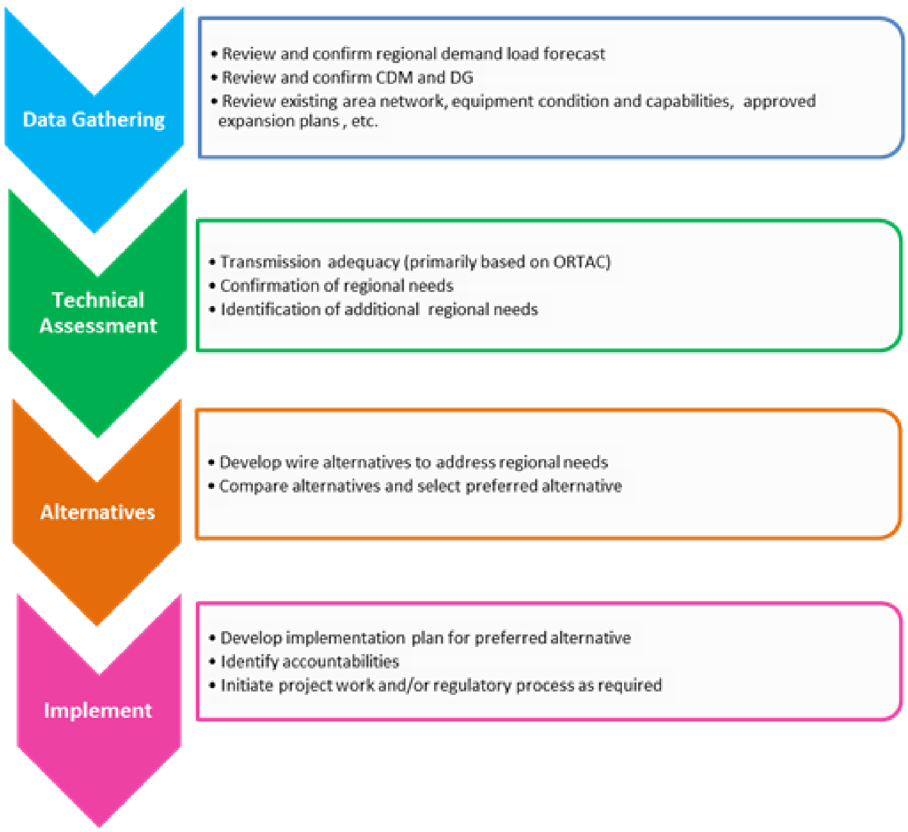

FIGURE 2-3: RIP METHODOLOGY

3. Regional Characteristics

THE KWCG REGION COMPRISES OF THE CITIES OF KITCHENER, WATERLOO, CAMBRIDGE AND GUELPH, PORTIONS OF OXFORD AND WELLINGTON COUNTIES AND THE TOWNSHIPS OF NORTH DUMFRIES, PUSLINCH, WOOLWICH, WELLESLEY AND WILMOT AS SHOWN IN FIGURE 3-1.

The main sources of electricity into the KWCG Region are from four Hydro One transformer stations: Middleport TS, Detweiler TS, Orangeville TS and Burlington TS. Electricity is transformed from 500 kV and 230 kV to 230 kV and 115 kV, respectively, at these stations. Electricity is then delivered to the end users of LDCs and directly-connected industrial customers by twenty-four (24) step-down transformer stations.

A single line diagram showing the electrical facilities of the KWCG Region is provided in Figure 3-1, which illustrates these stations as well as the four major regional sub-systems: Waterloo-Guelph 230 kV sub-system, Cambridge-Kitchener 230 kV sub-system, Kitchener-Guelph 115 kV sub-system and South-Central Guelph 115 kV sub-system.

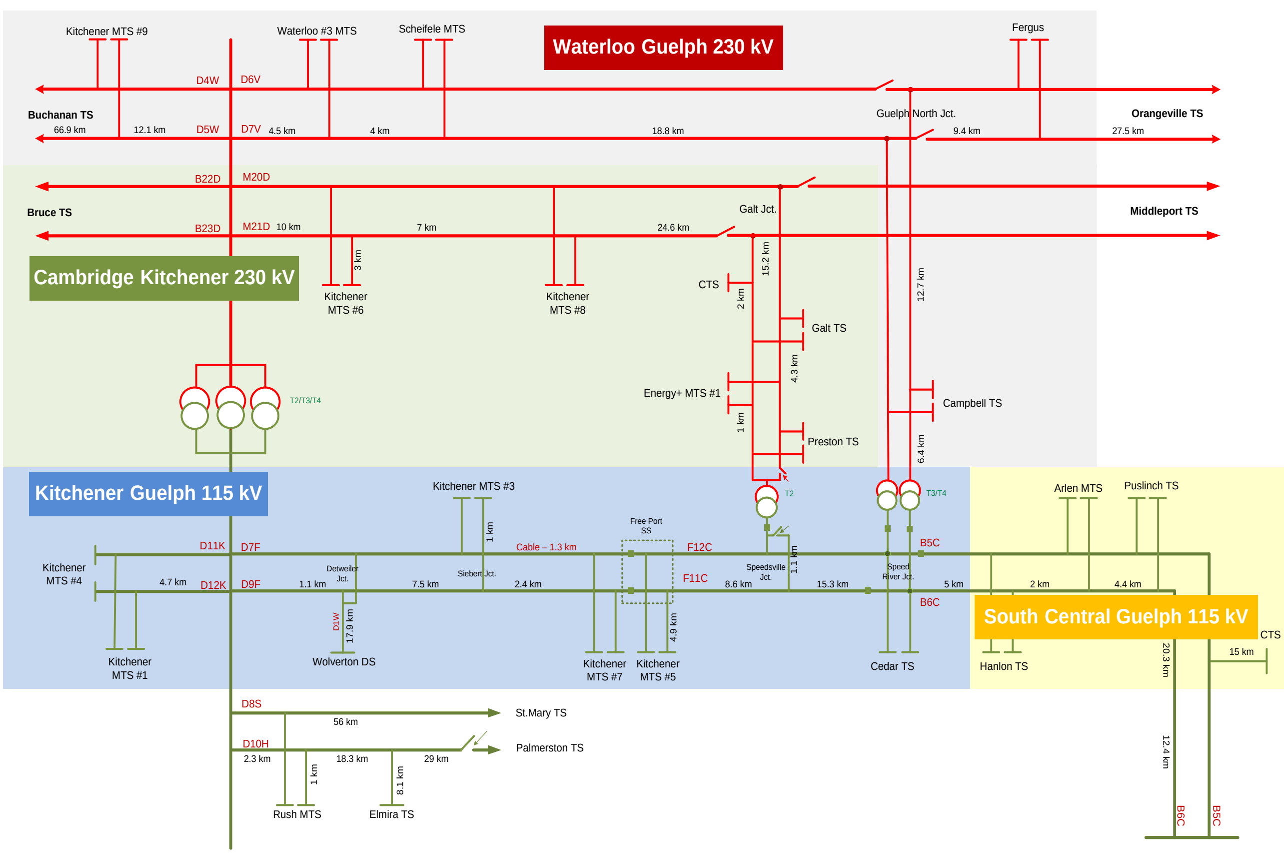

FIGURE 3-4: SINGLE LINE DIAGRAM OF THE KWCG REGION'S TRANSMISSION NETWORK

The twenty-four (24) KWCG's transformer stations can be grouped into six electrical (four major) zones based on their HV supply network:

1. **Waterloo-Guelph 230 kV Area:** The transformer stations in this area are supplied by Detweiler TS 230kV. This area includes transformer stations connected to the 230 kV circuits between Detweiler TS and Orangeville TS D6V/D7V, serving customers in the KWCG area. Below are the transformer stations in Waterloo-Guelph 230 kV area.
    - Campbell TS
    - Fergus TS
    - Scheifele MTS
    - Waterloo North MTS# 3

2. **Cambridge-Kitchener 230 kV Area:** The transformer stations in this area are supplied by Detweiler TS 230kV. This area includes transformer stations connected to the 230 kV circuits between Detweiler TS and Middleport TS M20D/M21D, serving customers in the KWCG area. Below are the transformer stations in Cambridge-Kitchener 230 kV area.
    - Energy + MTS# 1
    - Galt TS
    - Preston TS
    - Kitchener MTS# 6
    - Kitchener MTS# 8
    - CTS# 1

3. **Kitchener-Buchanan 230 kV Area:** The transformer stations in this area are supplied by Detweiler TS 230kV. This area includes transformer stations connected to the 230 kV circuits between Detweiler TS and Buchanan TS. This area has only one transformer station.
    - Kitchener MTS# 9.

4. **Kitchener-Elmira 115 kV Area:** This area covers the north-western part of the KWCG area which is supplied by the Detweiler TS 230/115 kV autotransformers. The transformer stations in this area are:
    - Elmira TS
    - Rush MTS

5. **Kitchener-Guelph 115 kV Area:** This area covers the Kitchener area and northern Guelph area, which is supplied by the Detweiler TS 230/115 kV autotransformers. The transformer stations in this area are:
    - Cedar TS
    - Kitchener MTS# 1
    - Kitchener MTS# 3
    - Wolverton DS
    - Kitchener MTS# 4
    - Kitchener MTS# 5

- Kitchener MTS# 7

6. **South-Central Guelph 115 kV Area:** This area covers the southern part of Guelph, which is supplied by the Burlington TS 230/115 kV autotransformers. The transformer stations in this area are:
    - Arlen MTS
    - Puslinch DS
    - Hanlon TS
    - CTS# 2

4. Transmission Facilities/ Projects Completed and/or Underway Over the Last Ten Years

OVER THE LAST TEN YEARS, A NUMBER OF TRANSMISSION PROJECTS HAVE BEEN PLANNED AND UNDERTAKEN BY HYDRO ONE AIMED TO MAINTAIN THE RELIABILITY AND ADEQUACY OF ELECTRICITY SUPPLY TO THE KWCG REGION.

A summary and description of the major projects completed and/or currently underway over the last ten years is provided below. These projects were identified as a result of joint planning studies undertaken by Hydro One, IESO and the LDCs; or initiated to meet the needs of the LDCs; and/or to meet Provincial Government policies. A brief listing of the completed projects is given below.

For distribution voltage level transformation capacity needs:

- Arlen MTS connected in 2011

For reactive and voltage support needs:

- 230 kV SVC (+350 MVAr @ 250 kV) installed at Detweiler TS in 2011[3]
- 115 kV shunt capacitor bank installed at Detweiler TS in 2012

For 230 kV transmission circuit capacity needs:

- 230 kV M20D/M21D circuit sections capacity increased by sag limit mitigation in 2014

For 115 kV transmission circuit capacity and 230 kV load restoration needs:

- Guelph Area Transmission Reinforcement (GATR) project in 2016 that includes:
  - extension the 230kV circuits D6V/D7V to Cedar TS;
  - two new 250 MVA, 230/115kV autotransformers at Cedar TS;
  - And two 230 kV in-line switches at Guelph North Junction on circuits D6V/D7V.

  This project reinforces the Kitchener-Guelph and South-Central Guelph 115kV sub-systems as well as improves restoration capability to the Waterloo-Guelph 230 kV sub-system.

- Two new additional 230kV in-line switches on M20D/M21D circuits installed at Galt Junction in 2017 to improve restoration capability of the Cambridge-Kitchener 230 kV sub-system

For station short circuit capacity needs:

[3] Two SVCs were installed for the contingency support in the South-western Ontario

- 13.8 kV series reactors were installed to mitigate short circuit levels at Arlen MTS. This project was identified in the last RIP phase.

For end of life needs addressed:

- Galt TS T7 and T8 Transformers Replacement
- Campbell TS T1 and T2 Transformers Replacement
- Detweiler TS AC Station Service and Component Replacement
- D7F / D9F 115 kV Tower Refurbishment, Tower 157 near Freeport SS
- D6V / D7V 230 kV Lines Refurbishment between Fergus TS and Campbell TS
- Detweiler TS 250 MVA 230/115 kV T2 and T4 autotransformers replaced

5. Load Forecast and Study Assumptions

5.1. Load Forecast

The electricity demand in the KWCG Region is anticipated to grow by about 10% over the next ten years. Figure 5-1 shows the KWCG Region's planning load forecast (summer net, coincident extreme weather corrected peak) developed during this RIP phase.

This RIP load forecast was used to determine the loading that would be seen by transmission lines and autotransformer stations and to identify the need for additional line and auto-transformation capacity.

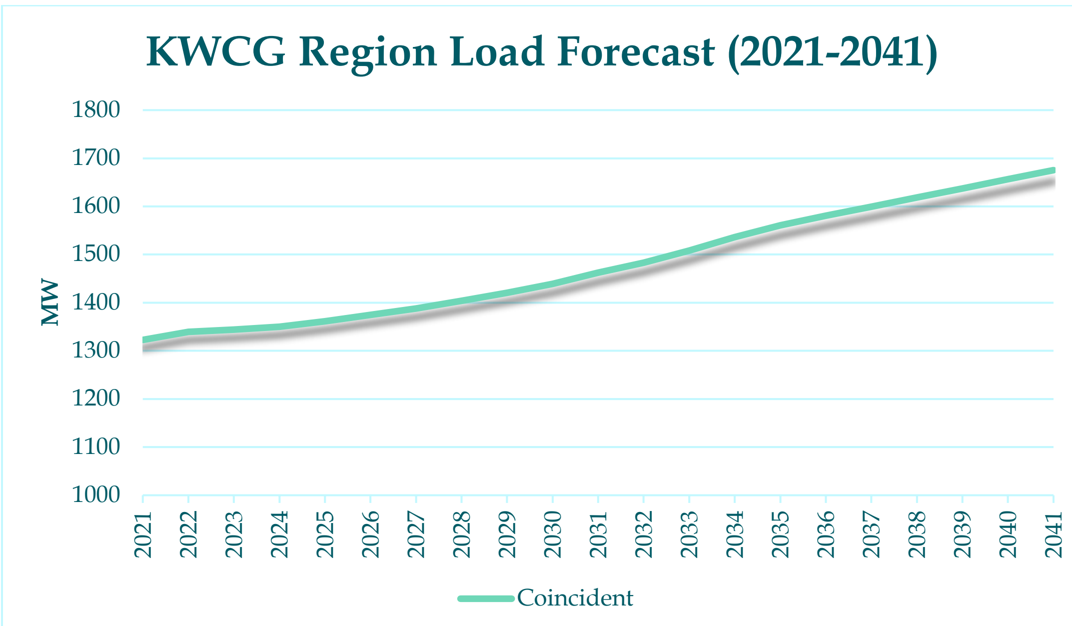

FIGURE 5-5: KWCG REGION LOAD FORECAST

The regional-coincident load forecast represents the total peak load of the 24 step-down transformer stations in the KWCG Region. The Region's peak summer load is forecasted to increase from 1323 MW in 2021 to 1462 MW by 2031.

The load forecast for KWCG RIP is provided in Appendix D. This load forecast is based upon the 2020 actual loads and the load forecast prepared by the IESO for the recently completed IRRP. The NA and the IRRP used the 2018 actual loads as the base. More than two years have passed since then and though 2020 seems to be unusual year in light of the COVID-19 pandemic; with all the applicable adjustments and the comparisons with 2018, 2019 and 2021 actual loads, it made sense to base the load forecast on 2020 actual station loads.

This approach was reviewed and accepted by the Study Team during the RIP phase. During the data gathering, some LDCs provided a revised load forecast while the other confirmed no changes to their load forecasts provided earlier to the IESO for the IRRP during the current

Regional Planning cycle. The IESO also updated the CDM and DG targets for the preparation of this RIP load forecast. The load forecast for this RIP was prepared by adjusting the actual 2020 summer peak loads applying an extreme weather correction factor and then applying growth rates derived from the LDCs' forecast. This forecast was further adjusted taking into account the impact of CDM and DGs provided by the IESO. Further details regarding the CDM and connected DG are provided in reference [2] [3]. The load forecast prepared for this RIP is slightly lower than the one prepared by the IESO for the purpose of IRRP but is in the same order of magnitude. The change in the load forecast due to the factors listed above has resulted in the shifting or elimination of previously identified needs, along with the emergence of new needs close to the end of the study period.

5.2. Study Assumptions

The following assumptions are made in this report.

- The study period for the RIP assessments is 2021-2041.
- All facilities that are identified in Section 4 and that are planned to be placed in-service within the study period are assumed to be in-service.
- Summer is the critical period with respect to line and transformer loadings. The assessment is therefore based on summer peak loads.
- Station capacity adequacy is assessed by comparing the non-coincident peak load with the station's normal planning supply capacity, assuming a 90% lagging power factor for stations having no low-voltage capacitor banks and 95% lagging power factor for stations having low voltage capacitor banks. Normal planning supply capacity for transformer stations is determined by the summer 10-day Limited Time Rating (LTR).
- Line capacity adequacy is assessed by using coincident peak loads in the area.
- Adequacy assessment is conducted as per Ontario Resource Transmission Assessment Criteria (ORTAC) [6].

6. Adequacy of Existing Facilities

THIS SECTION REVIEWS THE ADEQUACY OF THE EXISTING TRANSMISSION AND TRANSFORMER STATION FACILITIES SUPPLYING THE KWCG REGION OVER THE PLANNING PERIOD (2021-2041).

During this regional planning cycle three (3) separate assessments have been completed for the KWCG Region. The findings of these studies are the inputs to this Regional Infrastructure Plan (RIP). These assessments are:

- 2018 KWCG Region Needs Assessment (“NA”) Report
- 2019 KWCG Region Scoping Assessment (“SA”) Report
- 2021 KWCG Integrated Regional Resource Plan (“IRRP”) Report

The NA and IRRP reports identified a number of needs to meet the forecasted load demands and assets approaching end of life (EOL). This section provides a review of the adequacy of the transmission lines and stations in the KWCG Region. The adequacy is assessed using the latest regional load forecast provided in Appendix D from a loading perspective. Sections 6.1 to 6.6 present the results of this review. Sustainment aspects were identified in the NA report and are addressed in Section 7 of this report.

6.1. 230 kV Transmission Facilities

All 230 kV transmission circuits in the KWCG Region are classified as part of the Bulk Electricity System (“BES”). They connect the Region to the rest of the Ontario’s transmission system and are also part of the transmission path from generation in Southwestern Ontario to the load centers in the Hamilton, Niagara and GTA areas. These circuits also serve local area stations within the Region and the power flow on them depends on the bulk system transfer as well as local area loads. These circuits are as follows (please refer to Figure 3-1):

a) Detweiler TS to Orangeville TS 230 kV circuits D6V and D7V
    - supplies Fergus TS, Campbell TS, Waterloo North MTS# 3 and Scheifele MTS

b) Detweiler TS to Middleport TS 230 kV circuits M20D and M21D
    - supplies Kitchener MTS# 6, Kitchener MTS# 8, Energy + MTS# 1, Galt TS, Preston TS and Customer # 1 CTS

c) Detweiler TS to Buchanan TS 230 kV circuits D4W and D5W
    - supplies Kitchener MTS# 9

The RIP review of the current load forecast shows that based on the forecasted station loadings, all the above three (3) 230 kV transmission lines are expected to be adequate over the study period.

6.2. 230/115 kV Autotransformer Facilities

Bulk power supply to the KWCG Region is provided by Hydro One's 500 kV to 230 kV and 230 kV to 115 kV autotransformers. The number and location of these autotransformers are as follows:

a) Two 500/230 kV autotransformers at Middleport TS
b) Four 230/115 kV autotransformers at Burlington TS
c) Three 230/115 kV autotransformers at Detweiler TS
d) Two 230/115 kV autotransformers at Cedar TS
e) One 230/115 kV autotransformer at Preston TS

Middleport autotransformers are part of the south-western Ontario bulk supply system and will be studied separately under Middleport bulk planning studies for a more comprehensive understanding of the bulk system needs. However for the purpose of KWCG regional planning needs, these auto-transformer facilities are adequate over the study period.

Burlington TS autotransformers supply the South-Central Guelph 115 area that in turn supply Arlen MTS, Hanlon TS, Customer# 2 CTS and Puslinch DS. The Burlington TS autotransformer facilities are adequate over the study period.

Detweiler TS, Preston TS and Cedar TS autotransformers supply the Kitchener-Guelph 115 kV area that in turn supply Cedar TS, Kitchener MTS #1, Kitchener MTS #3, Kitchener MTS #4, Kitchener MTS #5, Kitchener MTS #7, Elmira TS, Rush MTS and Wolverton DS. The transformation facilities are adequate over the study period.

Note that the Preston TS autotransformer and the 115 kV Kitchener Guelph supply system may not have adequate supply capacity due to its inherent limitation of 115 kV supply system to address the load restoration concerns beyond the study period in case of the simultaneous loss of both the 230 kV circuits, M20D and M21D.

6.3. 115 kV Transmission Facilities

The KWCG Region contains five pairs of double circuit 115 kV lines. This 115 kV network serves local area load. The 115 kV transmission facilities can be divided into five main corridors summarized below.

a) Detweiler TS to Freeport SS 115 kV transmission circuits D7F/D9F
    - supplies Wolverton DS, Kitchener MTS #3, Kitchener MTS#7

b) Freeport SS to Cedar TS 115 kV transmission circuits F11C/F12C
    - supplies Kitchener MTS #5 and Cedar T1/T2 transformers

c) Burlington TS to Cedar TS 115 kV transmission circuits B5C/B6C
    - supplies Puslinch DS, Arlen MTS, Hanlon TS, Customer #2 CTS and Cedar T7/T8 transformers

d) Detweiler TS 115 kV radial transmission circuit D11K/ D12K

- supplies Kitchener MTS #1 and Kitchener MTS #4

e) Detweiler TS to Seaforth TS / Hanover TS 115 kV transmission circuit D8S/D10H with Normally Open (N/O) points

- supplies Rush MTS and Elmira TS (D10H only)

In the near and mid-term, all the 115 kV circuits are adequate and no supply capacity needs are identified under loss of one element. A marginal overloading was identified during the IRRP phase on B5C under the outage scenario of B6C and a subsequent loss of F12C. This marginal overloading can be managed by coordinated outage planning.

In the long term, near the end of the study period, the section of 115 kV D10H circuit between Detweiler TS and tap to Rush MTS may slightly be overloaded following the loss of companion D8S circuit under a peak load scenario. This is a need in the long term and will be revisited in the next planning cycle.

6.4. Step-Down Transformer Station Facilities

There are 24 step-down transformer stations within the KWCG Region. Twenty-two supply electricity to LDCs and two are transmission-connected customer transformer stations. These stations are listed within the load forecast in Appendix D. Of those 24 stations, 15 of them are owned and operated by the LDCs.

The stations summer peak non-coincident load forecast is given in Table D-1 of Appendix D.

TABLE 6-1: KWCG STEP-DOWN EXISTING TRANSFORMER STATIONS

230 kV		115 kV	
Campbell TS	Preston TS	Arlen MTS	Kitchener MTS #5
Energy + MTS # 1	Scheifele MTS	Cedar TS	Kitchener MTS #7
Fergus TS	Waterloo North MTS# 3	Elmira TS	Puslinch DS
Galt TS	CTS# 1	Hanlon TS	Rush MTS
Kitchener MTS # 6		Kitchener MTS# 1	Wolverton DS
Kitchener MTS # 8		Kitchener MTS# 3	CTS # 2
Kitchener MTS # 9		Kitchener MTS # 4	

As a part of RIP assessment, the step-down transformation station capacity was reviewed considering the non-coincident load forecast. Accordingly, the following step down transformation capacity needs are identified. The need timeframe defines the time when the peak load forecast first approaches the station's summer 10 day LTR:

TABLE 6-2: KWCG STEP-DOWN TRANSFORMER STATIONS SUPPLY CAPACITY NEEDS

Stations	Need Timeframe
Kitchener MTS # 5	2028
Cedar TS (T7/T8)	2030
Kitchener MTS # 8 T15/T16	2033
Energy + MTS # 1	2036
Campbell TS (T1/T2)	2038
Preston TS	2038
Arlen MTS	2040
Scheifele MTS	2041
Elmira TS	2041
Waterloo North MTS # 3	2041

6.5. System Reliability and Load Restoration

In case of contingencies on the transmission system, ORTAC provides the load restoration requirements relative to the amount of load affected. Planned system configuration must not exceed 600 MW of load curtailment/rejection. In all other cases, the following restoration times are provided for load to be restored for the outages caused by design contingencies.

- All loads must be restored within 8 hours.
- Load interrupted in excess of 150 MW must be restored within 4 hours.
- Load interrupted in excess of 250 MW must be restored within 30 minutes.

After the in-service of the Guelph Area Transmission Reinforcement project that included the installation of two new 230/115kV autotransformers at Cedar TS, two new 230 kV in-line switches on D6V/D7V circuits to improve restoration capability of Waterloo-Guelph 230 kV sub-system and two new 230kV in-line switches on M20D/M21D circuits to improve restoration capability of the Cambridge-Kitchener 230 kV sub-system; it is expected that all loads can be restored within 8 hours in the KWCG Region over the study period.

A simultaneous loss of M20D and M21D will result in the loss of up to 375 MW of load, by 2041, in the Cambridge area. Up to 150 MW of this load must be restored within 30 minutes as required by ORTAC. This is within the capability of the system and, so, no load restoration concern has been identified in this RIP. However, the Study Team agrees to monitor the load in the region for any new developments to ascertain that load restoration concern are identified ahead of time. Note that the Preston TS autotransformer and the 115 kV Kitchener Guelph supply system may not be adequate due to its inherent limitations to address the load restoration concerns beyond the study period in case of the simultaneous loss of both 230 kV circuits, M20D/M21D.

6.6. Station Short Circuit Capacities [2][3]

The regional planning process identified a need to examine short circuit levels at all the stations in the region as they pertain to LDC equipment ratings as well as to generation or storage resources connection challenges. The particular concerns raised at the time of initiation of this second cycle of the regional planning for the region have since been satisfactorily resolved. However, the Study Team recognizes the importance of a holistic system planning approach, which includes analysis related to short circuit levels.

Distribution system short circuit levels, as measured at the low-voltage (LV) bus of transmission connected transformer stations, are subject to change due to two main driving factors: changes in upstream impedance and changes in amount and type of DERs connected to the station. Changes in upstream impedance typically result from transmission system changes, such as network expansion or reconfiguration or changes in transformer impedance at the time of transformer replacement.

The upstream impedance generally has minimal impact on the station LV actual short circuit level because of the dominant effect of the station transformers impedance. However, changes in the amount and type of DERs connected to a LV bus of a station, unlike changes in upstream impedance, have a significant and direct impact on the station's LV short circuit level.

While equipment which limits the available short circuit capacity on the LV side of a transformer station may have options to be upgraded with higher rated equipment, the Study Team is cognizant that there is an effective practical limit to this rating established by in Appendix 2 of the Transmission System Code. Distribution systems components, including equipment owned by end-use customers, in Ontario, is designed, manufactured, and applied to this standard, which effectively is:

- 500 MVA @ 13.8 kV
- 800 MVA @ 27.6 kV
- 1500 MVA @ 44 kV

The amount of DER that can be connected to a station LV bus is thus limited by the above-mentioned short circuit level requirements. Some stations may have a smaller value due to pre-existing legacy equipment which was adequate and is deemed to be grandfathered. Hence, in examining the rated short circuit capacity of LV station components, the Study Team used lowest equipment rating, or TSC rating, whichever is lower in identifying stations that are at or approaching short circuit capacity limits.

Appendix E lists all stations in the KWCG region where new DER connection is restricted due to the LV short circuit level being extremely high, that is approximately equal to or greater than 90% of the equipment ratings or the TSC ratings capacity. The information presented in this table is obtained with consideration of known generation connections as of March 2021 and is subject to change primarily due to new DER connections.

The appropriate LDC should be consulted for up-to-date short circuit information and feasibility of connecting new DER.

6.7. Longer Term Outlook

While the RIP was focused on the 2021-2041 period, the Study Team has also looked at longer-term electricity sector scenarios and uncertain load growth possibilities within the study period under certain pockets within the KWCG region. Following two subsections describes two such items that requires longer-term insight for the regional needs.

6.7.1. Other Planning Considerations in the KWCG Region

Municipalities in KWCG region have developed their community energy plans with a primary focus to reduce their energy consumption by local initiatives over next 25 to 30 years. With respect to electricity, these communities are planning for an increased reliance on community energy sources such as distributed generation, generation behind the meters like rooftop solar systems and local battery storage systems to reduce cost and for improved reliability of electricity supply. The implementation timelines, as suggested in these plans, starts in longer term just near the end of the study period and requires greater attention in the next regional planning cycle.

Note that community energy plans may have potential to supplement and/or defer future transmission infrastructure development needs. The Study Team therefore recommends reviewing the community energy plans in the next regional planning cycle.

There are situations where behind the meter battery storage cannot be connected due to technical constraints. The LDCs in this region and Hydro One, outside the regional planning forum, can undertake the task of exploring the issue to assess technical constraints and /or other solutions that can facilitate connection of additional battery storage.

In parallel and within the Conservation and Demand Management initiatives, communities are also working towards self-sufficiency by improving efficiencies of existing local energy systems i.e. reducing energy consumption and losses by means of utilizing smarter buildings, houses, efficient heating, cooling, appliances, equipment, and processes for all community needs. Ultimately, the objective of these energy plans in the region is to be a net zero carbon community.

6.7.2. Uncertain Load Growths

There are some load growth possibilities in pockets of the region where, due to lack of confirmed status of development projects or uncertainty with connection point, were not included in the load forecast. These load growth triggers will be closely monitored and reviewed for further analysis in the next regional planning cycle:

- Metrolinx electrification project: Metrolinx is electrifying its rail lines and planning a traction power substation (TPSS). The amount of traction load is insignificant but has a very sensitive and peculiar characteristics that makes it troublesome for other customers in a weaker system. The connection point of TPSS is not yet finalized and therefore has a higher uncertainty.
- East Side Lands: Energy + is expecting load growth in its east side lands and are planning Energy + MTS # 2 to meet the increased load demand which has not materialized yet. Similarly, Waterloo North Hydro is also anticipating load growth in

the east side lands near Scheifele TS and are planning WNH MTS # 4 to cater the new load growth and some existing loads currently supplied from Scheifele TS. In addition, Hydro One is carrying out end of life like for like replacement of transformers at Preston TS in the 2026-2027 timeframe that will impart additional supply capacity to the station due to the alleviation of an inherent equipment limitation. This incremental capacity to be available in 2026 at Preston TS would be examined to determine if it is technically and economically feasible, meeting power quality requirements, to service both Energy+ and Waterloo North Hydro's East Side Lands development and surrounding areas under normal and/or contingency situations. These needs along with increased station capacity, therefore, will be revisited in the next regional planning cycle for optimal solution, hoping to have more clarity on the development projects in the pocket by then.

- Development of other projects such as Data Centers and Light Rail Transit from Kitchener to Cambridge will be monitored and assessed in the next regional planning cycle.

7. Regional Needs and Plans

THIS SECTION DISCUSSES ELECTRICAL INFRASTRUCTURE NEEDS IN THE KWCG REGION IDENTIFIED IN THE PREVIOUS REGIONAL PLANNING CYCLE, THE NEEDS ASSESSMENT REPORT FOR THIS CYCLE, SCOPING ASSESSMENT AND THE IRRP; AND SUMMARIZES THE PLANS DEVELOPED TO ADDRESS THESE NEEDS.

This section outlines and discusses infrastructure needs and plans to address these needs for the near-term (up to 5 years) and the mid-to long-term (beyond 5 years) planning horizon. This includes long-term needs associated with sustainment plans and the supply capacity needs. The long term needs will be assessed in the next regional planning cycle.

The near-term and mid to long-term electrical infrastructure needs in the Region are summarized below in Table 7.1 and Table 7.2, respectively. The details of the project / plan are discussed further in sections 7.1 and 7.2.

TABLE 7-3: IDENTIFIED NEAR AND MID-TERM NEEDS IN KWCG REGION

No.	Needs	Project / Need Timeframe	Section
1	Hanlon TS: EOL T1/T2 Supply Transformers Replacement	2022-2023	7.2
2	Kitchener MTS #5: EOL T9/T10 Supply Transformers Replacement	2023-2024	7.2
3	Scheifele MTS: EOL T1/T2 Supply Transformers Replacement	2025-2026	7.3
4	115 kV B5C/ B6C: EOL Burlington TS to Westover CTS Line Sections Refurbishment	2025-2026	7.2
5	Preston TS: EOL T3/T4 Supply Transformers Replacement	2026-2027	7.3
6	Cedar TS: EOL T7/T8 Supply Transformers Replacement	2026-2027	7.3

TABLE 7-4: IDENTIFIED LONG-TERM NEEDS IN KWCG REGION

No.	Needs	Timing	Section
1	Fergus TS: EOL T3/T4 Supply Transformers Replacement	2028-2029	7.3
2	Galt TS: EOL Breakers and other component Replacement	2028-2029	7.3
3	Campbell TS: EOL three (3) Breakers and other component Replacement	2028-2029	7.3
4	Kitchener MTS # 8 (T15/T16): Station Supply Capacity	2033	7.4
5	Energy + MTS # 1: Station Supply Capacity	2036	7.4
6	Campbell TS (T1/T2): Station Supply Capacity	2038	7.4

7	Arlen MTS: Station Supply Capacity	2040	7.4
8	Elmira TS: Station Supply Capacity	2041	7.4
9	Waterloo North MTS # 3: Station Supply Capacity	2041	7.4

7.1. Deteriorating Infrastructure, Optimization Opportunities and Replacement Plan of Major Equipment

7.1.1. Deteriorating Infrastructure

Hydro One and LDCs have provided high voltage asset information under the following categories that have been identified at this time and are likely to be replaced over the next 10 years:

- Autotransformers
- Power transformers
- HV breakers
- Transmission lines requiring refurbishment where an uprating is being considered for planning needs and require Leave to Construct (i.e., Section 92) application and approval
- HV underground cables where an uprating is being considered for planning needs and require EA and Leave to Construct (i.e., Section 92) application and approval

The end-of-life (EOL) assessment, which includes right sizing, for the above high voltage equipment typically includes consideration of the following options:

1. Maintaining the status quo;
2. Replacing equipment with similar equipment of lower ratings and built to current standards;
3. Replacing equipment with lower ratings and built to current standards by transferring some load to other existing facilities;
4. Eliminating equipment by transferring all of the load to other existing facilities;
5. Replacing equipment with similar equipment and built to current standards (i.e, “like-for-like” replacement);
6. Replacing equipment with higher ratings and built to current standards; and
7. Station reconfiguration

Accordingly, following major high voltage equipment has been identified as approaching its end of life, based on current condition information, over the next 10 years.

TABLE 7-5: DETERIORATING INFRASTRUCTURE, EOL NEEDS IN KWCG REGION

Stations / Lines Project	Details	Timeframe	High Level Cost[4] ($M)
Hanlon TS	T1/ T2 Transformer Replacement	2022-2023	17.8
Kitchener MTS #5	T9/ T10 Transformer Replacement	2023-2024	7.5
Scheifele MTS	T1/ T2 Transformer Replacement	2025-2026	-
B5C/B6C	Refurbishing 115kV line section from Burlington TS to Enbridge Westover CTS	2025-2026	16.8
Preston TS	T3/ T4 Transformer Replacement	2026-2027	22.9
Cedar TS	T7/ T8 Transformer Replacement	2026-2027	23.7
Fergus TS	T3/ T4 Transformer Replacement	2028-2029	30.0
Galt TS	Breakers and Other Component Replacement	2028-2029	12.0
Campbell TS	Breakers and Other Component Replacement	2028-2029	18.1

Maintaining status quo is not an option for any of the end of life autotransformers, station transformers or line sections due to risk of equipment failure, and would result in increased maintenance cost and prolonged customer outages and interruptions. Replacing "like-for-like" with nonstandard transformers would result in complexity with failures, difficulty with spares management strategies and with unique installation requirements. Nonstandard equipment also poses serious safety risk for employees under normal and emergency situations.

No other lines or HV station equipment in the KWCG region than listed above, have been identified for major replacement/refurbishment at this time.

7.1.2. Optimization Opportunities and Replacement Plans

For stations in the Cambridge-Guelph sub region, an analysis of the current distribution situation that includes under-utilized dedicated feeder capacities, determined that there are not enough spare feeder positions and capacity at HONI and Alectra stations to reallocate DESN loads in the sub-system without significant distribution system and neighboring station upgrades.

Similar is the situation with Kitchener-Waterloo sub region and therefore there are little or no significant optimization opportunities present at this time.

[4] Budgetary estimates

Hence, the Study Team recommends that the LDCs undertakes replacement of their end-of-life high voltage equipment as planned with standard size units, being technically and economical most suitable solution.

7.2. Needs in Near-Term (Projects in Execution)

The following end-of-life refurbishment needs are under execution. These needs were identified in the earlier phases of this 2nd cycle of regional planning.

7.2.1. 115 kV B5C/ B6C Line Sections

The 115 kV B5C/B6C circuits consist of about 45 km of double circuit line and 15 km of single circuit line supplying South-Central Guelph 115 kV loads. About 12 km of double circuit line section from Burlington TS to Harper's Jct. and about 15 km B5C 115 kV line tap from Harper's Jct. to a Westover Jct. requires refurbishment.

Not refurbishing these line sections would increase risk of failure due to asset condition, maintenance expenses and reduce supply reliability to the customers.

The refurbishment of the 27 km 115 kV B5C/B6C line sections from Burlington TS to a CTS is currently under execution and the work is planned to be completed by the end of year 2025. The delay in the in-service is attributed to a hold on project due to outage concerns with a customer.

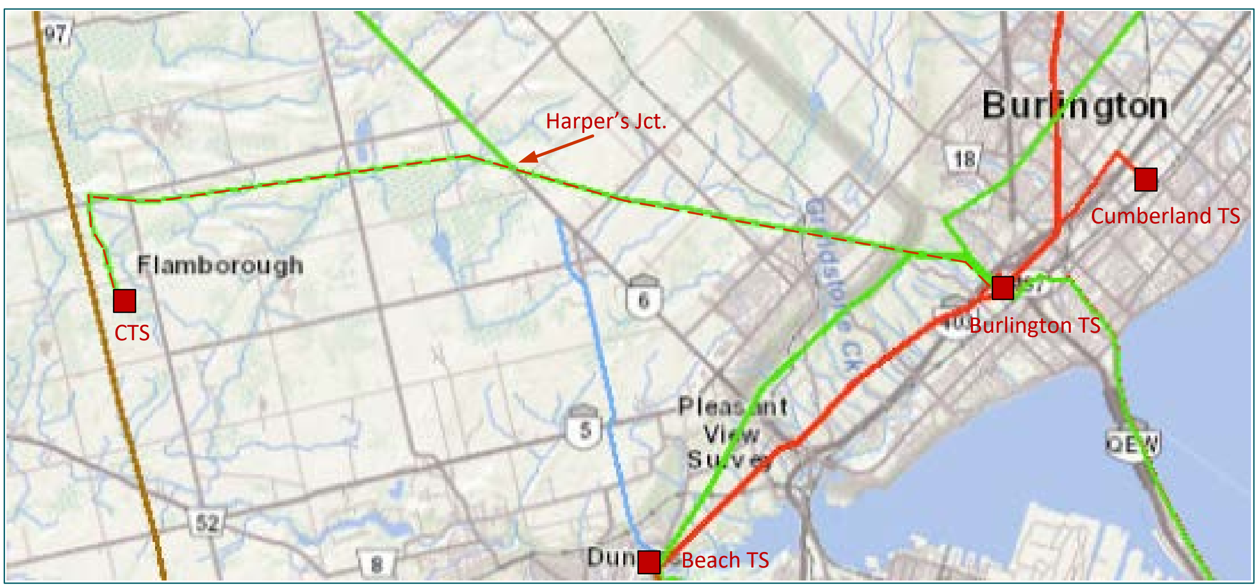

FIGURE 7-6: BURLINGTON TS TO HARPER'S JCT. TO CTS

7.2.2. Hanlon TS T1/T2 Transformer

Hanlon TS is located south of the city of Guelph supplying Alectra loads. Hanlon TS is a single T1/T2 DESN station of 33 MVA nonstandard transformers having a LTR of 48 MVA (43 MW @ 0.9 PF). This station is currently supplying about 27.5 MW of peak load. The loads at Hanlon TS are currently forecasted to remain flat over the entire study period. The supply capacity of this station is therefore expected to be sufficient over and beyond the study period.

The T1/T2 transformers were built in 1955-56 and have been identified as EOL due to poor condition requiring replacement. At this time none of other HV/LV equipment at this station has been identified as approaching EOL over the next 5-10 years.

There are no nearby supply stations to Hanlon TS with surplus capacity where this station's loads can be transferred therefore Hydro One plans to replace these EOL transformers with standard size units of 42 MVA in 2022-2023.

7.2.3. Kitchener MTS #5 T9/T10 Transformers

Kitchener MTS #5 is located in the city of Kitchener supplying Kitchener-Wilmot Hydro Inc. loads. Kitchener MTS #5 is a 115/ 13.8 kV single T9/T10 DESN station of 83 MVA nonstandard transformers having a LTR of 89 MVA (80 MW @ 0.9 PF), currently supplying 67 MW of peak load. The loads at Kitchener MTS #5 are currently forecasted to grow at about 15% over the entire study period and approaches the supply capacity of this station by 2028.

Both the T9/T10 transformers at this station have been identified as approaching end of life requiring replacement. At this time none of other HV/LV equipment at this station has been identified as approaching EOL over the next 5-10 years.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Kitchener MTS #5 having surplus capacity where this station's loads can be transferred. The Study Team recommends replacing the T9/T10 nonstandard transformers with standard units of similar or greater size, that can provide higher LTR for station capacity to be sufficient beyond study period, is the preferred option. Kitchener-Wilmot Hydro Inc. and Hydro One will coordinate the replacement plan of these transformers. The replacement of the EOL equipment is expected to be completed by 2023-2024.

7.3. Needs in Near, Mid and Long Term

The following end-of-life refurbishment needs have been identified in this regional planning cycle:

7.3.1. Scheifele MTS – T1/ T2 Transformers

Scheifele MTS is located in the city of Waterloo supplying Waterloo North Hydro Inc. loads. Scheifele MTS has four 230/13.8 kV transformers T1 and T2 of 69 MVA (LTR), and T3 and T4 of 110 MVA (LTR) currently supplying 145 MW of peak loads. The load at this station is forecasted to remain almost flat over the entire study period. The total supply capacity of Scheifele MTS is 161 MW expected to be sufficient over the study period, except marginal overloading in 2041.

The T1/T2 transformers based on their age have been identified by Waterloo North Hydro Inc. as approaching end of life potentially requiring replacement in the 2025- 2026 timeframe. Waterloo North Hydro will be monitoring the condition of these transformers to assess their replacement need. At this time none of other HV/LV equipment at this station has been identified as approaching EOL over the next 5-10 years.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Scheifele MTS having surplus capacity where this station’s loads can be transferred. The Study Team recommends that Waterloo North Hydro continue monitoring the condition of these T1/T2 transformers at Scheifele MTS and if required, proceed with replacement plan otherwise this need may be reassessed in the next regional planning cycle.

7.3.2. Cedar TS – T7/ T8 Transformers

Cedar TS is located in the city of Guelph supplying Alectra loads. Cedar TS has two 115/13.8 kV DESN units T1/T2 and T7/T8 of 75 MVA with a LTR of 115 MVA (103 MW @ 0.9 PF) and 37 MVA with a LTR of 44 MVA (40 MW @ 0.9 PF), currently supplying 67 MW and 36 MW of peak loads respectively. The loads at both Cedar TS DESNs are currently forecasted to grow at an average of about four percent (4%) over the entire study period. The supply capacity of T7/T8 may approach its LTR by year 2030 while that of T1/T2 is expected to be sufficient over the study period.

The T7/T8 DESN 38 MVA nonstandard transformers were built in 1958 and have been identified for replacement due to poor condition. The T1/T2 transformers are relatively newer and were built in early 1990s. At this time none of other HV/LV equipment at this station has been identified as approaching EOL over the next 5-10 years.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Cedar TS having surplus capacity where this station’s loads can be transferred therefore the Study Team recommends replacing the nonstandard transformers with standard units of 42 MVA in 2026-2027 timeframe, which will impart sufficient capacity (higher LTR) to the station over the study period.

7.3.3. Preston TS T3/T4 Transformers

Preston TS (DESN) is located in the city of Cambridge supplying Energy+ loads. Preston TS is a single T3/T4 DESN station of 125 MVA transformers with no additional LTR capability available i.e. 125 MVA (113 MW @ 0.9 PF). This station is currently supplying about 92 MW of peak load. The loads at Preston TS are currently forecasted to peak at about 120 MW during the study period.

The T3/T4 transformers are almost 50 years old, having been built in 1968. Condition assessment has identified that both T3/T4 transformers at EOL, requiring replacement. At this time none of other HV/LV equipment at this station has been identified as EOL over the next 5-10 years.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Preston TS having spare supply capacity where this station’s loads can be transferred. The Study Team recommends replacing the existing 125 MVA 230/ 27.6 kV T3/T4 transformers at Preston

TS with 125 MVA standard units. This will also result in an increased supplying capacity at Preston TS due to the alleviation of an inherent equipment limitation, required to meet the future Energy+ needs in the Cambridge distribution area. This incremental capacity may be available for Waterloo North Hydro's East-Side-Lands development as deemed technically and economically feasible, meeting power quality requirements. The replacement plan for the equipment will be developed by Hydro One and coordinated with the affected LDC and/or customers and it is expected to be completed by 2026-2027.

7.3.4. Fergus TS T3/T4 Transformers

Fergus TS is located in the township of Fergus supplying various loads LDCs in the KWCG region. Fergus TS has two 230/ 44 kV transformers T3 and T4 of 75/100/125 MVA, currently supplying 90 MW of peak loads. The load at this station is forecasted to grow at about 20 percent over the entire study period. The total supply capacity of Fergus TS is 154 MW expected to be more than adequate over the study period.

The T3/T4 transformers are almost 50 years old, having been built in 1972. Condition assessment has identified that both T3/T4 transformers and the feeder breakers are at their EOL requiring replacement.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Fergus TS having surplus capacity where this station's loads can be transferred. The Study Team recommends that Hydro One continue monitoring the condition of these T3/T4 transformers and other components at Fergus TS and if required proceed with the replacement plan by 2028-2029 or otherwise this need may be reassessed in the next regional planning cycle.

7.3.5. Galt TS Breakers and Components

Galt TS is located in the city of Cambridge supplying Energy + loads in the KWCG region. Galt TS has two 230/ 28-28 kV transformers T7 and T8 of 75/100/125 MVA, currently supplying 112 MW of peak loads. The load at this station is forecasted to grow at about 20 percent over the entire study period. The total supply capacity of Galt TS is 169 MW, expected to be more than adequate over the study period.

The T7/T8 transformers were replaced in 2010 and 2012 respectively to technical issue with the transformers. The breakers and other component at the station are almost 50 years old. Condition assessment has identified that these components are at EOL, requiring replacement.

The station cannot be downsized or eliminated because there is no nearby supply station/s to Galt TS having surplus capacity where this station's loads can be transferred. The Study Team recommends that Hydro One continue monitoring the condition of these EOL components at Galt TS and if required proceed with the replacement plan by 2028-2029 or otherwise this need may be reassessed in the next regional planning cycle.

7.3.6. Campbell TS (T1/T2) Breakers

Campbell TS is located in the city of Guelph supplying Alectra loads. Campbell TS has two 230/13.8 kV DESNs T1/T2 and T3/T4, both 100 MVA transformers. The loads on these two DESNs are currently supplying about 89 MW and 47 MW respectively and their loads are forecasted to grow at about 9 percent by the end of study period.

Two feeder breakers and a tie breaker for T1/T2 DESN are deemed to be end of life and requires replacement. Replacing these three breakers will impart additional 5 to 7 MW of capacity to the DESN, help mitigating the marginal station supply capacity concern at the end of the study period. The Study Team recommends implementing replacement plan by 2028-2029.

7.4. Mid and Long Term Supply Capacity Needs

When the station capacities were reviewed considering the net peak load forecast, below listed ten (10) stations were identified to approach their 10 day LTR. The last four stations were found to approach their 10 day LTR just at the end of the study period of this second regional planning cycle.

TABLE 7-4: KWCG STEP-DOWN TRANSFORMER STATIONS SUPPLY CAPACITY NEEDS

Stations	Need Timeframe
Kitchener MTS #5	2028
Cedar TS (T7/T8)	2030
Kitchener MTS #8 T15/T16	2033
Energy + MTS # 1	2036
Campbell TS (T1/T2)	2038
Preston TS	2038
Arlen MTS	2040
Scheifele MTS	2041
Elmira TS	2041
Waterloo North MTS # 3	2041

The deteriorating infrastructure replacement plans at Kitchener MTS # 5 (T9/T10), Scheifele MTS, Preston TS and Cedar TS (T7/T8) will help mitigate the station supply capacity needs of these stations over and beyond the study period. The Study Team recommends to review other long term station supply capacity needs in the next regional planning cycle.

8. Conclusions and Next Steps

THIS REGIONAL INFRASTRUCTURE PLAN CONCLUDES THE REGIONAL PLANNING PROCESS FOR THE KWCG REGION.

The major infrastructure investments recommended by the Study Team in the near and mid-term planning horizon are provided in Table 8-1 below are all end of life needs, along with their planned in-service date and budgetary estimates for planning purpose.

TABLE 8-6: RECOMMENDED PLANS IN KWCG REGION OVER THE NEXT 10 YEARS

Stations / Lines Project	Details	Timeframe	High Level Cost[5] ($M)
Hanlon TS	Transformers T1 and T2 Replacement	2022-2023	17.8
Kitchener MTS #5	Transformers T9 and T10 Replacement	2023-2024	7.5
Scheifele MTS	Transformers T1 and T2 Replacement	2025-2026	-
B5C/B6C	115KV Lines Refurbishment, refurbishing section from Burlington TS to Enbridge Westover CTS	2025-2026	16.8
Preston TS	Transformers T3 and T4 Replacement	2026-2027	22.9
Cedar TS	Transformers T7 and T8 Replacement	2026-2027	23.7
Fergus TS	Transformers T3 and T4 Replacement	2028-2029	30.0
Galt TS	End of life Breakers and Other Component Replacement	2028-2029	12.0
Campbell TS	End of life Breakers and Other Component Replacement	2028-2029	18.1

The Study Team recommends that:

- Hydro One and LDCs to continue with the implementation of infrastructure investments listed in Table 8-1 above while keeping the Study Team apprised of project status;
- All the other identified needs/options in the long-term will be further reviewed by the Study Team in the next regional planning cycle.

[5] Budgetary estimates

References

[1] KWCG Region Regional Infrastructure Plan (2015)
[2] KWCG Integrated Regional Resource Plan (2021)
[3] KWCG Integrated Regional Resource Plan - Appendices (2021)
[4] KWCG Region Needs Assessment (2018)
[5] Planning Process Working Group (PPWG) Report to the Board: The Process for Regional Infrastructure Planning in Ontario – May 17, 2013
[6] Ontario Resource and Transmission Assessment Criteria

Appendix A. Stations in the KWCG Region

Station*	Voltage (kV)	Supply Circuits
Waterloo-Guelph 230 kV sub-system		
Fergus TS	230 kV	D6V/D7V
Scheifele MTS	230 kV	D6V/D7V
Waterloo North MTS #3	230 kV	D6V/D7V
Campbell TS	230 kV	D6V/D7V
Cambridge-Kitchener 230 kV sub-system		
Kitchener MTS #6	230 kV	M20D/M21D
Kitchener MTS #8	230 kV	M20D/M21D
Energy + MTS #1	230 kV	M20D/M21D
Preston TS	230 kV	M20D/M21D
Galt TS	230 kV	M20D/M21D
Customer #1 CTS	230 kV	M21D
Kitchener–Guelph 115 kV sub-system		
Wolverton DS	115 kV	D7F/D9F
Kitchener MTS #3	115 kV	D7F/D9F
Kitchener MTS #7	115 kV	D7F/D9F
Kitchener MTS #5	115 kV	F11C/F12C
Cedar TS (T1/T2)	115 kV	F11C/F12C
South-Central Guelph 115 kV sub-system		
Puslinch DS	115 kV	B5C/B6C
Arlen MTS	115 kV	B5C/B6C
Hanlon TS	115 kV	B5C/B6C
Cedar TS (T8/T7)	115 kV	B5C/B6C
Customer #2 CTS	115 kV	B5C
Other Stations in the KWCG Region		
Kitchener MTS #9	230 kV	D4W/D5W
Rush MTS	115 kV	D8S/D10H
Elmira TS	115 kV	D10H
Kitchener MTS #1	115 kV	D11K/D12K
Kitchener MTS #4	115 kV	D11K/D12K

*All MTSs are LDC owned stations

Appendix B. Transmission Lines in the KWCG Region

Location	Circuit Designations	Voltage (kV)
Detweiler TS – Orangeville TS	D6V/D7V	230 kV
Detweiler TS - Middleport TS	M20D/M21D	230 kV
Detweiler TS - Buchanan TS	D4W/D5W	230 kV
Detweiler TS - Freeport SS	D7F/D9F	115 kV
Freeport SS - Cedar TS	F11C/F12C	115 kV
Burlington TS - Cedar TS	B5C/B6C	115 kV
Detweiler TS – Kitchener MTS # 4	D11K/D12K	115 kV
Detweiler TS – Palmerston TS	D10H	115 kV
Detweiler TS – Seaforth TS	D8S	115 kV

Appendix C. Distributors in the KWCG Region

Distributor Name	Station Name	Connection Type
Alectra Utilities Corporation	Fergus TS	Dx
Alectra Utilities Corporation	Arlen MTS	Tx
	Campbell TS	Tx
	Cedar TS	Tx
	Hanlon TS	Tx
Centre Wellington Hydro Ltd.	Fergus TS	Dx
Energy + Inc.	Energy + MTS# 1	Tx
	Galt TS	Tx
	Preston TS	Tx
	Wolverton DS	Dx
Halton Hills Hydro Inc.	Fergus TS	Dx
Hydro One Networks Inc.	Fergus TS	Tx
	Elmira TS	Tx
	Puslinch DS	Tx
	Wolverton DS	Tx
	Galt TS	Dx
Kitchener-Wilmot Hydro Inc.	Kitchener MTS#1	Tx
	Kitchener MTS#3	Tx
	Kitchener MTS#4	Tx
	Kitchener MTS#5	Tx
	Kitchener MTS#6	Tx
	Kitchener MTS#7	Tx
	Kitchener MTS#8	Tx
	Kitchener MTS#9	Tx
Milton Hydro Distribution Inc.	Fergus TS	Dx
Waterloo North Hydro Inc.	Elmira TS	Dx
		Tx
	Fergus TS	Dx
	Rush MTS	Tx
	Scheifele MTS	Tx
	Waterloo North MTS #3	Tx
	Preston TS	Dx
	Kitchener MTS#9	Dx
Wellington North Power Inc.	Fergus TS	Dx

Appendix D. KWCG Region Load Forecast

TABLE D1: KWCG NET NON-COINCIDENT LOAD FORECAST

Transformer Station	Station Capacity	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Arlen MTS	45	26	27	27	28	29	30	30	31	32	33	34	35	36	38	39	40	41	42	44	45	46
Campbell TS (T1/T2)	94	86	86	86	86	86	86	86	86	87	87	88	90	91	92	92	93	94	94	95	95	96
Campbell TS (T3/T4)	56	46	46	46	45	45	46	46	46	46	46	47	47	48	48	48	49	49	49	50	50	50
Cedar TS (T1/T2)	103	93	94	94	95	96	96	97	97	98	99	99	99	100	100	100	101	101	101	101	101	102
Cedar TS (T7/T8)	40	30	32	34	35	37	38	38	39	40	40	41	41	41	41	41	42	42	42	42	42	43
Elmira TS	55	34	35	35	35	36	36	37	38	38	39	40	41	42	49	50	51	52	53	54	55	56
EnergyInc(Cam) MTS#1	102	86	87	87	87	87	88	89	90	91	93	94	96	97	99	101	103	104	106	107	108	110
Fergus TS	154	88	91	91	91	92	92	93	94	94	95	98	99	103	104	106	108	108	109	110	111	111
Galt TS	169	112	113	113	114	115	116	117	118	120	122	124	125	127	129	132	134	136	137	139	141	143
Hanlon TS	43	27	28	28	28	29	29	29	30	30	31	31	32	32	33	33	34	34	35	36	36	37
Kitchener MTS # 1	54	33	34	34	34	35	35	36	36	37	38	38	39	40	41	41	42	43	43	44	45	45
Kitchener MTS # 3	108	55	55	55	56	56	57	57	58	59	59	60	61	62	63	64	65	66	67	67	68	69
Kitchener MTS # 4	90	54	55	55	55	55	56	56	56	57	58	58	59	60	61	61	62	63	63	64	64	65
Kitchener MTS#5	80	77	77	77	78	78	78	79	80	80	81	82	83	84	85	86	87	88	88	89	90	91
Kitchener MTS#6	90	72	73	73	73	74	74	75	76	76	77	78	79	80	81	82	83	83	84	85	86	87
Kitchener MTS#7	54	34	34	34	34	35	35	35	36	36	37	38	38	39	40	40	41	41	42	42	43	43
Kitchener MTS#8	54	37	38	40	41	42	44	45	47	48	50	51	53	55	56	58	60	61	63	64	66	68
Kitchener MTS#9	90	32	33	33	33	33	33	34	34	34	35	35	36	36	37	38	38	39	40	40	41	41
Preston TS	113	90	92	93	93	94	95	96	97	99	100	102	103	105	107	109	110	112	114	115	117	118
Puslinch DS	56	31	32	32	32	32	32	33	33	34	34	34	35	35	36	36	37	37	38	38	39	39
Rush MTS	68	52	52	52	52	52	52	53	53	54	54	58	58	59	60	60	61	61	62	63	63	64
Scheifele MTS	161	140	140	140	140	141	142	143	144	145	147	145	147	149	150	152	154	155	157	158	160	161
Waterloo North MTS 3	77	51	53	53	54	54	55	56	57	59	60	61	62	64	65	67	68	70	71	73	74	76
Wolverton DS	54	12	13	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	14
CTS Total	-	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Total	**-**	**1409**	**1428**	**1433**	**1441**	**1453**	**1467**	**1482**	**1498**	**1516**	**1536**	**1560**	**1581**	**1607**	**1636**	**1662**	**1682**	**1702**	**1722**	**1742**	**1762**	**1782**

TABLE D2: KWCG NET COINCIDENT LOAD FORECAST

Transformer Station	Station Capacity	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Arlen MTS	45	26	26	27	27	28	29	30	31	32	32	33	34	36	37	38	39	40	41	43	44	45
Campbell TS (T1/T2)	94	81	81	80	80	80	80	81	81	81	82	82	84	85	86	87	87	88	88	89	89	90
Campbell TS (T3/T4)	56	42	42	42	41	41	42	42	42	42	42	43	43	44	44	44	45	45	45	45	46	46
Cedar TS (T1/T2)	103	76	77	77	77	78	79	79	79	80	80	81	81	81	82	82	82	82	83	83	83	83
Cedar TS (T7/T8)	40	27	29	30	31	33	34	34	35	35	36	36	36	36	37	37	37	37	37	38	38	38
Elmira TS	55	33	34	34	35	35	36	36	37	38	38	39	40	41	48	49	50	51	52	53	54	55
EnergyInc(Cam) MTS#1	102	86	86	86	86	87	88	89	90	91	92	94	95	97	98	100	102	103	105	106	108	109
Fergus TS	154	87	89	90	90	90	91	91	92	93	94	96	97	101	103	105	106	107	107	108	109	110
Galt TS	169	112	113	113	114	115	116	117	118	120	122	124	125	127	129	132	134	136	137	139	141	143
Hanlon TS	43	25	26	26	26	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34
Kitchener MTS # 1	54	33	34	34	34	35	35	36	36	37	38	38	39	40	41	41	42	43	43	44	45	45
Kitchener MTS # 3	108	53	53	53	53	54	54	55	56	56	57	58	59	60	61	62	63	63	64	65	65	66
Kitchener MTS # 4	90	54	55	55	55	55	56	56	56	57	58	58	59	60	61	61	62	63	63	64	64	65
Kitchener MTS#5	80	73	74	74	74	74	74	75	76	76	77	78	79	80	80	82	83	83	84	85	85	86
Kitchener MTS#6	90	66	67	67	67	67	68	68	69	70	70	71	72	73	74	75	76	76	77	78	78	79
Kitchener MTS#7	54	34	34	34	34	35	35	35	36	36	37	38	38	39	40	40	41	41	42	42	43	43
Kitchener MTS#8	54	37	38	39	40	42	43	45	46	48	49	51	52	54	56	57	59	61	62	64	65	67
Kitchener MTS#9	90	32	32	32	32	33	33	33	34	34	34	35	35	36	37	37	38	38	39	40	40	41
Preston TS	113	74	76	76	76	77	77	78	79	80	81	83	84	85	87	89	90	91	93	94	95	97
Puslinch DS	56	29	30	30	30	30	30	31	31	32	32	32	33	33	34	34	35	35	35	36	36	37
Rush MTS	68	49	49	49	49	50	50	50	51	51	52	55	56	56	57	57	58	58	59	60	60	61
Scheifele MTS	161	122	122	122	122	122	123	124	125	126	127	126	128	129	131	133	134	135	137	138	139	141
Waterloo North MTS 3	77	50	51	52	52	53	54	55	56	57	58	60	61	63	64	65	67	68	70	71	72	74
Wolverton DS	54	12	13	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	14
CTS Total	-	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Total	**-**	**1323**	**1340**	**1344**	**1350**	**1361**	**1375**	**1388**	**1404**	**1421**	**1439**	**1462**	**1483**	**1508**	**1536**	**1561**	**1581**	**1599**	**1619**	**1637**	**1657**	**1675**

Appendix E. Stations with Extremely High Short Circuit Level*

Station	Bus	Owner	Nominal Voltage (kV)	Short Circuit Capacity** (MVA)	Short Circuit Level (MVA)
Campbell TS	EZ	Hydro One	13.8	443	437
Kitchener MTS # 1	B1B2	Kitchener-Wilmot Hydro	13.8	468	447
Kitchener MTS # 3	B51B61	Kitchener-Wilmot Hydro	13.8	468	436
	B52B62	Kitchener-Wilmot Hydro	13.8	468	474***
Kitchener MTS # 4	B71B81	Kitchener-Wilmot Hydro	13.8	468	466
	B72B82	Kitchener-Wilmot Hydro	13.8	468	467
Kitchener MTS # 5	B91B101	Kitchener-Wilmot Hydro	13.8	468	415
	B92B102	Kitchener-Wilmot Hydro	13.8	468	415
Kitchener MTS # 6	B111B121	Kitchener-Wilmot Hydro	13.8	468	459
	B112B122	Kitchener-Wilmot Hydro	13.8	468	459
Kitchener MTS # 7	B13B14	Kitchener-Wilmot Hydro	13.8	468	446
Rush MTS	B1B2	Waterloo North Hydro	13.8	467	441
Scheifele MTS A	BY	Waterloo North Hydro	13.8	500	455
Scheifele MTS B	QT	Waterloo North Hydro	13.8	500	454

*** Data provided in this table are valid as of March 2021. For up-to-date information, contact LDCs.**

**** Capacities smaller than TSC requirement are due to pre-existing legacy equipment which was adequate and is deemed to be grandfathered.**

***** To be replaced.**

Appendix F. List of Acronyms

Acronym	Description
A	Ampere
BES	Bulk Electric System
BPS	Bulk Power System
CDM	Conservation and Demand Management
CIA	Customer Impact Assessment
CGS	Customer Generating Station
CSS	Customer Switching Station
CTS	Customer Transformer Station
DESN	Dual Element Spot Network
DG	Distributed Generation
DSC	Distribution System Code
GATR	Guelph Area Transmission Reinforcement
GS	Generating Station
HV	High Voltage
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kV	Kilovolt
LDC	Local Distribution Company
LP	Local Plan
LTE	Long Term Emergency
LTR	Limited Time Rating
LV	Low Voltage
MTS	Municipal Transformer Station
MW	Megawatt
MVA	Mega Volt-Ampere
MVAR	Mega Volt-Ampere Reactive
NA	Needs Assessment
NERC	North American Electric Reliability Corporation
NGS	Nuclear Generating Station
NPCC	Northeast Power Coordinating Council Inc.
OEB	Ontario Energy Board
ORTAC	Ontario Resource and Transmission Assessment Criteria
PF	Power Factor
PPWG	Planning Process Working Group
RIP	Regional Infrastructure Plan
SA	Scoping Assessment
SIA	System Impact Assessment
SPS	Special Protection Scheme
SS	Switching Station
TS	Transformer Station
TSC	Transmission System Code