1.5.7 Incremental Hosting Capacity Determination

N-1 contingency analysis for each bus was determined using a multi-step process. The first step in the process was to determine the N-0 export capability for each bus. This was done by netting the load and generation to determine where the distribution transformer or a radial supply line was at or above capability. The second step was to determine the N-1 export capability for each bus. The objective was to determine the amount of additional capacity that could be added to each bus respecting BES level contingencies and the single element contingencies on the sub-transmission systems. The N-1 hosting capacity for each bus was determined using the TARA Transfer Limit Analysis tool (TrLim). The last two steps used TARA Security Constrained Re-Dispatch (SCRD) tool to identify hosting capacity on a zonal basis, then on an area wide basis.

- **Step 1** – Determine buses that already at or above the hosting capacity, based on distribution transformer capacity.
    - This was done by netting the load and generation at each bus and determine where the distribution transformer(s) are at or above the Normal rating.
    - This test determines which buses may be excluded from consideration for additional generation
- **Step 2** – Determine additional hosting capacity for each GMP load bus that was not excluded in Step 1.
    - The TARA Transfer Limit tool (TrLim) was used to determine the incremental capacity that could be added to each individual bus in the GMP area until N-0 or N-1 system conditions caused thermal violations on the sub-transmission system. Only Single element contingencies were evaluated.
    - The combination of Step 1 & Step 2 provide the hosting capacity for each single bus on a standalone basis.
- **Step 3** – Determine N-1 hosting capacity by zone.
    - The results from Steps 1 & 2 were used to determine hosting capacity (location and size) on a bus-by-bus basis, without regard for additional generation that may be added nearby. Step 3 modeled generators at each bus representing the bus by bus hosting capacity determined in steps 1 & 2.
    - The TARA Security Constrained Re-Dispatch (SCRD) tool re-dispatches (reduces) generation to optimize the dispatch to resolve thermal violations.
    - TARA SCRD was run with generators added to the case representing steps 1 & 2, one zone at a time. The SCRD tool reduced the output of the generation where needed to eliminate thermal violations, which equates to the zonal hosting capability.
- **Step 4** – Determine N-1 hosting capacity for the GMP system with results from step 3.
    - Step 4 modeled generators at each bus representing the zonal hosting capacities from step 3.
    - TARA SCRD was run, allowing all of the zones to optimize to resolve all of the thermal violations in the GMP area. The SCRD tool reduced the output of the generation where needed to eliminate thermal violations, which equates to the area-wide hosting capability.

1.6 Steady State Analysis Results

1.6.1 Steady State Contingency Analysis Results

Steady state thermal and voltage analyses examined system performance and compared that against the performance criteria. The contingency analysis results help show where areas are already export or import constrained. The export-constrained areas show where there is no additional hosting capacity available. At the peak load levels, the import-constrained areas show areas that would benefit by deployment of energy storage technologies.

1.6.1.1 Steady State Thermal Results

The following observations were made from the steady state thermal analysis of the sub-transmission system:

- There were thermal violations in the vicinity of the Ryegate and McNeil generating stations caused by generating levels of existing generation and increases of the forecast DER.
- The Summer Peak and Winter Peak load cases for 2030 and 2035 showed thermal violations that did not previously exist, likely caused by the addition of the Electric Vehicles, Heat Pumps, and Forecast DER.
- There were existing thermal violations that were made worse by the addition of the Electric Vehicles, Heat Pumps, and Forecast DER.

1.6.1.2 Steady State Voltage Results

The following observations were made from the steady state voltage analysis of the sub-transmission system:

- There were no low voltage violations in the light load cases
- The PV additions did not cause low voltage violations to get worse
- There were low voltage violations in the Summer and Winter Peak load cases that were made worse by the addition of the Electric Vehicles and Heat Pump loads.
- There were some high voltages in the light load case in the Poultney area that were caused by the addition of the forecast DER and made worse by the generation added from the hosting capacity analysis.

1.6.2 Steady State Incremental Hosting Capacity Results

The incremental hosting capacity analysis was performed using the methodology described in Section 1.5.7 on the light load cases. These cases started with the existing DG, forecasted DG that is < 25 kW, and Standard Offer Projects in service. The incremental hosting capacity investigated possible locations for additional future solar generation.

1.6.2.1 Step 1 – Distribution Transformers at/near Capacity

The first step in locating substations with additional hosting capacity is to determine the substations that are already at or above the distribution transformer export capacity. Table 1-7 lists the transformers that have flows above 80% of the transformer rating. The transformer flow represents the net export from the low side bus (generation minus load). These stations should be considered to have zero available hosting capacity.

Table 1-7: Transformers with Flows Above 80% Capacity

Station	From Bus	To Bus	ID	Zone	Zone Name	Normal Rating (MVA)	LTE Rating (MVA)	Base Flow (% Normal)
QUECHEE 12.5/46	109135	108246	1	842	Central	14	14	**166.4**
BAY STREET 12.5/35	109242	108555	1	712	St. Johnsbury	10.5	10.5	**131.0**
BRANDON_D1 12.5/46	109081	108410	1	802	Rutland	3.8	3.8	**113.4**
CASTLETON_D 12.5/46	109029	108477	1	802	Rutland	5.25	5.25	**101.9**
JAMAICA 12.5/46	108995	108523	1	822	Southern	7	7	98.6
WELLS RIVER 12.5/46	109129	108230	1	772	Montpelier	4.2	4.2	96.4
POWNAL_D 12.5/46	108983	108493	1	822	Southern	7	7	92.7
WEYBRIDGE_D 12.5/46	109099	108424	1	792	Middlebury	14	14	86.1
SHARON_D 12.5/35	109115	108859	1	842	Central	10.5	10.5	84.2
BRADFORD 12.5/46	109125	108216	1	842	Central	7	7	84.1

1.6.2.2 Step 2 – Determine Incremental Hosting Capacity for Each Bus on Standalone Basis

The second step in determining the system wide hosting capacity was to utilize the TARA Transfer Limit tool (TrLim) to determine the incremental capacity that could be added to each individual bus in the GMP area until N-0 or N-1 system conditions caused thermal violations on the sub-transmission system. The excluded buses from Step 1 and the transfer limit results from Step 2 provide the hosting capacity for each single bus on a standalone basis. There were locations that GMP reduced/eliminated from consideration based on knowledge of the area and/or transmission system. The total hosting capacity from steps 1 & 2 was approximately 765 MW. The transfer limit results testing results are located in Appendix D.

1.6.2.3 Step 3 – Determine Incremental Hosting Capacity for Each Zone

The third step in determining the system wide hosting capacity was to utilize the TARA SCRD tool to optimize the dispatch by zones to prevent thermal violations for N-0 and N-1 system conditions. SCRD optimizes the dispatch to resolve the sub-transmission constraints that would caused by the addition of generation from step 2 within each zone. Generators with capabilities from step 2 of the hosting capacity analysis were added to the base cases. The total hosting capacity from step 3 was 373 MW.

1.6.2.4 Step 4 – Determine Incremental Hosting Capacity for the GMP Area

The fourth step in determining the system wide hosting capacity was to utilize the TARA SCRD tool to optimize the dispatch for all GMP zones to prevent thermal violations for N-0 and N-1 system conditions. Generators with capabilities from step 3 of the hosting capacity analysis were added to the base cases. SCRD optimized the dispatch to resolve the sub-transmission constraints that would caused by the addition of generation from step 3 from all of the GMP zones simultaneously.

The remaining Tier 2 renewable goal objective is 150 MW. The total hosting capacity from step 3 was 373 MW. RLC and GMP decided to reduce the final portfolio of generation to 250 MW in order to provide some margin above the required 150 MW when siting PV, to minimize the inter-zonal impact, and reduce the number of reliability violations caused by the additional generation. This reduction was accomplished by reducing the following zones to 62% of the step 3 capacities: Rutland (Zone 802), Ascutney (Zone 812), Southern (Zone 822), and Central (Zone 842). The 250 MW was added to the cases and analyzed with SCRD to ensure that none of the proposed generation portfolio was reduced further. A summary of the incremental and total hosting capacity is shown in Table 1-8The detailed hosting capacity results are located in Appendix D.

Table 1-8: Summary of Incremental & Total Hosting Capacity

Zone	Total Existing Solar	Total Forecasted Solar (net-metered and utility-scale)	Additional Solar for Tier II from Step 4)	Optimized Forecasted Solar (from Step 3)	Total Solar Hosting Capacity (Interconnected + Forecasted, Level Tested to meet Tier II Goals from step 4)	Total Optimized Solar Hosting Capacity (Interconnected + Forecasted + Optimized from step 3)
Ascutney	25.1	6.0	34.2	55.2	65.2	86.2
Burlington	82.7	25.7	8.8	8.8	117.2	117.2
Central	51.7	20.2	21.2	21.2	93.1	93.1
Florence	0.4	0.2	0	0	0.6	0.6
Johnson	0.6	0.4	0	0	0.9	0.9
Middlebury	41.5	5.9	11	11	58.5	58.5
Montpelier	35.2	24.3	4.2	4.2	63.6	63.6
Morrisville	5.0	2.9	0	0	7.9	7.9
Rutland	64.6	28.5	49.9	80.5	143.1	173.7
Southern	55.2	25.8	119.5	192.8	200.4	273.7
StAlbans	38.4	24.9	0	0	63.3	63.3
StJohnsbury	15.2	3.4	0	0	18.7	18.7
Total	**415.5**	**168.1**	**248.8**	**373.7**	**832.4**	**957.3**

The following observations were made during the analysis:

- Although there was interaction between generation levels in the different zones, it was less than expected. Allowing SCRD to optimize the generation in all GMP zones resulted in a small reduction in total hosting capacity from step 3.
- SCRD reduced a significant amount of generation in some zones and very little in other zones. This analysis helps identify the better areas of the GMP service territory to site new PV generation to meet the Tier 2 objectives.
- There were 115 kV contingencies that removed west to east transmission paths and caused SCRD to reduce generation in the Montpelier, Burlington, Middlebury and Morrisville zones to prevent thermal violations. Sensitivity analysis was performed to check the impact of other resources, such as Highgate and the flows on the Granite PARs. Reducing flow on Highgate and adjustment of the Granite PARs to reduce west to east transfer will restore some additional capacity in these four zones.
- There were sub-areas that are supplied by a series of 34.5 kV or 46 kV lines. The loss of one end of these lines forces all of the generation to export from the other end of the loop, which can limit the amount of generation added in these sub-areas. The following contingency and limiting element pairs will limit the amount of generation that can be added in these sub-areas.
    - Loss of 34.5 kV Line 3331 between Middlesex and Bolton Falls causes thermal violations on 34.5 kV Line 3302 between Sand Road and Essex.

- Loss of 46 kV Line L-33 between Newfane and East Jamaica causes thermal violations on the 46 kV Line L-18 between Bromley and East Arlington.
- Loss of the Stowe 115/34.5 kV Transformer causes thermal violations on the 34.5 kV Line 3312 between Little River and Middlesex.
- Loss of Blissville 115/46 kV Transformer causes 46 kV Line L-44 between Hydeville and W. Rutland and 46 kV Line L-47A between Poultney and Hydeville.
- Loss of the 115/34.5 kV Barre Transformer causes thermal violations on the 34.5 kV Line 3325 between Montpelier and Berlin. This contingency does not leave the 3325 line radial like the ones listed above.

- In order to allow SCRD to function properly, some contingencies and/or limiting facilities were excluded from the SCRD process. The following lines were excluded in the SCRD process:
    - There were lines that were overloaded due to generation additions near the McNeil generator. These lines were excluded from the SCRD process to prevent SCRD from reducing McNeil or other nearby generation to be conservative.
    - There were lines that were overloaded due to generation levels at Ryegate Wood, Ryegate Falls, McIndoes, and in nearby New Hampshire. These lines were excluded from the SCRD process to prevent SCRD from reducing generation to be conservative.
    - Contingencies involving 115 kV K23 and K27 were excluded. There is a Remedial Action Scheme that will open 34.5 kV lines to prevent thermal overloads following either of these contingencies. TARA does not have Remedial Action Scheme functionality while running SCRD. Excluding these contingencies from SCRD prevents SCRD from reducing generation to resolve thermal violations that would not exist due to the Remedial Action Scheme.
    - Non GMP sub-transmission lines were excluded (all, not just SCRD) to prevent SCRD from reducing the generation for violations in other areas.

The hosting capacities described from the results above were used to create a map of the total hosting capacities for the GMP Service territory, as shown in Figure 1-2.

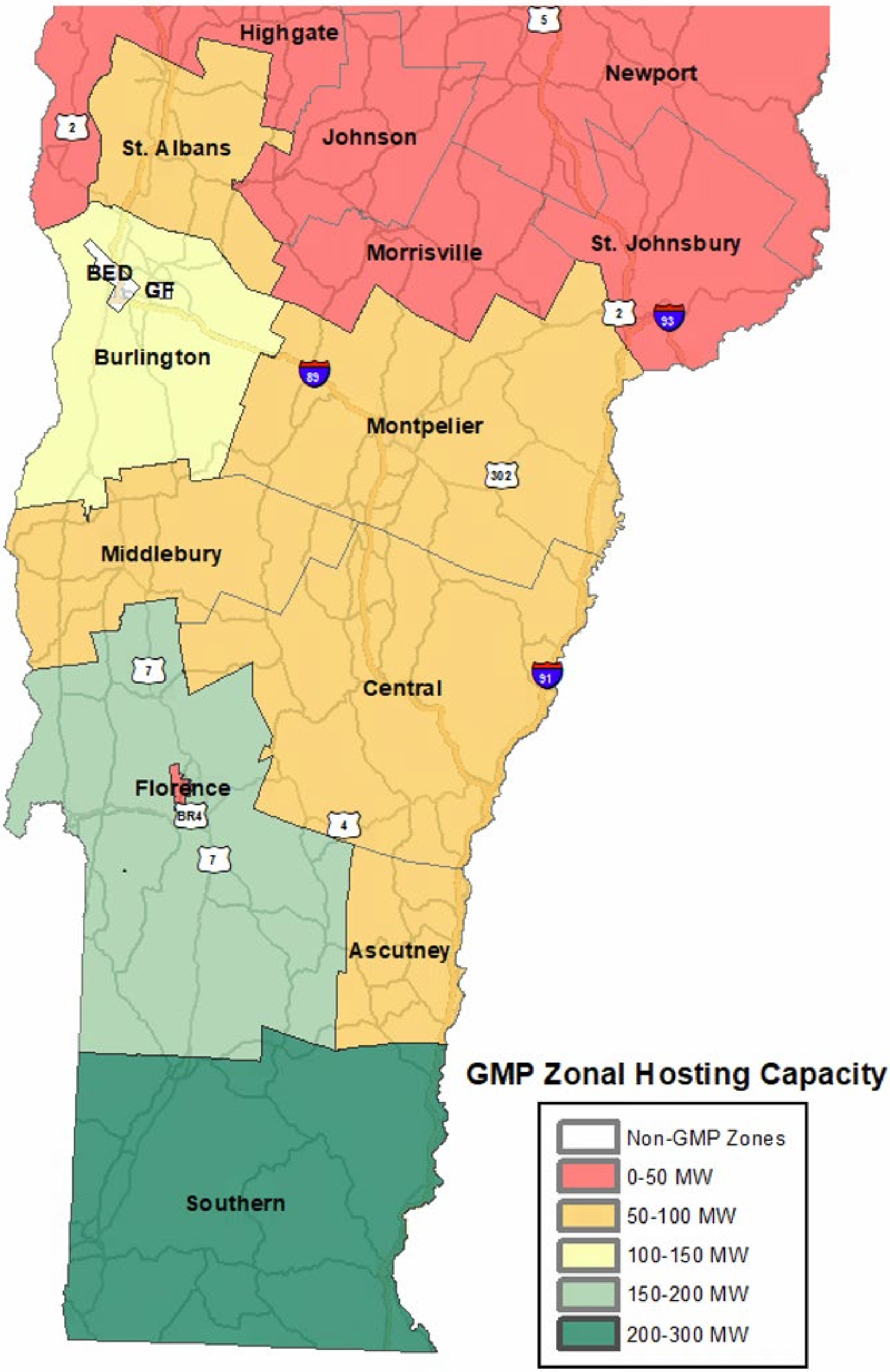

Figure 1-2: Geographic Map with Hosting Capacity