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G. SYSTEM ALTERNATIVES

This section complies with the provision in the Council's application guide that an applicant identify "system alternatives and the advantages and disadvantages of each." First, non-transmission system alternatives are addressed, including:

- No action alternative.
- Energy alternatives, including expanded generation capacity (both distributed generation and central station utility generation).
- Strategies to reduce load (demand side management or DSM)

This discussion of non-transmission system alternatives is based on a report of ICF Resources, LLC, *Assessment of Non-Transmission Alternatives for the NEEWS Transmission Projects: Greater Springfield Reliability Project*, (September, 2008) (ICF Report). A copy of the ICF Report, redacted to secure Critical Energy Infrastructure Information (CEII), is provided in Volume 5 of this Application. CL&P anticipates that the Council and its staff, parties and intervenors to the proceeding on this Application, and their counsel and consultants will be able to obtain complete copies of the ICF Report pursuant to a protective order and non-disclosure agreements.

Alternative transmission solutions are next addressed. Part G.2 of this section briefly summarizes how the proposed projects (GSRP and MMP) were developed from a set of transmission system "Options" identified by the previously discussed Options Analysis performed by the ISO-NE Working Group. That development process is described in detail in the GSRP Solution Report, which is provided as part of Volume 5 of this Application.

G.1 NON-TRANSMISSION ALTERNATIVES

G.1.1 No-Action Alternative

Under the no-action alternative, no new transmission facilities would be developed and no improvements would be made to the existing electrical transmission system or generation resources in SWCT. This alternative was rejected because it would do nothing to correct violations of national (NERC) and regional (NPCC and NEPOOL) reliability standards, and thus the Greater Springfield and north-central Connecticut areas would continue to be at risk for electric outages. Moreover, no improvement of the Connecticut import capacity would be realized. Higher cost generation resources would necessarily have to continue to operate to support the Greater Springfield load. Finally, failure to build the GSRP and the MMP would undermine the long range plan of improving the flow of power from east to west across Connecticut and across Southern New England as a whole.

G.1.2 Resource Alternatives

To evaluate whether the addition of distributed generation, generation, or demand management resources could displace or defer the need for the GSRP, NUSCO commissioned a comprehensive study from ICF Resources LLC (ICF).

The reliability violations addressed by the GSRP might theoretically be resolved by adding large amounts of demand and supply resources in Massachusetts or Connecticut. Solving reliability problems as if they were simply resource deficiencies does not, however, address the basic inadequacy of transmission facilities that are few in number, small in current-carrying capacity relative to load and largely consist of double-circuit 115-kV lines. In order to determine whether the addition of new area demand and/or supply resources would provide a reliability solution equivalent to that of the GSRP, the effect of such additions must be tested in the same way that the reliability violations were found in the first instance, and in the same way that the proposed transmission improvements have been proven to be a solution: by running power-flow models to determine if overloads and voltage violations have been eliminated by the addition of the extra resources.

Accordingly, in their Non-Transmission Alternatives Study, ICF considered a variety of resource alternatives including, but not limited to, the addition of distributed generation, large scale generation, combined heat and power supply options, and demand resources. ICF then tested the impact of the combined penetration of these resources on the overall reliability of the study area as determined through power-flow modeling analysis under stressed system conditions. At each stage of the analysis, ICF compared the effectiveness of the resource alternatives that were simulated to the effectiveness of the Project with respect to the reliability of the Greater Springfield area transmission system.

G.1.3 Background of ICF Resources LLC

ICF is a leading management, technology and policy consulting firm with global presence that provides advisory and program implementation services to public and private clients in various sectors including Energy, Environment and Transportation. ICF has extensive consulting experience in the areas including electric power and renewable energy resources. Its clients include government agencies and utilities. ICF also has consulting experience in the field of electric transmission; specifically, in performing system impact studies and stability studies, and cost-benefit assessments.

G.1.4 ICF's Characterization of the Problems

In their Non-Transmission Alternatives Study, ICF presents a brief overview of the many reliability violations that affect the present day Greater Springfield area and north-central Connecticut transmission systems. Contingencies on the 345-kV and 115-kV lines between the Greater Springfield area and north-central Connecticut, as well as on the outdated Springfield area 115-kV lines which frequently have low conductor size and share common structures, result in numerous overloads and voltage violations. This portion of Southern New England faces a challenging match of load requirements, area supply resources and transmission facilities. The Greater Springfield area is adjacent to and interconnected with Connecticut. The entire state of Connecticut is a load pocket with local generation approximately equal to 75% of local peak load and with transfer capability less than 30% of state-wide load. Soon, a transfer capability deficiency in Connecticut will emerge. The number of reliability violations that exist now and can potentially occur in the coming years poses a challenge in designing any cost-effective solution, whether transmission or non-transmission approaches are being considered.

G.1.5 Summary of the ICF Study

The ICF Study is summarized as follows:

G.1.5.1 Alternatives Assessed

In assessing the potential for alternative resources to either displace or defer the GSRP and MMP, ICF considered the following three Non-Transmission options both individually and in combination:

- ***Combined Heat and Power Resources (CHP):*** Resources that would typically serve large industrial or commercial loads with both steam and electric power. They are typically the primary source of power for these loads and hence, there is no direct demand from the loads for regional generation resources. This implies that the demand for transmission services to serve such loads is zero.
- ***Demand-Side Management Resources (DSM):*** Demand Side Management resources tend to reduce the demand for system generation and transmission services either through direct reductions in the load, or the addition of generation as a distributed source[1].
- ***Large Scale Generation:*** Large scale generation resources of appropriate sizes located close to the load demand centers may also help reduce the overall load on the transmission system.

These resource alternatives were tested for their effectiveness in either deferring or displacing the upgrades to the existing transmission system while maintaining the same level of reliability i.e., fully complying with the national and regional reliability criteria. All resource quantities were considered to be market-based in the initial analysis[2]. Thereafter, additional DSM and generation resources, without regard to their economic feasibility, were included in various scenarios that tested the bounds of the

[1] ISO-NE terminology refers to DSM resources as active and passive Demand Response (DR).
[2] See the description of the Reference Case below in this Section G.1.5.4.

ability of non-transmission alternatives to achieve reliability comparable to that provided by the project. In this regard, unlike DSM and large scale generation, the CHP resources included in these subsequent scenarios did not exceed the CHP amounts that were considered economically feasible. See: Table G.1, below, in Section G.1.5.4.

G.1.5.2 Key Assumptions for Alternatives

ICF's Non-Transmission Alternatives Study reviewed the technical potential on a state level by assessing the potential locations that currently are not served by CHP sources. ICF utilized its own projections for forward market prices to assess the economics of the CHP options in combination with market surveys of the penetration rates for the equipment. The resulting additions were 193 MWs in Massachusetts, with 33 MWs in western Massachusetts.

ICF projected DSM savings based on publicly available information for the maximum technically achievable DSM and the market information revealed through the ISO-NE Forward Capacity Auction (FCA) process. For this study, the total demand resources cleared in the first FCA, in addition to those showing interest in the second FCA, was determined to be just over 4,200 MWs. This total represents approximately 12% of the peak capacity requirement in the 2011/12 commitment period throughout New England. The west-central Massachusetts resources that were selected in the 2010/2011 auction amounted to 327 MWs or 8.4 % of the expected West-Central Massachusetts summer peak load in 2010. From analyzing the growth in resources submitted to the FCA between auction periods and from the 2008 Connecticut Integrated Resource Plan, ICF assumed that the total committed demand resources in western Massachusetts area would grow at the same rate as the aggressive technically achievable DSM identified in Connecticut forums as the "demand focus" case[3]. Based on these assumptions, the annual growth rate for demand resources in Massachusetts was determined to be 17 %. This assumed growth rate results in a

[3] CEAB Appendix G, Table 1 of the CEAB's 2008 Comprehensive Plan for Procurement of Energy Resources submitted to the DPUC. CL&P has identified the demand focus case as requiring the expenditure of over an additional billion dollars over the next five years.

total of 527 MW of peak DSM in west-central Massachusetts in 2013 which is about 13% of the total western Massachusetts area load level. It should be noted that although the transmission system reliability violations are all concentrated in the Greater Springfield and north-central Connecticut areas, the DSM and CHP resource additions considered in the study were dispersed within the entire western Massachusetts and Connecticut systems, and not solely in Greater Springfield and north-central Connecticut.

Supply-side resources were also reviewed in this study to ensure that adequate supply was maintained for generation planning purposes. Since resource adequacy called for little additional generation in the Springfield area, under various scenarios studied, numerous large scale generating resources additions at the electrically most ideal sites such as West Springfield and South Agawam (Berkshire Power) were simulated without regard to the economic feasibility and tested for their effectiveness in rendering the overload-prone Springfield transmission system reliable in accordance with the NERC reliability criteria.

In addition to an assessment of how DSM, large scale generation additions, distributed generation additions and a combination of these resource alternatives compared to the GSRP in terms of solving the reliability problems, ICF's study separately attempted to determine the total amount of demand-side reductions that would be necessary to achieve the same reliability benefits as achieved by the GSRP and MMP. This "top-down analysis" was done without regard to whether or not the quantities of DSM resources found to be required were economic or technically feasible, and without regard to whether or not ISO-NE would be able to acquire the control systems and technology to operate the system reliably and securely with such levels of DSM.

G.1.5.3 Power-Flow Model Development

The starting point for the Non-Transmission Alternatives Study analysis was the 2012 power-flow planning case from ISO-NE. This information was provided to ICF under confidentiality restrictions by Northeast Utilities so as to protect Critical Energy Infrastructure Information (CEII) in accordance with

FERC requirements. Since the study year for the alternatives analysis was 2013, there were several modifications that were made to the case to reflect 2013 conditions.

The key assumptions for the power-flow modeling include:

- ***Load Projections:*** The original power-flow case provided was based on a 2005 vintage forecast for load growth. ISO-NE released a revised forecast in April 2008[4] which was adopted for purposes of this analysis. To modify the peak load input, the load at each node was scaled by the ratio of the 2005 and 2008 vintage forecasts. In compliance with standard transmission reliability planning methods, ICF used the extreme weather peak demand forecast (also known as the 90/10 forecast). Under the 90/10 forecast, the western Massachusetts zonal peak demand was estimated to be 2490 MW in 2013 based on the 2008 vintage forecast. The same approach was applied to all areas within New England.
- ***Forced Outage Rate and Spinning Reserves:*** From the dispatch perspective, forced outages and spinning reserves were accounted for in the dispatch. The forced outage rate assumed for Springfield area in this ICF study was 7 percent of the total zonal capacity. To implement the forced outage in the power-flow model, ICF turned off selected generation units to reach 7 percent of the total capacity such that these units were assumed to not be available to meet system demand. The same forced outage rate assumption was used for each zone in New England. A spinning reserve requirement of approximately 15 percent of total capacity was also implemented in the power-flow model across New England. This represents generation capacity that is made available to respond to system contingencies and reflects roughly the largest generation contingency in each zone.

[4] "2008-2017 Forecast Report of Capacity, Energy, Loads, and Transmission," April 2008, ISO New England.

- ***Generation Asset Lifetime:*** With regard to the existing generating assets, ICF assumed that any non-hydro asset within New England that reached the age of 60 years by 2013 would retire. No generators in Springfield were affected by this retirement assumption.
- ***Dispatchable DSM Resources:*** In their analysis, ICF assumed that the dispatchable DSM resources such as the emergency generators and demand response (active DR in ISO-NE's terminology) are reserved for emergency conditions and are not removed from the ISO-NE peak load projection in the power-flow cases.[5] However, the Springfield area peak load was decremented by 225 MW to account for the non-dispatchable DSM resources (passive DR in ISO-NE's terminology) for the power-flow analysis, accounting for about 43% of the total western Massachusetts DSM projection.

G.1.5.4 Study Details

The Study of Non-Transmission Alternatives to Greater Springfield Reliability Project conducted by ICF is comprised of various resource alternatives options delineated above. Table G-1 below illustrates the non-transmission scenarios that were modeled and analyzed by ICF for their effectiveness in eliminating transmission facility overloads in Greater Springfield and north-central Connecticut, in order to render those transmission systems reliable according to national and regional reliability criteria. In an attempt to bound the area's problems and the potential solutions, ICF's study evaluated seven different scenarios, some of which did not observe the original condition that resources added be market-based and economically feasible. Thus, four of the seven scenarios listed in Table G-1 are not resource alternatives to transmission reinforcement but rather, are scenarios simulated to comprehend the extent of the overload problems in the Greater Springfield and north-central Connecticut areas. Thus, the scale of the load reduction modeled in these scenarios render the scenarios to be only hypothetical. These four scenarios attempt to answer the "top-down" question, "How much load in and around the problem areas[6]

[5] ISO-NE views dispatchable DSM as supply side resources

[6] In one case, the load reduction was simulated to occur within the entire Connecticut zone, and was not restricted to the north-central Connecticut area.

needs to be dropped with or without assumed new large scale generation, to resolve the reliability problems in the Greater Springfield and north-central Connecticut areas?" In addition, the scenarios adding between 400 and 600 MWs of new generation in the Greater Springfield area are only hypothetical since resource adequacy does not call for, and would not economically support, such additions. The seven scenarios altogether encompass all the resource alternatives options listed previously i.e., large scale generation additions, zonal demand reductions and focused DSM.

Table G-1: Non-Transmission Resource Alternatives Simulated[7]

Scenario No.	Description
1	Reduce Connecticut Zonal Demand by 1,000 MWs
2	Reduce Western Massachusetts Zonal Demand by 1,000 MWs which includes specific load reduction in certain substations[8]
3	West Springfield and Berkshire power plants operational and new 400-MWs facility at Berkshire Power (Total of 854 MW in Greater Springfield area)
4	West Springfield and Berkshire power plants operational, new 200-MWs facility at Berkshire Power, and new 200-MW facility at Mount Tom (Total of 854 MWs in Greater Springfield area)
5	West Springfield and Berkshire power plants operational, new 400-MWs facility at Berkshire Power, and new 200-MW facility at Mount Tom (Total of 1054 MW in Greater Springfield area)
6	West Springfield and Berkshire power plants operational, reduce CT Zone demand by 500 MWs, and curtail load at Chicopee, Clinton, East Springfield, Agawam, and Breckwood substations
7	Same as Case 6 but with West Springfield and Berkshire power plants unavailable

ICF performed a detailed power-flow analysis of the system assuming both normal and emergency conditions for each of the seven resource alternatives scenarios listed in Table G-1. To begin with, ICF assessed system performance under normal conditions assuming no unplanned failure of a transmission element such as a transmission line, a transformer, a circuit breaker, or a pair of transmission lines on a multiple circuit transmission tower. Next, the process was repeated for the unexpected failure of key transmission elements (N-1 contingency condition).

7 Exhibit 6-8 in the study report titled "Assessment of Non-Transmission of Alternatives to the NEEWS Transmission Projects: Greater Springfield Reliability Project", Report by ICF Resources, LLC
8 Specific substations include Chicopee, Clinton, East Springfield, Agawam and Breckwood.

ICF also conducted a similar analysis to evaluate system performance under line-out conditions, that is, following the outage (planned or unplanned) of a single transmission element, a second element was then considered to fail (N-1-1 contingency condition). System performance was measured by monitoring transmission lines for thermal overloads under all three system conditions; Normal, N-1 and N-1-1 conditions.

Furthermore, ICF assessed the ability of the system to operate reliably if the Millstone Unit #3 generation facility was out of service. In this case, other generation facilities were adjusted to replace the lost output. The performance of the system was then examined for transmission facility overloads

G.1.5.5 Study Results & Conclusion

ICF concludes in its study report that no non-transmission alternatives to the Greater Springfield Reliability Project were found to be satisfactory or sufficient in nature to displace or defer the need for the project. This conclusion is supported by results of the power-flow analysis, which indicate that despite the addition of the large scale generation, DSM, and CHP resources previously described, numerous transmission facility overloads occur under contingency conditions and hence, the system fails to fully comply with the mandated national and regional system reliability criteria. Furthermore, ICF in its study report concludes that the GSRP is critical to the reliable operation of the New England transmission grid, and in particular, the transmission systems of Greater Springfield and north-central Connecticut. The results of the additional analyses performed with the project in operation (in contrast with the Non-Transmission Alternatives Assessment) confirm and validate these conclusions. The following sections of this document summarize the results for each of the three resource alternatives options (large scale generation, DSM, zonal load reduction) simulated and tested by ICF in their study.

G.1.5.5.1 Consideration of DSM as a Resource Alternative to Transmission Reinforcement

The downtown Springfield transmission system and the 115-kV western Massachusetts – Connecticut tie lines continue to overload, when load is reduced in accordance with an aggressive DSM "focus case." Even an unrealistic assumption of extraordinarily large and impractical DSM measures does not resolve all of the criteria violations on the Greater Springfield and north-central Connecticut transmission systems. For example, reducing about 273 MWs of coincident peak load within key locations in Springfield (e.g., the Breckwood, Clinton, Agawam, Chicopee and East Springfield substations) and further decrementing Western Massachusetts (WMA) zonal load uniformly by about 727 MWs to represent a total WMA zonal load reduction of 1000 MW (about 44 % of the peak demand projected for the entire western Massachusetts sub-area in 2013)[9] still failed to resolve all the Greater Springfield and north-central Connecticut overloads. As an illustration, Figure G-1 below depicts how, even after such aggressive load reduction, the Greater Springfield and north-central Connecticut area reliability problems continue to persist. Further details can be found in the ICF Report.

[9] The zonal reduction of 1,000 MW was in addition to the focused DSM in west-central Massachusetts (13%) and Connecticut (5%)

Figure G-1: Number of Distinct Facility Overloads under Contingency Conditions (N-1 and N-1-1) for Various Load Reduction Scenarios

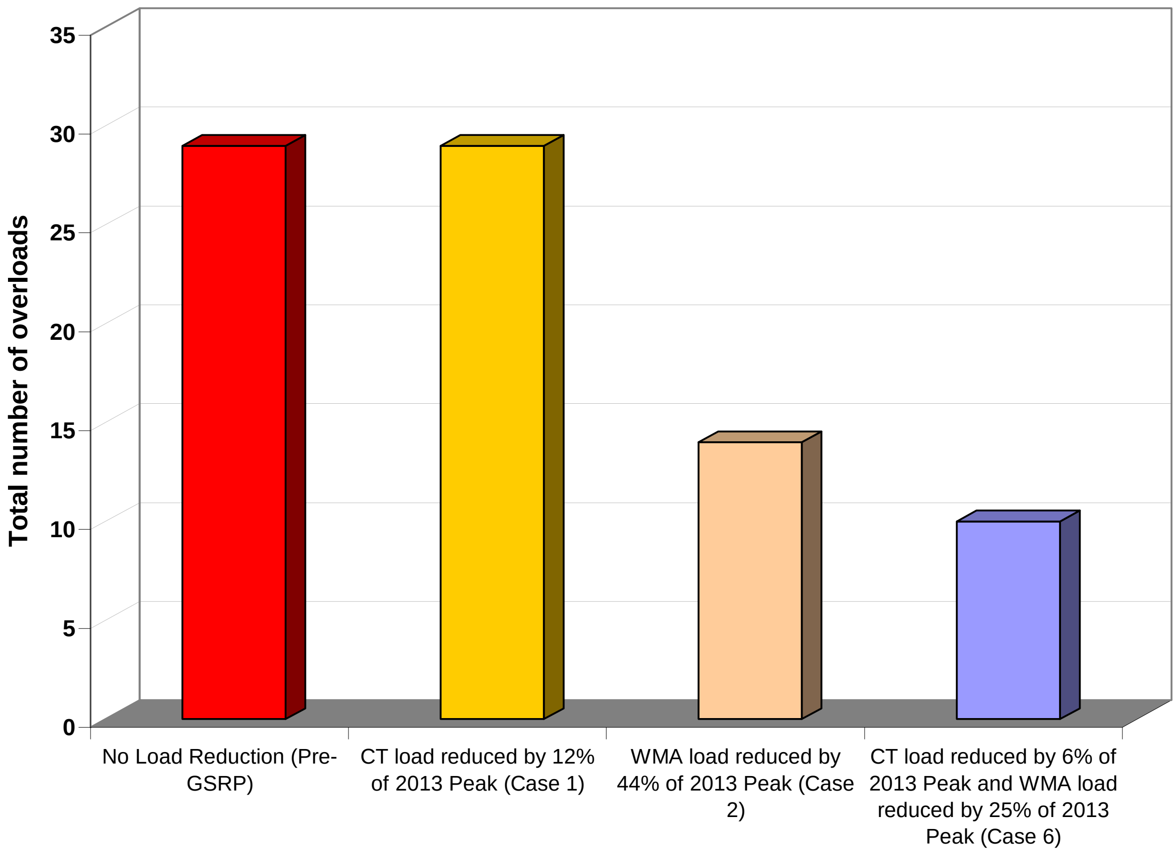


Figure G.1: Greater Springfield and North Central Connecticut area transmission facility overloads[10] as a function of the 2013 Greater Springfield area peak demand projection (bar heights in the chart are approximate). Note that the percent load reduction shown on the graph is in addition to the estimates from the focused DSM case that was modeled in all scenarios tested in the study.

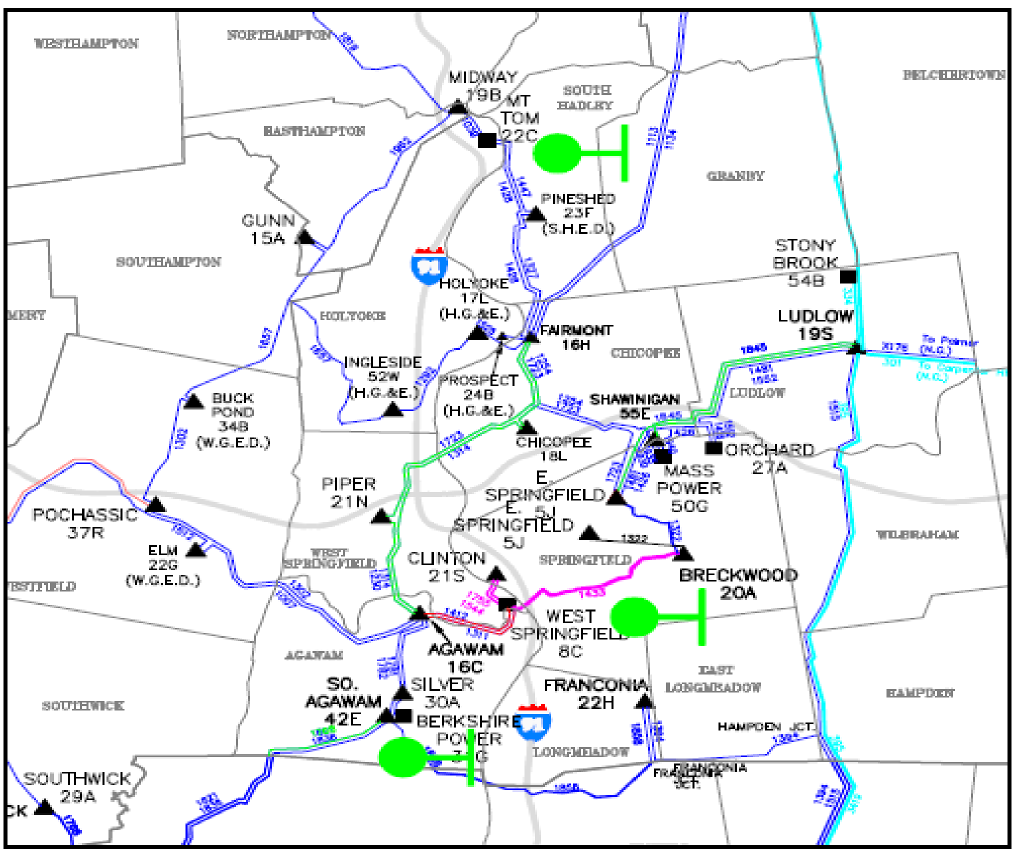
G.1.5.5.2 Consideration of Large Scale Generation as a Resource Alternative to Transmission Reinforcement

Scenarios 3, 4 and 5 in Table G-1 represent large scale generation additions in combination with focused DSM as resource alternatives. Through scenarios 3, 4 and 5, ICF assessed the ability of generation additions at key locations in the western Massachusetts zone to eliminate the Greater Springfield and north-central Connecticut area reliability problems. The scenarios examined included the addition of 200 MW to 400 MW of new generation at the site of Berkshire Power, 200 MW at the Mount Tom site, and

[10] The total number of possible transmission facility overloads is illustrated for those limited scenarios tested by ICF Resources LLC in their analysis; there could be more overloaded facilities under other dispatch scenarios.

the assumption that the existing West Springfield and Berkshire generation facilities are operational during the study period. This latter assumption implies that the West Springfield and Berkshire generation facilities may be required to be operated as “Reliability Must Run” units (under Reliability Agreements under the ISO-NE system in effect until 2010) during the summer peak period. In all the cases tested, ICF found that the generation addition scenarios – both individually and in combination – were not sufficient to relieve the Greater Springfield and north-central Connecticut transmission overloads. Figure G-2 below illustrates the geographical locations where the assumed new generations were modeled in the tested scenarios. Note that the ability of these locations to actually accommodate these hypothetical generators was not considered in choosing the locations for generator additions.

Figure G-2: Geographical locations of assumed new generation additions in scenarios 3, 4 and 5



Further, the results of the generation addition analyses performed by ICF show that generation additions in the downtown Springfield area (downtown Springfield being the most logical site for generation addition) are not effective in repelling the natural flow bias from the northeast (east of the river) under certain contingencies and, instead contribute to higher flows through downtown Springfield to Connecticut, leaving downtown Springfield drawing power from the same sources that cause overloads on the Springfield system. Large scale generation such as that proposed in Stony Brook (north of Ludlow) will only exacerbate Greater Springfield and north-central Connecticut system reliability problems; this generation interconnection would require improvement of the transmission system in order to be built (per ISO-NE). In contrast, the Greater Springfield Reliability Project is expected to be a possible solution for transmitting an additional 300 MWs of power from Stony Brook. Study results also indicate that under certain operating conditions, the large scale generation alternative causes new overloads on the Greater Springfield transmission system. As a result, additional large scale generation cannot solve the Greater Springfield and north-central Connecticut reliability problems.

ISO-NE has evaluated adding significant new generation (in multiple locations under different proposals) in the greater Springfield area and has determined that such additions may not be feasible unless transmission upgrades and modifications are made to the Springfield system. The feasibility studies conducted by ISO-NE in assessing the need for transmission enhancement in Springfield before the possible generation capacity increase/interconnection can be found in the report titled *"Feasibility Study Report for the Thermal, Voltage and Short Circuit Analysis of the Stony Brook Phase 2 Project (280 MW)"*. The full report is available for reference upon request from ISO-NE via the OASIS website.

G.1.5.5.3 Consideration of Large Scale Zonal Load Reduction

Scenarios 1, 2, 6 and 7 in Table G-1 represent large scale load reduction in western Massachusetts, Connecticut and the Greater Springfield area. As described in the earlier sections, the results of the analysis performed in the Non-Transmission Alternatives Study by ICF clearly show that even highly impracticable load reduction levels of up to 1,000 MWs[11] are not viable alternatives to the Greater Springfield Reliability Project. Details can be found in the full study report.

Furthermore, the ICF report points out that these conclusions are based on conservative assumptions used to generate the Reference Case[12]. Less conservative assumptions would result in greater line overloads than were determined in this study. The conservative nature of these assumptions is focused on both the supply and the demand side including the following:

- ICF's analysis under the Reference Case reflects a normal peak-day operation for the system assuming that adequate spinning reserves are maintained and further that no active demand resources are called on. These conditions do not reflect the standard which suggests that transmission planning be performed under reasonably stressed conditions. ICF further examines several generation stress cases in comparison to the Reference Case.
- ICF's analysis does not include any economic assessment of the aggressive levels of DSM (above and beyond the DSM focus case) assumed in its Non-Transmission Alternatives scenarios. The economic challenges facing the DSM focus case itself are illustrated by the Connecticut Energy Advisory Board (CEAB) in its *2008 Comprehensive Plan for the Procurement of Energy Resources* (Approved Aug. 1, 2008) (Comprehensive Plan), in which it estimates the cost of the DSM focus case from 2009 through 2014 for Connecticut alone as in excess of $1.6 billion, of which more than $880 million represents a budget deficit, after application of anticipated

[11] This 1,000-MW reduction would be above and beyond the focused DSM in both west-central Massachusetts and Connecticut, and was modeled in addition to assumed generation additions.

[12] The assumptions in the Reference Case regarding the penetration of additional demand and supply side resources over time are derived considering an aggressive demand side penetration in combination with a primarily economic driven generation addition. Generation additions are primarily driven based on ensuring that adequate reserves are maintained over time. The types of resources added are those which would provide the least cost option to maintain reserves. In addition, units which may already be under construction, or units which had been approved in non-marketed programs (such as the Kleen units in Middletown, Connecticut) at the time this analysis began are considered as generation additions.

revenues from three anticipated funding sources.(Comprehensive Plan, Appendix G, p. 9, Table 1).

- In estimating which generators currently operating under RMR agreements could be expected to retire for economic reasons after RMR agreements expire in 2010, ICF did not treat the Montville (Connecticut) and Middletown (Connecticut) units, which have an aggregate 1,263 MWs capacity, as retiring. However, those units are confronting environmental as well as economic challenges, and their owner, NRG Energy Inc., stated in a July, 2008 Interrogatory response to the Connecticut Siting Council that the Council "should assume for planning purposes" that the units at Montville and Middletown Station would be retired within the Council's forecast period "if they are not repowered under long term contracts or other market based arrangements that provide certainty of revenues" Consistently with this statement, the CEAB Comprehensive Plan recognizes that the cost of complying with environmental regulations could produce the retirement of 1,400 MWs of Connecticut generation.
- ICF's assumed generation outages do not reflect the extreme generation outage conditions which have occurred on occasion in New England. However, the equipment overloads found under ICF's cases could occur under such extreme conditions.

The conservative nature of these assumptions further reinforces the conclusions above given that even under these conservative assumptions, the reliability of the system must be addressed through the proposed transmission upgrade. The proposed transmission upgrades and modifications are expected to solve the Springfield area reliability problem for many years.

G.2 ALTERNATE TRANSMISSION SOLUTIONS CONSIDERED BUT REJECTED

As explained in detail in the *GSRP Solution Report*, a copy of which is included in Volume 5, NUSCO closely evaluated 39 combinations of 345-kV and 115-kV improvements in developing the proposals to be submitted to the Massachusetts and Connecticut Siting authorities. Since there were routing alternatives for many of the components of these 39 “Top System Solutions,” NUSCO screened a total of over 860 system/route combinations. The selection and design of the 115-kV improvements in Massachusetts was complex and challenging. That process is described in detail in the Solution Report, but will not be repeated here, since none of the new or reconstructed 115-kV facilities are proposed to be in Connecticut.

The choices to be made with respect to the portion of the GSRP proposed to be located in Connecticut were far fewer and more straightforward than those required for designing the 115-kV portion of the GSRP. In addition to the 345-kV lines from North Bloomfield to Agawam to Ludlow that CL&P and WMECO now propose, the Options Analysis by the ISO-NE Working Group identified only two other potential 345-kV connections for resolving the Springfield area reliability problems. The choice of this solution dictated that a new 345-kV line between North Bloomfield, Connecticut and the Connecticut/Massachusetts state border would be proposed.

As previously discussed, this selection of the best transmission solution required a further choice between alternate routes for the Agawam to Ludlow segment of the new 345-kV line. The choice of the Northern route, which is entirely within Massachusetts, over the Southern alternative route, which would be partly in Connecticut, is explained in Section H of this Application and in the GSRP Solution Report included in Volume 5 of this Application. This choice was based primarily on environmental impact and cost considerations. The system benefits provided by the proposed improvements would not vary according to which of these two alternate routes were to be chosen (unless a choice of the Southern route resulted in the Connecticut portion of the line being underground.). This section explains the selection of the North Bloomfield – Agawam- Ludlow electrical path as the best 345-kV transmission solution, based primarily on a consideration of system benefits and costs. The comparative environmental effects of the best variants of each of the three “Options” are quite similar.

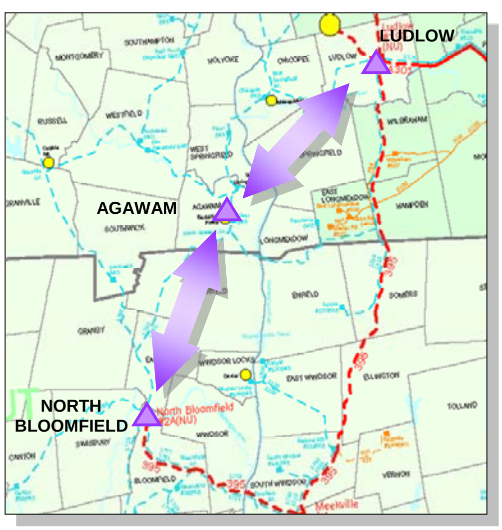
G.2.1 Identifying the North Bloomfield to Agawam to Ludlow Lines as the Best 345-kV Solution

The advantages of the proposed North Bloomfield to Agawam to Ludlow solution have been presented previously in this Application, particularly in Section F. In the Options Analysis, this 345-kV configuration was referred to as "Option A." The other two 345-kV solutions that the ISO-NE working group found to exhibit acceptable system performance were:

- A 345-kV line between the North Bloomfield and Ludlow Substations that did not tie into the Agawam Substation ("Option B"); and
- A 345-kV line from Manchester Substation in Manchester, Connecticut to the Ludlow Substation ("Option C").

The electrical connections that would be affected by these alternatives are illustrated in Figures G-4 and G-5. For comparison, the electrical connections that would be affected by the proposed North Bloomfield to Agawam to Ludlow solution are also displayed in Figure G-3.

Figure G-3: Preferred North Bloomfield – Agawam – Ludlow Solution ("Preferred Solution")



Note: Dotted red lines illustrate existing 345-kV transmission lines, whereas the purple arrows indicate the 345-kV alignments proposed to complete the Greater Springfield 345-kV loop.

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The Options Analysis pointed out that all three of these options provide a new 345-kV connection between western Massachusetts and Connecticut, and that, with respect to the system benefits they provide, the main differences between these plans are whether they provide another area bulk supply point, eliminate the weak western Massachusetts/Connecticut 115-kV ties, or utilize phase shifters to restrain power being wheeled through the area.

When the three basic 345-kV line Options were identified, it was already clear that although all three Options eliminated the weak Massachusetts/Connecticut 115 kV ties, only Option A – the North Bloomfield – Agawam – Ludlow 345-kV line provided another bulk power supply point and did not utilize phase shifters. As explained in the following paragraphs, these characteristics provide significant system benefits and advantages as compared to the other two Options.

Figure G-4: N. Bloomfield – Ludlow ("Option B")

(No Connection to Agawam)

Figure G-5: Manchester – Ludlow ("Option C")

G.2.1.1 Advantages of a 345-kV Connection to the Agawam Substation

The new bulk power supply point for the Springfield 115-kV system that only the proposed solution provided was at the Agawam Substation. That supply point would not be part of the 345-kV system under either of the other Options. With this additional supply point, bulk power could be provided to the Springfield area's 115-kV system from the south, in addition to the pre-existing supply from the north

(Ludlow). Should the Ludlow Substation supply to the 115-kV transmission system be lost for any reason, there would still be a path from the south for power to flow into the Springfield area to meet customer load and to maintain transmission system voltages within acceptable ranges. Because of this new source, there would be less reliance on the Ludlow autotransformers. Additionally, a double-contingency outage of the Ludlow – Barbour Hill 345-kV line and the Ludlow – Agawam 345-kV line will not interrupt a 345-kV supply to the Agawam Substation, making it a very reliable new source for the Springfield 115-kV system. With the proposed configuration, the Agawam Substation also provides voltage support to the Springfield area. Finally, since all of the area's 115-kV lines tie into the Agawam Substation, it is a strategic location for limiting power flows through the Springfield area; and since it is close to area load centers, it is well sited to provide flexibility in expanding the 115-kV network to serve future growth.

G.2.1.2 Advantage of Avoiding Phase Shifters

Only the proposed solution would not also require the use of 115-kV phase-shifting transformers. These are specially designed transformers for connecting systems at the same voltage in a way to act as a valve to control or limit power flow. A phase-shifting transformer requires additional substation space, adds cost to the Project, and would be unique to the Connecticut and western Massachusetts systems. Parts would have to be obtained and maintained so that reliability is not significantly decreased. Also, as system conditions change, the phase-shifting transformers would have to be adjusted to provide continuous optimum performance. This requirement would place additional burden on those actually operating the system and their support staff providing short-term planning support. Consultations by the planning team with the system operators ascertained that the operators have a strong preference for avoiding the use of phase shifters where possible.

G.2.1.3 Further Investigation of the Options

The NUSCO planners investigated Options B and C further in order to determine whether either of them presented any system benefits, cost, or environmental advantages that would overcome the system benefits advantages of the proposed solution. That analysis confirmed the superiority of the proposed solution.

G.2.1.3.1 Elimination of Option C – Manchester to Ludlow

System Benefits/Disadvantages

Since the Ludlow to Manchester line configuration would not connect to North Bloomfield Substation, it would not increase the reliability of supply to this important substation, which serves an area of Connecticut experiencing higher than average load growth; and it would not create an additional loop around the north-central Connecticut and Springfield area.

Moreover, a new Manchester to Ludlow 345-kV line would be along the same path as the existing Manchester (Connecticut) to Barbour Hill (Connecticut) to Ludlow 345-kV transmission line. Placing the two 345-kV lines on the same right-of-way (ROW) would not be a criteria violation. However, a system with two 345-kV lines on the same ROW would be less reliable than the proposed looped configuration and could interrupt the Massachusetts – Connecticut interconnection if an extreme contingency on the right-of-way affected both 345-kV lines.

Associated Construction Requirements and Cost

The Options Analysis recognized that Option C would require construction of more 115-kV facilities in Connecticut than the other Options. However, further analysis disclosed that these requirements were significantly greater than had been recognized at the time the studies underlying the Options Analysis were done.

Option C would require the following 115-kV construction in Connecticut, which would not be required by Options A or B:

- A new underground 115-kV circuit between the Manchester and South Meadow (Hartford) Substations, constructed in and along public streets, for a distance of approximately 4.7 miles;
- A new underground 115-kV circuit between the Southwest Hartford and South Meadow Substations, a distance of approximately 3.8 miles, which would probably be installed in an existing empty pipe conduit;
- A new underground 115-kV circuit between the Northwest Hartford and Southwest Hartford Substations, constructed in and along public streets for a distance of approximately 3.6 miles;
- Reconductoring the #1783 Farmington to Newington line for a distance of approximately 3 miles with 556-kcmil ACSR conductors, and
- Reconductoring the #1785 Berlin to Newington line for a distance of approximately 3 miles with 795-kcmil ACSR conductors.

A planning grade estimate of the total cost of this work is $230.6 million, broken down in Table G-2.

Table G-2: Hartford Area Construction Summary

Segment	Length (miles)	Cost[1]
Manchester to South Meadow	4.7	$97 million
Southwest Hartford to South Meadow	3.8	$18.9 million
Northwest Hartford to Southwest Hartford	3.6	$73.8 million (one cable only)
Farmington to Newington	3.4	$13.5 million
Berlin to Newington	6.9	$27.4 million

[1]: This cost estimate includes construction costs, overhead costs, financing costs during construction and expected escalation to the in-service date. All other cost estimates will be calculated and stated in a similar way.

In contrast, the only ancillary work required in Connecticut by the choice of Option A is the Manchester to Meekville Junction Circuit Separation Project – which entails the separation of two segments of 345-kV and 115-kV circuits now on common structures, along approximately 2.2 miles of ROW, as described in Section I. The total cost of this work is estimated at $14 million. Therefore, Option C has a cost disadvantage relating to the Connecticut 115-kV work alone of approximately $217 million, as compared to Options A and B.

That cost disadvantage is not offset by any requirements of Options A or B that are not common to Option C (other than the Manchester – Meekville Junction circuit separation.). All three projects require a similar scope of 115-kV line construction and reconstruction in Massachusetts. Moreover, the cost of the 345-kV component of Option C is driven by its length of 31.6 miles, which is only 3.4 miles shorter than the 35-mile length of the new 345-kV line construction for the proposed solution. This Option C cost advantage for the 345-kV portion of the project, together with the advantage of no 345-kV facility costs at Agawam Substation, does not offset the large excess cost of the 115-kV construction.

G.2.1.3.2 Elimination of Option B – North Bloomfield – Ludlow

There are two potential routes along existing ROW's between the North Bloomfield and Ludlow Substations. One would be along the ROW that leads from the North Bloomfield Substation south and east to Meekville Junction in Manchester, Connecticut, turning north from there to Ludlow Substation. The other route would be from North Bloomfield Substation north to the South Agawam Junction, and from there to Ludlow Substation over either of the previously described Northern or Southern Route alternatives. (Note, however, that because the line would not be tied into the Agawam Substation, if the Southern Route were chosen, there would be no 345-kV construction between the South Agawam Junction and Agawam Substation and no 345-kV facility additions at Agawam Substation.) These potential routes are illustrated in Figures G-6 and G-7.

Figure G-6: Potential Routes - Option A

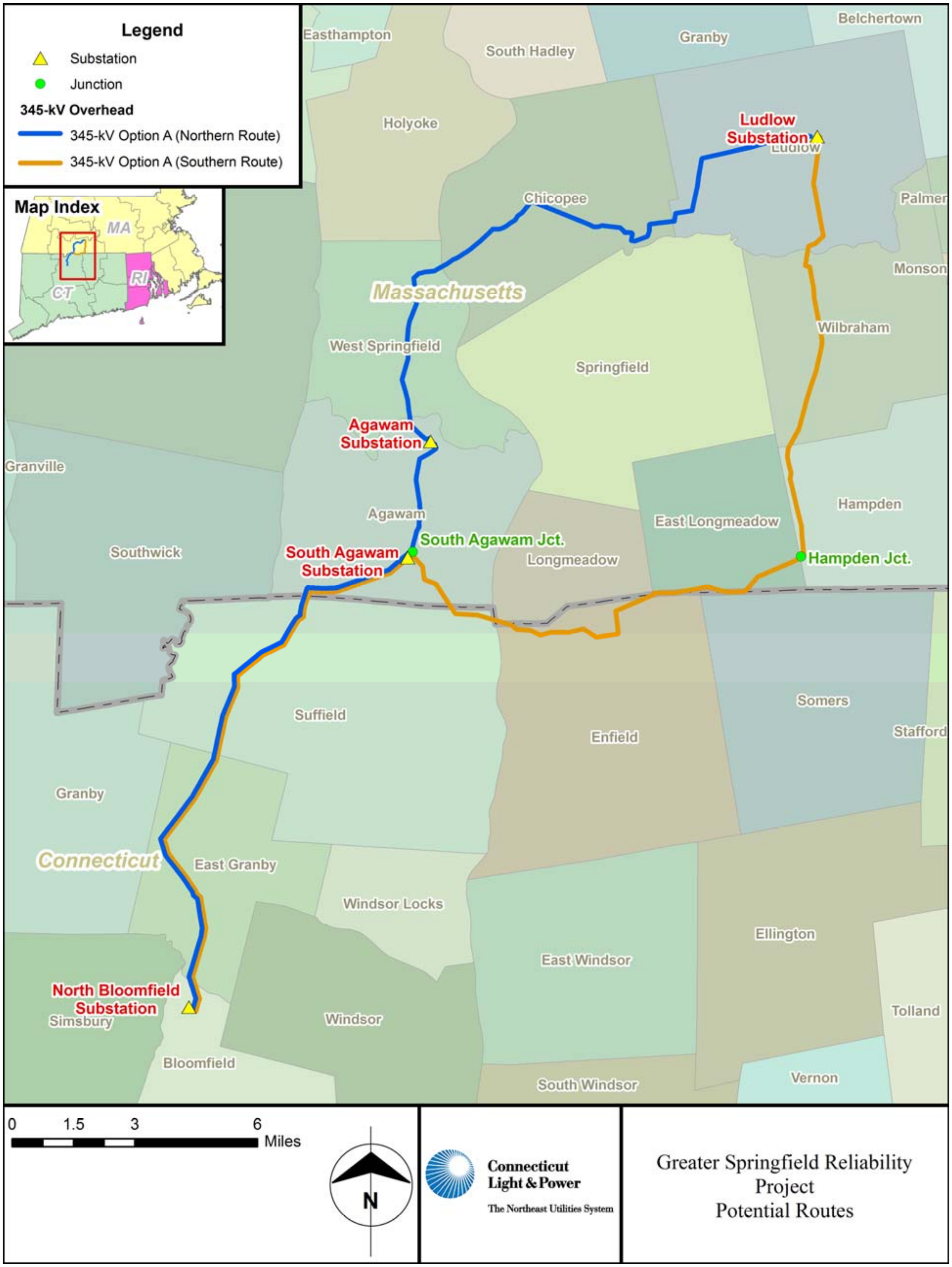
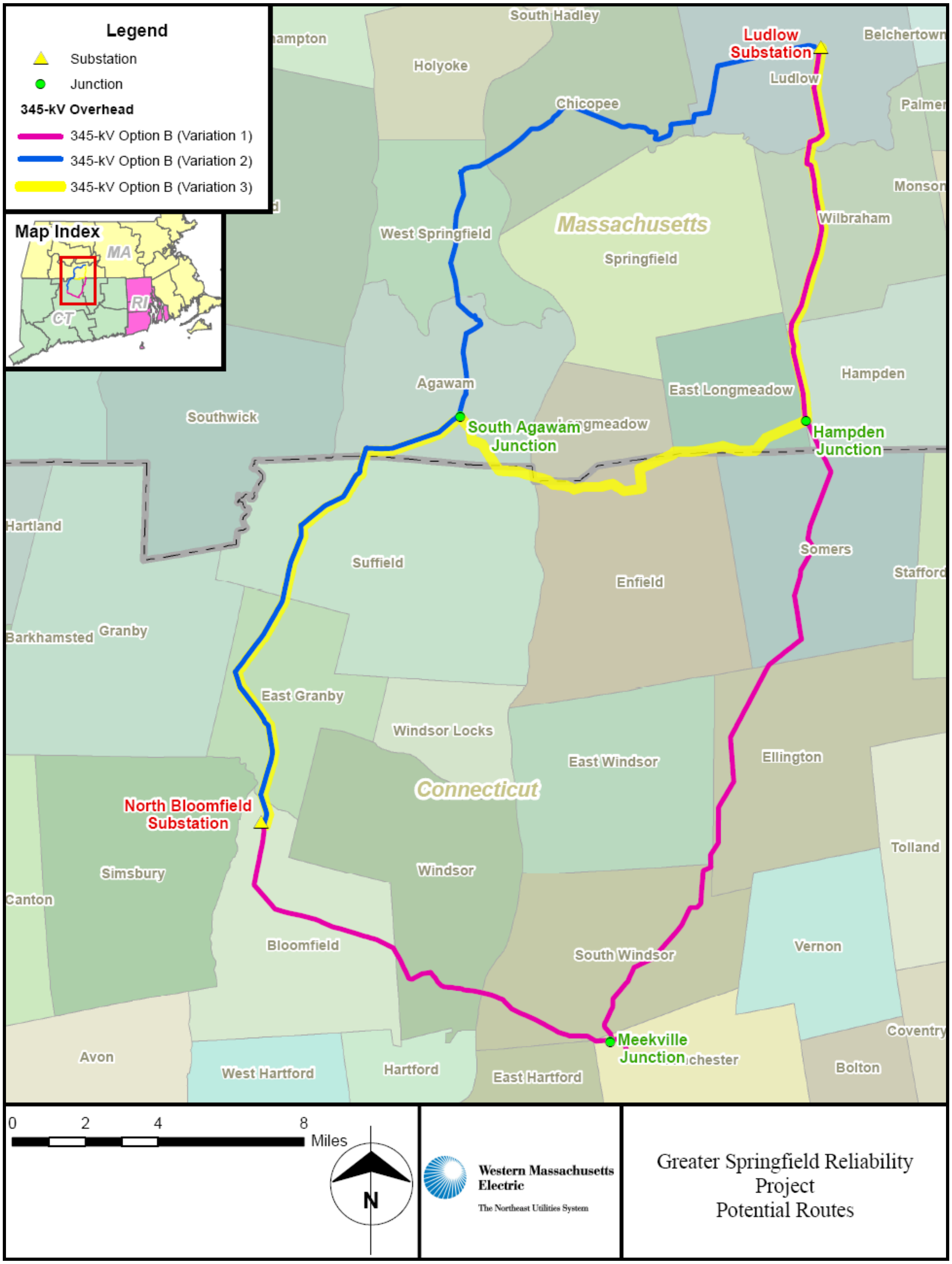


Figure G-7: Potential Routes - Option B



The North Bloomfield – Meekville Junction - Ludlow Route

A 345-kV line constructed along a North Bloomfield – Meekville Junction – Ludlow route (see: Figure G-7, above) would be approximately 44.5 miles long, 31.5 miles of which would be in Connecticut. From Meekville Junction to Ludlow Substation, a distance of approximately 31 miles, the new 345-kV line would be along the same path as the existing Manchester to Barbour Hill (Connecticut) to Ludlow 345-kV transmission line, which would present a reliability disadvantage as compared to the GSRP.

The North Bloomfield – Meekville Junction – Ludlow route would be between approximately 7.2 miles and approximately 9.5 miles (about 19 to 27 percent) longer than the North Bloomfield - South Agawam - Ludlow route (depending on whether the shorter Northerly (total length of 35 miles) or the longer Southerly (total length of 37.3 miles) segment between South Agawam Junction and Ludlow Substation were employed for the latter route). This increased length translates into increased cost: the planning grade estimate is that the North Bloomfield – Meekville Junction – Ludlow route would cost approximately $240 million, as compared to $197 to $210 million for the North Bloomfield – South Agawam Junction – Ludlow 345-kV line routes.

The increased line length of the route through Meekville Junction would also entail increased environmental effects. Further, the social effects of that route would be greater than the route through South Agawam Junction, because there are more densely settled areas along the ROW.

Accordingly, were Option B, the North Bloomfield to Ludlow 345-kV line, to be selected, the proposed route for the line would be one of the two routes through South Agawam Junction and not the route via Meekville Junction.

The North Bloomfield – South Agawam Junction – Ludlow Route

A 345-kV line from North Bloomfield to South Agawam Junction to Ludlow would present virtually all of the same routing choices and environmental effects as does the proposed solution.

The only differences between this configuration and that of the proposed solution would be:

- No expansion of the Agawam Substation to accommodate 345-kV equipment additions and transformation to 115 kV would be required since no connection to the 115-kV system would be made at Agawam Substation with this Option B configuration;
- In place of transformers at the Agawam Substation, this configuration (on both the Northern and the Southern Route) would require much more costly phase shifters installed at the North Bloomfield Substation in Connecticut. In place of these expensive phase shifters, the proposed solution uses a lower cost approach of re-configuring 115-kV lines going south from the South Agawam Substation into Connecticut and cutting these lines off from the North Bloomfield Substation to prevent power from flowing onto the Connecticut 115-kV system there.
- If the Southern Route between South Agawam Junction and Ludlow Substation were chosen, there would be no 345-kV line construction required between the South Agawam Junction and Agawam Substation.

However, the same considerations that favor the selection of the Northern Route segment discussed in Section G.2.1 would apply here as well. The Northern Route for Option B would require the same 35.0 miles of new 345-kV line construction as for the proposed solution. Eliminating a section of 345-kV line back and forth between South Agawam Junction and Agawam Substation, a distance of approximately 3.2 miles one way, would result in the Southern Route for Option B being 6.4 circuit miles shorter than the Southern Route for Option A. However, that leaves the Southern Route for Option B with 37.3 miles of new 345-kV line construction. For the 345-kV line construction, the Southern Route segment would therefore still be more expensive than the Northern Route segment based on the planning grade cost/mile estimates (2.3 miles difference = $13 million). In addition, the environmental and social advantages of the Northern Route would provide reason to prefer it in the same way that these factors strongly favor the proposed solution's use of the Northern Route.

If the Northern Route were chosen for Option B, the only cost difference between Option B and the proposed solution (Option A on the Northern Route) would result from the difference in the scope of the work required to:

> (i) expand the Agawam Substation for 345- to 115-kV transformation, and implement the low cost re-configuration of the 115-kV lines which go south into Connecticut but no longer deliver power at 115 kV to the North Bloomfield Substation (at a total cost of $74 million and $2.6 million, respectively, for a total cost of approximately $76.6 million);

as opposed to that required to

> (ii) install phase shifters, including a spare, at the North Bloomfield Substation (at a total cost of $165 million).

This large difference, of approximately $88 million, provides a second strong leg of support for the selection of the proposed solution. Not only does the proposed solution provide more system benefits, it is also more economic than the best variation of Option B.

Accordingly, after extensive evaluation, the 345-kV solution consisting of the now proposed North Bloomfield to Agawam to Ludlow 345-kV lines, with the Agawam to Ludlow line routed along the Northern route, was identified as the best solution, offering the most system benefits, at lower or comparable cost, and with comparable environmental impacts, as compared to the better variants of the other Options.