Policy Proposal – Summary
Distribution Substation Voltage Regulator Strategy
Electricity Distribution

A **Strategy** paper by Eileen Duarte/Pat Hogan

Date: 01/13/10

Description

The purpose of this strategy is to replace substation voltage regulators with condition or design issues that present a risk to the system. This strategy targets substation voltage regulators as follows:

Siemens Type JFR manufactured between 1989 and 1993 and
General Electric Type IRT and Type IRS

A list of regulators with condition or design issues can be found on a per state basis in the state specific section of this document.

This strategy supports both reliability and a sustainable network by removing substation voltage regulators with condition or design issues on a per state basis that are considered unreliable, and a program to do so when it is feasible.

The Distribution Substation Voltage Regulator Strategy is attached as an Appendix to this paper.

Category: **NA**
Project Prioritization Score: **NA**

Finance

Sanction Cost	**NA**
Probability that project cost will exceed 10% tolerance:	**NA**
Project included in approved Business Plan?	**NA**
Project cost relative to approved Business Plan	**NA**
If cost > approved B Plan how will this be funded?	**NA**

Other financial issues: None

	Current planning horizon							
$M	**Prior YR'S**	**Yr 1 09/10**	**Yr 2 10/11**	**Yr 3 11/12**	**Yr 4 12/13**	**Yr 5 13/14**	**Yr 6+**	***Total***
Proposed investment								

Resources

Availability of internal resources to deliver project:	**NA**
Availability of external resources to deliver project:	**NA**
Operational impact on network system:	**NA**

Key issues

- All voltage regulators with design and condition issues have been identified for replacement and listed on a per state basis.
- All voltage regulators with design and condition issues are identified to be replaced on an opportunistic or problematic basis.

Key milestones

- **NA**

Climate change

Contribution to National Grid's 2050 80% emissions reduction target: **NA**

Impact on adaptability of network for future climate change: **NA**

Are financial incentives (e.g. carbon credits) available? **NA**

Prior sanctioning history including relevant approved Strategies

- N/A

Recommendations

The Distribution Capital Investment Group is invited to:

(a) APPROVE the Distribution Substation Voltage Regulator Strategy

Supporting signatures (not required if DCIG minutes reflect approval of paper)

Investment planning

Signed Date
Christian Brouillard, Director, Investment Management

On behalf of Regulation by

Signed Date
Peter Zschokke, Director US Regulatory Research & Special Projects

On behalf of Procurement by

Signed Date
Ross R. Turrini, VP Procurement

Sponsor's Signature

(Required)
Signed Date 2/6/10
Patrick Hogan, Sr. VP Network Strategy

Decision of the DCIG Sanctioning Authority
(Required)
I hereby approve the recommendations made in this paper

Signed Date
John Pettigrew, Chief Operating Officer & EVP, EDO &G

Voltage Regulators
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Strategy Statement

The purpose of this strategy is to replace substation voltage regulators with condition or design issues on an opportunistic basis that may present a risk to the system. This strategy targets substation voltage regulators as follows:

- Siemens Type JFR manufactured between 1989 and 1993 and
- General Electric Type IRT and Type IRS.

A list of regulators with condition or design issues can be found on a per state basis in the state specific section of this document.

This strategy supports both reliability and a sustainable network by removing substation voltage regulators with condition or design issues on a per state basis that are considered unreliable, and a program to do so when it is feasible.

This strategy will be phased-in after FY11 since the initial strategy targeted replacements using a ten-year rolling program, resulting in money budgeted for FY11 replacements. Therefore, units have been identified for FY11.

Amendments Record

Issue	Date	Summary of Changes / Reasons	Author(s)	Approved By (Inc. Job Title)
	01/13/2010	Revision	Eileen Duarte Distribution Asset Strategy	John Pettigrew Executive Vice President, Electric Distribution Operations
1	01/03/2008	Initial Issue	Anthony McGrail Substation Engineering Services	John Pettigrew Executive Vice President,

				Electric Distribution Operations

Strategy Justification

1.0 Purpose and Scope

This strategy sets forth a Distribution Substation Voltage Regulator replacement program to allow National Grid to maintain a reliable and sustainable network, and to identify those voltage regulators that are in need of replacement.

This strategy supports National Grid's objective to improve reliability and meet service quality standards in all states in which National Grid operates. This strategy pertains to substation voltage regulators denoted as distribution.

2.0 Background

There are particular voltage regulators on our system that have condition or design issues and may impact reliability. There has been a high failure rate of Siemens JFR regulators purchased between 1989 and 1993. In 2006, this family of regulators represented 8% of National Grid USA's substation regulator population and was responsible for 50% of the regulators that were replaced due to failure or maintenance issues. The most common failure mode is failure of the moveable or stationary contacts [3]. General Electric IRS and IRT induction regulators and the Westinghouse IRT regulators have presented operating problems when removing from service. In addition, parts are obsolete, and National Grid has experienced failures due to through faults with this type of regulator. Voltage Regulators manufactured by Cooper experienced contact issues in the late 80's; however the current vintage have not posed a problem but are continuously monitored, as are all regulators, via Visual and Operational (V&O) inspection and Thermographic inspection surveys.

2.1 Substation Maintenance Standards

Step voltage regulators are maintained in accordance with SMS 404.01.1 Step Voltage Regulator [1]. Induction voltage regulators are maintained in accordance with SMS 404.02.1 Induction Voltage Regulator [2]. Both types of regulators receive a thermographic inspection at least once a year in accordance with SMS 400.07.1. In addition, there is SMS 404.40.1 Siemens JFR Regulator Replacement [3] and SMS 404.40.2 GE IRS/IRT Voltage Regulator Replacement [4]. The later two standards describe the problems National Grid has experienced and identified with these types of regulators.

2.2 Data

The substation distribution voltage regulator population consists of 2,980 operating units and 345 spares as of September 2009. This is based on FERC D substation voltage regulators listed in AIMMS. Of the 2,980 operating units and 345 spares, 1,742 units and 199 spares have associated age data.

The age profile for regulators displayed in Figure 1 shows that 90% of regulators are less than 40 years old, and the average age of units with age data being 17 years. However, 42% of the population does not have age data, and previous evaluation of assets without age data has concluded that these units are older. Manufacturers in the earlier years did not provide manufacture dates on their nameplates. The average age of the spare population is 31 years.

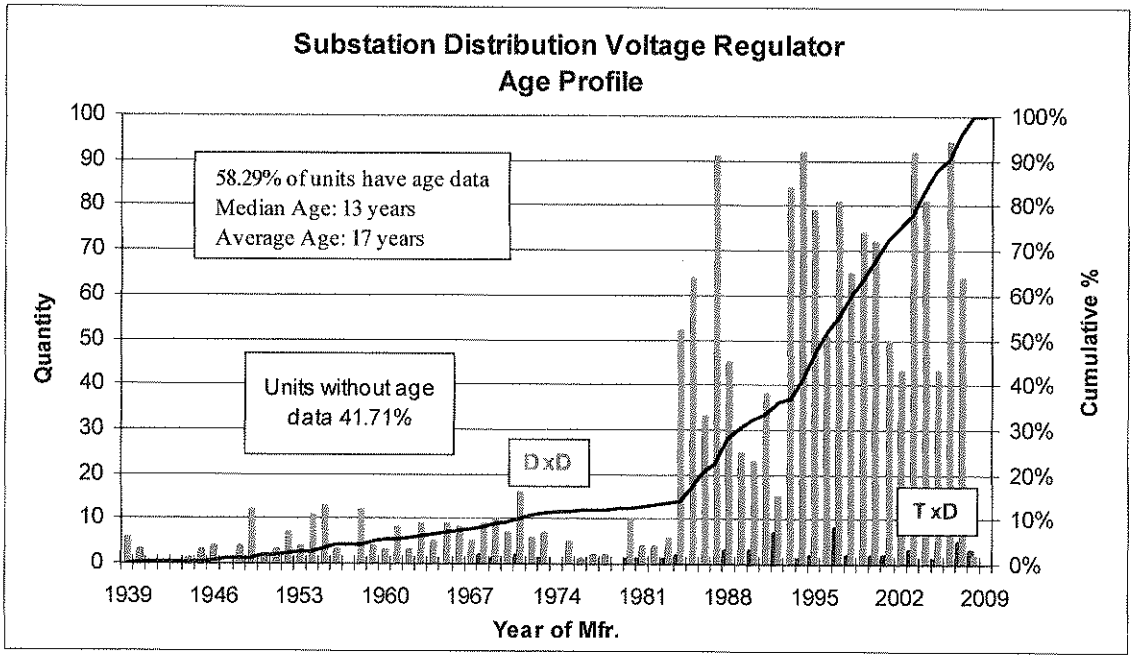

Figure 1. Voltage Regulator Age Profile

The voltage regulator manufacturer with age distribution is shown in Figure 2.

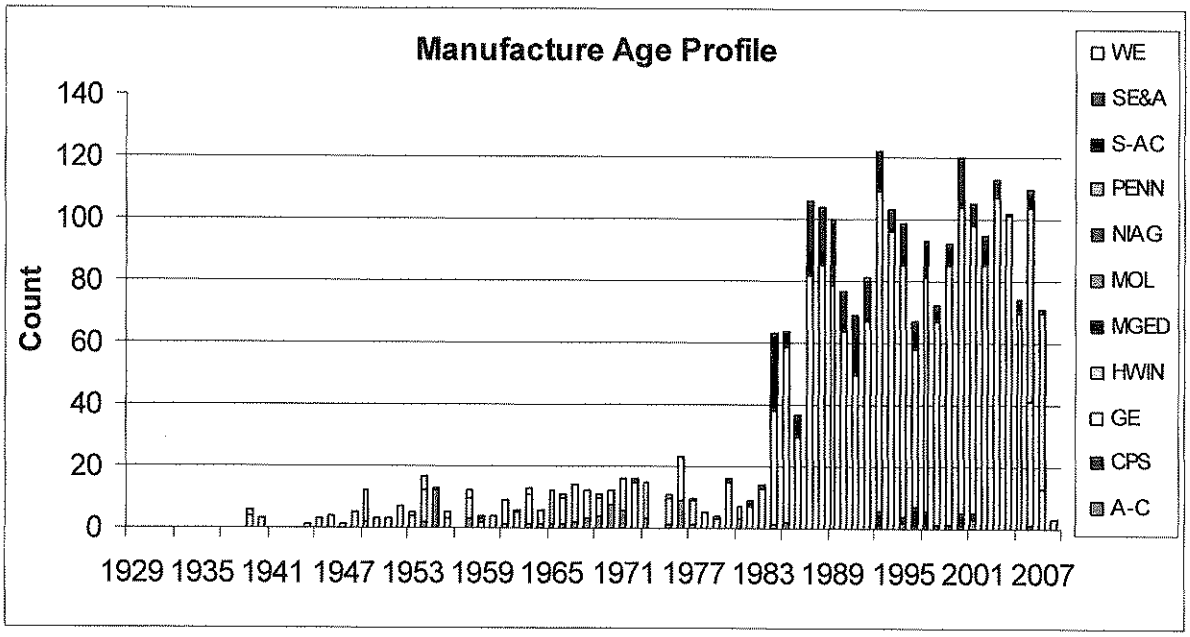

Figure 2. Voltage Regulator by Manufacturer and Age

In accordance with Figure 2, GE (General Electric) is the predominant supplier of voltage regulators in our system. HWIN (Howard Industries) is the newest supplier of voltage regulators while GE, WE (Westinghouse) and A-C (Allis-Chalmers) are the oldest suppliers.

2.3 Events

There were 95 regulator related events system wide over the last ten years that led to 86,815 customer interruptions. Fifty-six of the 95 events were due to a voltage regulator failure leading to 52,797 customer interruptions. This is a failure rate of 0.19% per year, and is below the average yearly failure rate of 0.29% based on a recent survey involving ten North American utilities. The survey was performed in 2009 via the ASKDoble[1] E-mail forum. In addition, all utilities who participated in this survey have phased-out their induction type regulators with the exception of one utility who is replacing them on an accelerated basis. Most utilities in this survey have Siemens Type JFR's (as targeted by National Grid for replacement) on their system but do not yet have a replacement program in place. However, they are seeing problems with the controls and have replacement plans under consideration.

The voltage regulators identified for replacement are Siemens Type JFR, General Electric Type IRS and IRT Induction, and Westinghouse Type IRT. Cooper Type VR-32 regulators exhibited contact problems in the 80's. All Cooper Type VR-32 regulators have been replaced in New England. The remaining units are located in New York, but they are of a later vintage and do not pose the same problem. Below is a list of the voltage regulators and their count targeted to be replaced on an opportunist basis in accordance with the SMS 404.40.2 and SMS 404.40.1:

- Siemens JFR (80 units)[2], manufactured between 1989 and 1993
- General Electric IRS Induction (222 units)
- General Electric IRT Induction (106 units)

Figure 3 shows the voltage regulator failure rates on a per year basis of those utilities who participated in the survey. National Grid is utility J, and we are doing well in comparison to the other utilities.

[1] ASKDoble is an e-mail forum provided by Doble Engineering Co. for Doble clients to ask technical questions of other utilities world-wide

[2] This includes manufacturers S-A, SE&A type JFR listed in AIMMS

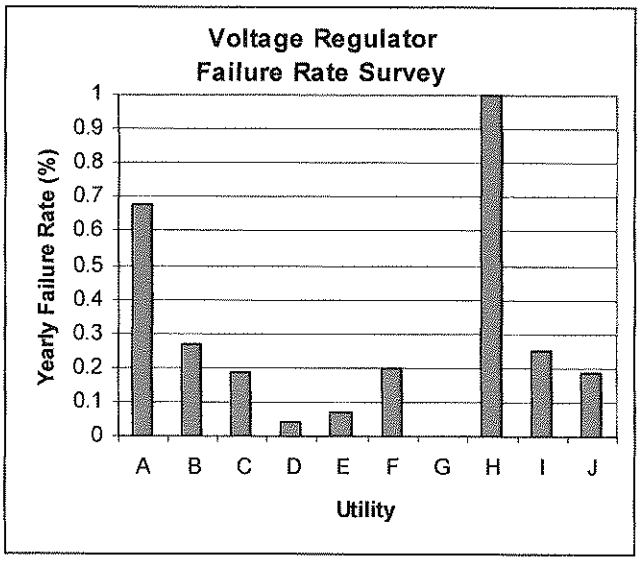

Figure 3. Voltage Regulator Failure Rates

3.0 Benefits

By replacing units with condition and design issues, reliability will improve due to reduced interruptions and voltage fluctuations.

3.1 Safety and Environmental

Voltage regulators are high current, low impedance devices and are subject to failure due to complexity, number of operations, and exposure to through faults. The National Electric Safety Code (NESC) requires new installations and replacements to have different height requirements for clearance purposes. The new installations will conform to the latest safety clearances required by NESC.

3.2 Reliability

Replacement of voltage regulators with condition and design issues reduces the risks of interruptions and outages and will improve reliability to the system.

3.3 Customer/Regulatory/Reputation

Improvement in our voltage regulator fleet will reduce voltage fluctuations and interruptions.

3.4 Efficiency

Replacement of older induction type regulators will improve efficiency to the system by reducing maintenance costs.

4.0 Estimated Costs

There are approximately 300 GE Type IRT and IRS induction regulators, and 80 Siemens Type JFR remaining in the system. Although some may be 3-phase regulators, this indicates approximately 127 sets of regulators that may need to be replaced in an opportunistic basis.

Based on engineering estimates - Cost: $300k per set installed (average)

- 100 sets of GE Type IRT/IRS is a total of $30.0M over 30 years time period
- 27 sets of Siemens Type JFR is a total of $8.1M over 30 years time period

The cost is reflective of a direct replacement, induction or step type voltage regulators, and for either indoor or outdoor substations. There may be additional costs associated with raising the bus, foundation repair, wiring and other, which is not reflected in the above estimation.

5.0 Implementation

Implementation of this strategy should include replacement of 80 Siemens Type JFR step voltage regulators and approximately 300 General Electric Type IRT and IRS induction regulators when condition issues arise as described in SMS 404.40.1 (Siemens Type JFR) and SMS 404.40.2 (GE Types IRS/IRT). In addition, these regulators should be replaced on an opportunistic basis in regards with associated capital projects. Opportunistic would include replacement of regulators on the same feeder position if another regulator in the same feeder position is replaced for any reason provided they fall into the families identified in this strategy; if the circuit breaker or recloser in the same feeder position is replaced; if the regulator's operations count has exceeded 250,000 (for Siemens JFR only), and for any other associated substation work. It is the goal of National Grid to replace the GE Type IRS/IRT induction regulators from the system within a thirty-year timeframe.

Due to NESC clearance requirements, planned replacement must include a prior site evaluation to determine whether structures will require raising or if foundation work is necessary. Indoor substations should also be site evaluated prior to replacing voltage regulators due to the possibility of size restrictions. For example, the Melrose #4 substation regulators are a triplex induction style located in the rear of the building. Extraction and replacement of this equipment would be very difficult, and there is not sufficient space to install three single-phase regulators.

6.0 Risk Assessment

6.1 Safety & Environmental

These units are oil-filled and a failure may result in an oil release. However, since the number of events and voltage regulator failures has been minimal over the past ten years, safety or environmental risks are low.

6.2 Reliability

A voltage regulator failure may lead to interruptions and outages that will affect reliability. However, with a failure rate of 0.19% per year, the reliability risk is manageable.

6.3 Customer/Regulatory/Reputation

The loss of a voltage regulator may impact several regulatory targets. Failure of a voltage regulator may lead to customer outages. By-passing a voltage regulator or a regulator that does not operate properly may lead to voltage fluctuations.

6.4 Efficiency

If older induction type regulators are not replaced, efficiency of the system will reduce due to increased maintenance costs. In addition, the older induction type regulators pose another maintenance issue due to obsolete parts.

7.0 Data Requirements

7.1 Existing/Interim:

AIMMS, PIWS, IDS

7.2 Proposed:

Cascade
A spreadsheet identifying the substation locations of the voltage regulator families discussed in this strategy will be maintained by Network Asset Strategy and shared with Network Asset Reliability Planning, Capacity Planning, and Integrated System Planning.

7.3 Comments:

N/A

8.0 References

1. SMS 404.01.1 Step Voltage Regulator
2. SMS 404.02.1 Induction Voltage Regulator
3. SMS 404.40.1 Siemens JFR Regulator Replacement
4. SMS 404.40.2 GE IRS/IRT Voltage Regulator Replacement
5. SMS 400.07.1 Thermographic Inspection
6. Survey, Distribution Substation Voltage Regulators – Summary, ASKDoble E-mail forum, 12/01/2009, Doble Engineering Co.

9.0 New York

National Grid has approximately 672 regulators, and 66 spares located in New York. The average age of the operating regulator population with age data is 22 years, with 4 percent of the population being greater than 60 years old, while the majority of the units are less than 24 years old. Although 37.20% (250 units) of the regulators in New York do not have age data, this typically pertains to older units. Therefore, the population being greater than 60 years old may be closer to 40%. The age profile for regulators located in New York is found in Figure 3.

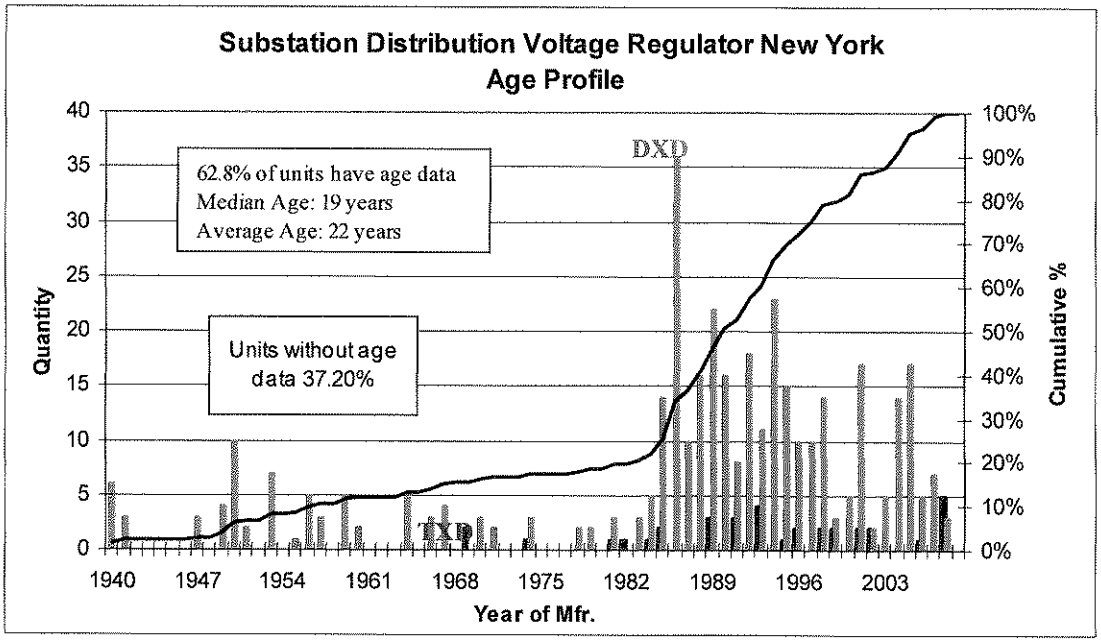

Figure 4. New York Regulator Age Profile

In regards to the manufacture and type of voltage regulators that this strategy aims to replace, New York has the following count:

- Siemens JFR (approximately 2 sets)
- General Electric IRS/IRT Induction (approximately 32 sets)

Cost of Replacement: 34 sets at $300k per unit (average) is a total of $10.2M

These regulators are planned to be replaced on an opportunistic and problematic basis in accordance with the existing standards discussed in Section 2.1 Substation Maintenance Standards.

10.0 Massachusetts

National Grid has approximately 1,698 regulators, and 241 spares located in Massachusetts. The average age of the operating regulator population is 16 years with 3% of the population being greater than 50 years old, while the majority of the units are less than 24 years old. Although 11.37% (193 units total) of the regulators in Massachusetts do not have age data, this typically pertains to older units. Therefore, the average age of units greater than 50 years may be more like 14% of the population. The age profile for regulators located in Massachusetts is found in Figure 4.

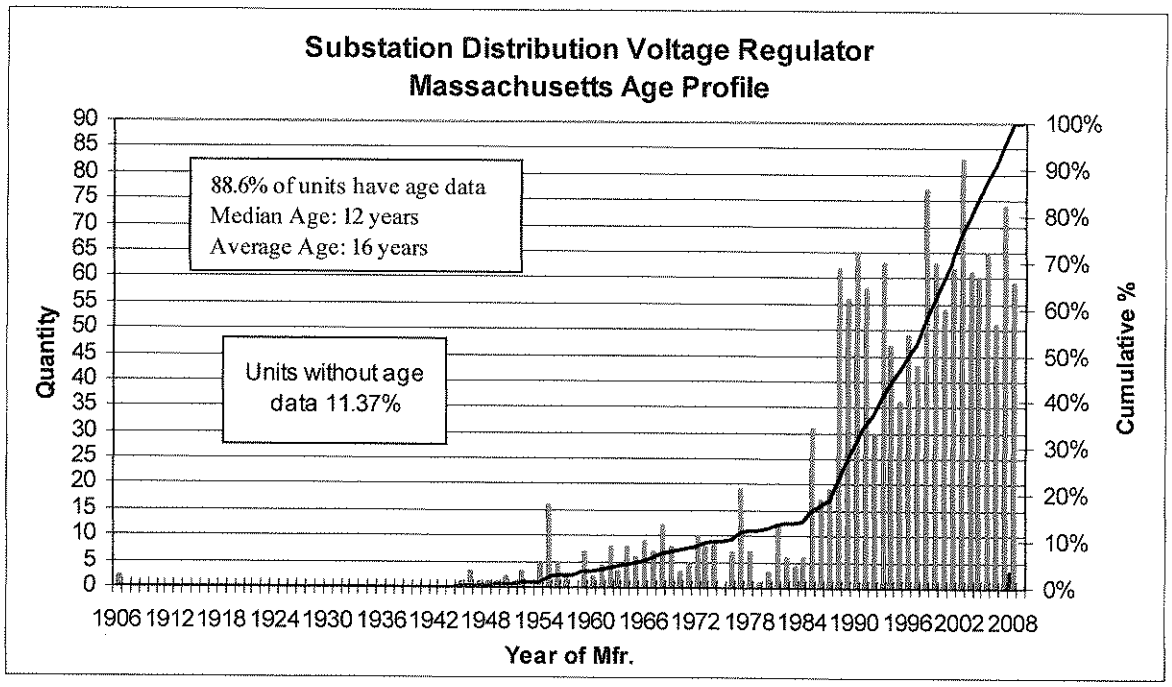

Figure 5. Massachusetts Regulator Age Profile

In regards to the manufacture and type of voltage regulators that this strategy aims to replace, Massachusetts has the following count:

- Siemens JFR (approximately 12 sets)
- General Electric IRS/IRT Induction (approximately 72 sets)

Cost of Replacement: 84 sets at $300k per unit (average) is a total of $25.2M

These regulators are planned to be replaced on an opportunistic and problematic basis in accordance with the existing standards discussed in Section 2.1 Substation Maintenance Standards.

11.0 Rhode Island

National Grid has approximately 507 regulators, and 32 spares located in Rhode Island. The average age of the operating regulator population is 14 years with only 3 units being greater than 50 years old, while the majority of the units are less than 18 years old. Although 6.52% (33 units total) of the regulators in Rhode Island do not have age data, this typically pertains to older units. Therefore, the average age of units greater than 50 years may be 7% of the population. The age profile for regulators located in Rhode Island is found in Figure 5.

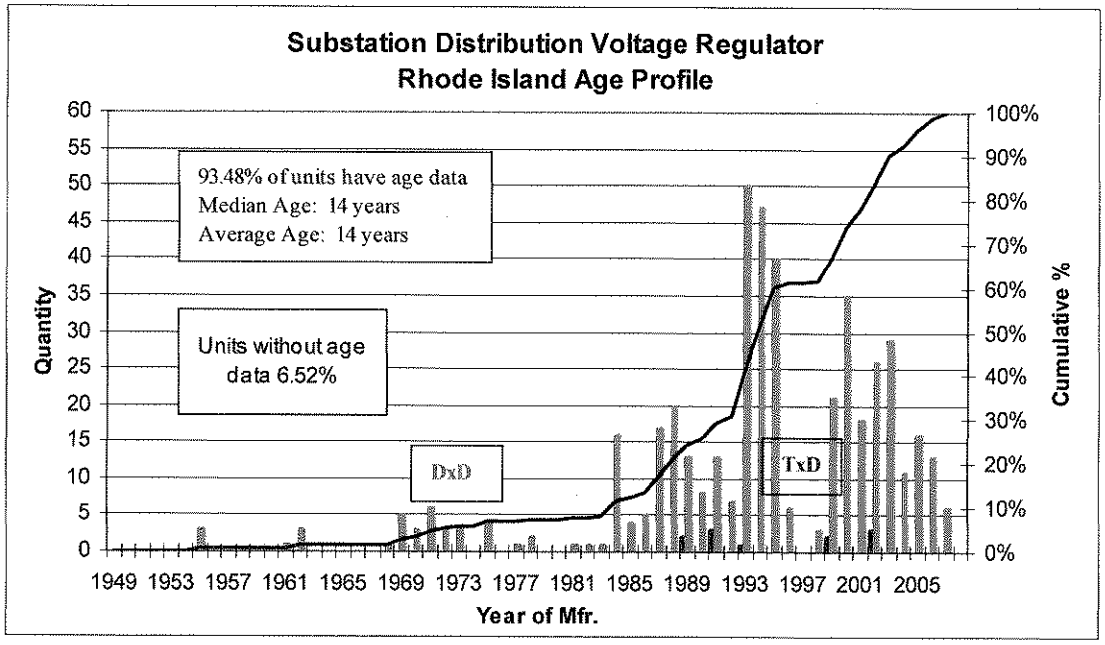

Figure 6. Rhode Island Regulator Age Profile

In regards to the manufacture and type of voltage regulators that this strategy aims to replace, Rhode Island has the following count:

- Siemens JFR (approximately 13 sets)
- General Electric IRT Induction (approximately 6 sets)

Cost of Replacement: 19 sets at $300k per unit (average) is a total of $5.7M

These regulators are planned to be replaced on an opportunistic and problematic basis in accordance with the existing standards discussed in Section 2.1 Substation Maintenance Standards.

12.0 New Hampshire

National Grid has approximately 95 regulators, and 6 spares located in New Hampshire. The average age of the operating regulator population is 13 years and all units are less than 40 years in age, while the majority of the units are less than 24 years in age. In addition, all units in New Hampshire have appropriate age data. The age profile for regulators located in New Hampshire is found in Figure 6.

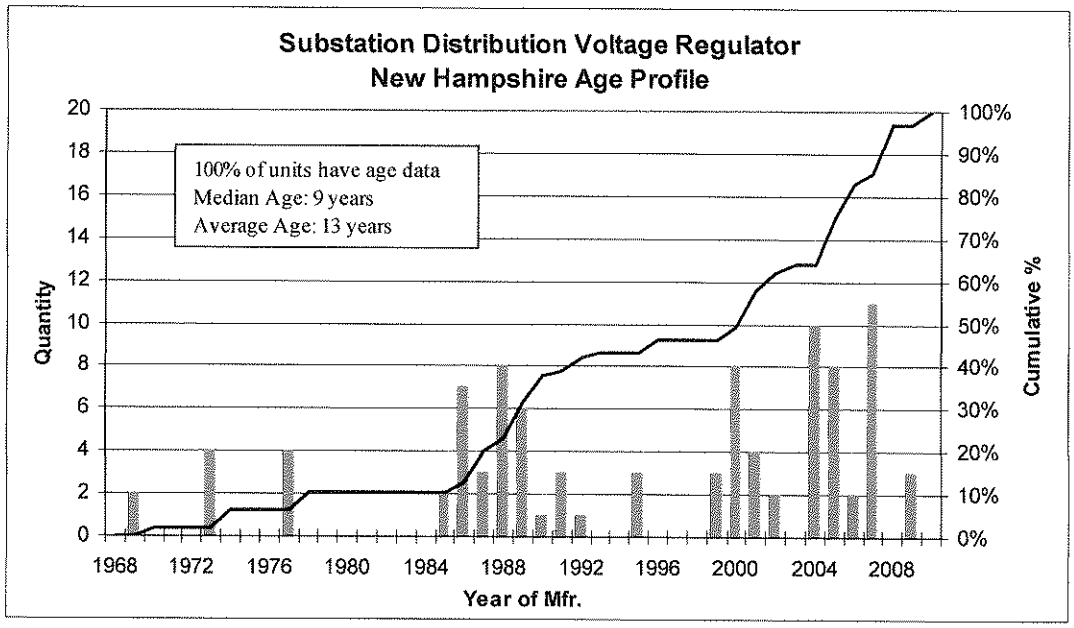

Figure 7. New Hampshire Regulator Age Profile

In regards to the manufacture and type of voltage regulators that this strategy aims to replace, New Hampshire has the following count:

- General Electric IRS Induction (approximately 1 set)

Cost of Replacement: 1 set at $300k per set (average) is a total of $300k

These regulators are planned to be replaced on an opportunistic and problematic basis in accordance with the existing standards discussed in Section 2.1 Substation Maintenance Standards.

13.0 Vermont

National Grid has approximately 9 operating regulators, and 0 spares located in Vermont. The average age of the operating regulator population is 21 years. All units have appropriate age data. The voltage regulators located in Vermont do not appear to have condition or design issues.