REGULATORY APPROACHES TO ADDRESSING THE IMPACT OF STRAY VOLTAGE ON FARM OPERATIONS

Submitted to
The Ontario Energy Board
March 31, 2008

BDR

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EXECUTIVE SUMMARY

Stray voltage is variously defined in scientific literature and in regulatory documents reviewed in the course of this research. For purposes of this report, stray voltage is defined as the voltage difference between two points that a farm animal can come in contact with simultaneously. The cause of stray voltage is a steady state "neutral-to-earth" potential difference that can develop on multi-grounded distribution systems due to flow of unbalanced electric current returning to the system source via the earth and the neutral wire. Stray voltage is normally less than 10 volts and as such not considered to be hazardous to the general public.

Stray voltage on a farm may be caused by both the on-farm wiring system and utility distribution systems. More specifically, stray voltage can be caused by either one or both of the following sources:

- electric utility's distribution lines or primary system, that powers the transformer from which service conductors for the farm are supplied; and/or
- the low voltage or secondary system—the farm's electric system.

In response to a Directive from the Minister of Energy, the OEB initiated consultation process on the issue of farm stray voltage, and commissioned this cross-jurisdictional study of regulatory approaches to address the impact of stray voltage on farm operations. The scope of work included a review of legal and regulatory measures implemented in various jurisdictions. Three Canadian and six United States jurisdictions were reviewed in detail, and six other Canadian regulators were contacted.

Of the US jurisdictions surveyed, four (Wisconsin, Idaho, Connecticut and Michigan) have addressed the issue through regulatory requirements; Vermont, after considering action at the regulatory level adopted a voluntary program. In Pennsylvania, the regulator will act through its normal customer complaint process but otherwise leaves stray voltage management to the utilities under its jurisdiction. Of the jurisdictions reviewed, only Idaho has passed specific legislation on the subject.

No Canadian jurisdiction currently addresses the issue of farm stray voltage through specific requirements of the utilities defined and enforced by the regulator. Therefore, if the Ontario Energy Board were to adopt and enforce a code for farm stray voltage, it would be the first regulator in Canada to do so.

In the absence of regulatory requirements to address farm stray voltage some utilities have nonetheless developed and maintained internal standards and procedures (note especially Québec, Vermont, and Alberta).

In all jurisdictions surveyed, the utility is responsible for any costs of testing and remediation of off-farm sources of stray voltage. On-farm sources are the responsibility of the farmer. The utility's costs of testing and remediation of stray voltage are recovered from consumers through rates.

In the four jurisdictions where regulatory requirements to address stray voltage have been established (Connecticut, Idaho, Michigan and Wisconsin), the requirements address:

- definition of a level at which remediation is required;
- testing requirements to determine the total amount of animal contact voltage and the source (on farm or off farm);
- remediation requirements; and
- process issues, such as data collection and reporting.

Idaho, Michigan and Wisconsin have adopted the level of 2 mA (milliampere) as the level of animal contact voltage at which remediation is required, and 1 mA as the level of utility contribution at which the utility is required to undertake remediation. Connecticut has defined a level of concern as cow contact level of 0.5 volt or 1.0 mA and primary neutral to earth level exceeding 1.0 volt.

Utilities are typically given broad discretion in deciding how best to carry out remediation. Isolation of the neutral is adopted as a universal practice in some jurisdictions (e.g. Vermont), allowed as a permanent option at the discretion of the utility in others, and allowed only as a temporary measure in Wisconsin. In Connecticut, neutral isolation is required if stray voltage cannot be reduced below the level of concern within 15 days, but may be removed once other remediation measures are in place. Some other remediation means employed by utilities include improvements to grounding and rebalancing the loads along the distribution line. In some cases, utilities also rehabilitate or rebuild the distribution lines using larger conductor size for neutral, where required. In Wisconsin, the utility also has the option of addressing its share of contribution to stray voltage through on-farm mitigation, if the farmer agrees. No regulator in the jurisdictions studied has established requirements related to these remediation strategies. The choice is left to the utility, which would typically consider engineering issues and costs.

Based on this review, there is a range of options open to the OEB in addressing stray voltage on farms.

- The OEB might, as is done in Pennsylvania, refrain from setting any specific requirements, but deal with complaints where the customer is not satisfied with actions taken by the utility.
- It might, as in Vermont, require utilities to develop and follow internal standards and procedures.
- Alternatively, it might develop a mandatory uniform code in this regard, as has been done in Idaho, Michigan, Connecticut and Wisconsin.

In the jurisdictions with mandatory requirements, those requirements address: definition of the level at which remediation is required; specification of testing requirements and allowed or mandated approaches to remediation; measures of customer service, complaint handling processes; reporting requirements, and cost recovery mechanisms for the utilities. The OEB might also take a role in addressing the issues of development of expertise within utilities, education of farm customers, and monitoring of results of the utilities' initiatives.

Other initiatives which can contribute to success in addressing farm stray voltage include coordination of agencies working on the issue (see especially Québec, Vermont and Wisconsin) and training of rural electricians (see Québec and Wisconsin). The OEB may choose a facilitation role to assist in these efforts.

1 INTRODUCTION

1.1 *Study Context and Scope*

Following the Minister of Energy's May 16, 2007 Directive, the Ontario Energy Board (OEB or Board) is charged with the objective of implementing measures necessary to ensure electricity service to farm customers, in relation to "tingle" or "stray" voltage, is of a quality that does not unduly impact the operation of the farm. In response to this Directive, the Board has initiated a Consultation on Farm Stray Voltage (EB-2007-0709) and has formed a Farm Stray Voltage Consultative Group with representatives from various stakeholder groups, to solicit input from interested parties.

As part of the Consultation process, the Board early in November, 2007 commissioned BDR NorthAmerica Inc. ("BDR") to conduct a cross-jurisdictional survey of regulatory approaches to address the impact of stray voltage on farm operations. The scope of work included a review of legal and regulatory measures implemented in various jurisdictions, as well as any subsequent economic impacts, utilities cost increases and rate impacts. The scope of work also included assessment of the suitability and appropriateness for the Ontario context of any legal or regulatory measures adopted in other jurisdictions.

This document is the detailed report resulting from the review.

1.2 *Methodology*

The study consisted of a detailed review of nine North American jurisdictions, specifically Wisconsin, Michigan, Pennsylvania, Connecticut,, Idaho, and Vermont in the United States; and Québec, Alberta and British Columbia in Canada. BDR also contacted the regulators in Saskatchewan, Manitoba, Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland and Labrador, to verify whether they took any specific actions with regard to farm stray voltage; and also made a high level internet survey to determine whether approaches taken outside North America (specifically in Europe and in Australia) might have value for the study. However the work concentrated in North America, because both the nature of electricity systems and regulatory approaches are most similar to Ontario and therefore most likely to result in useful models.

BDR commenced in each jurisdiction with an internet based search. Regulatory agencies typically maintain web sites that offer databases where materials and documents for a minimum of the last few years may be accessed. The type of documents available include Decisions and Orders, transcripts for oral hearings, evidence for written proceedings as well as codes, rules, licenses, and legislative Acts and Regulations. Other internet sources of data include the utilities that operate within the jurisdictions, as well

as a general internet search for reports and documents on the topic of Farm Stray Voltage. Provincial and state government web sites were also a source for copies of useful material.

The web search enabled BDR to obtain high level information as to the local approach and to identify the best source(es) for additional detail. We then followed up with telephone interviews with key contacts to clarify information and obtain additional documents not available from web sites.

In determining the aspects of practice in other jurisdictions most suited to the Ontario context, we considered such issues scope and powers of the regulator, industry structure (number and ownership of electric utilities), mandates of other agencies, and also technical issues of electricity system design, where these affected the suitability and cost of mandated tests or remedial actions.

1.3 *Report Structure*

The report is structured as follows:

- Section 2 provides an overview of the farm stray voltage problem from an electricity system perspective.
- Sections 3, 4 and 5 present a narrative review of Canadian, United States, and other jurisdictions, respectively, including, as available:
  - Some background as to how the current approach being taken has evolved;
  - Description of the agency or agencies involved, their mandates and role in addressing farm stray voltage;
  - Testing and remediation requirements established in the jurisdiction;
  - Process, record-keeping and complaint resolution requirements;
  - Costs and cost recovery provisions; and
  - Any other noteworthy features of the approach taken, including, if any, mechanisms of assistance and support to affected farmers.
- Section 6 sets out a tabular summary to facilitate comparison of the key features of the jurisdictions, and
- Section 7 presents BDR's conclusions as to workable models for Ontario.

2 TECHNICAL CONTEXT FOR REGULATORY APPROACHES TO STRAY VOLTAGE

A comprehensive technical analysis of the dairy animal impacts, contributing causes and mitigation of stray voltage problems is beyond the scope of this assignment. The

following brief descriptions are provided to set the context for review of the regulatory solutions that have been applied in other jurisdictions outside of Ontario.

2.1 *Stray Voltage and its Impacts on Animals*

Literature on stray voltage, including both scientific and regulatory documents, includes various definitions intended to clarify and distinguish the phenomenon. For example, the Public Service Commission of Wisconsin defined and described stray voltage as follows:

> "'Stray' voltage is a term that has often been used to describe different situations. It is important to have a common understanding when terms are used to distinguish between 'stray' voltage and neutral to earth voltage. Neutral to earth voltage is voltage measured from the electrical system neutral and/or any structure bonded to this neutral to earth (e.g., to a driven reference ground). Neutral to earth voltage is always present at some level on a multiple-grounded neutral primary electrical distribution system, and on a farm electrical system, as the result of the electrical current flow in a multiple-grounded electrical system. 'Stray' voltage is a special case of voltage in which the neutral to earth voltage is present across points (generally grounded metal objects) in which a current flow is produced when an animal comes into contact with them…These contact points can include any two conductive points which the animal may simultaneously contact to complete a circuit which allows current to flow. Stray voltages are low-level voltages and should be distinguished from painful shocks felt by humans."[1]

Among its rules for the measurement of voltage, the Idaho Public Utilities Commission defines stray voltage as "any steady state, sixty (60) Hz (including harmonics thereof), root mean square (rms) AC voltage of less than ten (10) volts, across (in parallel with) a five hundred (500) ohm resistor (i.e., shunt resistor) connected between cow contact points, as measured by a true rms meter."

In Michigan rule R 460.2701 Definitions, paragraph (t), "'Stray voltage'… means the measured difference in an AC electrical potential when measured with a shunt resistor between 2 points that an animal can simultaneously contact in locations normally accessible by the animal through step or touch both inside and outside of farm buildings."

In the context of this report, stray voltage is defined as the voltage difference between two points that a farm animal can come in contact with simultaneously. The cause of

[1] Public Service Commission of Wisconsin, Findings of Fact, Conclusion of Law and Amended Order, 05-ED-106, August 10, 1989.

stray voltage is a steady state "neutral-to-earth" potential difference that can develop on multi-grounded distribution systems due to flow of unbalanced electric current returning to the system source via the earth and the neutral wire. Stray voltage is normally less than 10 volts and as such not considered to be hazardous to the general public

While "stray voltage" is considered responsible for adverse impacts on dairy animals, it is in fact the current that the stray voltage causes to flow through an animal's body that affects its behavior. Although there is not complete consensus among experts, a number of controlled laboratory studies have shown that cows can detect relatively low levels of current, as low as one milliamp (mA), however it takes at least 4 mA of current to cause adverse behavioral changes. It is conservatively estimated that a cow's resistance to current flow or impedance is 500 ohms in wet areas. By applying Ohm's law, this translates into an animal contact voltage of 2 Volts, which is considered the threshold level for adverse impacts on cows in published literature.[2]

2.2 *North American and European Distribution Systems*

Figure 2.1 displays the key differences in the characteristics of distribution systems commonly employed in North America and Europe. As shown in Figure 2.1(a), North American distribution systems commonly employ four wires on distribution lines; the top three wires serve as phase conductors and the fourth wire at the bottom, labeled Np is the neutral wire on the primary circuit. This typical distribution system is suitable for serving low load density and rural service areas in North America and allows the use of single-phase spur lines (with one phase and one neutral wire) and single-phase transformers (connected between the phase wire and the neutral) to economically serve small loads spread over large geographic areas. As shown, the neutral wire is connected to the ground at multiple points (labeled G), including the supply substation and each step-down transformer. The primary feeder neutral is also connected to the secondary service neutral at the transformer which is connected to the ground at each customer's service panel. Bonding (connecting together) of primary and secondary neutrals and grounding (connecting to the earth) of the neutral at multiple points provides significant advantages in detecting and clearing line-to-ground arcing faults on long rural feeders. However neutral-to-earth potential arising due to unbalanced (not equally balanced among three phases) loads can also transfer from the primary line neutral conductor to the low voltage neutral conductor (where Np joins Ns in Figure 2.1 (a)).

For cost reasons, utilities in the provinces of Alberta and Saskatchewan employ an earth wire return scheme while serving farms in far off rural areas, which is a variation of the

[2] "Stray Voltage Problems in Livestock Production" Jack Rodenburg, Dairy Production Systems Program, Ontario Ministry of Agriculture, September 1998.

typical North American distribution system shown in Figure 1(a). In this scheme, only a single wire is installed on poles, which serves as the phase conductor. The return current on primary feeders employs earth as the return conductor. This type of supply system relies on the presence of sufficiently low soil resistivity, and therefore would not be suitable in all regions of North America.

European distribution systems, as shown in Figure 2.1(b), commonly employ three-phase, three-wire medium voltage distribution lines, without a neutral conductor. A majority of the distribution transformers are three-phase and connected in a delta configuration on the primary side. Single phase transformers are rarely used and when used they are connected between two phase conductors of primary feeder as shown on the extreme right side of Figure 2.1(b). Use of three-phase transformers results in better balance of load among phases and since there is no neutral employed on the medium voltage (primary), there is no direct connection between primary feeders and low voltage lines and stray voltage cannot transfer from primary feeders to low voltage lines.

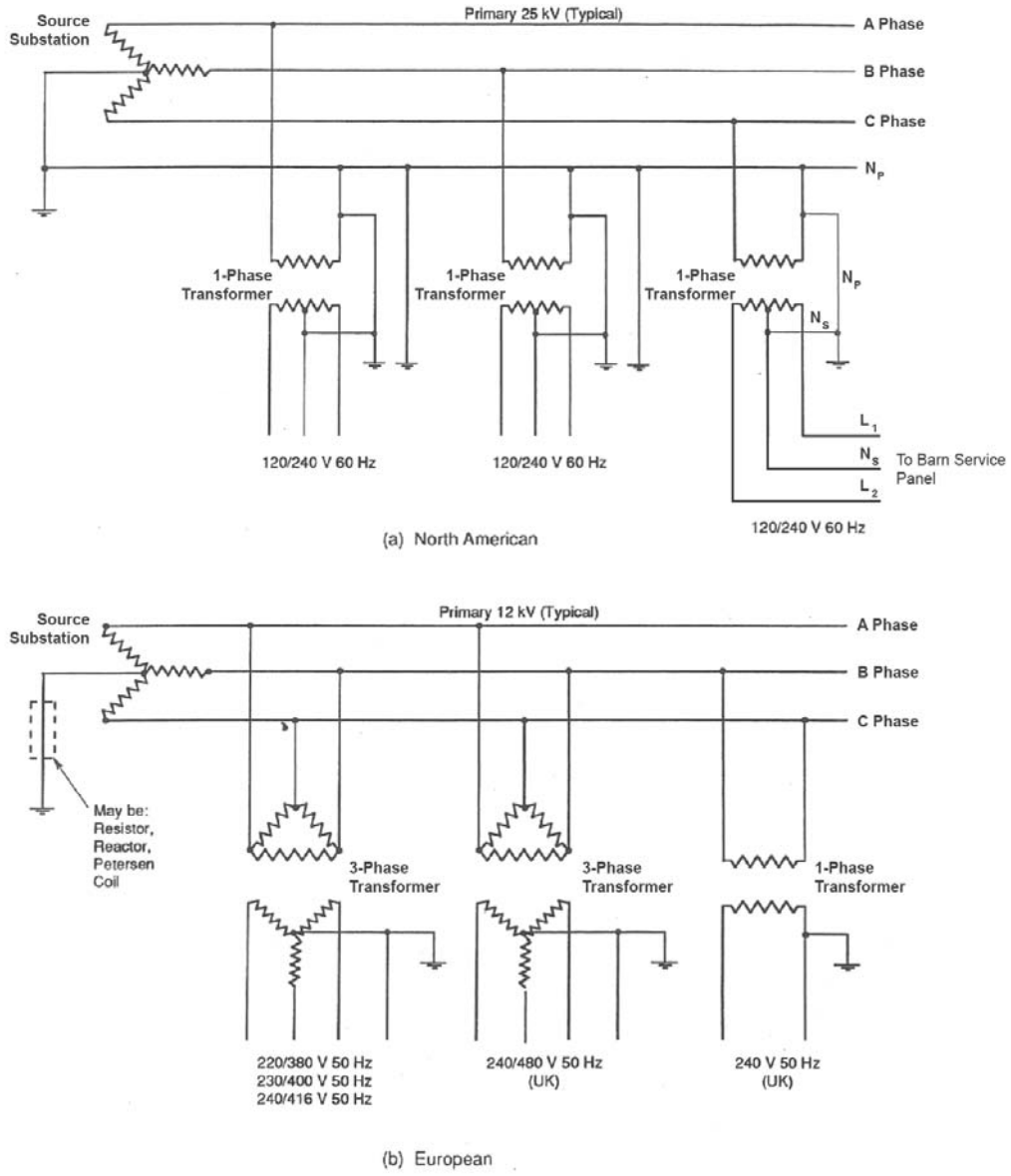

Figure 2.1: Schematic Diagram North American and European Distribution Systems[3]

[3] Adapted from "A comparison between European and North American Electricity Distribution Systems" – Dr. Jan Carr, The World Bank Electric Power Distribution Design Workshop - May 1997.

2.3 *Causes of Stray Voltage*

Stray voltage on a farm may be caused by both on-farm wiring system and utility distribution systems. The neutral to earth voltage (NEV) measured at any point on the system can come from any of the following sources, although the first two are the most likely source in a majority of cases:

- Electric utility's distribution lines or primary system, that powers the transformer from which service conductors for the farm are supplied (as shown in Figure 2.2); and/or
- the low voltage or secondary system—the farm's electricity distribution system (as shown in Figure 2.3).
- Other external sources, such as traction power railways, cathodic protection systems, telephone lines and/or cable TV services.

Figure 2.2 shows the schematic of a neutral circuit, for a typical customer on a North American style distribution system and development of neutral to earth voltage due to unbalanced current on primary line.

When the load on a three-phase primary feeder is not completely balanced or where a single phase spur line is used to supply a farm, a significant part of the current returns to the source through the neutral conductor, as shown by arrows. The higher the neutral current, the higher will be the potential of the neutral in relation to remote earth. Because the neutral terminals on a transformer primary and secondary are bonded together (Np and Ns connected together), the neutral to earth potential can be transferred through the neutral to the farm's service panel.

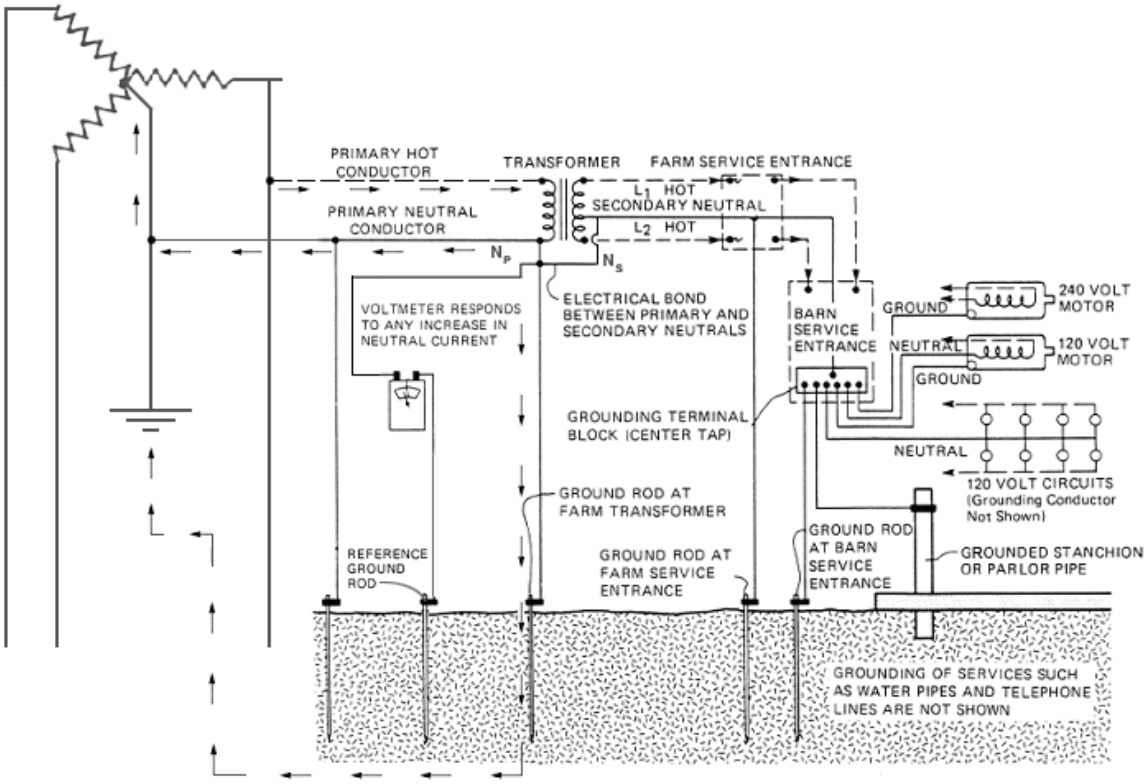

Figure 2.2: Neutral to Earth Voltage Resulting from Unbalanced Primary Feeders[4]

Similarly, if the loads on the low voltage service panel at the farm are not balanced among the two-phase buses, it may also result in unsatisfactory neutral to earth potentials on farm. Figure 2.3 shows the current path through secondary neutrals responsible for stray voltage.

[4] Adapted from "Agriculture Building Systems Handbook – Plan 314-40" – British Columbia Ministry of Agriculture, Food and Fisheries, BC, Canada.

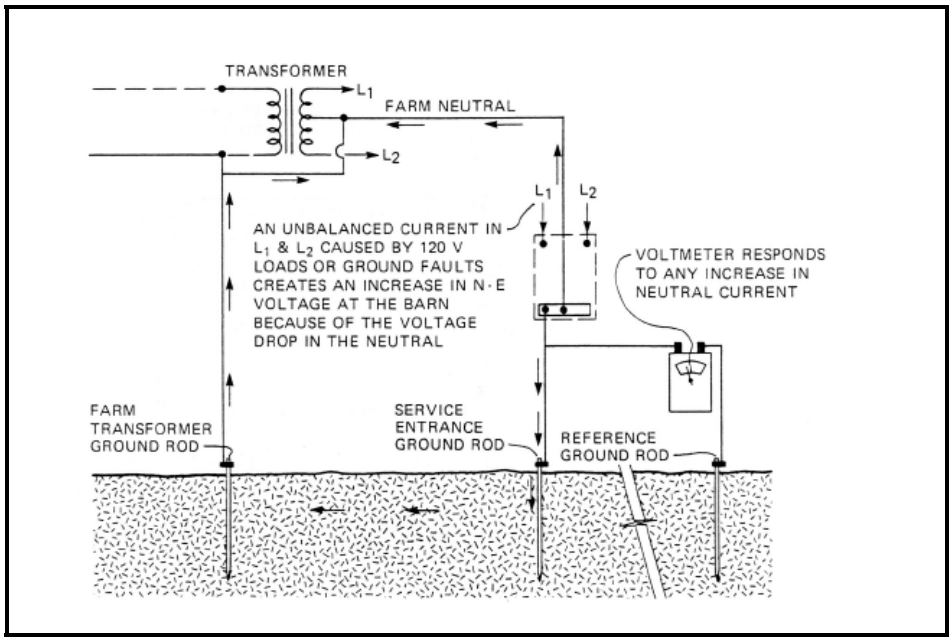

Figure 2.3: Neutral to Earth Voltage Resulting from Unbalanced 120 V Loads Customer Side[5]

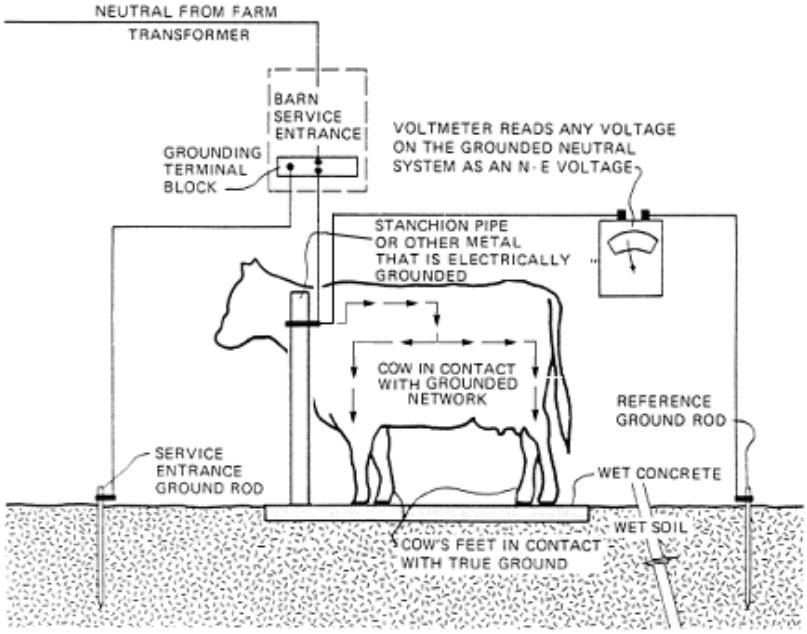

Figure 2.4: A Cow Subjected to Stray Voltage[6]

[5] Ibid.
[6] Ibid.

Finally, the current flow path indicated by arrows in Figure 2.4 shows how a farm animal could be subjected to the stray voltage between metal stabling and floor surfaces. Because metal stabling, water lines and case grounds on electrical equipment are all bonded back to the neutral of the system at the service entrance panel for safety reasons, they provide a path for flow of current through the animal's body.

2.4 *Stray Voltage Testing*

In order to implement most effective and cost efficient mitigation measures, the first step is to determine the magnitude of stray voltage and its source through field testing.

The states of Michigan, Wisconsin and Idaho have developed comprehensive standards for stray voltage testing. The test standards for the state of Idaho, which are very similar to those used by the State of Wisconsin, are reproduced in the Appendix. The test procedures specified by the state of Michigan for Stray voltage testing are also included in Appendix. Although slightly different, these procedures are also aimed at measuring the stray voltage and identifying its contributing source. These test standards can serve as a resource, if the OEB decides to implement a standardized procedure for stray voltage testing at dairy farms.

The key features of the test standards in use in the states of Wisconsin and Idaho are discussed below:

(a) The tests are mandated to be carried out upon receipt of a stray voltage complaint by the power supply company within a specified time period.
(b) The tests are required to be carried out by qualified professionals, using specified test procedures and calibrated instruments of specified accuracy.
(c) The preventative action level (PAL) of stray voltage beyond which mitigation against stray voltage is mandated is specified.
(d) The following six tests are specified

Test 1 – Cow Contact Test: The purpose of this test is to determine the location(s), if any, where stray current or voltage exceeds the preventive action level (PAL) and to identify the location(s) at which the cow contact voltage will be recorded in the forty-eight (48) hour test.

Test 2 – Forty-Eight (48) Hour Test: The purpose of this test is to determine whether stray current or voltage exceed the preventive action level (PAL) at selected location(s) over a forty-eight (48) hour period and to determine whether the primary or secondary sides of the system have a specific impact on the recorded current or voltage at specific times of day.

Test 3 – Primary Profile Test: The purpose of this test is to measure or calculate neutral-to-earth voltage (NEV) for a multi-grounded distribution system

Test 4 – Secondary Neutral Voltage Drop Test: The purpose of this test is to determine the impact of each secondary service on the neutral-to-earth (NEV) and cow contact voltages on the dairy under controlled conditions.

Test 5 – Load Box Test: The purpose of this test is to determine the extent to which the primary system contributes to stray current or voltage at cow contact points.

Test 6 – Signature Test: The purpose of this test is to determine the contribution to stray current or voltage of individual pieces of equipment operating on the dairy.

2.5 *Stray Voltage Remediation*

The following set of mitigation options represents solutions that address the source of the problem as well as cures where the source of the problem cannot be eliminated.

(i) Solutions Aimed at Eliminating the Source of the Problem

- Load balancing;
- Reducing neutral impedance;
- Improved grounding techniques;

(ii) Cures When Problem Source Cannot be Eliminated

- Isolation between primary and secondary neutral;
- Isolation between service panel neutral and earth
- Equipotential ground planes in milking parlors;
- Insulating floor mats in milking parlors.

Each of the solutions in these two categories is briefly described below:

(a) Load Balancing on Utility Distribution Line and Customer Service Panel

This mitigation measure may involve work on electric utility's distribution system or on customer's service panel and wiring depending on whether the unbalanced currents on primary or secondary circuits are the source of the problem.

On three-phase, grounded-wye distribution systems with perfectly balanced phase currents, the net neutral current should be zero, that is the neutral current from the three phases effectively cancels out. Unfortunately, in the real world perfect balancing cannot be achieved due a number of factors, such as use of single phase spur lines, load

unbalance among phases, and presence of harmonic currents. These phenomena can cause current to flow in the neutral conductor and into the ground rod at the neutral-to-ground bonding point, which creates a proportional NEV. Balancing the phase currents can reduce the 60-Hz-caused NEV across the entire distribution system.

Similarly, if the load on the customer service panel is balanced between the two phases, current in the low voltage neutral conductor of the service line will be very low, lowering the neutral to earth voltage to acceptable levels. However, in the case of an unbalanced loading on a customer's service panel, the flow of current through the LV neutrals will result in an increase in NEV levels, the exception being that the NEV level due to customer loads affects only those customers connected at that transformer and does not directly affect the other customers on the distribution system.

(b) Reducing Neutral Impedance

This mitigation measure may also involve work on either electric utility's distribution system or on customer's service panel and wiring depending on whether the unbalanced currents on primary or secondary circuits are the source of the problem.

Current flowing through primary or secondary neutral conductors would cause a voltage drop across the impedance of the neutral conductor. Because the neutral conductor is grounded, the impedance of the earth return path in parallel with the impedance of the neutral return path dictates the percentage of earth current and the corresponding NEV at that neutral-grounding point. By reducing neutral impedance, stray voltage can be reduced. Reducing neutral impedance involves making sure neutral connections are tight and ensuring the neutral conductor is sized appropriately.

There are limitations to the extent to which neutral impedance would decrease from use of larger size conductors, given that the value of resistance would decrease in direct proportion to the conductor size, but the reduction in inductive reactance due to a single larger conductor would be only marginal. Use of two neutral conductors separated by distance would be more effective in reducing the neutral impedance.

(c) Isolating Farm Service Neutral from Distribution Line Neutral

This mitigation measure involves work on electric utility's distribution system, through installation of the VTNI on the utility pole where the supply transformer is installed.

A simple and effective means of keeping stray voltage from getting to animal and human contact points would be to not bond the primary and secondary neutral conductors at the service transformer. If there is no metallic connection, there can be no voltage and no opportunity for current flow from the primary neutral.

Isolation can be accomplished by a physical separation (i.e. no connection whatsoever) or through the use of a separate isolation transformer. The key considerations in such an approach, however, are the adverse effect on protection on the load-side of the transformer in the event of a lightning strike, a system fault, or a wiring error. Therefore, the benefits of isolating the secondary neutral must be weighed against the very serious risk during these abnormal events occurring and the undesirable consequences that would result.

Use of a variable threshold neutral isolator (VTNI), shown in Figure 2.5, offers the benefits of isolated neutrals while mitigating the adverse impacts. VTNI serves as an electronic switch that, during open state, keeps the transformer low voltage neutral isolated from the primary neutral under normal operating conditions. However during fault conditions if the potential difference between the two neutrals reaches unsafe levels, the electronic switch closes automatically, temporarily bonding the two neutrals and then re-opens when conditions return to normal.

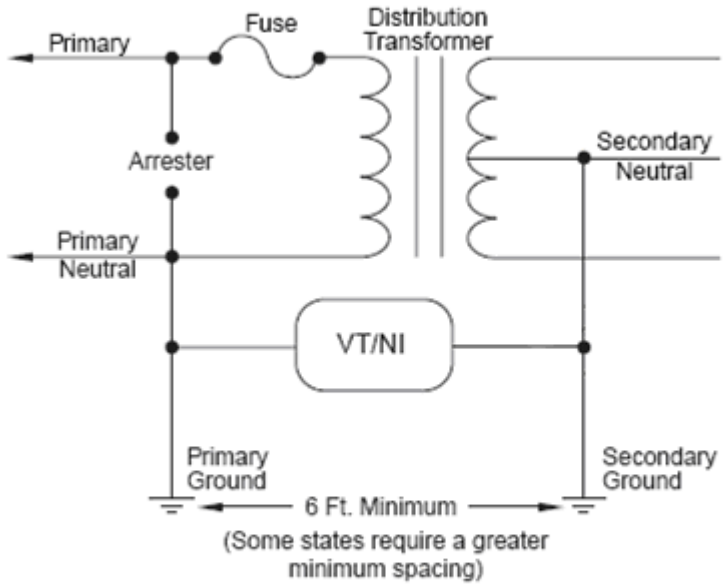

Figure 2.5: Variable Threshold Neutral Isolator[7]

[7] Adapted from "Installation Instructions – Variable Threshold Neutral Isolator (VTNI)" – Dairyland Electrical Industries, Wisconsin, USA.

The device sells for approximately $875 and has been in use for approximately 20 years in many states in USA and also by BC Hydro.

Revisions in Ontario Electrical Code introduced in 2002 permit removal of the bond between the primary and secondary neutrals of distribution transformers under special cases, to allow the use of a VTNI, provided conditions specified in clause 75-504 of the Code are met.

A device to achieve the same objective of isolation between primary and secondary neutrals with different type of design is called Ronk Blocker. This device is essentially a stray voltage filter installed between the primary and secondary neutral. It results in a percentage decrease of voltage transfer from primary to secondary. A Ronk Blocker sells for approximately the same price as the VTNI.

It is noteworthy that while the VTNI or Ronk Blocker can be extremely effective in blocking stray voltage transfer from primary feeder to the low voltage system at the dairy farm, they can lead to an increase in stray voltage magnitude, when the source of the stray voltage is not the primary feeder but the low voltage line.

(d) Isolating Service Neutral from Earth

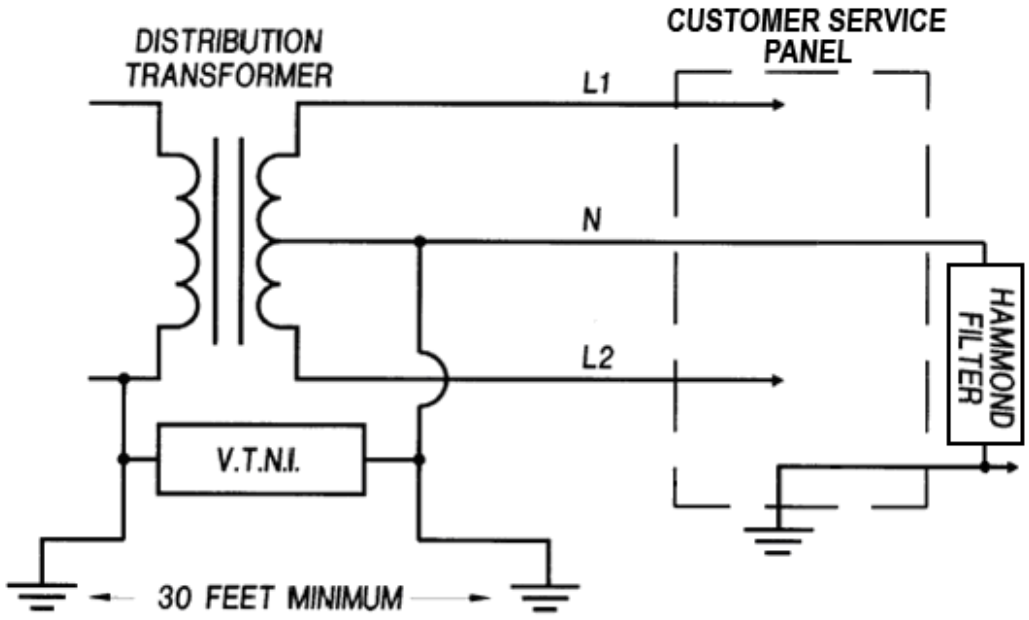

Figure 2.6: Hammond Filter[8]

[8] Adapted from a sketch received from Lorne Lantz – a stray voltage test service provider in Ontario.

This mitigation measure involves work on customer premises, through installation of the Hammond filter near the service panel.

Just as VTNI or Ronk blocker allow isolation of the secondary service neutral from the primary line neutral, Hammond filter shown in Figure 2.6 was developed by Ontario Hydro Research to provide controlled isolation between service neutral and earth. This device can be an effective mitigation tool in some cases. While VTNI or Ronk blocker are installed on the electric utility pole and provide isolation between the primary and secondary neutrals, Hammond filter, as shown in Figure 2.6 is installed near customer's service panel and provides isolation between the secondary neutral and the earth.

(e) Improved Grounding Techniques

This mitigation measure involves work on electric utility's grounding system.

Neutral to earth voltage levels on utility distribution lines can be improved by:

(a) Lowering substation ground grid impedance by increasing the foot print of ground electrodes at substations, particularly when substations are located in regions of high soil resistivity; and/or
(b) Improve the grounding impedance of power poles and distribution transformers.

Obviously, the cost of improving pole ground impedance on a large scale could be cost prohibitive because there can be literally thousands of pole grounds versus a relatively smaller number of ground rods for a substation ground grid. In order to extend the benefits of lower substation electrode impedance, the impedance of neutral conductors will also need to be lowered.

(f) Equipotential Planes

This cure is available for implementation by the customer. Similar to the ground-reference structures used for computer rooms and the ground mats that minimize step potentials at utility substations, the equipotential plane is a useful means of minimizing nuisance shocking at animal contact points.

An equipotential plane typically consists of a conductive wire mesh installed under the area where nuisance shocking has been reported, and attaching most (if not all) conductive materials in the area directly to the mesh. The technique, while not necessarily eliminating the original fundamental causes of the nuisance shocking problem (stray voltage, NEV, etc.), essentially "move the problem" away from areas where people, animals, or equipment are likely to insert themselves into the conducting path. If done properly, the typical results at animal contact points are voltage levels measured in tenths of a volt. However, retrofitting such a grid can be expensive particularly if it

requires excavation or even cutting grooves in an existing concrete floor to insert the metallic mesh. Also, care must be taken to ensure that the edge of the mesh doesn't simply move the nuisance shocking to another location. For example, voltage-gradient ramps may be required to entice livestock to step onto the plane because it will likely be at a voltage potential different from the surrounding earth.

(g) Insulating Floor Mats

This cure also requires implementation by the customer.

Although the use of insulating floor mats in milking parlors or near watering areas as a solution to the stray voltage problem is not supported in any of the published literature researched, we believe properly designed insulating mats that could be easily washed off may be a cost effective solution. Even a low-grade insulating mat may be sufficient to mitigate low level stray voltages.

3 REVIEW OF CANADIAN JURISDICTIONS

3.1 *Alberta*[9]

3.1.1 Agencies, Mandates and Industry Structure

The provincial regulator is the Alberta Utilities Commission (AUC), an independent, quasi-judicial agency of the Government of Alberta. Its mission is to ensure that the delivery of Alberta's utility services take place in a manner that is fair, responsible, and in the public interest.

The AUC regulates investor-owned natural gas, electric, and water utilities and certain municipally owned electric utilities to ensure that customers receive safe and reliable service at just and reasonable rates. This regulatory role is currently in a state of evolution due to the ongoing deregulation of the natural gas and electric industries. Staff also responds to customer inquiries and complaints respecting utility matters. In addition, the AUC ensures that electric facilities are built, operated, and decommissioned in an efficient and environmentally responsible way.[10]

The major transmission and distribution utilities are investor owned and operated for profit. The four largest distribution utilities in the province include FortisAlberta, ATCO Electric, EPCOR and ENMAX Power. A majority of the dairy farms fall within the service territory of FortisAlberta and ATCO Electric.

3.1.2 Evolution of an Approach to Farm Stray Voltage

According to both AUC and utility contacts, there is no provincial legislation or regulations regarding stray voltage, and the AUC has not addressed it through rules or standard requirements.

3.1.3 Testing Requirements

No threshold levels for neutral to earth voltage or cow contact voltage have been set by the AUC, nor has the AUC established any testing requirements.

[9] Information collected on Alberta is primarily based on telephone conversations with contacts at both the AUC and FortisAlberta in November 2007.
[10] http://www.auc.ab.ca/portal/server.pt?open=512&objID=277&PageID=0&cached=true&mode=2

3.1.4 Remediation Requirements

No specific remediation requirements are established by the AUC. One Alberta utility contacted (FortisAlberta) has indicated that it will install a neutral isolator if other approaches do not resolve the problem.

3.1.5 Process, Record-Keeping and Complaint Resolution

There is no set procedure, but typically, if FSV is suspected, the dairy farmer's first point of contact is the distribution utility, where a request would be placed for the utility to conduct an investigation and undertake remediation measures. If the dairy farmer is not satisfied, a formal complaint can be filed with the AUC to resolve the issue.

The AUC has no pre-defined approach to farm stray voltage and will handle each situation on an individual basis. Given that there are no neutral to earth or cow contact standards or thresholds levels, it is at the farmer's discretion to file a complaint with the AUC.

Currently there is one farm stray voltage complaint filed with the AUC that involves both Alta Link (HV transmission lines) and FortisAlberta (distribution system). Farm stray voltage complaints to the AUC are considered rare.

Typically, FortisAlberta will voluntarily respond to customer complaints regarding farm stray voltage to maintain a maximum neutral to earth voltage of 10 volts (established for safety purposes not farm stray voltage).

FortisAlberta will respond with a site investigation as follows – 1) measurement, 2) check ground, 3) implement remediation measures if necessary and test again; and 4) install neutral isolator if the grounding check does not resolve the situation.

3.1.6 Costs and Cost Recovery

Cost for the neutral isolator (Ronk Blocker) is $800 to $900 per unit plus installation (1 lineman x 3 hours). The cost is treated as an operating expense and recovered through rates. There is no specific regulatory policy providing approval to do so, but the cost is negligible as Fortis would install 1 or 2 neutral isolators a year.

3.1.7 Other Issues and Comments

As previously described in Section 2.2, remote rural communities in Alberta are served using an earth wire return system. In service areas of FortisAlberta, approximately 90% of the dairy farms may be served from an earth return distribution system, with no neutral on primary feeders. While it could be expected that this distribution system would

increase the likelihood of farm stray voltage, the soil resistivity in these regions is so low compared to Ontario, it has not been a major problem.

3.2 *British Columbia*[11]

3.2.1 Agencies, Mandates and Industry Structure

The British Columbia Utilities Commission (BCUC) is the energy regulator for the province. The BCUC's mission is to ensure that ratepayers receive safe, reliable and nondiscriminatory energy services at fair rates from the utilities it regulates, and that utilities are afforded a reasonable opportunity to earn a fair return on their capital invested. The BCUC has not taken any action regarding stray voltage and there is no legislation or other government direction requiring it to do so.

BC Hydro is the vertically integrated utility that provides electricity distribution service to most of the province, and is regulated as to rates and facilities by the BCUC.

3.2.2 Safety Codes

BC has adopted the Canadian Electrical Code (2006), with amendments for standards related to both wiring in buildings and utility distribution infrastructure.

3.2.3 Evolution of an Approach to Farm Stray Voltage

There is a voluntary program of responding to stray voltage issues which dates back to the mid 1980's. A Customer Service Instruction (CSI) for the Control of Neutral-to-Earth Potential[12] was developed in 1989 to define BC Hydro's responsibilities for limiting neutral to earth potential and farm stray voltage. While this document addresses the issue of neutral to earth voltage and is not specific to dairy farmers, it does include a defined Maximum Tolerable Stray Voltage For Livestock that describes the contact points as being "stanchion to floor, stanchion to milk pipeline". The approach detailed in the CSI document has now been abandoned and each situation is handled on a "case by case" basis.

3.2.4 Testing and Remediation Requirements

BC Hydro Customer Service Instruction - 1989 (CSI): while this document is now considered obsolete and is no longer followed, it states that BC Hydro will, at its expense test for FSV (magnitude of primary neutral to earth potential), take corrective measures if potential is greater than 10 volts, and offer expert advice if potential is less than 10 volts

[11] Information on BC Hydro's current approach to FSV testing and remediation collected through correspondence with BC Hydro staff in November 2007.
[12] B.C. Hydro CSI 012-1, 89/11/15, Customer Service Instructions, Control of Neutral-to-Earth Potential

and FSV problem exist (regardless of source). This document also defines a Maximum Tolerable Stray Voltage For Livestock (cow contact) which is deemed to be one (1) volt.

There are no specific requirements considered to be currently in effect.

3.2.5 Process, Record-Keeping and Complaint Resolution

While there is no set approach or procedure, a typical sequence of events would be as follows:

- A dairy farmer makes a customer request to BC Hydro to check for neutral to earth voltage. The farmer's awareness of the services provided by BC Hydro has in many cases been passed on from the Milk Quality Inspector who routinely visits every dairy farm in the province.
- BC Hydro staff would visit the farm and assess the situation, which would typically include a test to measure the neutral to earth voltage. While there is no set threshold level, a neutral to earth measurement in the range of 0.5 volts would be considered significant.
- If the customer agrees and is willing to sign a consent form, BC Hydro will install a neutral to earth isolator at BC Hydro's expense. The neutral isolator used by BC Hydro is manufactured by Dairy Land Electronic Industries (Wisconsin).
- If stray voltage problems persist, BC Hydro will provide expert advice to the customer including additional testing if deemed appropriate. Advisory and testing is provided at BC Hydro's expense, and on-farm remediation measures are at the expense of the customer.

3.2.6 Costs and Cost Recovery

Utility costs to test for stray voltage and remediation measures are considered operations expenses and are recovered through the overall rates charged to all customers. Standard remediation measure is to install a neutral isolator (Dairyland VT-NI is $875 USD) with an installed cost ranging from $2,000 to $4,000 (average would be just less than $3,000).

Cost for testing is estimated as follows:

- Average of 3.0 hours per test (farm visit)
- Inspectors salary - assume 240 days per year @ $100,000 (incl. benefits)
  $100,000 / 240 days / 8 hours per day x 3.0 hours per visit = $156
- Assumes 3 Visits per farm stray voltage case (average) - approximate cost per FSV case: 3 x $156 = $469 or approximately $500.

BC Hydro never uses the load box testing, as, in their opinion, extensive knowledge of multi-service interactions is required to fully understand and interpret the data and to draw the proper conclusions. There have been rare instances where neighbouring farms

have influenced load box testing on the subject farm, both through the power system and 3 other utility systems and through the earth[13].

3.3 *Québec*

3.3.1 Agencies, Mandates and Industry Structure

Legislation gives Hydro-Québec the exclusive right to distribute electricity throughout the territory of Québec, excluding the territories served by a distributor operating a municipal, cooperative or private electric power system (of which there are a very small number). Municipal systems also have exclusive distribution rights within the territories they serve. Hydro-Québec is also provides transmission service throughout the province.

The Régie de l'énergie is the Québec body corresponding to the OEB, and has the authority to fix the rates and conditions for the transmission and distribution of electric power by Hydro-Quebec, after holding public hearings. It also monitors the operations of the electricity distributor to ascertain that consumers are adequately supplied, and it monitors the operations transmission and distribution operations to ascertain that consumers are charged fair and reasonable rates. It approves the electricity distributors' supply plans and commercial programs. The Régie also approves investment projects, the construction of facilities or the acquisition of assets intended for the transmission or distribution of electric power. The Régie has sole authority to examine consumer complaints about a decision rendered by the electricity transmitter or distributor concerning the application of the rates or conditions of service. The transmitter and distributor are required to apply an internal complaint examination procedure approved by the Régie.

There is no legislation regarding farm stray voltage in Québec. According to both the Régie staff[14] and Hydro-Québec[15] staff, the Régie has taken no role in administering an approach to mitigation of farm stray voltage. The agencies involved are Hydro-Québec, as the transmission and distribution utility, the Québec department of agriculture, fisheries and food ("MAPAQ"), and a farm interest group the Union des producteurs agricoles ("UPA").

3.3.2 Evolution of an Approach to Farm Stray Voltage

The technical standards for farm stray voltage from the utility side were written by Hydro-Québec on its own initiative and the current document has been in effect for about 20 years.

[13] Conversation with David Rogers, BC Hydro, February 11, 2008.
[14] Pierre Méthé, Régie staff, in email dated November 14, 2007.
[15] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007.

In the mid-1990's a 3-party liaison committee was formed of representatives of Hydro-Québec, MAPAQ and the UPA to address issues of concern to farmers, and this has included stray voltage. The liaison committee agenda from 1999 to 2006 included development of an approach to stray voltage and a program to educate and assist farmers. The committee addressed stray voltage concerns generally, and also concerns related to construction of a new 735 kV line[16].

Issues raised by farmers about the health or behaviour of their animals are treated through what is termed a global approach[17]. About 80% of such problems have been found to be unrelated to stray voltage. The global approach developed by the liaison committee, and now in operation, attempts first to screen for the many possible alternative causes of the problem, before incurring the costs of a field visit by specialists in stray voltage (see description of process).

Revised standards are now being prepared by Hydro-Québec (C 26.01). Hydro-Québec has verified[18] that the technical component of the standard will be largely unchanged, and is in their view compatible with what the industry in North America is doing. The major change is in administration. In the prior standard, complaints were first directed to Hydro-Québec.

3.3.3 Testing Requirements

The current standard for remediation of stray voltage came into effect in 1987, and is an internal document of Hydro-Québec. It replaces a prior document dated 1981, so that Hydro-Québec has had a systematic approach to this issue for nearly three decades.[19]

The document addresses stray voltage problems resulting from voltage differential between the neutral and the remote earth, and notes that the problem is characteristic of North American systems that have a neutral grounded at various points.

The maximum acceptable neutral voltage is 10 V. Higher levels are subject to remediation. It is also provided that levels exceeding 5 V when measured are of concern, because it is possible that higher levels can occur at certain times, such as in winter. Farm animals are very susceptible to negative effects because they are typically in damp environments.

The first part of testing is to determine the customer contribution to the neutral voltage that is measured. Measurements are taken on the customer's premises with the main breaker closed and with the main breaker open. If the difference exceeds 0.5 V, that

[16] Comité de liaison, Hydro-Québec —Union des producteurs agricoles, Rapport d'Activite, 2001-2006.
[17] Hydro-Québec, Guide pratique, Les tensions parasites à la ferme, 2005.
[18] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007.
[19] Hydro-Québec, C.26.01, Correction des Tensions Parasites chez les clients, July, 1987.

component of the neutral to earth potential is considered to be due to unbalanced loading on the customer's side, and the customer is advised to have it addressed by a qualified electrician.

Measurements are then made at the transformer to determine if there is a problem with the continuity of the neutral, and the total neutral to earth voltage at that point. For measurements less than 5V, no remediation is considered to be required. Above 5V, inspections will be made to determine the probable cause and the best remedial action. At least three measurements are taken within a 24 hour period to verify that the voltage is not likely to exceed 10 V at any time.

3.3.4 Remediation Requirements

If mitigation is required, a filter may be installed between the primary and secondary neutrals, but this solution is considered temporary, for a maximum period of 12 months. Longer-term solutions that are considered satisfactory include an increase in the number of grounds or an increase in the size of the primary neutral, or to convert a single phase line into a 3-phase line and ensure that the loads are balanced.[20]

Once remediation steps are complete, tests are made again to ensure that the problem has been corrected.

3.3.5 Process, Record-Keeping and Complaint Resolution

All inquiries from farmers are directed first to MAPAQ. On line and printed guides available to farmers to address the problem invite inquiries to MAPAQ. MAPAQ first addresses the farmer's concern through a global approach that assesses various causes for behaviour or health issues of farm animals. 80% of the complaints are shown not to be related to stray voltage.

MAPAQ typically receives 200-300 inquiries per year. Of these, about 30 are referred to Hydro-Québec, and there is a requirement to modify the network in only about 6-8 cases[21].

The global approach is intended to identify and address the cause of the farmer's problem whether or not it is stray voltage. Initially the farmer completes a questionnaire assessment, which includes questions about such matters as changes in equipment, types of equipment, and results of any tests by an electrician. If the probable cause cannot be diagnosed by MAPAQ staff over the phone, they will conduct a study for which a charge

[20] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007, and Hydro-Québec, C.26.01, Correction des Tensions Parasites chez les clients, July, 1987.
[21] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007.

is made to the farmer (maximum $400). Some regions receive financial support from the government (not HQ).

Based on the results, MAPAQ may ask Hydro-Québec to check the network as the source. They can measure voltage on the neutral, but don't know whether the source is the farm or the network. Hydro-Québec will send a team to identify the appropriate remediation, and will also assist by checking the equipment on the farm. Testing will be done after any modifications. Hydro-Québec provides expertise and research to MAPAQ on an exception basis, and keeps in-house expertise.

Hydro-Québec will help with testing even if the problem is believed to originate with the farm. If not sure, then will sometimes pay for a neutral filter to isolate, or will share costs, but Hydro-Québec pays for all the tests.

Customer can go back to MAPAQ if not satisfied. MAPAQ administers the program and maintains files for each incident. MAPAQ can carry the complaint to Hydro-Québec; there is recourse to the Régie, if necessary but that is not happening.

3.3.6 Costs and Cost Recovery

Aside from an occasional unusual problem that may be complex and expensive to address (example $140,000), problems typically encountered are not expensive to mitigate. Hydro-Québec has no specific budget for either testing or remediation, and amounts are considered small, provided as a service for the customers and collected in the revenue requirement.[22]

3.3.7 Other Features

A plain language guide has been developed and published for farmers, explaining the concept, the global approach, and alternatives for remediation[23]. MAPAQ web site also posts instructions to farmers who observe behaviour or health problems in their herd. Most of the discussion is geared to help the farmer in maintaining the farm to minimize a variety of electrical and other problems.

Hydro-Québec along with MAPAQ and UPA sponsored a 2-day training course for electricians to diagnose and correct stray voltage problems on farms. It was free for the electrician. First course took place in the 90s. A new one is now being planned. Costs are shared among the three agencies.[24]

[22] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007.
[23] Hydro-Québec, Guide pratique, Les tensions parasites à la ferme, 2005.

[24] Yvan Charbonneau, Hydro-Québec, in conversation dated November 21, 2007.

3.4 *Other Canadian Jurisdiction*

3.4.1 Methodology

A brief survey was made of Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador, to determine whether the regulators in any of these jurisdictions had established requirements for utilities with regard to farm stray voltage. The survey was conducted first by examining the web site of each regulator, and then by a telephone call to staff at the regulator. No utilities or other agencies in these jurisdictions were contacted. Searches of the web sites did not locate documents on the subject of farm stray voltage in any of these jurisdictions.

3.4.2 Manitoba

The regulatory agency in Manitoba is the Manitoba Public Utilities Board. According to staff[25] the PUB has no authority over the provincial electric utility, Manitoba Hydro, which is self-regulating, except as to approval of rates. If a customer complained, they would be directed to Manitoba Hydro, and if unsatisfied the only recourse would be to the Minister.

3.4.3 New Brunswick

The regulatory agency in New Brunswick is the New Brunswick Energy and Utilities Board. The NB EUB has no policies or requirements with regard to farm stray voltage.[26]

3.4.4 Newfoundland and Labrador

The Newfoundland and Labrador Board of Commissioners of Public Utilities is the regulatory agency. There are no Board established policies, guidelines or requirements with regard to stray voltage. The Board has a mandate to deal with consumer complaints, but there are no such complaints on record at the Board for the past 20 years.[27]

3.4.5 Nova Scotia

The Nova Scotia Utility and Review Board is the provincial regulator. The Board has no policies or requirements with regard to farm stray voltage, and its mandate does not typically include technical or safety requirements relating to the utility, but only rates.

[25] Telephone conversation with Jerry Gaudreau, PUB staff, December 19, 2007.
[26] John Lawton, telephone conversation, December 21, 2007.
[27] Bob Byrne, Director of Regulatory Services, telephone conversation December 19, 2007.

However, the Board does have a consumer complaint mandate, and would handle if a customer made a written complaint to them.[28]

3.4.6 Prince Edward Island

The regulator is the Island Regulatory and Appeals Commission ("IRAC"). IRAC has no policies on farm stray voltage. No complaints are being directed to IRAC by farmers, although the IRAC has received occasional complaints on health issues for humans.[29]

3.4.7 Saskatchewan

The Saskatchewan Rate Review Panel is the regulatory agency in Saskatchewan. The web site indicates that the Panel "was formed to conduct reviews and provide opinions on the fairness and reasonableness of rate changes proposed, from time to time, by certain Crown corporations in Saskatchewan. The Saskatchewan Crown corporations currently identified within the Panel's mandate are SaskEnergy, SaskPower and Saskatchewan Government Insurance (SGI) AutoFund. The Panel receives specific instructions on the scope of each review through a "ministerial order" from the Minister of Crown Management Board."[30]

The Panel has to date not become involved in the farm stray voltage issue.[31]

[28] Ross Young, Senior Advisor, telephone conversation December 19, 2007.
[29] Mark Lanigan, telephone conversation December 18, 2007.
[30] http://www.sashratereview.ca/
[31] Lynn Shyluk, telephone conversation January 2, 2008.

4 REVIEW OF UNITED STATES JURISDICTIONS

4.1 *Connecticut*

4.1.1 Agencies, Mandates and Industry Structure

The Connecticut Department of Public Utility Control (DPUC) is statutorily charged with regulating, to varying degrees, the rates and services of Connecticut's investor owned electricity, natural gas, water and telecommunication companies and is the franchising authority for the state's cable television companies. The mission of the DPUC is to provide residential, commercial, business and industrial consumers with courteous, timely and high-quality responses to their complaints and questions, and to equip them with the tools necessary to make informed choices in competitive utility markets, while protecting them from any fraudulent, abusive and deceptive practices.

The DPUC Decision and Order on farm stray voltage was the result of a single complaint from a dairy farmer. There is no legislation on this subject.

Multiple electricity distribution utilities provide service to customers in the state of Connecticut.

4.1.2 Safety Codes

There are 2 national safety codes that have been adopted by the State of Connecticut:

1. National Electrical Safety Code (NESC) which applies to public utilities, and
2. National Electrical Code, which is applicable to the installation of wires and facilities used to convey current and to apparatus to be operated by such electric current.

4.1.3 Evolution of an Approach to Farm Stray Voltage

On February 9, 1995, the DPUC conducted a proceeding on farm stray voltage to:

1) develop a proper education program for use by the utilities and farmers;
2) establish an electric protocol for how these stray voltage or stray current occurrences are investigated, who should be involved and to what extent; and
3) try to tie in a protocol for the telephone and cable companies and how they relate to the situation. The Decision, dated June 30, 1995, concluded that:

1. A **Protocol for the Study and the Implementation of Procedures Regarding Stray Voltage/Current and Its Possible Effects on Farm Animals** (the "Protocol"), be adopted as a guide to correcting the stray voltage/current conditions, and

2. Ordered the establishment of the **Connecticut Stray Voltage Task Force** to foster cooperation among the various interest groups on stray voltage issues, take on the role of dispute resolution, and assist in mediating problems of farmers or utilities.

The Protocol has not been revised or modified from its original form, and the Connecticut Stray Voltage Task Force was never established even through there was an order to do so. No farmer has raised a stray voltage concern with Connecticut Light and Power, which serves 80% of the state, over the last 10 years.

The Protocol included 8 guidelines to correct stray voltage/current conditions which are summarized below.

1. Education Program – electric, telephone and cable utilities were required to cooperate in the development of a stray voltage education program with the DPUC, the Department of Agriculture and various other appropriate entities. Other electric utility requirements regarding stray voltage include sending information to farmers annually, assist in training sessions for farmers, and the implementation of a training program for employees.
2. Electric Utility Stray Voltage Team – each electric utility will designate a stray voltage team who is charged with the task of monitoring on-going research and policies in other states, and periodically assessing their respective company's testing procedures and mitigation measures. The Stray Voltage Team will also be responsible for conducting investigations on dairy farms and one member will serve as the key contact person.
3. Connecticut Stray Voltage Task Force – comprised of electric utilities, state agencies and other interested parties, the task force is to i.) Foster cooperation among utilities, state agencies, private agencies and the farm community, ii.) Monitor and evaluate research and make recommendations, iii.) Monitor policy and regulatory actions in other states, and iv.) Determine the feasibility and implementation of a dispute resolution function within the task force.
4. Stray Voltage Testing – electric utilities are required to conduct stray voltage testing for all livestock farmers who have expressed a concern. If off-farm stray voltage is observed, testing / mitigation will continue until the problem has been solved at no cost to the farmer. If on-farm stray voltage is observed, the electric utility will conduct up to 2 days of testing at no cost to the farmer, and will provide the farmer a report indicating what has been found, if any additional testing or mitigation required. The utility will cooperate with persons hired by the farmer as needed and to confirm the source is not off-farm.
5. Level of Concern – cow contact is 0.5 volts or 1.0 milliampere and primary neutral to earth exceeding 1.0 volts.
6. Neutral Isolation – shall be provided by electric utilities when the levels of concern cannot be met or achieved by the utility within 15 days. The Task Force

shall determine the types of devices that are acceptable for neutral isolation. Other conditions include:

a. On-farm ground resistance testing will be provided to the customer prior to neutral isolation. Isolation will not be implemented if the on-farm ground resistance does not meet NEC requirements.
b. Isolation will be coordinated with the telephone and CATV companies.
c. If an isolation device is installed at a dairy farm, the farm will be tested following such installation, to confirm that the device is effective.
d. The isolation device may be removed when the stray voltage at cow contact is lowered to less than the level of concern (0.5 volt/1 milliampere) and the primary neutral to earth voltage is 1.0 volts or less.
e. The isolated service will be clearly identified on both the utility's facilities and on the customer's facilities.

7. Notification of Telephone, Cable TV, Gas, Sewer and Water Companies - Electric utilities will notify the appropriate telephone and cable TV companies of dairy farms that are presently isolated or served by a delta circuit, and of those that are isolated in the future. The telephone and cable TV companies will take appropriate steps to ensure that their plant is not acting as an alternate path for stray voltage on these dairy farms. Where appropriate, gas sewer and water companies will also be notified.
8. Additional Support Services – electric utilities will also do the following:
    a. At the farmer's request provide engineering support for the isolation of an isolation transformer on the farmer's side of the meter.
    b. Provide a separate service to the barn or milking facility at the farmer's request. Any applicable charges in accordance with the utilities service policy shall apply.
    c. Electric utilities will alert livestock farmers of major changes to the electrical system serving their farms, and offer stray voltage testing after converting the supply from delta to wye.

4.1.4 Testing Requirements

Electric utilities are required to conduct stray voltage testing for all livestock farmers who have expressed a concern. If off-farm stray voltage is observed, testing and, if necessary, remediation will continue until the problem has been solved at no cost to the farmer. If on-farm stray voltage is observed, the electric utility will conduct up to 2 days of testing at no cost to the farmer.

There are no specific testing procedures set out in the Protocol and it has been left to the discretion of each utility.

4.1.5 Remediation Requirements

Level of Concern the level of concern is defined as cow contact voltage at 0.5 volts or 1.0 milliampere and primary neutral to earth levels exceeding 1.0 volts.

Neutral isolation is required to be provided by electric utilities when the levels of concern cannot be met or achieved by the utility within 15 days. The Task Force shall determine the types of devices that are acceptable for neutral isolation. Other conditions include: On-farm ground resistance testing will be provided to the customer prior to neutral isolation. Isolation will not be implemented if the on-farm ground resistance does not meet NEC requirements. Isolation will be coordinated with the telephone and CATV companies. If an isolation device is installed at a dairy farm, the farm will be tested following such installation, to confirm that the device is effective. The isolation device may be removed when the stray voltage at cow contact is lowered to less than the level of concern (0.5 volt/1 milliampere) and the primary neutral to earth voltage is 1.0 volts or less.
The isolated service will be clearly identified on both the utility's facilities and on the customer's facilities.

4.1.6 Process, Record-Keeping and Complaint Resolution

There are no specific procedures to file complaints on farm stray voltage. If not satisfied with utilities testing or remediation measures, a farmer may file a general complaint to the DPUC. The Protocol requires reports on what was found in testing and the remediation actions required to be provided to the farmer. There is no specific requirement for reports to the DPUC.

4.1.7 Cost Recovery

The cost to the utilities of implementing the stray voltage Protocol are treated as a cost of service and are passed through to all customer classes as a general utility expense. While there is no monitoring or reporting of the costs incurred (including remediation), they are considered to be insignificant from the utility perspective (zero in the last 10 years).

4.2 *Idaho*

4.2.1 Agencies, Mandates and Industry Structure

The Idaho Public Utilities Commission (the "Commission") is responsible for investor-owned or privately-owned utilities that provide gas, water, electricity or telephone service for profit. The Commission is responsible for rates, billing issues, quality of service, customer relations and the safe operations of the utilities it regulates.

The Commission is responsible for adopting the safety standards (i.e. the 2 safety codes noted below) but does not conduct any oversight or facility inspections. Inspections for electrical equipment installations and wiring are handled through the Idaho State Labour Bureau and the Idaho State Electrical Inspectors.

4.2.2 Safety Codes

The Rules[32] reference 2 national safety codes which have been adopted by the State of Idaho without modification:

- National Electrical Safety Code (NESC) which applies to public utilities, and
- National Electrical Code, which is applicable to the installation of wires and facilities used to convey current and to apparatus to be operated by such electric current.

4.2.3 Evolution of an Approach to Farm Stray Voltage

Stray Current and Voltage Remediation Act (61-801) of March 28, 2005, requires that the Commission promulgate temporary and proposed rules establishing uniform procedures and protocols for the measurement of stray current or voltage within six months. The rules shall be applicable to dairy producers, utilities, and all persons or entities involved in any way in the measurement or remediation of stray current or voltage in the state.

Subsequent to the March 28 legislation, the Commission issued a notice of negotiated rule making on May 4, 2005. A negotiation workshop was held on June 7, 2005, and draft set of Temporary and Proposed Stray Voltage Rules were reached by July 19, 2005. Stakeholders participating in the process include Idaho Power, the Milk Producers of Idaho, Idaho Dairyman's Association, and IPUC staff. The rules (as amended) came into effect December 5, 2005.

4.2.4 Testing Requirements[33]

The Commission rules, as promulgated pursuant to the authority of the Idaho Public Utilities Law and the State Legislature, are designed to identify the presence of stray voltage or current, the source, and to also determine the percent contribution from the utility side and dairy side of the dairy service entrance. The rules apply specifically to dairy farms and do not apply to beef farms or other types of livestock.

[32] The Idaho Public Utilities Commission--Agency 31, Title 61, Chapter 1, Rules for the Measurement of Stray Current or Voltage (The Stray Voltage Rules), IDAPA 31.61.01.000

[33] The Idaho Public Utilities Commission--Agency 31, Title 61, Chapter 1, Rules for the Measurement of Stray Current or Voltage (The Stray Voltage Rules), IDAPA 31.61.01.000

The Rules are divided into 4 major sections:

1. Qualifications of persons performing and analyzing stray voltage data.
2. Calibration and standards of measuring and recording equipment.
3. The 6 stray voltage tests and the corresponding forms to record the test data.
4. Analyzing the stray voltage data and conducting remediation actions, if necessary.

Definition – "Stray voltage or current" is:

a. Any steady state, sixty (60) hertz (Hz) (including harmonics thereof) root mean square (rms) alternating current (AC) less than twenty (20) milliAmperes (mA) through a five hundred (500) ohm resistor (i., shunt resistor) connected between cow contact points, as measured by a true rms meter; or

b. Any steady state, sixty (60) Hz (including harmonics thereof), rms AC voltage of less than ten (10) volts, across (in parallel with) a five hundred (500) ohm resistor (i. , shunt resistor) connected between cow contact points, as measured by a true rms meter.

c. Stray current and voltage is a normal, inherent and unavoidable result of electricity traveling through grounded electrical systems, including a dairy producer's on-farm system and a utility s distribution system. These systems are required by the National Electrical Code (NEC) and the National Electrical Safety Code (NESC) to be grounded to the earth to ensure safety and reliability.

d. Unless the context otherwise requires, the term "stray voltage" shall mean stray current or stray voltage.

Testing Procedures

Inspections and testing related to farm stray voltage are to be completed by the electrical utility upon a dairy producer serving a written complaint to the utility. The rules specify the qualifications of the persons performing and analyzing the test results, standards for the testing equipment, the tests to be performed and that remediation measures to be undertaken if necessary.

Measurement and testing for stray voltage under these rules and for consideration by the Commission, shall be completed by either a qualified Professional Engineer or Master Electrician with 48 hours of Commission-approved stray voltage training and who has been involved in no fewer than 5 prior investigations. Alternatively, a technician under the supervision of a Professional Engineer or Master Electrician who has completed no fewer than 8 hours of Commission approved training and who has been involved in no fewer than 5 prior investigations is also considered qualified.

Investigators must complete a Commission approved FSV trained course that complies with the Wisconsin PSC's Phase II protocol.

Tests 1 (Cow Contact Test) and Test 2 (Forty-Eight Hour Test) are used to determine the presence and level of stray voltage. If the stray voltage does not exceed the Preventative Action Level (PAL), the utility has no further testing or remediation obligations. PAL is defined as:

> ***Preventive Action Level (PAL)***. *Stray current or voltage that, when correctly measured, is either:*
> *a. A steady state, root mean square (rms) alternating current (AC) of two (2) milliamperes (mA) or more through a five hundred (500) ohm resistor (i.e., shunt resistor) connected between cow contact points, as measured by a true rms meter, or;*
> *b. Any steady state, rms AC voltage of one (1.0) volt or more across (in parallel with) a five hundred (500) ohm resistor (i.e., shunt resistor) connected between cow contact points, as measured by a true rms meter.*

If the PAL is exceeded, then the utility completes the remaining 4 tests (3 Primary Profile Test, 4 Secondary Neutral Voltage Drop Test, 5 Load Box Test and 6 Signature Test) and perform analysis to determine if the stray voltage attributable to the off-farm source exceeds 50% of the PAL. If not, the utility has no further testing or remediation obligations. If the off-farm source exceeds 50% of the PAL, the utility is required to conduct remediation measures.

4.2.5 Remediation Requirements

Remediation measures must commence within 5 business days and reduce that portion of the stray voltage attributable to the utilities distribution system to a level equal to or less than 50% of the PAL. Additionally, if the utility determines that another customer is a significant contributing source to stray voltage, the utility shall notify both the dairy and other customer in writing. While the rules stipulate the results to be achieved, there is no mention of the specific remediation measures to be undertaken.

4.2.6 Process, Record-Keeping and Complaint Resolution

A petition filed with the Commission shall contain background information, the date the notice was filed with the serving utility, a description of the alleged incident(s) of non-compliance with the Stray Current and Voltage Remediation Act, and the remediation actions (if any) undertaken by either the utility or the dairy farmer. A copy of the utility's entire stray voltage report shall accompany the petition.

A copy of the utility's report is filed with the Commission only if a petition has been filed.

4.2.7 Cost Recovery

The cost to the utilities of implementing the stray voltage rules are treated as a cost of service and are passed through to all customer classes as a general utility expense[34]. While there is no monitoring or reporting of the costs incurred (including remediation), they are considered to be insignificant from the utility perspective. No data is available as to costs incurred by farmers. Remediation costs on the utility side of the dairy service entrance are the responsibility of the utility, and cost inside the dairy service is the responsibility of the dairy farm.

4.3 *Michigan*

4.3.1 Agencies, Mandates and Industry Structure

Electricity is served in Michigan by 9 investor-owned companies, 12 cooperatives, and more than 40 municipal utilities. The investor-owned utilities and all but 2 of the cooperatives are regulated by the Michigan Public Service Commission. The MPSC is an agency within the Department of Labor & Economic Growth.[35]

Multiple electricity distribution utilities provide service to customers in the State of Michigan.

The MPSC is responsible for enforcing the National Electric Safety Code (NESC) but not the National Electric Code (NEC). The enforcement of the NEC (the customer side) is the responsibility of the Bureau of Construction Codes, which is an agency in the Department of Labor and Economic Growth (DLEG).[36]

4.3.2 Evolution of an Approach to Farm Stray Voltage

In Case No. U-11368, the MPSC conducted proceedings on proposed stray voltage rules. The Attorney General objected on the ground that the Commission lacked jurisdiction to promulgate the rules. In an order issued on March 14, 2000, the Commission closed the docket, but suggested that it might be appropriate to initiate another rulemaking depending on the resolution of Case No. U-11684.

The contested case commenced in 1998 with a complaint was filed by the State Attorney General against Consumers Energy Company, alleging that the utility's system design

[34] Information is based on a telephone conversation with staff at the Idaho Public Utilities Commission in November 2007.
[35] http://www.cis.state.mi.us/mpsc/electric/address.htm#InvestorOwnedUtilities.
[36] Email of Paul Proudfoot, MPSC, December 28, 2007.

and customer service practices were creating widespread and significant stray voltage problems for its agricultural customers. The complaint alleged:

- violation of commission statutes, and
- discrimination in service against rural customers.

The Attorney General argued that the MPSC should compel the utility to make changes in its distribution system and should reduce its allowed rate of return as a penalty.

The complaint was referred to an Administrative Law Judge ("ALJ") for hearing in 2002. Extensive expert evidence was brought by the Attorney General and by the utility. The ALJ found that the multi-grounded wye distribution system used by Consumers complies with the code, and that there was no evidence that the effects were sufficient to damage the herd, and also accepted the utility's evidence that its rural customer service staff were adequately trained to address any problems arising.

On review by the MPSC in 2003, the MPSC considered the views of the ALJ and also the recommendation of its own Staff that there was a need to provide electric utilities and their agricultural customers with guidance that better defines each party's rights and responsibilities. The Staff recommended that the MPSC should promulgate stray voltage standards that set measurable levels of concern or action to serve as baselines for remedial responses.

The MPSC therefore concluded that it was appropriate to undertake a generic reappraisal of whether the public interest would be best served by the promulgation of stray voltage standards based on the best scientific evidence available. The MPSC therefore initiated Case No. U-13934 to solicit stakeholder comments before deciding whether and how to set standards that would be acceptable to as many different interests as possible. The MPSC received stakeholder input during 2005, and in August 2006 issued an order approving a set of rules. These became final in February 2007, and have the force of law even though there is no specific legislation.

4.3.3 Testing Requirements

"Preventive action level" is defined in the rules[37] as a steady state animal contact current that meets or exceeds 2 milliamperes RMS using a nominal 500 ohms resistor at 60 Hz from all sources, including the farm itself and the utility.

The measurement approach is to take a voltage measurement between 2 points which an animal can simultaneously contact and under which animal contact voltage is most likely to occur. When measuring from the floor or earth, a single metallic plate with an area of

[37] Rules and Regulations Governing Animal Contact Current Mitigation, Michigan Administrative Code R 460.2701

12 to 16 square inches is used to simulate the foot of the animal. The plate is placed on the floor or each where the animal would stand. One lead of the measuring instrument is connected to the plate and the other lead of the measuring instrument is connected to a conductive object that the animal could reasonably contact while one of its feet is at the location of the plate. For all measurements of animal contact voltage a shunt resistor must be used to simulate the resistance of the animal. A suitable material, such as a medical grade electrode contact gel is required to simulate real conditions and maintain conductivity to the floor or earth for the duration of the testing period.

A specific approach to quantify the utility's contribution to animal contact voltage is set out as quoted below, but a utility may submit a different approach for approval. The approach assumes that the utility has a grounded distribution system with a primary neutral conductor:

"(a) Identify animal contact location to be tested.

(b) Measure and record the steady state animal contact voltage (AcV) at the animal contact location concurrently with the neutral-to-earth voltage at utility primary distribution system (NpEV) and at the animal building panel (NbEV) for a period of 72 hours during a mutually agreed upon time frame to determine the maximum probable level of animal contact current under normal operating conditions.

(c) Determine the highest level of animal contact voltage that occurred during the 72-hour monitoring, and the primary neutral-to-earth voltage at the utility transformer location that occurred at that same time.

(d) Turn off farm electrical load and apply a temporary electrical load at the utility transformer to produce the same level of neutral-to-earth voltage at the utility transformer as found in subdivision (c) of this subrule. Measure the animal contact voltage again.

(e) Using the animal contact voltage measured in subdivision (d) of this subrule, compare it to the animal contact voltage measured in subdivision (b) of this subrule to determine the utility contribution to animal contact current using Ohm's law."[38]

More detailed requirements for the measurement approach and equipment are also established:

"(a) The level of animal contact current shall be determined from measurements of animal contact voltage using Ohm's Law. The voltage measurement shall be made between 2 points, which an animal can simultaneously contact and under which animal

[38] R 460.2707.

contact voltage is most likely to occur. When measuring from the floor or earth, a single metallic plate with an area of 12 to 16 square inches shall be used to simulate the foot of the animal. One lead of the measuring instrument shall be connected to the plate, which shall be placed on the floor or earth where an animal may stand. The other lead of the measuring instrument shall be connected to a conductive object that an animal could reasonably contact while 1 of its feet is at the location of the plate. For all measurements of animal contact voltage a shunt resistor shall be used to simulate the resistance of the animal. A suitable material, such as a medical grade electrode contact gel, shall be used to simulate real conditions and maintain conductivity to the floor or earth for the duration of the testing period."[39]

4.3.4 Remediation Requirements

If remediation is required, isolation of the neutral is allowed[40]. The rules specify only that "utility shall make modifications or corrections to its facilities in accordance with the standards and codes approved by the commission."[41]

There are no provisions for work on the customer premises by the utility to offset its contribution.

4.3.5 Process, Record-Keeping and Complaint Resolution

If the complaint is first made to the utility, then the utility would track complaints and the resolution. If a utility is unable to resolve the issues with the customer then the process would move forward to the MPSC staff. However, if the customer made a complaint directly to the MPSC then the MPSC would track the resolution of that complaint as they would with any customer compliant.

4.3.6 Costs and Cost Recovery

The costs of this program are handled as utility expenses and are recovered through the rates. MPSC staff had not assembled any direct rate impact numbers but believed the cost to be small. They believe there are only a small numbers of customers out there with issues regarding animal contact levels. The concentration of the dairy industry has resulted in the elimination of a number of small to medium farms where this problem is believed to be more of an issue.[42]

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[39] R 460.2702

[40] Per Paul Proudfoot, PSC staff in an email dated November 28, 2007.

[41] Rules and Regulations Governing Animal Contact Current Mitigation, Michigan Administrative Code, R 460.2703.

[42] Per Paul Proudfoot, PSC staff in an email dated November 28, 2007.

4.3.7 Other Features or Comments

As the rules were the product of a stakeholder process, it is believed that at present there is a high level of satisfaction with the approach. However, since it is newly implemented, there is no experience. The intent is that complaints should be handled by the utilities as they arise, and that few if any should be directed to the MPSC for resolution in the future.

4.4 *Pennsylvania*

4.4.1 Agencies, Mandates and Industry Structure

Pennsylvania customers are served by 11 regulated investor-owned utilities and rural cooperatives.

The utility regulator in Pennsylvania is the Public Utility Commission ("PUC").

4.4.2 Safety Codes

Pennsylvania has adopted the national set of codes for customer-side safety. The codes are enforced by local municipal inspectors. This governs building and grounding practices. It is under the regulatory purview of Pennsylvania's Department of Labor and Industry.

Complaints regarding utility company practices and construction can be filed with the PUC and as a result of such complaints companies can be fined up to $1,000 a day for each instance of non adherence to the National Electrical Safety Code. Adherence is assessed on the basis of code requirements at the time of construction.[43]

4.4.3 Evolution of an Approach to Farm Stray Voltage

According to staff[44], the PUC has not established any testing or remediation requirements unique to stray voltage issues, but deals with such issues if they arise in the form of customer complaints. Their view is that because of its complexity, the issue of stray voltage has not been conducive to specific regulations. As well as complaints related to farm situations, the PUC has had claims resulting from humans receiving shocks.

4.4.4 Testing Requirements

No specific requirements have been established by the PUC.

[43] Robert Rosenthal, PUC staff, email December 28, 2007.
[44] Robert Rosenthal, PUC staff, email November 27, 2007.

For all complaints, the PUC expects utilities to fully investigate and attempt to resolve. Due to rural territory, four electric utilities maintain customer service teams for investigating stray voltage, First Energy, PPL, West Penn Power and Pike County. Also rural cooperatives in Pennsylvania have teams to resolve stray voltage. The investigations involve field monitoring and ground testing, in the best judgment of the utility. These are generally addressed through review of grounding of equipment, however, length of service line, phasing and transformer installation have also been found to contribute to the problem[45].

4.4.5 Remediation Requirements

No requirements have been established by the PUC.

4.4.6 Process, Record-Keeping and Complaint Resolution

Customer complaints that are not satisfied by the utility can be directed to the PUC, which will hold a hearing if appropriate, with evidence submitted by the utility and the customer[46].

4.4.7 Costs and Cost Recovery

The line of demarcation for cost bearing by the utility is the company's meter; the PUC has no authority to award damages as a result of a customer's complaint. There have been past decisions where the PUC ordered a cost sharing for remediation of 75% utility-25% customer. Costs borne by the utility are recoverable as an expense in rates.[47]

4.5 *Vermont*

4.5.1 Agencies, Mandates and Industry Structure

The Vermont Public Service Board is responsible for rates, quality of service, and overall financial management of Vermont's public utilities (including electrical among others). The Board's mission is to ensure the provision of high quality public utility services in Vermont at minimum reasonable costs, measured over time periods consistent with the long-term public good of the state.

[45] Robert Rosenthal, PUC staff, email November 27, 2007.
[46] Robert Rosenthal, PUC staff, email November 27, 2007.
[47] Robert Rosenthal, PUC staff, email November 27, 2007.

Customers in the state are served by a total of thirty entities, including investor-owned utilities, municipal utilities and cooperatives.

4.5.2 Evolution of an Approach to Farm Stray Voltage

A Bill was tabled in January 1994 to address the issue of stray voltage. However, following resistance from Vermont's various electrical utilities to a legislated solution, the Department of Agriculture, Food and Markets in cooperation with the Department of Public Service, and the utilities joined forces to prepare a voluntary program. The outcome of this combined effort is The Voluntary Program for the Control of Stray Voltage (August 9, 1994), which sets out goals and recommended policies for both on-farm and off-farm stray voltage.[48] Each utility has adopted a proactive program of testing for stray voltage at farm customers as part of the Voluntary Program.

On-farm stray voltage originates on the farm and is generally under the Farmer's control. The Milk Quality Enhancement Program (MQEP), administered by the Department of Agriculture, Food and Markets, will:

1. Oversee the development and implementation of education programs on stray voltage to farmers, electricians and other agribusiness related professionals. Prevention causes and mitigation will be the bases for these programs.
2. Oversee the development of a formal training program relative to farm wiring. Of special importance will be training on proper farm wiring methods and procedures. The various solutions will also be shared to ensure that one person's solution doesn't circumvent efforts being made by others.
3. Oversee the research needed to answer other questions that have arisen about stray voltage as noted in the next section.
4. Continue to offer technical services to the agricultural community and those serving it for stray voltage problems.

Uniform response to stray voltage complaints will include:

1. Priority to stray voltage complaints on farms.
2. Standardized procedures for testing primary neutral to earth potential, secondary neutral-to-earth potential, bulk tank or other piece of equipment bonded to the secondary neutral potential, to earth, and voltage between primary and secondary neutrals after isolation.

[48] A Voluntary Program for the Control of Stray Voltage on Farms, Stray Voltage Proposal, August 9, 1994, the State of Vermont

3. Close cooperation between electrical utilities and the various telephone and cable TV utilities to ensure that they do not inadvertently circumvent measures previously made to mediate stray voltage.
4. Monitoring of neutral-to-earth voltages on regular intervals to ensure the continued effectiveness of the neutral isolation device.

Each Utility was required to submit a proposed Service Policy to the Department of Agriculture, Food and Markets by October 1994. Following review of the various utility Policies, it was reported to the legislature that a program has been implemented and no regulatory action was necessary.

4.5.3 Testing Requirements

To minimize stray voltage from off-farm utility sources, each utility has adopted a proactive program that tests for stray voltage on all farm customers. Neutral isolation devices, rated for the purpose, will be installed, at the utility's expense, when neutral to earth voltages in excess of .5 volts are encountered. If less than 0.5 volts are found the utility may, at its discretion, install an isolator anyway; or if the utility decides not to install an isolator, the voltage will be monitored with a voltage recorder for a sufficient period of time to ensure the voltage does not exceed the 0.5 volt threshold.

The testing procedures are described[49] as a 3-step process: 1) test for stray voltage, 2) install the neutral isolator and 3) test again for stray voltage. Through this process it can be determined if there is an on-farm source of stray voltage.

4.5.4 Remediation Requirements

Since no specific requirements are established by the regulator, the service policies of two Vermont utilities under the Voluntary Plan are described.

Green Mountain Power (GMP) – in a letter dated October 27, 1994, GMP committed to installing neutral to earth isolators (Ronk Blockers) to all 263 dairy farms in their service territory within 2 years. For complaints on neutral to earth voltage problems beyond the installation of the neutral isolators, GMP service policy included a standard set of investigation and documentation procedures. The customer's neutral will be isolated in the course of the investigation (after the Ronk blocker has been installed).

Central Vermont Public Service Corporation (CVPS) – in a letter dated Sept 27, 1994, CVPS committed to installing neutral to earth isolators (Varistar Storm Trapper High Energy MOV Arrester, or customer provided Ronk Blocker) on all consenting dairy farms by Jan 1, 1995. The program also includes a yearly check of each isolation device.

[49] Information is based on a conversation with staff at the State of Vermont Department of Agriculture, Food, & Markets in November 2007.

Where the customer has refused the installation of the neutral isolator, it will be the responsibility of the customer to notify the utility if FSV is suspected. CVPS will respond to such requests in a timely manner and in accordance with a standardized set of investigation and documentation procedures.

4.5.5 Costs and Cost Recovery

Costs to the utility of installing the neutral isolator are recoverable through rates (across all customer classes). The argument for spreading the cost of the program across all rate classes is that all users of the distribution network (by virtue of being connected and using electricity) contribute to the problem of stray voltage. It was indicated[50] that since the program was started in the mid 1990's, 99% of the 1,100 farms in Vermont have had neutral isolators installed. The cost per isolator has been estimated at $1,000 USD. The total utility cost of the program is estimated at $1.1 million over approximately a 10-year period (likely a negligible rate impact).

The perspective in Vermont is that the adopted policy of systematically installing the neutral isolators is less expensive than identifying the source of the stray voltage through extensive (and costly) testing.

4.6 *Wisconsin*

4.6.1 Agencies, Mandates and Industry Structure

The Public Service Commission of Wisconsin (Commission or PSC) is an independent regulatory agency responsible for the regulation of 1,125 Wisconsin electric, gas, water, and telecommunications utilities, including those that are municipally owned. The purpose of regulation by the PSC is to ensure provision of safe, adequate, and reasonably priced service to utility customers. The electric utilities under regulation by the PSC include 13 non-municipal electric utilities, 15 municipal electric utilities, and 67 municipal utilities serving both electricity and water[51].

In 1989, Wisconsin Stray Voltage Analysis Team (SVAT), consisting of an electrical engineer, a master electrician and a veterinarian, was formed under the joint administration of the PSC and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) to collect and analyze data about farm stray voltage. . This group is now called Rural Electric Power Services (REPS). The major investor-owned utilities (IOUs) in Wisconsin have also recorded information from their stray

[50] Information is based on a conversation with staff at the State of Vermont Department of Agriculture, Food, & Markets in November 2007.

[51] Public Service Commission of Wisconsin, 2003-2005 Biennial Report, page 6.

voltage investigations at the request of the PSCW since 1988. The data is submitted to the PSCW every six months and is entered into a utility database[52].

4.6.2 Safety Codes

Under Wis. Stat. § 196.02(3), the PSC may adopt reasonable rules to regulate electric utilities with respect to inspections, tests, audits, investigations and hearings. Wis. Stat. § 196.74 requires all public utilities to construct, operate and maintain the wires and any related equipment in a manner which is reasonably adequate and safe, and gives the PSC the power to issue orders or rules, after hearing, requiring electric construction and operating of such wires and equipment to be safe. With respect to safety, the PSC has adopted the National Electrical Safety Code with some additions, deletions, and modifications as the Wisconsin State Electrical Code, which is ch. 114 of the Wis. Admin. Code, and. has the force of law in Wisconsin[53].

4.6.3 Evolution of an Approach to Farm Stray Voltage

Stray voltage has been an active subject of investigation and action by the PSC for about two decades. The PSC first investigated this subject in 1987, and 1988, culminating in an order issued in docket 05-EI-106 on January 18, 1989. The order prescribes a set of standardized screening tests to determine the presence of stray voltage, and five standard diagnostic measurement tests to identify its source. During 1989 and 1990 the PSC issued further orders to address the need for coordination between electric and telephone utilities when neutral isolation is installed, and to give further consideration to practices related to neutral isolation. In its 1990 Supplemental Order, the PSC clarified a limit on the utility's contribution to stray voltage of than 1.0 milliampere (mA) at animal contact, and stated that if the utility fails to mitigate the stray voltage problem, it is not providing adequate service.

The PSC has worked in conjunction with utilities and University of Wisconsin research staff for many years to develop testing methodologies (protocols) that ensure comprehensive measurements are made. It has also, in conjunction with the University of Wisconsin College of Agriculture and Life Sciences outreach program, developed stray voltage courses that detail the proper actions involved in the data acquisition process.

In 1995 and 1996 hearings were held leading to a further decision under docket 05-EI-115 with the purpose of evaluating data collected by the SVAT and utilities and updating

[52] Public Service Commission of Wisconsin, Findings of Fact, Conclusions of Law, and Order, Docket 05-EI-115, July 16, 1996.

[53] History and Interpretation Of Electrical Grounding In Wisconsin
Public Service Commission of Wisconsin PSC White Paper Series, Mark A. Cook and Richard S. Reines, May 2003, pp. 6-7.

the original orders to reflect new information. Key findings included in this decision were[54]:

- A total stray voltage level of 2.0 mA is a conservative level of concern and is reasonable for a state in which dairy farming is so important. It is "a preventive level where cows can perceive the current, but well below where a cow's behavior or milk production would be harmed". Based on the concept of equal responsibility between the utility and the farmer, the utility's responsibility is to keep its contribution of stray voltage to 1.0 mA or less.
- The farmer should always receive a report on the results of the utility's investigation of stray voltage.
- A standard based on primary neutral to reference voltage would not be adopted because it is not of help in addressing specific stray voltage concerns.
- Neutral isolation is permitted to address the utility's contribution to stray voltage under limited conditions, and usually for a limited time. The utility would pay for and own the isolator under these conditions. A farmer may also request isolation to address the on-farm component of stray voltage. If the utility's contribution is below 1.0 mA, the farmer must pay the cost of the isolator, installation, and maintenance. If the farmer requests the utility to remove the isolator within one year after installation, though, the utility must do so at no cost and shall reimburse the farmer the resale value of the isolator.
- If the utility's contribution to stray voltage exceeds the allowed amount, and the problem cannot reasonably be mitigated by changes to the utility's system, the utility may mitigate with an on-farm solution with the consent of the farmer. Such mitigation is generally through equipotential planes and electronic grounding. The utility would pay the cost of installation, but is required to transfer ownership to the farmer. The cost of the device is not allowed as part of rate base, but the expenses of installation and maintenance can be recovered in rates.
- Testing protocols as defined by the SVAT were confirmed, including use of a 500 Ohm resistor.
- It is reasonable for utilities to continue using on-farm mitigation to address off-farm problems, if on-farm mitigation is the least costly solution and the farmer agrees to its installation.

Wisconsin law requires that the primary neutral be grounded to earth at every transformer and, in total, at no fewer than nine locations per mile[55]. The PSC also adopted a modification to the NESC to require that for newly constructed rural distribution systems the primary neutral be grounded at each pole.

[54] Ibid.
[55] Wis. Admin. Code § PSC 114.096(1).

4.6.4 Testing Requirements

In a 1989 decision[56], the PSC specified a series of five tests to be performed in cases of stray voltage on farms. The first two tests are made to determine off-farm sources. The other three tests are made to determine on-farm sources.

The primary or off-farm tests consist of:

- Disconnecting power to the farm at the main disconnect and adding 240 v farm load or load box, before taking measurement; and
- If a second test is necessary, opening the connection between the primary and secondary neutrals.

The on-farm tests consist of:

- Measuring from the barn panel neutral to a reference ground which is away from any other grounds or metal in direct contact with the earth;
- Using a known load, measurements are taken between the barn service panel and the secondary neutral of the transformer. The formula of voltage drop = current x length x resistance of the conductor per 100 feet divided by 100 is used to indicate abnormal voltage levels on the farm neutral.
- Turning on all equipment, one piece at a time that contacts the earth, measurements are taken between the barn panel and the reference ground. This is intended to check whether a ground fault is the problem.

The Phase II protocol was developed to provide stray voltage investigators with a tool to collect a reasonable set of data useful in the analysis of the quantity and "quality" of stray voltage, and the source of such stray voltage. Phase II testing is intended to determine AC, 60 Hz, rms, steady-state animal contact voltages on livestock farms. The Phase II approach consists of six data input forms to record the results of a set of five individual electrical tests of the farm/distribution power system network. The main form includes an area to record background information that is important for the overall understanding of the farm/utility electrical system. The forms were developed by the PSC as prototypes. Also included are instruction sheets and diagrams for the uniform wiring and arrangement of the test equipment[57].

4.6.5 Remediation Requirements

The PSC addressed neutral isolation as an approach to mitigating its share of stray voltage in docket 05-EI-106, and confirmed the approach in docket 05-EI-115. Its position is that neutral isolation is a useful short-term means of mitigating off-farm

[56] Public Service Commission of Wisconsin, Findings of Fact, Conclusion of Law and Amended Order, Docket 05-EI-106, August 10, 1989, p. 8.
[57] PSC STAFF REPORT: The Phase II Stray Voltage Testing Protocol, Richard S. Reines and Mark A. Cook, Rural Electric Power Services, Public Service Commission of Wisconsin, February 1999, p. 2.

sources of stray voltage which are above the level of concern, allowing a utility time to diagnose the real cause of stray voltage and correct the problem.

The installation, though, is subject to the following conditions:
1. The utility must install the isolator at its own cost.
2 Isolation is not available for stray voltage below the level of concern.
3. Isolation is not available if it creates unsafe conditions on the farm because of lack of grounding or increases the primary neutral voltage to unacceptable levels.
4. Isolation can remain in place no more than 90 days. Beyond that period, the utility must request an extension from the Commission.

In the longer term, the utility should be seeking alternative means to correct the problem on its own system. Data collected over several years indicates that improvements to grounding and increases to size of primary neutral conductor are the most common off-farm mitigation approaches. Less commonly the utility may rebuild the distribution line, install underground primary conductor, or re-balance primary loads. The utility also has the option of addressing its share of contribution to stray voltage through on-farm mitigation, if the farmer agrees.

4.6.6 Process, Record-Keeping and Complaint Resolution

The SVAT (now called REPS) has been collecting data from on-farm stray voltage investigations since being established in 1989. The major investor-owned utilities (IOUs) in Wisconsin have also recorded information from their stray voltage investigations at the request of the PSC since 1988

The data includes information from applications for on-farm investigations, and actual on-site investigations. Not all applications result in a full investigation, therefore some entries contain only the data sent by the applicant, or information from a partial investigation. The data is submitted to the PSC every six months and is entered into a utility database.

Customer complaints, if unresolved at the utility level, can be brought to the PSC.

The PSC has also specified:

> "The Commission agrees that the farmer should always receive a report on the results of the utility's investigation. The level of detail may vary, but it is reasonable for all reports to include information about the level of stray voltage found, the source of any current that exceeds the level of concern, the utility's farm wiring recommendations, a description of all distribution system changes the utility made, and the results of the utility's 24-hour tests."[58]

[58] Public Service Commission of Wisconsin, Findings of Fact, Conclusions of Law, and Order, Docket 05-EI-115, July 16, 1996, pp. 12-13.

4.6.7 Costs and Cost Recovery

Approximately 600 farms per year are tested in Wisconsin for stray voltage, at an average cost including administration of $4,000 per farm. All testing costs are borne by the utility.

Costs of off-farm mitigation are recovered by the utility through rates. Equipment is included in rate base, with maintenance expenses also included for recovery. If on-farm mitigation is used, the equipment must be paid for by the utility and ownership transferred to the farmer. It is then not included in rate base, but reasonable installation and maintenance costs can be recovered by the utility.

Over the past 20 years, approximately $1.5 billion have been spent on rural system renewal in Wisconsin. These expenditures have provided many benefits of safety and reliability, but remediation of farm stray voltage has been an important part of the impetus for the work. Because of the long term implementation schedule, the costs are not considered by staff of the regulator to have had a noticeable impact on rates.

5 JURISDICTIONS BEYOND NORTH AMERICA

5.1.1 Europe

As described in Section 2.2, in the context of stray voltage, the designs of electric power distribution lines used in Europe are significantly different from those employed in North America. The power distribution lines in Europe are designed to IEC standards and do not employ multi grounded neutrals. They use a higher level 230/400 V utilization voltage, which allows the use of higher kVA rated, 3-phase transformers reducing the level of unbalanced current on medium voltage lines. During our literature search, we did not uncover any published stray voltage related problems in Europe.

5.1.2 Australia

Australia also employs IEC distribution standards, similar to those employed in Europe. During our literature search we did not uncover any published reports on stray voltage problems in Australia.

6 COMPARATIVE SUMMARY OF NORTH AMERICAN JURISDICTIONS

6.1 *Comparative Overview of Jurisdictions*

The following description is intended to highlight certain key aspects of the approaches to farm stray voltage that were revealed in the research.

Farm Stray Voltage as an Issue for Legislation, Regulation, or Other Government Action

Of the US jurisdictions surveyed, four (Wisconsin, Connecticut, Idaho and Michigan) have addressed the issue through regulatory requirements; Vermont, after considering action at the regulatory level adopted a voluntary program. In Pennsylvania, the regulator will act through its normal customer complaint process but otherwise leaves stray voltage management to the utilities under its jurisdiction. Only Idaho has passed specific legislation on the subject.

No Canadian jurisdiction currently addresses the issue of farm stray voltage through specific requirements of the utilities defined and enforced by the regulator. Therefore, if the Ontario Energy Board were to adopt and enforce a code for farm stray voltage, it would be the first regulator in Canada to do so. It appears that in most jurisdictions in Canada, the issue has not to date gained profile with regulators through customer complaints. Other factors include the restricted mandates of regulators in some jurisdictions (for example, Nova Scotia and Manitoba), and the industry structure in some

provinces. In British Columbia and Québec, for example, where most customers are served by a large, provincial government owned integrated utility, those utilities are in a position to recruit expertise, develop policies and procedures, and implement them across the province to address the problem.

In three jurisdictions, Québec, Vermont and Wisconsin, the government agency responsible for agriculture played a significant role in the overall effort to address farm stray voltage and related farmer concerns. This involvement provides the opportunity for a wider scope of action on behalf of the farmer, to address a wider range of problems that can result in detrimental impacts on animals.

It is interesting to note a lack of a regulatory requirement to address farm stray voltage has **not** meant that the utilities themselves have failed to develop internal standards and requirements (note especially Québec, Vermont, Alberta).

Rights and Responsibility of Utilities

In all the jurisdictions surveyed, there was a high degree of recognition that:

- in terms of remediation, the utility should bear costs only up to the customer's meter, and such costs should be recovered as normal capital and operating costs in the rates[59], and
- that the utility should be free to determine the best approach to remediation of its own contribution to farm stray voltage.

Basis for Establishment of Limit to Acceptable Level of Stray Voltage

Of the jurisdictions that have taken the regulatory approach, three (Michigan, Idaho and Wisconsin) have adopted the same level of concern, which is animal contact current levels of 2 mA total, with 1 mA as the maximum utility contribution. Idaho also expresses the level as 1.0 volts. Connecticut has adopted a lower level of concern, and defined it in terms of both cow contact and primary neutral to earth: cow contact of 0.5 volts or 1.0 milliampere and primary neutral to earth exceeding 1.0 volts.

In Vermont's Voluntary Program, a neutral to earth voltage level of 0.5 volts was established as the point at which remediation is to take place. Hydro Québec also defines its point at which remediation will take place in terms of neutral to earth voltage; 10V is considered an unacceptable level, but remediation measures will be implemented at 5V, in order to ensure that a level of 10V will not be reached at any time of year.

[59] Connecticut requires the utility to bear the cost of up to two days' of *testing* on the farm, and Hydro Québec will at its own discretion, provide assistance to a farmer in seeking the sources of stray voltage on the farm system. In Wisconsin, the utility may pay for remediation measures implemented on the farm, if these are undertaken to address the utility's contribution to a stray voltage problem.

Testing Requirements

The four jurisdictions that have a regulator-defined requirement to address stray voltage have each addressed testing requirements in a slightly different way.

In Connecticut, no specific test protocol is defined, but the requirement for remediation is at the utility's cost is applicable only to "off-farm" stray voltage. Therefore it would be necessary for the utilities to make a test that would attribute the total measured stray voltage between on- and off-farm sources. In Connecticut, no stray voltage complaints from farmers have been received since the standard was adopted.

In Idaho, the regulatory protocol includes six specific tests. The first two tests establish whether the total level of stray voltage exceeds the preventative action level, and includes measurement over 48 hours. If it does exceed, four further tests, including specifically a load box test, are conducted to determine the portion of the total stray voltage attributable to off-farm sources.

In Michigan, the regulatory protocol specified as series of tests, but the utility may submit a different test procedure for approval. The steady state animal contact voltage is measured over 72 hours. To determine the component which is off farm, the required test is to turn off farm electrical load and apply a temporary electrical load at the utility transformer to produce the same level of neutral-to-earth voltage at the utility transformer as found in the prior test, and measure the animal contact voltage again.

In Wisconsin, there is a defined set of five tests, including two to test off-farm sources and three to test on-farm sources. The off-farm tests include a test that applies 240-volt farm load or a load box.

British Columbia and Québec are the two jurisdictions where a single dominant distributor has defined its own policies and processes.

British Columbia does not use a load box test.

According to Hydro-Québec documentation, the first part of testing is to determine the customer contribution to the neutral voltage that is measured. Measurements are taken on the customer's premises with the main breaker closed and with the main breaker open. Measurements are then made at the transformer to determine if there is a problem with the continuity of the neutral, and the total neutral to earth voltage at that point. If the measured value is above 5V, inspections will be made to determine the probable cause and the best remedial action. At least three measurements are taken within a 24-hour period to verify that the voltage is not likely to exceed 10 V at any time.

No uniform stray voltage testing requirements are in effect throughout the jurisdiction in either Alberta or Pennsylvania.

Approaches to Remediation

Remediation approaches appear to be differently treated across jurisdictions. In particular, the acceptability of neutral isolation has been decided differently. In Vermont, it has been adopted as a nearly universal practice as part of the Voluntary Program, and BC Hydro has adopted it as a standard internal practice. In Wisconsin and Québec, it is regarded as a temporary measure, until better mitigation strategies can be implemented. Elsewhere it appears to be allowed at the discretion of the utility. Wisconsin allows the customer to demand neutral isolation unless the utility has identified safety reasons to the contrary.

Neutral isolation represents the most cost-effective remediation approach, where allowed. The equipment itself has a cost of approximately $875 per unit. Installation costs were variously estimated across jurisdictions to add $1,000 to $3,000 per unit.

Where neutral isolation is not permitted as the long-term remediation strategy, or where additional measures are called for, changes may be made in the distribution system to address the problem. The specific measures are not identified by the regulator in the rules in any of the jurisdictions surveyed, but selected by the utility on the basis of engineering requirements and cost under the specific conditions. Improvements to grounding or increases in size of the primary neutral are typical measures taken. Load balancing on the primary system may also be undertaken. In Wisconsin, the utility is explicitly allowed to offset its own contribution to stray voltage with on-farm measures, if the farmer consents. This approach may represent a cost-effective alternative to measures on the distribution system.

Collection of Information by Regulators

In Alberta and Pennsylvania, where there are no regulatory requirements with respect to stray voltage and no dominant jurisdictional distributor (as in British Columbia and Québec), there is no requirement for the utilities to collect and/or file specific information about stray voltage complaints with the regulator. Any complaint by a farmer directly to the regulator would be monitored in the manner more generally established for consumer complaints.

In British Columbia, BC Hydro would maintain internal records but would have no specific requirement to analyze cases of stray voltage. In Québec, MAPAQ is the first responder to queries by the farmers, and maintains a data base. Hydro-Québec has developed internal requirements for reporting, mainly to ensure the appropriate handling of individual cases.

In Vermont, with the state-wide adoption of neutral isolation, in most cases without extensive testing, no database would be required.

In Connecticut, there have been no inquiries from farmers about stray voltage in about 10 years, and therefore no data have been collected.

In Idaho, the utility's report on any specific stray voltage investigation is filed with the Commission only if the customer is not satisfied and makes a petition to the Commission.

In Michigan, no requirement has been established for utilities to file with the regulator information about cases that are successfully resolved with the farmer.

In Wisconsin, the utilities have been required since 1988 to collect information about cases of stray voltage and file it with the regulator every six months, for incorporation into a central database.

Other Factors and Aspects of Approach to Farm Stray Voltage

Some jurisdictions have adopted requirements or practices with regard to:

- information to farmers with regard to farm stray voltage (see Wisconsin and Québec notably);
- training of rural electricians (e.g. Québec) and of utility personnel (e.g. Idaho); and
- reporting to the farmer of results of testing (e.g. Wisconsin and Connecticut).

All of these provide possible models for the OEB, Ontario utilities or other agencies in assisting farmers.

6.2 *Tabular Comparison of Jurisdictions*

Figure 4.1 compares the jurisdictions at the level of agency responsibility and policy. Figure 4.2 compares the key specific aspects of the jurisdictional approach to farm stray voltage. **A detailed comparative table is attached as an Appendix to this report.**

	Canada			United States					
	Alberta	BC	Québec	Connecticut	Idaho	Michigan	Penn	Vermont	Wisconsin
Related Legislation	No	No	No	No	Yes	No, but rules have the force of law	No	No	Requirement for increased grounding on rural systems
Jurisdiction-wide standard established by	--	Utility	Utility	Regulator	Regulator	Regulator	--	Voluntary Program	Regulator
Customer complaint first directed to	Utilities	Utility	MAPAQ	Utility	Utility	Utility or Regulator	Utilities	Utility	Utility
Regulator will deal with unsatisfied complaints	Yes	Yes, but this has almost never occurred.	Not expected	Yes	Yes	Yes	Yes	Yes	Yes
Other Agencies Involved			MAPAQ, UPA					Department of Agriculture, Food and Markets	Wisconsin Department of Agriculture, Trade and Consumer Protection
Initiatives for education or research	No	No	HQ, MAPAQ and UPA	Education program developed by utilities, regulator and Dept of Agriculture	Inspectors complete regulator approved training			Department of Agriculture, Food and Markets	PSC and University of Wisconsin
Total cost impact on rates	Very small	Very small	Very small	Very small	Very small	Very small	Very small	Very small	Rate impact considered "not noticeable" despite large spending on system upgrades in the State.
Costs paid by utility recoverable in rates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Factors affecting magnitude of issue	Soil resistivity is high, reduces stray voltage	--	Only 6-8 cases annually require remediation on the utility's system	FSV Standard or "Protocol" developed as a result of a single complaint in 1995 - no additional occurences	--	Concentration of the industry has eliminated many small farms.	--	99% of the State's 1,100 dairy farms have neutral isolators installed	Extensive program of rural distribution system upgrades is contributing to reduction in numbere of farms with a stray voltage issue.

Figure 4.1 – Comparative Summary of Agency Responsibility and Policy

	Canada			United States					
	Alberta	**BC**	**Québec**	**Connecticut**	**Idaho**	**Michigan**	**Penn**	**Vermont**	**Wisconsin**
Standard based on	No province wide standard	No current standard	Neutral V	Animal contact V and neutral to earth	Animal contact V	Animal contact V	--	Neutral V	Animal contact V, but utilities expected to submit an internal guideline on primary neutral to earth voltage.
Maximum level from all sources	--	--	10 V, will do remediation at 5 V	0.5 V/1 mA cow contact, 1.0 V neutral to earth	1 V/2 mA	2 mA	--	0.5 V	2 mA
Maximum utility contribution	--	--	--	--	1 mA	1 mA	--	--	1 mA
Test procedures specified	No	No	Internal standard	No	Yes	Yes	Best judgment of the utility	Yes	Yes
Off-farm mitigation paid by	Utility	Utility	Utility	Utility	Utility	Utility	Utility	Utility	Utility
On-farm mitigation paid by	Customer	Customer	Customer	Customer	Customer	Customer	Customer	Customer	Customer
Costs paid by utility recoverable in rates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes*
Isolation of neutral	Allowed, a small number annually	Yes, standard mitigation approach	Yes, maximum 12 month period	Task Force to identify appropriate device (Task Force never met)	No approach specified	Allowed	No approach specified	Mandatory if >0.5 V, may also install if <0.5 V	90 days maximum unless extension given by PSC
Other mitigation	--	--	Increase number of grounds or size of neutral	Neutral Isolation shall be provided by electric utilities when the levels of concern cannot be met or achieved by the utility within 15 days.	No approach specified	No approach specified	Additional grounding equipment	--	Improvements to grounding, increases to size of primary neutral conductor are most common off-farm mitigation approaches. On-farm mitigation of utility contribution also allowed.

Figure 4.2 – Comparative Summary of Specific Provisions

7 CONCLUSIONS

The following sets out the range of issues and options that have been discovered through the cross-jurisdictional research. All have been part of the approach adopted in one or more of the jurisdictions studied, and might be adopted by the OEB for Ontario utilities.

7.1 *Aspects of Farm Stray Voltage*

7.1.1 Definition of Stray Voltage Levels Requiring Mitigation

All of the four jurisdictions reviewed in this study that adopted a regulatory approach started with a definition of the level of stray voltage that would require mitigation. Michigan, Wisconsin and Idaho adopted an animal contact level of 2 mA total as their standard, and specified that the contribution of the utility to this total must not exceed 1 mA. Connecticut adopted a level of concern of 0.5 V or 1 mA.

In Wisconsin, the selection of a level of concern was informed by extensive consultations and scientific research. In Idaho and Michigan, hearings were held to which parties brought evidence.

The OEB has available to it a survey of scientific literature and the results of consultations that would assist in selecting an appropriate standard for Ontario.

7.1.2 Specification of Testing Requirements

The OEB would have the option of developing uniform and specific testing requirements as part of the Code, of requiring each utility to specify its own uniform testing requirements, or of allowing each utility to make the tests that appear appropriate in the individual conditions. The Wisconsin PSC summarized the advantages of standardized measurements "to screen for the presence of stray voltage and to diagnose the source. First, they will provide a consistent systematic analysis which can readily be documented and duplicated. Second, they can avoid needless controversy over whether an adequate analysis was performed or whether the nature of the tests was valid. Third, they can recognize the various interests of parties working on a stray voltage analysis. For example, standard tests to determine whether a problem has an on- or off-farm source can be used to reduce the time an electrician must spend on a farm and bill a farmer."[60]

A protocol of testing might include specification of:

- appropriate size resistors;

[60] Public Service Commission of Wisconsin, Findings of Fact, Conclusion of Law and Amended Order in Docket 05-EI-106, August 10, 1989, page 7.

- both primary/off-farm and on-farm tests;
- the duration of testing (for example, a minimum of 24 hours);
- requirement to repeat testing at different times or seasons.

The testing protocol might also specify training or qualification requirements for utility staff conducting the tests.

Should the OEB adopt the approach of specified tests, costs and the availability of expertise and equipment might be considered in determining the specific tests that form the required protocol. For example, Michigan, Idaho and Wisconsin include a load box or similar test. The Wisconsin Phase II Protocol specifies the load box test in detail, and provides forms to be completed as a result. However, BC Hydro reports that it never uses a load box test, because of the specialized expertise required to correctly interpret the results.[61] In Ontario, unless a centralized resource were made available, the necessity for highly developed expertise and special equipment, while manageable for Hydro One without noticeable impact on total revenue requirement, could impose a significant cost burden on smaller utilities.

7.1.3 Specification of Allowed Remediation Approaches

The remediation approach might be specified or restricted in a compulsory requirement, or left for decision by the individual utility.

One key area of difference in approach across jurisdictions was in the use of neutral isolation as a remediation approach. In Vermont, it has been adopted as a nearly universal practice as part of the Voluntary Program, and BC Hydro has adopted it as a standard internal practice. In Wisconsin and Québec, it is regarded as a temporary measure, until other mitigation strategies can be implemented. Other remediation approaches include improvements to grounding, increases in size of the primary neutral and load balancing on the primary system.

If the OEB wishes to specify a mitigation approach, or to prohibit or limit the use of specific mitigation approaches, including neutral isolation, stakeholder consultation or the advice of a distribution engineer experienced in these issues might be of assistance. In this case, cost implications are an important consideration.

7.1.4 Specification of Customer Service Aspects

As well as specifying what must be done, it is important to include requirements as to timing and manner in which the customer is dealt with. A precedent for the OEB is the establishment of service quality measures for electric distribution utilities several years

[61] Conversation with David Rogers, BC Hydro, February 11, 2008.

ago. As an alternative approach, each utility's procedure and targets might be included in an internal policy document. Aspects might include:

- time limits for testing
- time limit for remediation; and
- requirements for a report to the customer.

The formal codes reviewed do not specify a time limit for testing, but Michigan specifies commencement of remedial action in two business days, and Idaho in 5 business days.

If the compulsory or voluntary processes of customer service include an effective internal complaint handling procedure, with time limits and definitions of responsibility within the utility, the result may be to reduce the number of service complaints that may be brought to the OEB by customers. In establishing time limits for action on a specific customer's complaint, it may be appropriate for the OEB to take into account the possibility of a high volume of complaints during the initial period after the stray voltage standards become effective.

The Wisconsin Phase II Protocol sets out a requirement for the farm customer to receive "a written comprehensive SV investigation report … as the final result of a thorough investigation. It should contain reliable, scientifically-derived numbers indicating where any significant levels of stray voltage were found on his/her farmstead and the physical mechanisms whereby those voltages arose."[62] In Connecticut, the requirement is: "If on-farm stray voltage is observed, the electric utility will conduct up to 2 days of testing at no cost to the farmer, and will provide the farmer a report indicating what has been found, if any additional testing or mitigation required. The utility will cooperate with persons hired by the farmer as needed and to confirm the source is not off-farm. "

7.1.5 Specification of Reporting Requirements to Regulator

Whether the specifics of addressing stray voltage are established as compulsory or voluntary for utilities at this time, the OEB may wish to add information on the results of testing and remediation to the list of data that utilities are required to file. The jurisdictions studied (notably Wisconsin's Phase II protocol) offer some examples of forms to be completed for summary into a database. As an alternative, the utilities may be required by the OEB to retain such information and make it available for periodic audits.

The availability of such information to the OEB would enable the OEB to determine the number of stray voltage complaints, the stray voltage levels found, the remediation actions taken, results, and costs.

[62] PSC STAFF REPORT: The Phase II Stray Voltage Testing Protocol, Richard S. Reines and Mark A. Cook, Rural Electric Power Services Public Service Commission of Wisconsin, February 1999, page 2.

7.1.6 Specification of Cost Recovery Mechanisms

In all jurisdictions surveyed, utilities were responsible for the costs of testing, and the costs of remediation of off-farm sources of stray voltage, and such costs were recoverable through rates. Similarly, it is reasonable to expect that Ontario utilities would wish to recover the prudently incurred costs of testing and remediation through rates to customers, without undue delay. The cost of service reviews conducted by the OEB of each utility's costs at the time of rebasing would provide an opportunity to scrutinize costs incurred in testing and remediation of farm stray voltage and to determine what approach should be taken if there is an issue of imprudent costs. The OEB might also establish whether utilities should be obliged to conduct any testing to assist the farmer in diagnosing on-farm stray voltage sources (such as is required in Connecticut), and recover the costs of doing so through rates to all customers, or through a regulated charge to the farmer.

The impact of the costs of testing and remediation of farm stray voltage on the rates of any individual Ontario distribution utility would depend on these factors: size of utility, number of farm customers requiring testing and remediation, and the approach taken to remediation.

7.2 *Options for the OEB to Address Farm Stray Voltage*

7.2.1 Do Nothing

In this approach, the OEB would take no role with regard to farm stray voltage, and leave the issue to be dealt with by other agencies.

At present, no Canadian regulator has established explicit policies with regard to farm stray voltage; however, most have a mandate to deal with customer service complaints and would therefore address a complaint with regard to farm stray voltage if one were brought to them. The exceptions would be Manitoba and Saskatchewan, where the regulator's scope is restricted to rate issues for the electric utility.

The most interesting example in which the regulator "does nothing" is Québec, where the Régie has taken no role in this issue, but MAPAQ takes complaints, assists farmers, directs stray voltage problems to Hydro-Québec, and follows up with Hydro-Québec on the customer's behalf if necessary. The advantages of this approach include:

- The primary focus of the responsible agency is the farm, rather than the utility; and

- The farmer can receive help, even if the cause of the distress to the animals turns out not to be electrical in origin (as is true in the majority of inquiries by farmers to MAPAQ.

In Ontario, the primary mandate to establish requirements and guidelines with regard to farm stray voltage issues could possibly be directed to the Ministry of Agriculture or to the Electrical Safety Authority. However, it is the OEB in Ontario that has the power to require action by a utility, and to approve the recovery of the costs of that action in the rates.

7.2.2 Management by Complaint

In this approach (e.g. Pennsylvania and Alberta), the regulated utilities are allowed to establish whatever approaches to farm stray voltage they might consider reasonable, and implement them in accordance with the best judgment of their management. This approach is consistent with the present approach of the OEB to many aspects of the day-to-day operation of the utilities it regulates. The OEB presently has the mandate and organization structure to address specific complaints from customers, and might use these mechanisms to intervene on a customer's behalf if the customer is not satisfied with a utility's response to a stray voltage complaint.

In view of the process that has now taken place, if this approach is adopted it might be supported by specific information to farmers as to how to bring a complaint to the OEB.

7.2.3 Voluntary Program for Utilities

In this approach (e.g. Vermont), the OEB would require each utility (with farm customers) to adopt a self-developed internal standard for dealing with stray voltage issues. Utilities might be encouraged to work together in the development of such standards to enhance uniformity and also to reduce the costs incurred within each utility. In Ontario, most rural customers are served by Hydro One, a utility with approximately 1.2 million customers. For Hydro One, the costs of developing an internal policy and procedure for farm stray voltage would not have a noticeable impact on rates, because of its large total revenue base. However, it is possible that for the few small utilities with farm customers, the administrative burden of such a project, undertaken without sharing resources, would be significant.

The OEB presently requires each utility to have a service and connection policy, but leaves the specific details of the policy to the individual utilities. This provides a model for a similar approach with regard to farm stray voltage policies and procedures. The OEB might require that the individual policy documents be filed for approval.

This approach could be adopted in conjunction with an OEB commitment to hear complaints from customers, as discussed in the previous section.

7.2.4 Compulsory Code

In this approach (e.g. Michigan, Idaho, Wisconsin, and Connecticut) the OEB would adopt a mandatory code for utilities which might be a condition of their licence. Ontario examples of this type of approach include the Distribution System Code and other codes. The advantage of a uniform code is that every customer would have access to the same protections, regardless of the utility providing service. This is an important consideration in a jurisdiction with many electric distribution utilities that serve farm customers. In Ontario, although Hydro One serves the majority of rural customers, other utilities do have farm customers. A compulsory code would provide consistency so all customers have access to the same protections, regardless of which utility services them.

It would also be possible to address some aspects of the issue through compulsory requirements, and others through internal standards voluntarily adopted by the utilities.

As mentioned in the previous section, a compulsory code would potentially impose a significant cost burden on a small utility, if the utility were required to, for example, maintain trained experts in stray voltage on staff, purchase test equipment, change business processes or install software, as well as meeting whatever reporting requirements might be established. The OEB would doubtless consider these costs, and their effects on rates, in any framework it might establish. The OEB and/or the utilities themselves might investigate the cost efficiencies that could be achieved through sharing resources, but this could be expected to entail some flexibility as to deadlines for response to a customer inquiry.

If the OEB establishes compulsory requirements for utilities with regard to farm stray voltage, it might also consider development of an explicit policy with regard to non-compliance.

7.3 *Implementation Issues*

7.3.1 Expertise

In several jurisdictions, an issue was raised as to the availability of expertise to deal with stray voltage both on the utility side and on the customer's side. However, it is primarily the expertise available to utilities that would be an issue for the OEB. As an example, Idaho has established a certification requirement for utility employees who test for stray voltage on farms.

Options for the OEB include:

- leaving the issue to utilities and their association(s) (such as the EDA);
- coordinating the efforts of utilities to establish training programs for their staff;
- coordinating with other agencies (such as the Electrical Safety Authority, and out-of-jurisdiction utility or a for-profit contractor) to make available the services of trained testers to utilities on a fee for service basis.

Clearly the burden on smaller utilities in Ontario would be significant if they were required to maintain in-house expertise on farm stray voltage. Some arrangement for the sharing of trained experts would be likely to provide the overall lowest cost across Ontario.

7.3.2 Costs

Cost issues to be addressed include total costs of the testing and mitigation activity and the impact of recovery on rates; cost/benefit analysis of alternative remediation approaches; and the potential benefits of resource sharing among utilities to reduce costs.

7.3.3 Monitoring

In Connecticut, there have been no inquiries from farmers about stray voltage in about 10 years, and therefore no data have been collected.

In Idaho, a copy of the records with regard to any specific stray voltage investigation is filed with the Commission only if the customer makes a petition to the Commission.

In Michigan, no requirement has been established for utilities to file with the regulator information about cases that are successfully resolved with the farmer.

In Wisconsin, the utilities have been required since 1988 to collect information about cases of stray voltage and file it with the regulator every six months, for incorporation into a central database.

In order to implement effective monitoring, the OEB might implement requirements might for the use of forms to record test results and remediation, regular filing of data with the OEB, establishment of a data base, and maintenance of records within the utility for audit by the OEB.

7.4 *Additional Elements to Provide Comprehensive Assistance to Farmers*

7.4.1 Dispute Resolution

In Michigan, which has established regulatory requirements with regard to farm stray voltage, the regulator will hear a customer complaint if the customer is not satisfied with actions taken by the utility. Pennsylvania provides an example of a jurisdiction that has not established regulatory requirements, but where the regulator will hear and resolve a complaint if one is directed to it. Most jurisdictions contacted, including the Canadian jurisdictions (none of which presently have regulatory requirements on this issue), indicated that a complaint related to farm stray voltage would qualify for the regulator's established customer complaint resolution process.

The OEB presently has mechanisms to address customer complaints about a utility's service. These could be used to address complaints about farm stray voltage. The more explicit and uniform the requirements for the utility, the more clarity there may be in determining whether the utility has fulfilled its obligation to the farm customer or not.

An alternative may be to have customers contact some organization other than the utility or the OEB, either initially or to address unresolved complaints. For example, in Québec, initial concerns about stray farm voltage are directed to MAPAQ, which conducts a screening process before referring the issue to Hydro-Québec. This process allows potential causes of problems with farm animals other than stray voltage to be identified, and advice provided, by staff whose knowledge of farm issues is wider than that of an electric utility. In Québec, only 20% of concerns brought by farmers to MAPAQ are found to be related to stray voltage. MAPAQ will also advocate for the farmer in dealings with Hydro-Québec if the farmer is not satisfied.

This example could be followed in Ontario, with customers turning to the Ministry of Agriculture, or to the Electrical Safety Authority.

7.4.2 Farmer Information and Education

Farm stray voltage problems can best be addressed if farmers are knowledgeable about:

- what stray voltage is and how it might affect their livestock;
- what problems other than stray voltage need to be investigated;
- what conditions on the farm, including the customer's electrical system, can contribute to stray voltage problems, and what remediation is possible;
- sources of help and advice; and
- the process for bringing a stray voltage concern to the utility or to the OEB.

Québec provides some good examples of informative material prepared for farmers, and of work done cooperatively between the utility, the government, and farm advocacy organizations. In Connecticut, electric utility requirements regarding stray voltage include sending information to farmers annually, assisting in training sessions for farmers, and the implementation of a training program for employees.

The OEB may choose to play a role in development of such informative material, or to require utilities to do so, as a public service.

7.4.3 Training of Rural Electricians

It is helpful to farmers in addressing the on-farm contribution to stray voltage if rural electricians are knowledgeable about the problem and approaches to on-farm mitigation. The electricians should also be able to advise their clients in dealings with utilities.

Hydro-Québec along with MAPAQ and UPA sponsored a 2-day training course for electricians to diagnose and correct stray voltage problems on farms. It was free for the electrician. First course took place in the 90s. A new one is now being planned. Costs are shared among the three agencies

In Vermont, the Milk Quality Enhancement Program (MQEP), administered by the Department of Agriculture, Food and Markets, has responsibility to oversee the development and implementation of education programs on stray voltage to farmers, electricians and other agribusiness related professionals.

The OEB may choose to play a role in education programs for rural electricians, or require utilities to do so.

7.4.4 Coordination with Other Agencies and Organizations

Since there is a potential role for other agencies, perhaps including the Electrical Safety Authority and the Ministry of Agriculture, in addressing the problem of farm stray voltage, the OEB may choose to establish continuing lines of communication with these agencies, and/or with stakeholder groups representing utilities and farmers.

Examples of coordination with similar agencies include:

- Connecticut Stray Voltage Task Force – comprised of electric utilities, state agencies and other interested parties, the task force is to i.) Foster cooperation among utilities, state agencies, private agencies and the farm community, ii.) Monitor and evaluate research and make recommendations, iii.) Monitor policy and regulatory actions in other states, and iv.) Determine the feasibility and implementation of a dispute resolution function within the

task force. Although this task force was specified in the regulator's order on the subject, the task force was never formed.

- In Québec, Hydro-Québec coordinates its activities with regard to stray voltage with MAPAQ and a farmer advocacy organization, UPA.

APPENDIX A – INFORMATION SOURCES AND REFERENCES

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APPENDIX B – DETAILED COMPARISON OF JURISDICTIONS

Jurisdiction Summary of Regulatory Approaches to Farm Stray Voltage – United States

Item	Connecticut	Idaho	Michigan	Pennsylvania	Vermont	Wisconsin
Responsible Authorities/ Agencies	Department of Public Utility Control (DPUC)	Idaho Public Utilities Commission (IPUC)	Michigan Public Service Commission	Public Utility Commission has not established rules or policy, but will deal with complaints on a case by case basis.	Department of Agriculture, Food and Markets Department of Public Service	Public Service Commission of Wisconsin Regulates the utilities and is responsible for electrical safety code. The Rural Electric Power Services (REPS) is jointly administered by the Public Service Commission of Wisconsin (PSCW) and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP).
Related Legislation	No.	1) Stray Current and Voltage Remediation Act (61-801), Mar 28, 2005. 2) Rules for the Measurement of Stray Current or Voltage	Standard set in Case No. U-13934 has the force of legislation.	No.	Legislation tabled but never passed - agreement reached on a voluntary program Voluntary Program for the Control of Stray Voltage (August 9, 1994)	
Definition of Stray Voltage	Yes	Yes designed to 1) determine presence, 2) identify source and 3) determine contribution from utility/farm	"Stray voltage," also referred to as AcV, means the measured difference in an AC electrical potential when measured with a shunt resistor between 2 points that an animal can simultaneously contact in locations normally accessible by the animal through step or touch both inside and outside of farm buildings.	No	As part of the voluntary program, each Utility required to submit a proposed Service Policy by Oct 1994. Neutral isolators installed on all dairy farms in the State.	Yes

Item	Connecticut	Idaho	Michigan	Pennsylvania	Vermont	Wisconsin
Utility (Primary) Neutral to (remote) Earth Voltage Standard?	Level of concern - 1.0 V	No	No.	No.	No	Primary neutral to reference voltage standard not considered useful to the stray voltage problem by the PSCW Some utilities have set their own standard.
Animal ("Cow") Contact Standard?	Level of concern - 1.0 milliampere or 0.5 V	Yes - Mandatory IPUC Rules Preventative Action Level (PAL) - either 2 milliamperes, or 1.0 volt (assumed cow resistance of 500 ohm)	"Preventive action level" means a steady state animal contact current that meets or exceeds 2 milliamperes RMS using a nominal 500 ohms resistor at 60 Hz from all sources, including off-premises and on-premises sources.	No.	No	Docket 05-EI-115 - Total level of concern set at 2.0 mA, and mitigation by the utility must occur if its contribution exceeds 50% or 1.0 mA
Utility Remediation Requirement Specified?	Remediation specified only when off-farm source cannot be reduced to level of concern within 15 days (neutral isolation).	FSV attributable to Utility must be reduced to < 50% of PAL Defined set of tests and forms to document results	Utility required to modify its system.	No.	Neutral isolation devices installed on all dairy farms	Neutral isolation discouraged but allowed as a short term measure.
Utility Responsible for remedying what FSV sources?	Off-farm sources remediated at utilities expense; will provide 2 days of testing for on-farm sources free of charge.	All non-farm sources to be reduced to < 50% of PAL	Utility contribution identified by measurement, as specified in the Rules.	Utilities with rural customers have teams to address stray voltage issues as they arise.	If FSV is encountered, utility policy is to automatically install neutral isolator. If FSV is still encountered then on-farm issue - Utility will investigate as per Service Policy	Non-farm sources must be mitigated to below 1.0 mA.
Utility can address Off-farm sources by paying for On-farm measures	No specific policy.	Yes Reconductoring of service line. All work "before the meter" is at utility expense.	No.	No specific policy.	Yes	Yes, if the utility cannot mitigate its contribution through modifications to its own system, or if less costly. On-farm measures must be agreed by the farmer.

Item	Connecticut	Idaho	Michigan	Pennsylvania	Vermont	Wisconsin
Isolation of Utility (primary) and farm (secondary) neutrals is allowed	Yes - Utility shall provide neutral Isolation when the levels of concern cannot be met or achieved within 15 days.	Remediation measures not specified in Rules Idaho Power - generally will install neutral isolators as a short-term measure until service can be reconductored (for safety reasons), then will remove isolator	Yes	No specific policy.	99% of farms in State now have neutral isolators installed (program initiated in 1994). Approach is not to test extensively - install neutral isolator first	As a short term measure to mitigate utility's responsibility. Isolator can also be installed at the farmer's request, and at the farmer's cost.
Safety Codes	National Electrical Safety Code - utilities National Electrical Code - electrical wiring in buildings	National Electrical Safety Code - utilities National Electrical Code - electrical wiring in buildings	National Electrical Safety Code - utilities	National Electrical Safety Code - utilities	National Electrical Safety Code - utilities National Electrical Code - electrical wiring in buildings	PSCW has adopted the NESC with suitable additions, deletions, and modifications as the Wisconsin State Electrical Code Vol. 1.20 It is also known as Wis. Admin. Code ch. PSC 114.
Type of Rural System	Primary and Secondary Neutral	Primary and Secondary Neutral	a grounded distribution system with a primary neutral conductor:	Primary and Secondary Neutral	Primary and Secondary Neutral	Primary and Secondary Neutral
Distribution Utility Structure	Electricity sector restructured in 2000 - 2 public electricity distribution (and transmission) companies.	< 10 private utilities and cooperatives	investor owned utilities and coops	>10 private utilities and rural cooperatives	< 10 private utilities and cooperatives	> 10 private utilities, municipal electric utilities and municipal electric / water utilities.
Process	Farmer to file complaint with Utility	Farmer files a written notice to utility Idaho Power - will automatically install neutral isolator within 5 days to satisfy Rules	Customer can bring the complaint to the utility or to the regulator. Testing process specified in the rules.	To the utilities on a case by case basis. Complaints can be brought to the PUC for resolution.	Utility Service Policy to install Ronk Blocker on all farms within 2 years (1996) Complaints are given priority for installation of neutral isolator	Farmer to file complaint with Utility. Customer complaints, if unresolved at the utility level, can be brought to the PSC.
Utility Requirements	Remediate off-farm sources within 15 days, provide 2 days of free testing for on-farm sources	Utility must respond to customer notification within 5 business days Utility will conduct standardized testing to determine off-farm and on-farm contribution to FSV. Rules determine if remediation required	Complaints are handled by the utility on a case by case basis as they arise. There are no specific utility requirements.	Utilities are expected to fully investigate, test and attempt to resolve FSV complaints.	Defined program to install neutral isolators to all dairy farms. Farmers may request to not have a neutral isolator installed	Utility will conduct standardized testing to determine off-farm and on-farm contribution to FSV. Approach consists of six data input forms to record the results of a set of five individual electrical tests of the farm/distribution power system network.

Item	Connecticut	Idaho	Michigan	Pennsylvania	Vermont	Wisconsin
Utility Remediation	Not specified. If not resolved within 15 days must install neutral isolator	No specific remediation is specified - utility discretion Idaho Power - long-term solution for off-farm FSV is to reconductor service line	Remediation as determined by the utility.	Not specified	Utility source of FSV believed to be solved	Improvements to grounding and increases to size of primary neutral conductor are the most common off-farm mitigation approaches Utility may use neutral isolation as a short term measure (up to 90 days)
Remediation cost	Cost for off-farm sources are paid by the utility, on-farm sources are paid by the farmer.	Idaho Power - install and removal of neutral isolator, plus the cost of reconductoring the service line. Cost will depend on the length of the service line	No cost data available but believed to be small.	The line of demarcation for cost bearing by the utility is the company's meter	Cost estimated at $2 k per neutral isolator x 1,100 farms = $2.2 million Ronk Blocker $800 to $900 USD plus installation - $1,000	State has a program of rural system improvement; $1.5 billion spent over 20 years; contributes to remediation of stray voltage and provides other benefits. If on-farm measures are used to mitigate off-farm source, utility pays and transfers ownership of equipment to farmer.
Cost Recovery	Assumed general cost of service - unconfirmed as there has been only one instance in 1995.	Yes - across all customer classes	In rates.	Utility costs are recovered as an expense through rates.	Yes - across all customer classes	Utility off farm costs are recovered through rates. Cost of equipment is at utility expense, installation and maintenance may be recovered through rates.
Other Comments		Largely adopted the Wisconsin approach Inspectors must have Commission Approved FSV training.			Vermont Elec Cooperative - VPSB stipulates that VEC install isolators where neutral to earth >0.5 volts by June 1, 2001	

Jurisdiction Summary of Regulatory Approaches to Farm Stray Voltage – Canada

Item	Alberta	British Columbia	Quebec
Responsible Authorities/ Agencies	Alberta Utilities Commission (AUC) - no set rules or regulations regarding FSV AUC will handle complaints filed by individual farmers on a case-by-case basis.	BC Hydro - voluntary program of responding to FSV	3 Party collaboration 1) Hydro Quebec (HQ), 2) Dept of agriculture, fisheries and food ("MAPAQ"), and 3) a farm interest group the Union des producteurs agricoles ("UPA"). Through a liaison committee of these three parties, the mechanisms for treatment of FSV have been evolving since the mid-90s.
Related Legislation	None	None FSV Customer Service Instruction (CSI) 1989 approach now abandoned. Each farm is handled on a "case by case" basis	None
Definition of Stray Voltage	None	No CSI provides a general definition	Tension parasite : Faible différence de potentiel qui existe entre deux points d'une personne ou d'un animal. Cette tension fait circuler un courant qui excite les nerfs et donne à cette personne ou à cet animal une sensation désagréable de picottements.
Utility (Primary) Neutral to (remote) Earth Voltage Standard?	None - Fortis Alberta has applied CSA standard of 10 volts (for safety purposes) to FSV situations Neutral to ground safety standard as per CSA C22.3	No set threshold (measurements in the range of 0.5 volts is considered significant) CSI Document (abandoned) - 10 volts	Maximum acceptable is 10 V, but action taken if measured above 5V, to prevent possibility of exceeding 10V at certain times.
Animal ("Cow") Contact Standard?	None	No set threshold (measurements in the range of 0.2 volts is considered significant) CSI Document (abandoned) - 1.0 volts	No.
Utility Remediation Requirement Specified?	Fortis - No set process or requirements - 1 or 2 situations per year - handled case by case 1) Measurement, 2) Check ground, 3) measurement	No set requirement Utility will work with the customer to resolve FSV regardless of source.	Filter may be installed for maximum of 12 months. Longer term solutions are to increase the number of grounds or to increase the size of the primary neutral, or to convert to a 3-phase line and ensure that the loads are balanced.
Utility Responsible for remedying what FSV sources?	Utility will install neutral isolator for off-farm source remediation	Off-farm sources reduced to acceptable levels On-farm remediation at cost of farm. Utility will provide expert advice and testing (at utility cost).	Hydro-Québec will pay for remediation of its own system. On-farm problems dealt with at the customer's expense.
Utility can address Off-farm sources by paying for On-farm measures	Yes	Yes	No.

Item	Alberta	British Columbia	Quebec
Isolation of Utility (primary) and farm (secondary) neutrals is allowed	Yes Cost is passed through to rate payers as a general expense	Standard remediation measure is to install a neutral isolator (contradicts CSI) CSI document indicates that the neutral isolator will not normally be installed	Filter installed as a temporary measure.
Safety Codes	Canadian Electrical Code (2006), with amendments Alberta Labour, Electrical Protection Branch	Canadian Electrical Code (2006), with amendments	Canadian Electrical Code (2006), with amendments
Type of Rural System	Earth Return System	Primary and Secondary Neutral	Primary and Secondary Neutral
Distribution Utility Structure	< 10 private utilities and cooperatives	BC Hydro distributes power to the majority of the province	Hydro Quebec is a vertically integrated utility that distributes electricity to the entire province
Process	Case by case - farmer contact utility, if not satisfied may file a complaint with the AUC	Farmer will contact BC Hydro directly. In many cases the Milk Quality Inspector will inform the farmer of the service provided by BC Hydro	Complaints first referred to MAPAQ which has a process to screen for alternative causes. MAPAQ maintains records associated with all farm issues. If customer is not satisfied with actions taken, recourse is normally to MAPAQ, who will deal with HQ if it is a stray voltage matter.
Utility Requirements	None specified Fortis Alberta has voluntarily adopted CSA safety code - 10 volts neutral to earth standard	No defined requirements BC Hydro has voluntarily tested every farm in the province (some as many as 20 times)	Hydro-Québec has its own standard which has been in place for 20 years. Now being modified but the key elements are unchanged. C.26.01
Utility Remediation	Neutral isolator	BC Hydro will install neutral isolators (Dairyland) where required BC Hydro does not pay for on-farm remediation	Filter may be installed for maximum of 12 months. Longer term solutions are to increase the number of grounds or to increase the size of the primary neutral, or to convert to a 3-phase line and ensure that the loads are balanced.
Remediation cost	Ronk Blocker ($800 to $900 plus installation - 1 line worker x 3 hours) = $1,800	$3,000 to install neutral isolator (avg cost installed). Estimated labour cost for FSV testing is $167 per visit. Average of 2 to 4 visits per FSV case.	Costs variable, but not considered significant in total.
Cost Recovery	Yes - across all customer classes Costs in Alberta are considered immaterial	Yes - across all customer classes	Yes - across all customer classes
Other Comments	1 or 2 cases per year - not material expense	BC Hydro approach has been modified significantly from CSI	