# NOVA SCOTIA UTILITY AND REVIEW BOARD

# NSPI P-882

**IN THE MATTER OF:** *The Public Utilities Act*, R.S.N.S. 1989, c.380 as amended

- and -

**IN THE MATTER OF:** An Application by Nova Scotia Power Incorporated for Approval of Certain Revisions to its Rates, Charges and Regulations

Evidence of

Dr. Larry Hughes

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**What is your name, affiliation, and business address?**

My name is Larry Hughes; I am a full professor in the Department of Electrical and Computer Engineering at Dalhousie University in Halifax, Nova Scotia.

**What is your academic background?**

I have a Bachelor of Science degree in Computer Science and Chemistry from Carleton University in Ottawa. My Masters and PhD are from the Computing Laboratory at the University of Newcastle upon Tyne in the United Kingdom.

I teach undergraduate courses in Computer Engineering and graduate courses in energy and the environment.

**Describe your research work.**

I have three active research areas at Dalhousie University: computer communications, embedded systems, and energy and environment. It is the third of these research areas that are of most interest to these hearings.

My energy and environment research consists of two related areas:

- Mitigating the effects of climate change by changing the way energy is used, and
- Improving Nova Scotia's energy security by reducing our reliance on foreign energy sources.

Although seemingly distinct, these two areas overlap, and I believe that if one of these two issues can be "solved", it will go a long way to solving the other.

My research has been published in energy and environment research journals, including Energy Policy, Energy Conversion and Management, International Journal of Energy, Environment, and Economics, and Environment. I have also made presentations on my research at conferences across North America and in Europe.

My website contains reviews of various provincial government energy publications, including the 2001 Energy Strategy and its subsequent Progress Reports. This past summer, I wrote a review of the state of Nova Scotia's energy sector in 2004 for the Canadian Centre for Policy Alternatives (CCPA-NS). In October 2004, I made a submission on the proposed "Electricity Act" to the Law Amendments Committee of the provincial legislature.

I have also examined NSPI's Green Power Rider, which was subsequently used to show how NSPI's "Solicitation for Renewable Energy 100KW to 2 MW on Distribution" treated itself differently from the Independent Power Producers who were competing for contracts.

I have also been interviewed in the local media on my views on energy and the environment, including the morning (both mainland and Cape Breton Island) and afternoon CBC radio programmes, the Daily News, the Chronicle-Herald, and other local papers. My letters and articles have appeared in local Nova Scotian papers as well as the Globe and Mail. I have given presentations to various groups around the province on energy and environmental issues.

I was a member of the HRM Regional Planning Committee from its inception in 2002 until I left on sabbatical in 2004. I am also a member of the HRM Chamber of Commerce renewable energy subcommittee.

I am the project leader of the Nova Scotia Wind Energy Project, a $400,000 project designed to educate Nova Scotians about the benefits of wind energy. The first phase of the project collected wind data from various sites around the province. The second phase will see the installation of three 20 kW turbines.

During my 2004-05 sabbatical from Dalhousie University, I was a Visiting Fellow at the Science and Technology Policy Research Unit (SPRU) at the University of Sussex in Brighton, England.

**What is the Energy Research Group?**

The Energy Research Group consists of those of my graduate students who are working under my supervision on energy-related research or are taking energy-related courses from me, as well as visiting academics. The size of the group fluctuates as new members arrive and others graduate; at present there are four graduate students in the group working on research projects for me. Recently completed theses include “Net metering policies in North America” (by Mr. Jeff Bell) and “Design of a district energy system” (by Mr. Jaspreet Nijjar). Other ongoing research projects include an analysis of Nova Scotia’s “Smart Energy Choices” programme and the design of a wind-biomass system.

The research group meets weekly and often includes a seminar from Nova Scotians or visitors from outside the province with backgrounds in energy matters. We have had seminars from Jim Conners (NSPI), Will Apold (REIANS), Peter Berg (UOIT), and David Hughes (NRCan).

**Why are you making this presentation?**

I have knowledge of and research experience in areas of energy and environment that will allow me to contribute to the debate and make recommendations to these hearings. I believe that serving the community is one of my primary responsibilities as an academic.

**What is the “flat rate” model?**

The flat rate model is a method used by energy suppliers for billing their residential consumers. The model takes the record of a consumer’s energy consumption (usually measured in kilowatt-hours over a given period) and applies a known price (usually expressed in dollars or cents per kilowatt-hour) to the volume of energy consumed. The result (kilowatt-hours times dollars per kilowatt-hour) is the consumer’s charge, expressed in dollars. The simplicity of the flat rate mode makes is easily understood by consumers and energy suppliers alike.

The flat rate model uses induction-type electricity meters that record the consumer’s energy consumption.

**What are the limitations of the flat rate model?**

First, all consumers pay the same price for a unit of energy, regardless of consumption. With only a single price, the energy supplier has few means available to influence consumers’ consumption patterns. Any change in price affects all consumers; for example, raising rates to discourage consumption impacts all consumers, including those with existing low levels of consumption.

Second, it can result in cross-subsidies from consumers with demands that are not peak-coincident to those with demands that are peak-coincident.

The cost of energy generation varies by season, day-of-the-week, and the time-of-day. In periods of low demand (typically midnight to 6:00am), when most, if not all, demand is met by baseload generation, the cost of generating a unit of energy is typically the lowest. On the other hand, when demand is high (often in the early evening), it is necessary to operate more expensive peaking units, resulting in the highest cost for energy generation.

Since the flat rate charges a consumer only for the energy consumed, not the demand, the unit price must be a 'blend' of the different costs of generation. The flat rate model implies that all consumers exhibit the same consumption profile; put another way, a consumer's energy consumption is assumed to be proportional to the demand they put on the system. Experience shows this is not always the case: a consumer's maximum demand is not necessarily coincident with the system peak, meaning that the cost of generation can vary between consumers. An example of this can be found in the supporting document.

The flat rate model normally use induction-type electricity meters that record energy consumption only.

**What are the alternatives to the flat rate?**

There are many different rate models in existence, based upon demand (kilowatts) and energy consumed (kilowatt-hours). In order to bill a consumer, it is necessary to have metering equipment that can measure and record the maximum demand, or the total energy consumed, or both.

Rate models such as Hopkinson, Doherty, Wright, and real-time-usage, all require interval timers that can measure both demand and energy consumption over given periods of time. With the demand and energy consumption known, these rate models allow the energy supplier to create a variety of price signals, ideally making the price cost reflective.

Time-of-use meters can also measure intervals, although in most applications only energy and the time the energy is consumed are recorded. These rate models allow the energy supplier to vary the rate based upon the season, day-of-week, or time-of-day, once again, potentially becoming cost reflective. This rate model can incorporate price signals that are intended to encourage various consumption patterns by applying different rates at different times.

Although induction-type meters remain in widespread use because they are inexpensive, energy suppliers with these meters are not restricted to using the flat rate model for determining consumer rates. Other rate models are available, notably the step meter rate and the block meter rate.

The step meter rate charges consumers using a ‘sliding scale’, where the rate is determined by the energy usage. The step meter rate, as originally envisaged, exhibits problems at the energy consumption limits: a consumer with energy consumption slightly below a limit may gain significant savings simply by increasing consumption slightly above the limit. The step rate model can be modified to handle this problem, at the expense of added complexity.

The block meter rate divides a consumer’s total energy consumption into one or more blocks, with each block assigned its own price. In the block meter rate, the consumer’s bill is created by dividing the consumption into a series of blocks and then applying a price to each block, while in the step meter rate, a single price is applied to the consumer's total energy consumption, depending upon the level of consumption.

Both the step and the block meter rates were originally designed to work with declining prices; that is, the more energy consumed by a consumer, the less the price per unit of energy. Declining energy prices are intended to reflect the fact that increased generation spreads the fixed charges over a greater number of units of energy, meaning that the price of energy should decrease as consumption increases. With rising fuel prices and growing environmental concerns over the ways in which electricity is generated, many people are questioning the wisdom of creating price signals that encourage the consumption of energy.

**If time-of-use rate structures are beneficial, why not simply re-meter all of NSPI's residential consumers?**

Ideally, this would be done. However, the six weeks between the start of these hearings and the date the new rates are to take effect, would not result in a significant number of meters being installed.

Furthermore, re-metering all 400,000 of NSPI's residential consumers at $300 per meter and $50 per installation will cost about $147 million. Although this is recouped from the consumer, NSPI would probably be expected to bear the cost until it was paid by the consumer.

If NSPI were to devote its $5 million DSM fund to this, about 14,000 residential consumers (households) could be switched to time-of-use metering.

**What is the inverted block rate?**

Block rates need not have a declining price structure; if the block rate increases with increasing energy consumption, the block rate is said to be inverted. The inverted block rate differs from the flat rate in that it allows the energy supplier to introduce price signals, rewarding consumers for reducing consumption and reducing the impact of cross-subsidies.

Energy suppliers must develop rate structures that generate sufficient revenues to recover costs and give a satisfactory rate of return. When developing a rate structure for an inverted block rate for a given consumer class, the energy supplier must determine:

- The revenue to be generated from the consumer class.
- The number of blocks.
- The energy consumption limits associated with each block.
- The price associated with each block.

The selection of the blocks, the limits, and the prices allows the energy supplier to employ price signals that can encourage changes to consumer energy consumption habits.

**Where is the inverted block rate used?**[1]

Inverted block rates have been used in California since 2001, where the California Public Utilities Commission imposed a five-tier inverted block rate to encourage energy conservation. The blocks consist of a “baseline” (determined by the consumer’s energy requirements), then increasing percentages of the baseline (101 to 130 percent, 131 to 200 percent, 201 to 300 percent, and finally, greater than 300 percent). Southern

[1] The information on Ontario’s inverted block rate and the inverted block rate used in Gujarat in India, was supplied by Ms. Niki Sheth, a graduate student in the Energy Research Group.

California Edison's price per unit energy per block ranges from 13.009 cents per kilowatt-hour (lowest block) to 25.993 cents per kilowatt-hour (highest block).

In Vermont, the Burlington Electric Department has a two-block inverted block rate for residential consumers: the first 200 kWh are charged 5.945 cents per kilowatt-hour, while the tail-block is charged 10.1427 (summer) or 10.5309 (winter) cents per kilowatt-hour.

In Ontario, the Ontario Energy Board has created at two-block inverted block rate for residential consumers; unlike the other block rates discussed above, the size of the first block varies by season. From 1 April 2005, the first block is charged at 5.0 cents per kilowatt-hour up to a threshold of 750 kilowatt-hours, the tail-block rate is 5.8 cents per kilowatt-hour. The 750 kilowatt-hour threshold is to be raised to 1,000 kilowatt-hours on 1 November 2005, with the same rates. The threshold is scheduled to fall to 600 kilowatt-hours in 1 May 2006, at which point new rates will be instituted. These rates are for monthly usage.

Another example of inverted block rates are the 'lifeline' rates which charge a rate lower than the residential flat rate to low- and fixed; income individuals and families for a limited number of kilowatt-hours per year. The reason for such programs can be illustrated by a recent study from Ontario which found that the lowest earning 20 percent of the population spends up to five times the relative amount of their income on water, energy, and electricity as does the highest earning 20 percent.

The inverted block rate is used outside North America; for example, in Surat, in the Indian state of Gujarat, the state run utility has a five-block rate, as shown in the following table:

| Consumption | Charge |
|---|---|
| First 50 Units | 270 Paise Per Unit |
| Next 50 Units | 300 Paise Per Unit |
| Next 100 Units | 360 Paise Per Unit |
| Next 100 Units | 410 Paise Per Unit |
| Above 300 Units | 470 Paise Per Unit |

**Can you give an example of an inverted block rate?**

As an example, consider an inverted block rate consisting of three blocks: the blocks and their associated prices are shown below:

| Block | Price ($/unit) |
|---|---|
| 0 to 2,000 units | 0.09 |
| 2,001 to 4,000 units | 0.10 |
| Greater than 4,000 units | 0.11 |

Three consumers consume 1,500 units, 2,500 units, and 4,500 units respectively. The consumption breakdown (by block) and charges associated with each consumer are shown in the following table. Note that all consumers are charged by energy consumption per block, meaning that as a consumer's energy consumption increases, the price per unit of energy increases (conversely, the less consumed, the lower the price per unit of energy).

| Consumer consumption | Block 1 ($0.09/unit) | Block 2 ($0.10/unit) | Block 3 ($0.11/unit) | Total charges | Price/unit |
|---|---|---|---|---|---|
| 1,500 | 1,500 | 0 | 0 | $135.00 | $0.090 |
| 2,500 | 2,000 | 500 | 0 | $230.00 | $0.092 |
| 4,500 | 2,000 | 2,000 | 500 | $435.00 | $0.097 |

**What are the advantages of the inverted block rate?**

The inverted block rate offers a number of advantages over the flat rate, including:

- Price signaling. The inverted block rate allows the energy supplier to introduce price signals: low consumption consumers have less of an incentive to increase consumption as this leads to a higher price per unit of energy, while high consumption consumers have an incentive to decrease consumption as this leads to a lower price per unit of energy.
- Same metering technology. Both the inverted block rate and the flat rate can use induction-type meters. This means that the energy supplier is not required to purchase new metering equipment and that existing meter-reading technology can still be used. The only change required by the energy supplier is in the billing software, as the data obtained from the meter (i.e., the record of the consumer's energy consumption during the billing period) remains unchanged.
- By introducing the inverted block rate structure, consumers with small energy consumption requirements would be paying less, while those with large energy consumption requirements would be paying more.

**High energy rates are often said to be a good thing because they encourage consumers to decrease consumption, is this true?**

It can be true. High energy rates will eventually discourage those on low- and fixed-income to decrease their energy consumption because they cannot afford the high cost. However, this is an extremely short-sighted and questionable approach to conducting energy policy because it shifts the conservation burden disproportionately onto those on low- and fixed-income. The energy efficiency of residential buildings must be improved before embarking upon draconian measures intended to decrease energy consumption.

**Why should an energy supplier such as NSPI be interested in the inverted block rate?**

Three reasons:

- The inverted block rate can be made revenue neutral, meaning that NSPI will not lose revenue by switching from the flat rate to the inverted block rate.
- The inverted block rate can be an important "tool" in NSPI's recently found interest in Demand Side Management, allowing it to generate price signals to encourage changes in consumption habits.
- The inverted block rate is a "fairer" rate structure, reflecting the consumption habits of consumers.

**Does the inverted block rate penalize high-demand, low-income consumers?**

It can, if the consumer's demand is such that it straddles several blocks and the per-unit charge exceeds the flat rate which it is designed to replace.

These consumers are often on low- or fixed-incomes, using electric heating, and living in poorly insulated buildings, and the monthly bill may be high with the inverted block rate than with the flat rate model. There are a number of ways in which these consumers can be assisted, including changing their rate class, addressing their energy consumption patterns, or improving their energy efficiency. One such solution is discussed below.

Energy suppliers that can afford to supply all consumers with interval timers that can record energy consumption (and possibly demand) should do so, as this will allow billing that is more cost reflective. Until then, consumers whose energy consumption is recorded by induction meters should be billed according to an inverted block rate model, as it can be cost reflective and encourage the efficient use of energy, something the existing flat rate structure cannot do.

**Should NSPI introduce a Fuel Adjustment Mechanism?**

The Fuel Adjustment Mechanism is a policy whereby energy suppliers can pass increasing fuel costs to their consumers without the need of regulatory hearings. Our research has shown that there are advantages and disadvantages associated with the Fuel Adjustment Mechanism[2]:

- It acts as "insurance" for energy suppliers against rising fuel prices as the supplier can shift the burden of increasing prices onto its customers.
- It lessens the regulatory lag, allowing the energy supplier to bypass the regulatory review board, without potentially costly and lengthy hearings before being able to implement new rates.
- The mechanism can encourage generation investment by private firms thereby leading to open markets (depending upon the jurisdiction).
- If the prices of fuel decrease, then customers can benefit from lower fuel prices earlier with use of the mechanism.

However, there a number of problems associated with the Fuel Adjustment Mechanism, including:

[2] The material on the Fuel Adjustment Mechanism was obtained by Ms. Mandeep Dhaliwal, a graduate student in the Energy Research Group.

- There is no incentive for the energy supplier to improve its fuel efficiency and management, as the supplier has no any incentive to seek cheaper fuel costs. It is easier to increase the rates rather than find ways of generating energy more efficiently.
- It does not contribute to long term energy stability.
- It might protect the energy supplier against long time revenue loss but it does not protect the energy dependent economy.
- There are no incentives for use of non-conventional technologies or the conservation of energy.
- The mechanism does not provide any incentive to energy supplier to protect the environment, especially if jurisdiction lacks legislation forcing the supplier to follow environmental guidelines.
- It may increase in the work of regulatory body as it will have to monitor the implementation of the mechanism.

Bundling all fuel costs into a single charge overlooks the fact that the cost of the energy generated depends upon when it was produced. For example, a kilowatt-hour of electricity produced at 3am will cost considerably less than a kilowatt-hour produced at 7pm – this is the same problem the Inverted Block Rate is attempting to address and time-of-use metering comes closer to addressing.

A more progressive Fuel Adjustment Mechanism strategy is to ensure that consumers are charged for the energy when they use it. That is, the price reflects the cost of the energy at the moment of use; a way this can be done is to use time-of-use meters to record consumption and to have meters recording the type and volumes of fuel(s) being used to generate the energy. With this information, accurate billing information can be generated.

Maritime Electric in Prince Edward Island uses a Fuel Adjustment Mechanism referred to as the Energy Cost Adjustment Mechanism, which was introduced April 2005. According to the regulations, Maritime Electric must approach the commission two months prior to the proposed rate change to allow time for review to take place.

**How should NSPI spend the $5 million it has proposed for DSM?**

There are probably many ways in which this can be done, such as installing time-of-use meters as discussed above, two of which are considered here: the first makes everyone feel good about NSPI and themselves, the second is more narrowly focused and helps a limited number of people.

The first approach is to offer free compact fluorescent lights (CFLs) to all 400,000 of NSPI's residential consumers. The following shows how this could be done and the potential benefits:

- NSPI has approximately 400,000 residential consumers; if the $5 million was distributed evenly amongst these consumers, it would come to about $12.50 per consumer.
- If NSPI entered into a contract with a CFL supplier and purchased three 27 W CFLs for $12.50, each residential consumer would be supplied with these bulbs. The 27 watt CFL has about the same number of lumens as does a 100 watt incandescent bulb. Electrical consumption before and after the introduction of these bulbs would be

(assume that a typical bulb is used three hours/day for 365 days/year, that is, 1,095 hours per year):

100 watt incandescent: 3 × 1,095 × 100 or 328.5 kWh

27 watt CFL: 3 × 1,095 × 27 or 88.7 kWh

For all 400,000 residential consumers, the total energy consumption would be:

100 watt incandescent: 328.5 kWh × 400,000 or 131.4 GWh

27 watt CFL: 88.7 kWh × 400,000 or 35.5 GWh

The reduction in energy generation required by NSPI is: 131.4 GWh – 35.5 GWh or 95.9 GWh.

- NSPI would reduce its residential generation by about 2.4 percent (95.9 ÷ 4,039 GWh). The cost to NSPI is about 0.005¢/kWh.
- The savings to the consumer is about 328.5 – 88.7 kWh × $0.10/kWh or about $24 per year.

The second approach is to upgrade the insulation standards of the neediest of NSPI's residential consumers who use electric heating:

- Assume that low- and fixed-income residential consumers use an average of 10,000 kWh per year for space heating. Assume as well that the average cost of an energy upgrade would be in the range of $1,000 and that the consumers could take advantage of NRCan's Energuide energy audit.

- At $1,000 per upgrade, NSPI could perform 5,000 upgrades ($5 million ÷ $1,000 per upgrade). These upgrades would be applied to NSPI's neediest residential consumers (about 1.2 percent of NSPI's residential consumer base).
- The total energy consumption by these consumers would be 5,000 × 10,000 kWh or 50 GWh. The benefits from the energy upgrade will vary; the following table shows the effect of 20, 25, and 30 percent energy reductions:

| Percent reduction | NSPI generation reduction (50 GWh × reduction) | Number of kWh saved by consumer | Savings to consumer per year (10¢/kWh) |
|---|---|---|---|
| 20% | 10 GWh | 2,000 kWh | $200 |
| 25% | 12.5 GWh | 2,500 kWh | $250 |
| 30% | 15 GWh | 3,000 kWh | $300 |

- The decrease in energy demand is small in terms of NSPI's overall generation; however, the potential savings to the consumers are significant, in these examples, ranging from $200 to $300 per year.
- The number of residential consumers benefiting from such a programme could increase even further, given the fact that the provincial government is now offering to contribute $1,000 to home energy upgrades.

In light of the above, NSPI should consider devoting at least part of its proposed $5 million for DSM projects to upgrading the neediest of its residential consumers.

**Does this conclude your testimony?**

Yes.