Compensating Customer-Generators: A taxonomy describing methods of compensating customer-generators for electricity supplied to the grid

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Abstract:

The increasing popularity of on-site power generation is driving the demand for methods to compensate customer-generators that supply electricity to the grid. Although many practices exist for providing such compensation, confusion surrounds the terms often used to describe such practices (notably, net metering and net billing). To help clarify this situation, the following paper proposes a taxonomy that distinguishes between sixteen distinct compensation practices.

Keywords: Customer-generator, Net metering, Net billing, feed-in tariffs, compensation, small power producer.

1. Introduction

A growing number of homeowners, small businesses, and small factory managers are investing in on-site electricity generation to partially or wholly displace their electricity demands (loads) (IEA, 2003; Lovins, 2003). This trend can be attributed to factors such as the economic attractiveness of on-site power generation and an increased sense of independence from utilities and energy imports. In the case of renewable systems and co-generation investments, reasons include a wish to gain experience with renewables in anticipation of their increased market penetration and a desire to generate electricity in ways less damaging to the environment. (Henderson, 2003).

For many technologies, investment in grid-connected generation capacity is growing at a faster rate than off-grid applications (IEA, 2003, Dunn, 2000). A typical grid-

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connected home or business will meet on-site loads using a combination of customer-generated electricity and electricity from the grid (such home or business owners are often referred to as ‘customer-generators’). The grid is essentially treated as a battery, meeting all or part of the load whenever the customer-generator’s system is unable to do so.

Since customer-generators purchase electricity from the grid at some times and supply electricity to the grid at others, traditional methods of calculating the amount owed to the electrical utility can become problematic. Many different technical and accounting strategies have been suggested for keeping track of how much a customer owes (or is owed). Some of these strategies are more attractive than others from the perspective of either the customer-generator or the utility. The fact that the same term is often used to describe more than one strategy can create confusion when the merits of the various approaches are discussed. Consider, for example, ‘net metering’, a term often applied to the practice of compensating customer-generators for the electricity they supply to the grid:

- A recent study of Canadian utilities, utility review boards, and provincial governments showed that there is no consensus and very little consistency as to the definition of the term ‘net metering’ (Bell, 2003).
- A literature review found twenty-two distinct definitions for the term ‘net metering’. For example, according to Payne (2000) all electricity must be paid the retail rate in order for a policy to constitute net metering. While Watt (1998) and Howell (2003), specify that a requirement for a utility to buy excess power from a system owner is incompatible with what is understood by the term net metering.
- The United States’ National Energy Policy Development Group (2001) specifies that a net metering policy must allow the customer-generator to carry any excess generation from one billing period to the next in the form of a credit. This diverges from Peterson’s definition (1999) that implies that banking power from month to month is not necessary in order for a policy to be considered net metering.

There are a number of reasons why it is important to eliminate the confusion surrounding the practice of compensating customer-generators. Perhaps the most important being that it allows policy makers or advocates from different jurisdictions to know how a practice they have adopted, or are considering adopting, compares with a practice in neighbouring jurisdictions.

If a utility allows customer-generators to connect to its grid, policies and guidelines must be established for both technical standards and compensation for excess generation. Questions that must be asked when considering compensation include:

- To what extent should a customer-generator be compensated?
- What form should the compensation take?
- What is fair for the producer, other ratepayers, and the utility itself?

Not surprisingly, different utilities and jurisdictions have come up with widely differing responses to these questions. Without a common nomenclature describing how compensation can take place, it is difficult for diverse stakeholders effectively to learn from the experiences of their neighbours. Similarly, only after all stakeholders have a common understanding of the terms can any productive debate occur, given that some compensation methods are more attractive than others from the perspective of either the customer-generator or the utility.

To date, there has been no systematic attempt to classify the various methods of compensating customer-generators. This paper presents a systematic enumeration of some of the more common compensation methods and proposes a taxonomy that can clarify which approach is ideal for a given situation (for example, jurisdiction, system scale, and goals).

2. Background

Electricity can be generated by utilities and non-utility generators; there are two distinct classes of non-utility generators: independent power producers (or IPPs) and customer-generators. IPPs are primarily in the business of electrical generation, often making long-term agreements with utilities or other customers for the sale and purchase of electricity. On the other hand, customer-generators are customers who own generation facilities that can meet a portion of their load: when the load exceeds generation, the customer-generator purchases electricity from the grid, and when the generation exceeds the load, the customer-generator can supply electricity to the grid. Although the customer-generator may have an agreement with the local utility to supply electricity, the customer-generator is not considered an IPP since any excess electricity is not generated for profit.

2.1 Metering

Before a utility can compensate a customer-generator, the amount of electricity consumed or generated must be measured using a meter. A meter measures electrical flow (usually in kWh).

There are many different types of meter on the market, including unidirectional and bi-directional electromechanical meters, as well as digital pulse meters. Some newer, more sophisticated, digital meters are capable of tracking multiple accounts simultaneously (for example, keeping track of incoming electricity in one account or ‘register’ and outgoing electricity in another) (MC, 2004). Electro-mechanical meters can be ratcheted (i.e., they are physically capable of rotating in a single direction only, although the electricity can flow in both directions) or unratcheted (capable of moving both forwards and backwards). Regardless of the type of meter, electro-mechanical meters are capable of tracking a single account or register only (MC, 2004).

2.2 Compensation

At the end of each billing period, the customer-generator’s meter (or meters) are read by the utility and will indicate whether the customer-generator is a net consumer or producer of electricity. If the customer-generator has generated excess electricity during this period, the utility can ignore the excess (i.e., the customer-generator is not compensated) or offer compensation for the excess.

When the excess is ignored by the utility, it is necessary to ensure that the excess is not credited to the customer-generator. On the other hand, compensation can take one of two forms. First, the utility can ‘buy-back’ the excess, paying the customer-generator for the number of kilowatt-hours generated. Second, the utility can allow ‘banking’, whereby the excess kilowatt-hours are credited to the customer and rolled in the next billing period.

A ‘banking period’ consists of a finite number of billing periods. At the end of the banking period, the utility can treat any excess generation the same way the excess is treated at the end of a billing period: ignored or compensated. Since no further rolling credits are possible, any compensation must be monetary (i.e., buy-back).

Broadly speaking, there are four possible buy-back categories:

None: Any excess kilowatt-hours are granted to the utility and the customer-generator receives no compensation.

Below retail: A rate that is less than what the customer pays for electricity from the utility (for example, ‘avoided cost’, ‘wholesale cost’, or ‘marginal cost’).

Retail: The rate that the customer is charged for electricity from the utility.

Premium: A rate that is higher than what the customer pays for electricity from the utility. Premium prices have typically been offered in attempt to promote specific renewable electricity generating technologies. Such price incentives are often adopted by governments or regulating bodies in the hopes of helping a particular industry develop, such as wind turbine or PV cell manufacturing (Cerveny, 1998; Goldstein, 1999; Sijm, 2002)

2.3 Coincident vs. Non-coincident generation

During a billing period, a customer-generator consumes electricity from the grid to meet load requirements and generates electricity to meet the load or supply to the grid. The generation of electricity by the customer-generator is either coincident with the load (meeting all or part of the load) or non-coincident (being supplied to the grid). When using a single meter, whether or not the generation is coincident has no effect on the final bill.

For example, assume that during a given billing period, the customer-generator has a load of 100 kWh and a generator that generates 100 kWh. If the generator runs intermittently during the billing period, one of three things can happen:

- The load can be coincident with the generation, meaning that there is no demand from the grid. Since the entire load was met by on-site generation, the end-of-billing-period reading is zero.
- The load can be non-coincident with the generation, meaning that the entire load is met by the grid (i.e., all generation occurs when there is no load). However, since the generation still takes place, the end-of-billing-period reading is zero.
- The load can be partially coincident with the generation, meaning that the load is met by both on-site generation and the grid. If the on-site generation meets X kWh, then the grid must meet the remaining demand, or (100 - X) kWh. Since the generator generates 100 kWh during the billing-period and the amount required to meet the load is X kWh, the remainder not required to meet the load (i.e., the excess) is (100 - X) kWh, or the same amount drawn from the grid to meet the load.

  The fact that the grid supplied (100 - X) kWh and the excess generation was (100 - X) kWh means that meter value at the end-of-billing-period reads zero, the difference between what was supplied and what was produced.

Seasonal or other variations can be applied to the above observations. For example, if the on-site generator produces only 80 kWh for a billing period, the customer will be charged for 20 kWh, since the load (100 kWh) must be met, whether generation is coincident or not.

On the other hand, if the generator produces 120 kWh for a billing period, the customer will be credited with 20 kWh. How the customer-generator is credited depends upon the utility (see Section 2.2).

3. Net Metering

In net metering, a single, bi-directional meter (i.e., one register) is used to record the customer-generator's electricity consumption at the start and end of the billing period. When the customer-generator's generation exceeds the demand, the meter "runs backwards", supplying electricity to the grid. The difference between these two values indicates whether the customer-generator:

- consumed more electricity than generated (the end value is greater than the start value), or
- generated more electricity than consumed (the end value is less than the start value).

By using a single register, it is impossible to determine how much electricity was generated and how much was consumed during the billing period. For example, a final bill of 10 kWh may hide the fact that 100 kWh were generated by the customer-generator and 110 kWh were consumed. Similarly, a register value of zero means that the amount consumed was equal to the amount generated (in the most extreme case, the customer-generator neither consumed nor generated electricity).

Since a single register is being used, all electricity generated, up to the amount consumed, is valued at the customer-generator's retail rate. Whether the excess can be banked and how it is valued, depends upon agreements between the utility and the customer-generator.

The remainder of this section describes different approaches to net metering.

3.1 Simple Net Metering

In simple net metering, the customer-generator uses a single, bi-directional meter to record the amount of electricity banked. The banking period associated with simple net metering is confined to one billing period. At the end of the billing period, the customer-generator either:

- Generated less electricity than the load. In this case, the customer-generator must pay the utility for the electricity used (the difference between the register at the start of the billing period and the end of the billing period).
- Generated more electricity than the load. In this case, the customer-generator owes nothing to the utility and is paid nothing for the excess electricity generated. The end-of-billing-period meter reading is the value used at the start of the next billing period.

Simple net metering is merely a way to transfer the ownership of electricity that has been fed into the grid back to the customer-generator. It "constitutes an offset or exchange of electricity during the billing period rather than a purchase or sale of electricity" (Starrs, 1998). With simple net metering, no money actually changes hands, only kilowatt-hours.

3.2 Net metering with buy-back

An extension of simple net metering is net metering with buy-back, in which the utility pays the customer-generator for any excess electricity generated during the billing period. The excess electricity can be valued at below retail rate, retail rate, or above retail rate (i.e., a premium rate).

If the excess electricity has a below retail rate of zero, "net metering with below retail buy-back" is the same as "simple net metering".

3.3 Net metering with rolling credit

Net metering with rolling credit is an extension of simple net metering whereby the banking period extends over more than one billing period. Excess electricity generated in one billing period is used as a credit to reduce the charges in a subsequent billing period. As with simple net metering, the customer-generator gains retail value for any electricity generated.

At the end of each billing period, the amount owed by the customer-generator is determined by taking the difference of the register values from the start and end of the billing period. Credits from previous billing periods are applied to this difference.

The banking period extends over a number of billing periods, requiring the utility to maintain the credit value as well as the register value from the start of the billing period. When the banking period ends, the credits revert to zero and the customer-generator receives no compensation.

3.4 Net metering with rolling credit and buy-back

By combining net metering with rolling credit and net metering with buy-back, the customer-generator obtains a monetary credit for any excess electricity at the end of the banking period. In this scheme, the banking period is greater than one billing period.

Rolling credit allows the customer-generator to receive retail credit for all electricity generated up to the last billing period within the banking period. That is, any excess in one billing period is applied to consumption in the next. At the end of the banking period, the customer-generator is paid for any excess electricity generated.

As with other buy-back schemes, the customer-generator's excess can be paid at below retail rate, retail rate, or above retail rate. The customer-generator pays retail rate for any electricity consumed in a billing period.

4. Net Billing

In net billing, two registers are used to record the amount of electricity consumed and generated by a customer-generator within a billing period. Net billing allows the utility to charge the customer-generator for all electricity consumed and the customer-generator to obtain payment for all electricity generated.

The remainder of this section describes different approaches to net billing.

4.1 Net billing with buy-back

A net billing scheme in which customer-generators are not permitted to bank any excess electricity between billing periods is referred to as net billing with buy-back (that is, the banking period is the length of a single billing period). At the end of each billing period, the customer-generator pays the utility for any electricity consumed.

The utility purchases electricity from the customer-generated using a buy-back scheme.

As with other buy-back schemes, there are three possible price categories:

Below retail. The customer-generator is paid below retail price for all generation and pays the retail price for all electricity consumed. This method is widely used in the United States (Starrs, 1996; DSIRE, 2003).

Retail. All electricity (i.e., both consumed and generated) is valued at the customer-generator's retail rate; any excess is paid at the retail rate. (This is equivalent to a net metering programme with retail buy-back, described in section 3.2, above).

Premium. The utility pays the customer-generator a premium price for all excess generation (although the customer-generator only pays the retail rate for electricity consumed).

4.2 Net billing with rolling credit

Net billing with rolling credit allows customer-generators gain a rolling credit for any excess electricity generated. This credit can be used to offset charges in the next billing period. This scheme is functionally equivalent to net metering with rolling credit (section 3.3), except that two registers, rather than one, are employed to track and account for the electricity consumed and generated. Using two registers requires the utility to combine consumption and generation data in order to determine the amount of credit obtained.

At the end of the banking period, the customer-generator receives no compensation for any excess credits, as they are rolled into the next banking period.

4.3 Net billing with rolling credit and buy-back

If a utility allows the banking of excess electricity between billing periods and purchases any excess credits at the end of the banking period, the scheme is described as net billing with rolling credit and buy-back. As with any buy-back scheme, the three price categories are below-retail, retail, and premium.

5. The Taxonomy

The previous two sections described a set of different compensation arrangements. These arrangements can be brought together to form a taxonomy, based upon the following criteria, which are common to all of the arrangements:

Number of Registers: Does the arrangement specify the use of one or two registers?

Buy-back Policy: Will the utility purchase electricity supplied to the grid?

Banking Policy: Can excess electricity be banked from one billing period to the next (i.e., as a rolling credit)?

Buy-back Rate: If payment is offered, is the amount below retail, retail, or premium?

Table 1 is a tabular representation of the different compensation arrangements that are possible using the above criteria. By searching the table using the above characteristics, one can obtain the type of compensation arrangement. Alternatively, one can take the name of the arrangement and determine the characteristics associated with it.

Another way of interpreting the criteria to determine the compensation arrangement is to use a flowchart, with the criteria as the decision points. Figure 1 shows such a flowchart: to determine the name of a policy, start at the top and answer each question until a termination point with the recommended name is reached.

5.1 Examples

As mentioned in the Introduction, many utilities have some form of compensation arrangement with customer-generators. Table 2 is a list of utilities (principally from North America) that support compensation arrangements. Most of the utilities listed support, at a minimum, some form of buy-back policy.

5.2 Applications

There are a number of possible applications of the taxonomy, including:

Policy creation. The taxonomy can be employed as a tool for drafting a compensation policy or making changes to an existing policy. This allows policymakers to ask appropriate questions both in terms of the goal of the plan, the implications any choice would have in terms of administrative repercussions, and the fairness to all stakeholders involved.

Customer understanding. Utility customers can determine what, if any, compensation policy is used in their jurisdiction.

Meeting societal goals. The taxonomy can be used as a tool for utilities, consumer groups or environmental groups for advocating a policy that best meets a community's goals.

6. Summary

The on-site production of electricity is becoming more commonplace as the cost of renewable generation equipment falls. Some of these on-site producers (or customer-generators) remain connected to the grid to meet their load requirements when the renewable generation equipment is unable to do so. Conversely, when the customer-generator's generation exceeds the load, many utilities allow the electricity to be supplied to the grid. The compensation associated with the generation depends upon four factors:

- Number of registers. A register records the amount of electricity consumed or generated by a customer-generator. A single register simply indicates the net consumption, giving no indication as to how much electricity was either generated or consumed. Two registers allow for the recording of the electricity consumed and generated.
- Buy-back policy. A customer-generator with a single register may have produced more electricity than consumed during a single billing period; the utility has a choice in that it may (or may not) decide to pay the customer-generator for this electricity. When a customer-generator has two registers, the utility can purchase all the electricity generated or only the excess (that is, the difference between the two registers).
- Banking. A banking policy specifies whether any excess electricity can be 'banked' and used to offset future electrical consumption.

- Buy-back rate. The buy-back rate is the value assigned to the electricity purchased by the utility from the customer-generator and can be one of below retail, retail, or premium. When a single register is used, the customer-generator obtains the retail value of the electricity up to the point of excess generation.

A taxonomy describing different compensation policies for consumer-generators, based upon the above four factors, has been presented in this paper. By enumerating the number of registers, the buy-back policy, the banking policy, and the buy-back rate, it is possible to distinguish sixteen different compensation methods. These methods appear to cover the majority of compensation agreements used by North American utilities.

The taxonomy defined ‘net metering’ as any single-register or two-register compensation arrangement that simply netted the different between the two registers in the latter case. In these cases, customer-generators could only receive compensation if they generated excess electricity.

A ‘net billing’ compensation arrangement requires the use of two registers. The customer-generator can be compensated for all electricity generated.

Banking electricity from one billing period to another can be support by both net metering and net billing. Similarly, the buy-back rate can be applied to either net metering or net billing.

With a single register, a customer-generator’s electricity can be *valued* at two rates: retail for electricity displaced and below retail or premium for excess. However, since a single register only records the net consumption, only one price can actually be paid by the utility. With two registers, the utility can pay two different rates. For example, the utility could pay one price for the base-amount and another for the excess amount. Alternatively, the utility could purchase up to the excess only, the excess only, but not the total amount. These combinations are not supported by the taxonomy although they could be added with little difficulty.

The taxonomy is intended for a wide audience, including policy makers, consumers, and utilities. One clear advantage of the taxonomy is that it allows the comparison of different compensation arrangements.

A factor omitted from the taxonomy is the possibility of time-of-use or real-time pricing in combination with any of the types of compensation arrangements outlined above. As electricity markets and metering technologies evolve, it is likely these possibilities may increase in importance -- the manner in which they affect the function of compensation policies will be explored in a future paper.

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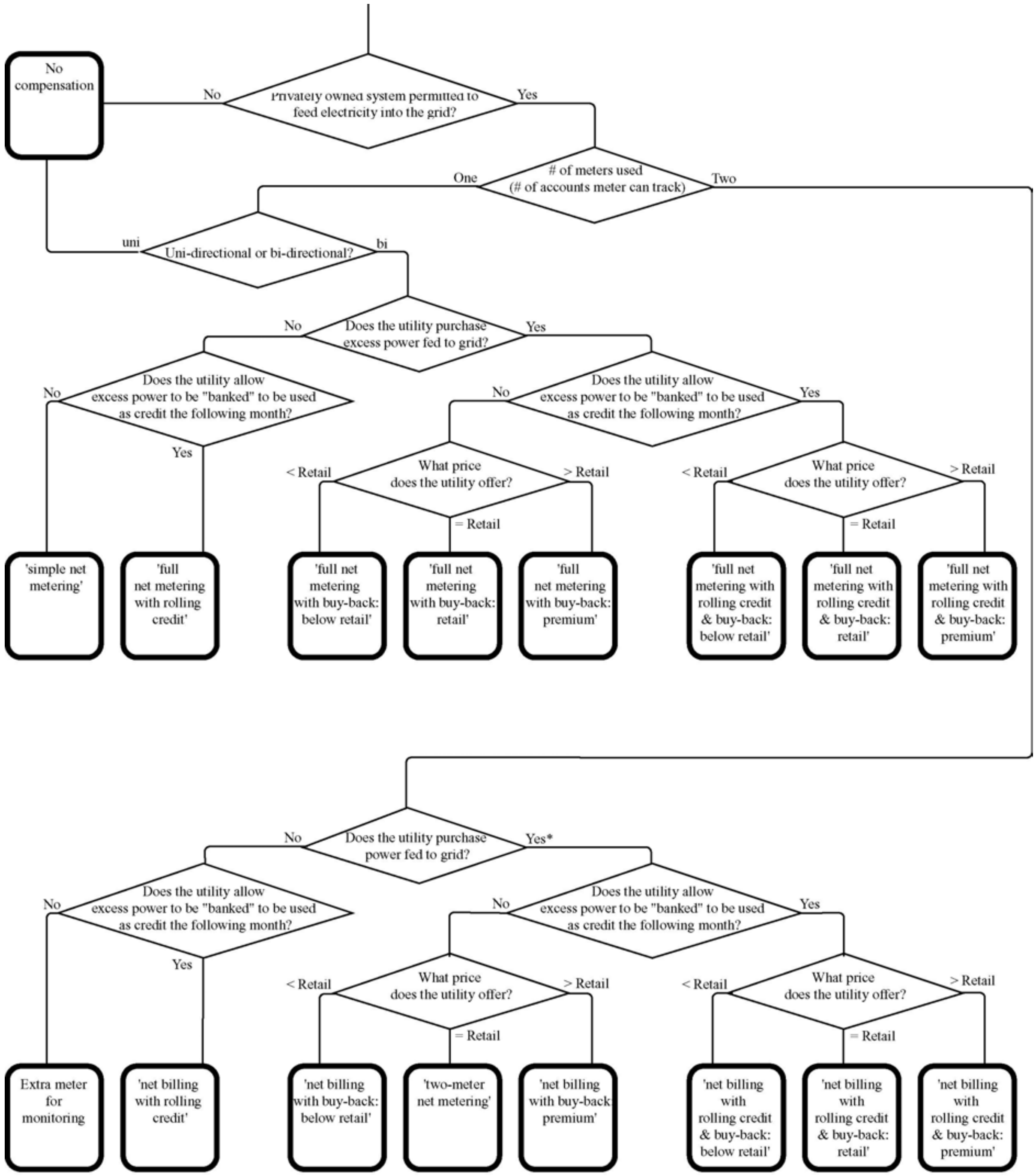

* The utility may purchase all or part of the electricity fed to the grid, and even if all the power is purchased, the base amount and the excess power may earn different rates. This matrix assumes that, if any power is purchased, all of the power is purchased and purchased at the same rate.

Figure 1: Flowchart for compensation arrangements

Table 1: Comparison of Compensation Arrangement Definitions

Compensation Arrangement	Definition Characteristics			
	Meters	Banking	Buy-back	Price
Net Metering (general)	1	N/A	N/A	N/A
Simple net metering	1	No	No	N/A
Net metering with buy-back (general)	1	N/A	Yes	N/A
Net metering with below retail buy-back	1	No	Yes	Below
Net metering with retail buy-back	1	No	Yes	Retail
Net metering with premium buy-back	1	No	Yes	Premium
Net metering with rolling credit (general)	1	Yes	N/A	N/A
Net metering with rolling credit, below retail buy-back	1	Yes	Yes	Below
Net metering with rolling credit and retail buy-back	1	Yes	Yes	Retail
Net metering with rolling credit and premium buy-back	1	Yes	Yes	Premium
Net billing (general)	2	No	N/A	N/A
Net billing with below retail buy-back	2	No	Yes	Below
Net billing with retail buy-back (Two-meter net metering)	2	No	Yes	Retail
Net billing with premium buy-back	2	No	Yes	Premium
Net billing with rolling credit	2	Yes	No	N/A
Net billing with rolling credit and below retail buy-back	2	Yes	Yes	Below
Net billing with rolling credit and retail buy-back	2	Yes	Yes	Retail
Net billing with rolling credit and premium buy-back	2	Yes	Yes	Premium

Table 2: Examples of Compensation Arrangements

Unless otherwise indicated, all Canadian examples are based on surveys from (Bell, 2003). Examples from the United States are taken from (DSIRE, 2004); when a state is mentioned, it means that the compensation practice applies to the entire state.

Compensation Arrangement	Examples
Simple net metering	Newfoundland and Labrador Hydro, Arkansas
Net metering with rolling credit	Toronto Hydro, LG&E Kentucky (unlimited carry forward)
Net metering with below retail buy-back	New Brunswick Power (option one), Massachusetts
Net metering with retail buy-back	Ottawa Hydro, Wisconsin, Minnesota, Ashland Oregon, California and Connecticut (in combination with real-time pricing)
Net metering with premium buy-back	Colorado, Aspen Electric (Sun Power Pioneers program), Italy (IEA, 1997)
Net metering with rolling credit and below retail buy-back	Yukon Electrical, Avista Utilities (Idaho), New Jersey
Net metering with rolling credit and retail buy-back	Waterloo North
Net billing with rolling credit	Nova Scotia Power
Net billing and below retail buy-back	Maritime Electric, Sask Power
Net billing and retail buy-back	Georgia
Net billing and premium buy-back	Tennessee Valley Authority, Sun Power Pioneers (Aspen Municipal Electric), Energy Cooperative (ECAP), Italy (IEA, 1997)