The economics of net metering

Larry Hughes
Energy Research Group
Department of Electrical and Computer Engineering
Dalhousie University
Halifax, Nova Scotia, Canada, B3J 2T3

Abstract

With declining equipment costs, reliability issues, and rising environmental awareness, a growing number of individuals and businesses are opting to produce their own electricity from grid-connected generation facilities. In jurisdictions that permit net metering, the owners of these facilities (the customer-generators) can supply electricity to the grid and bank their 'excess' electricity (when generation exceeds consumption) for times when consumption exceeds generation. This paper considers the economics of net metering and the impact of financial compensation on the selection of generation equipment from the perspective of the customer-generator.

1. Introduction

Over the past decade, there has been a growing trend of individuals and businesses installing their own grid-connected, on-site electrical generation facilities (IEA, 2003; Lovins, 2003). The reasons for this trend are varied and include (Bell, 2003; Dunn, 2000; Starrs, 1996):

- Declining prices of generation equipment
- The need for reliable power sources
- Environmental concerns over the way electricity is generated
- Potentially lower electricity costs

By interconnecting to the local grid, owners of facilities that generate electricity intermittently (typically renewables such as wind and solar) need not be concerned with storage, as they can turn to the grid when their facilities are not generating.

In some jurisdictions, energy suppliers[1] are required by law to accept any electricity generated by a customer-generator (that is, the owner of a grid-connected facility) (Bell, 2003). There are two broad categories of grid-connection, defined by the number of registers employed to record the flow of electricity (Hughes, 2005):

Net metering, consisting of one register that records the customer's net consumption of electricity over a billing period. The register records both the flow of electricity from the grid to the customer's site and the flow from the customer's site to the grid. At the end of the billing period, the customer has been either a net consumer or a net generator of electricity.

Net billing, consisting of two registers, one for recording the customer's consumption (i.e., the import of electricity from the grid) and the other for recording the generation (i.e., the export of electricity to the grid). At the end of the billing period, the customer-generator's consumption and generation are known.

Whether an energy supplier purchases electricity from a customer-generator and the amount paid can also depend upon the jurisdiction. In a net metering environment, the customer-generator receives the equivalent of retail rate for any electricity generated up to the amount consumed during the billing period; thereafter, the energy supplier has the option of purchasing the excess generation. The same does not hold true with net billing, since there are two registers; the register recording the generation allows the customer-generator to receive credit for all electricity produced.

Net metering has the advantage over net billing in that it is easier to implement and requires a single, bi-directional meter. For example, in those North American jurisdictions where grid-interconnection is permitted, most energy suppliers support net metering rather than net billing (Bell, 2003; DSIRE, 2005). With this in mind, this paper examines the economics a customer-generator must consider when operating in a net metering environment.

[1] For the purposes of this paper, an 'energy supplier' is a company (such as a vertically-integrated utility) or group of companies (such as generators and network operators) that supply electricity to a customer.

2. Net metering

In most net metering implementations, a single, bi-directional meter (i.e., one register) is used to record the customer-generator's electricity usage at the start and end of the billing period. During a billing period, a customer-generator consumes electricity from the grid to meet load requirements (causing the register to increase in value) and generates electricity to meet the load or supply to the grid (causing the register to decrease in value). At the end of the billing period, the difference between the register's starting and ending values determines whether the customer-generator (Hughes, 2005):

- Consumed more electricity than generated (the end value is greater than the start value).
- Generated more electricity than consumed (the end value is less than the start value); this is referred to as excess generation.

Most net metering programmes allow customer-generators to bank any excess generation from one billing period to another. For customer-generators with intermittent renewable generation facilities, this allows periods of excess generation to offset periods of excess consumption. For example, if a customer-generator has a wind turbine that produces more electricity than is needed in the winter, these 'excess' kilowatt-hours can be banked and used during the summer when there might be less wind.

Depending upon the jurisdiction and energy supplier, the customer-generator may be compensated financially for any excess generation, typically after a set number of billing periods (for example, spanning one year). The purchasing of the excess electricity is referred to as 'buy-back', of which there are three possible rates: below retail, retail, and above retail (or premium) (Hughes, 2005).

3. Economic considerations

In a net metering environment, it is the value of the register at the end of a billing period, along with any banked kilowatt-hours, that determines the amount owed by the customer-generator to the energy supplier. Clearly, the more electricity generated (or the less consumed) by a customer-generator means the less owed to the energy supplier.

When designing a net metering system, it is necessary for the customer-generator to know what financial savings, if any, are to be expected from the chosen equipment. For the purposes of this paper, the financial savings are determined from the avoided costs and the equipment costs.

3.1. Avoided cost

Over the lifetime of the customer-generator's net metering facilities, the difference between what the customer-generator would have paid the energy supplier without the generation equipment and what is paid with the equipment, is the avoided cost.

A project's avoided cost, A ($), is the product of the annual electrical generation, G (kWh), the cost of electricity, E ($/kWh), and the lifetime of the equipment, l (in years):

$$A = G \times E \times l$$

The value of G is determined by the customer-generator; its value can be less than or equal to the customer-generator's maximum annual consumption. However, G cannot exceed the maximum annual consumption. If the value of G is less than the maximum annual consumption, the customer-generator must pay for consumption that is not met by on-site generation.

3.2. Equipment

Obtaining equipment to meet the customer-generator's objectives is a two step process: first, the customer-generator must select the type of equipment required to meet the expected annual generation (discussed in the previous section). Second, the customer-generator must arrange for financing the equipment.

3.2.1 Selecting the equipment

Regardless of the type of equipment selected by the customer-generator, the equipment must be sized to meet the expected annual generation, G (kWh). This is done by determining the equipment's annual capacity factor, c_f, the percentage of time throughout a year the equipment is expected to be operating at full capacity; for renewables, this is both site and technology dependent. The capacity, C, (kW) of the equipment is obtained as follows:

$$C = \frac{G}{c_f \times 8760}$$

3.2.2 Financing the equipment

With the equipment's capacity known, it is possible to determine the cost of the equipment, P, by multiplying the capacity by the unit cost, U ($/kW):

$$P = C \times U$$

The total repayment, K ($), is obtained by amortizing the cost of the equipment, P, over the term, n (years), at a given interest rate, i (if the operating and maintenance costs are not part of the cost of equipment, P, then they must be included separately as the lifetime operating and maintenance costs, M):

$$K = P \times \frac{i}{1-(1+i)^{-n}} + M \times l$$

The equipment lifetime, l, can be longer than the term, n; ideally, it should not be shorter.

3.3. Discussion

Broadly speaking, the customer-generator's choices are limited to selecting the annual generation, the project's lifetime, and the type of equipment (although even these may be subject to restrictions imposed by the energy supplier). Other factors, notably the cost of electricity, the capacity factor, the unit cost of the equipment, interest rates, and the term, are, for the most part, beyond the control of the customer-generator.

The customer-generator can determine the financial viability of the project by comparing the avoided cost and the total repayment for the proposed system. If the avoided cost is greater than the total repayments, the project is financially viable, with or without buy-back; however, if the avoided cost is less than the total repayments, the project will require some level of buy-back to achieve financial viability.

As an example, consider a customer-generator who wants a net metering system based upon the data shown in Table 1 that will generate 5,000 kWh/y. The calculations for the system are presented in Table 2; since the avoided cost of $6,750 is greater than the total repayment of $5,280, the project is financially viable, regardless of whether buy-back is available.

By performing these calculations on a number of possible values for annual generation, the potential viability of different projects can be obtained. Figure 1 shows the results of calculations for 20 different annual generation values (from 1,000 kWh/y to 20,000 kWh/y). Line ABC (solid) is the avoided cost. Customer-generator consumption is greater than generation on line AB, at point B, generation equals consumption, and along line BC, generation exceeds consumption. Line BC has the maximum possible avoided cost of $13,500; this value is constant because the avoided cost is limited by the maximum annual consumption (10,000 kWh).

Line DE (dashed) is the total repayments. While line DE is below line ABC, the project is financially viable; however, where line DE crosses line BC, the project will be financially viable only with certain levels of buy-back.

The total repayments need not always be a straight line; if the unit cost changes as the equipment's capacity increases, the line can assume a saw tooth shape. For example, Table 3 lists the costs per unit for given capacities of a certain type of equipment selected by a customer-generator. Figure 2, based upon the data from Table 1, shows the effect of the variable unit costs on the total repayments for the different annual generation values; the unit costs change at positions P ($2,250/kW), Q ($2,000/kW), and R ($1,750/kW). The declining unit cost improves the financial viability of the project.

4. The effect of buy-back

Buy-back is the energy supplier's purchase of any excess generation at the end of a number of billing cycles. This section considers the economic consequences of net metering and buy-back on the consumer-generator.

4.1. Net metering without buy-back

When an energy supplier supports net metering without buy-back, the customer-generator receives no financial compensation for any excess electricity generated. In this situation, there is clearly no incentive or advantage for the customer-generator to generate more electricity than is consumed. In other words, the total repayment, K, must be less than the avoided cost, A.

If K exceeds A, the customer-generator is supplying electricity to the energy supplier without compensation. When the difference between K and A becomes negative, the total repayments exceed the avoided cost, meaning that the customer-generator is subsidizing the electricity supplied to the energy supplier, making the project financially unviable.

In short, over the lifetime of a project, the project will result in either savings ($A > K$) or losses ($A < K$) to the customer-generator. The lifetime savings and losses of the project presented in Figure 1 are shown in Figure 3. The difference between the avoided cost (dotted line) and the total repayment (dashed line) is the lifetime savings and losses (solid line).

While the lifetime savings are positive, the customer-generator is not losing financially, as these are the savings obtained by installing the generating equipment. However, when the lifetime savings become negative, the customer-generator is subsidizing the electricity supplied to the energy supplier.

4.2. Net metering with buy-back

When an energy supplier has a net metering programme with buy-back, customer-generators can receive financial credit for any excess generation at the end of an agreed-upon number of billing periods. Although the compensation is the product of the buy-back rate and the excess generation, it does not represent the actual revenue of the project, as it is necessary to take the lifetime losses, if any, into account.

Project losses occur when the avoided cost is less than the total repayment. Since these losses represent an expense that the customer-generator should recoup, there are two ways to determine the lifetime revenues of the project when buy-back is supported:

$$R = \begin{array}{cc} BB \times E & \text{when } A > K \\ BB \times E - (K - A) & \text{when } A < K \end{array}$$

where R is the lifetime revenue (\$), BB is the buy-back rate (\$/kWh), and E is the excess generation (kWh). When the avoided cost, A, is greater than the total repayment, K, the difference between *A* and *K* is not included in the calculation as this simply represents a savings, not income, to the customer-generator.

Figure 4 shows the lifetime revenue associated with the net metering project presented in Figure 1; the buy-back rate is the retail rate (0.090 $/kWh). The revenues (solid line) is the compensation (dashed line, the product of the buy-back rate and the excess generation) until the lifetime savings (dotted line) become negative; at this point, the difference between the savings and compensation must be taken into account, hence the leveling off of the revenue.

Net metering with buy-back does not necessarily mean that the revenue obtained from a project will make the project financially viable. If the lifetime savings exceed that compensation, the customer-generator is supplying electricity at a loss to the energy supplier (even though compensation is taking place). This is illustrated in Figure 5, where three different buy-back rates, shown in Table 4, are applied to the project presented in Figure 1. The retail buy-back rate (0.090 $/kWh) and the premium buy-back rate (0.135 $/kWh or 150% of the retail rate) result in lifetime compensations that exceed the lifetime losses; however, the lifetime compensation from the below-retail buy-back rate (0.045 $/kWh or 50% of the retail rate) does not.

5. Summary

Advances in generation technology, with concomitant declines in cost, offers individuals and businesses the opportunity to install their own generating equipment to meet on-site demand. In some jurisdictions, this technology can be interconnected to the local grid, allowing the individual or business to become a customer-generator, consuming electricity from, or supplying electricity to, the grid.

Since the customer-generator's facilities may still depend upon the energy supplier for electricity, the energy supplier continues to meter the customer-generator's electrical consumption. However, since the customer-generator can also supply excess electricity to the grid, the meter is allowed to 'run backwards'; meaning that at the end of a billing period, the meter's register indicates net consumption or net generation. This single-register model is referred to as net metering. Depending upon how the energy supplier implements its net metering programme, the customer-generator can bank any excess electricity from one billing period to the next, and, at the end of a given number of billing periods, can receive financial compensation for any excess.

Before entering into a net metering agreement with an energy supplier, the potential customer-generator must determine if the project is economically sound and will be financially viable. This paper has shown that, at a minimum, the customer generator must determine the project's avoided cost and the total repayments associated with the proposed equipment.

The avoided cost is obtained from the proposed annual electrical generation, the cost of electricity, and the lifetime of the project. The total repayments depend upon the proposed annual generation, the equipment (i.e., the site's capacity factor and the unit cost), and the financing of the equipment (i.e., the cost of the equipment, the interest rate, the term, and any lifetime maintenance costs). Varying any of these parameters can determine whether the project succeeds or fails.

A net metering project is financially viable if the avoided cost is greater than the total repayments, since the customer-generator's expenses on the project are less than what the customer-generator would have had to pay the energy supplier.

When the avoided cost is less than the total repayments, it is necessary to take other factors into consideration. If the difference between the avoided cost and the total repayments is positive, the project is still viable; however, when this value is negative, the project's viability depends upon whether the energy supplier supports buy-back.

There are three levels of compensation that an energy supplier can offer for a customer-generator's excess generation: below retail, retail, and premium. The compensation is the product of compensation rate and the total excess generation. When the difference between the avoided generation and the total repayments is negative, it is necessary to include this value with the compensation, to obtain the lifetime revenue of the project. In some cases, the availability of compensation from buy-back is not sufficient to cover the losses incurred from the total repayments.

Net metering, like most other endeavors, is associated with certain costs. The calculations described in this paper allow potential customer-generators to be aware of them and make the necessary decisions.

A spreadsheet handling the calculations described in this paper is available from www.dal.ca/~lhughes2/environment/nm_econ.zip.

Acknowledgements

The author would like to thank Alain Joseph and Jaspreet Singh of the Energy Research Group, Jeff Bell of WADE, and Raphael Sauter at SPRU, for their valuable comments on an earlier version of this paper.

References

Bell, J., 2003. *A Survey of Canadian Policies to Compensate Small Power Producers for Electricity Fed to the Grid: Net Metering and Net Billing*, Masters Thesis, Dalhousie University, Halifax Canada

DSIRE (Database of State Incentives for Renewable Energy), 2005. Online database accessible at: http://www.dsireusa.org/, Raleigh, USA

Dunn, S., 2000. *The Next Electrical Era*, Worldwatch Institute, WW Norton, New York NY, USA.

Henderson, 2003. *Small-scale Renewable Energy Systems, Grid-connection and Net Metering: An Overview of the Canadian Experience in 2003*, Abri Sustainable Design and Consulting, Glen Haven, Canada

Hughes, L., and Bell, J., 2005, *Compensating Customer-Generators: A taxonomy describing methods of compensating customer-generators for electricity supplied to the grid*. Energy Policy. To appear.

IEA, *Photovoltaic Power Systems Programme*, www.task2.org. Accessed April 2005.

Lovins, A., Datta, K., Feiler, T., Rábago, K., Swisher, J., Lehmann, A., Wicker, K., 2000. *Small is Profitable: The Hidden Benefits of Making Electrical Resources the Right Size*, Rocky Mountain Institute Boulder, CO, USA.

Starrs, T., 1996. *Net Metering: New Opportunities for Home Power*, Kelso Starrs and Associates, Vashon, Washington, USA

Table 1: Data for a potential net metering system

Cost of electricity	0.090 $/kWh
Annual consumption	10,000 kWh
Interest rate	5%
Period	10 years
Lifetime	15 years
Capacity factor	0.35
Equipment cost	2,500 $/kW

Table 2: Avoided cost and total repayment calculations

Item	Calculations	Result
Avoided cost (A)	$5{,}000 \times 0.090 \times 15$	$6,750
Capacity (C)	$\dfrac{5{,}000}{0.35 \times 8760}$	1.63 kW
Equipment cost (P)	$1.63 \times 2{,}500$	$4,077
Total repayments (K)	$4{,}077 \times \dfrac{0.05}{1-(1.05)^{-10}}$	$5,280

Table 3: Sample capacities and costs

Maximum Capacity (kW)	Cost per kW
2.0	$2,500
4.0	$2,250
6.0	$2,000
8.0	$1,750

Table 4: Buy-back revenues

Buy-back model	Rate ($/kWh)
Below retail	0.045
Retail	0.090
Premium	0.135

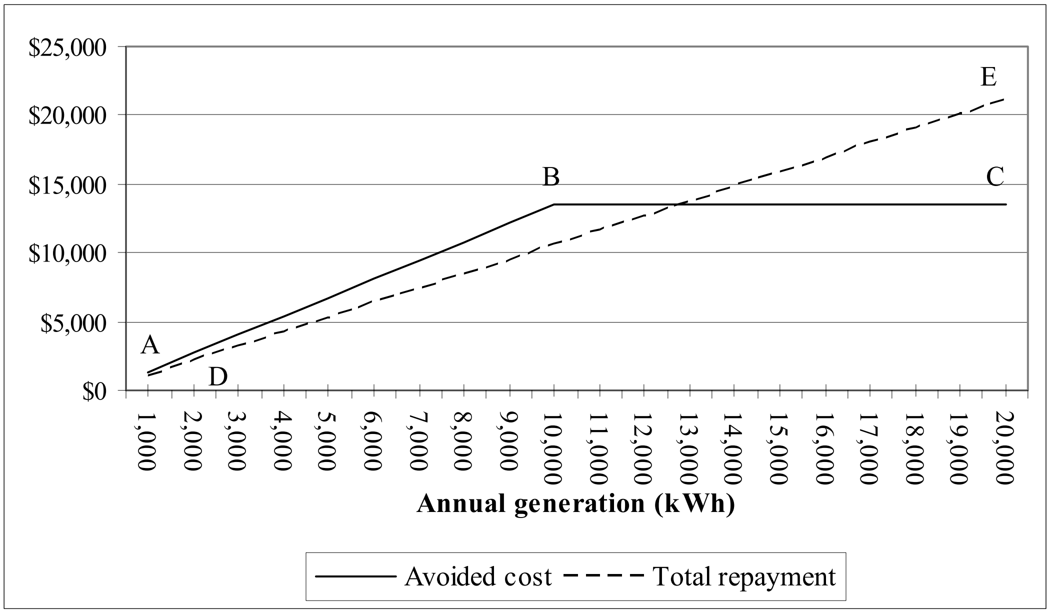

Figure 1: Avoided cost vs. total repayment

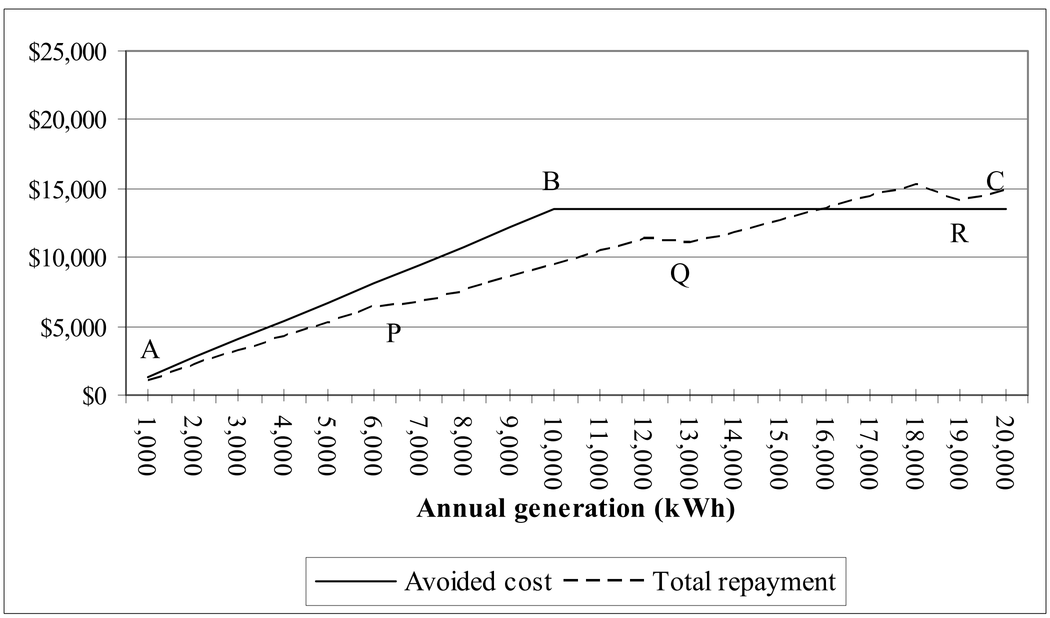

Figure 2: Effect of variable unit costs

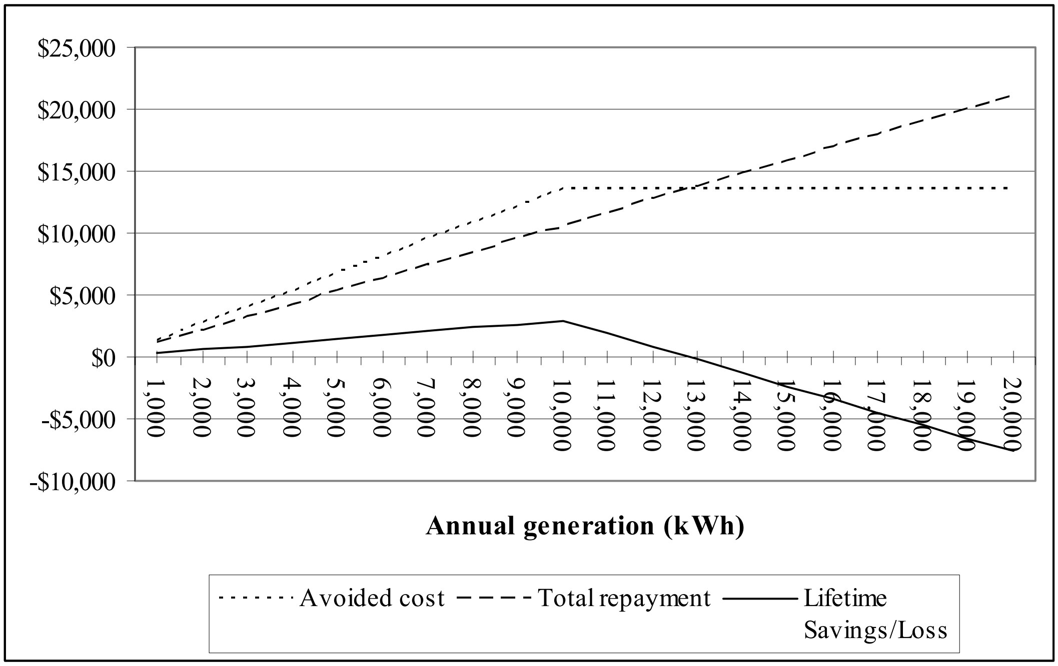

Figure 3: Lifetime savings (losses) for net metering without buy-back

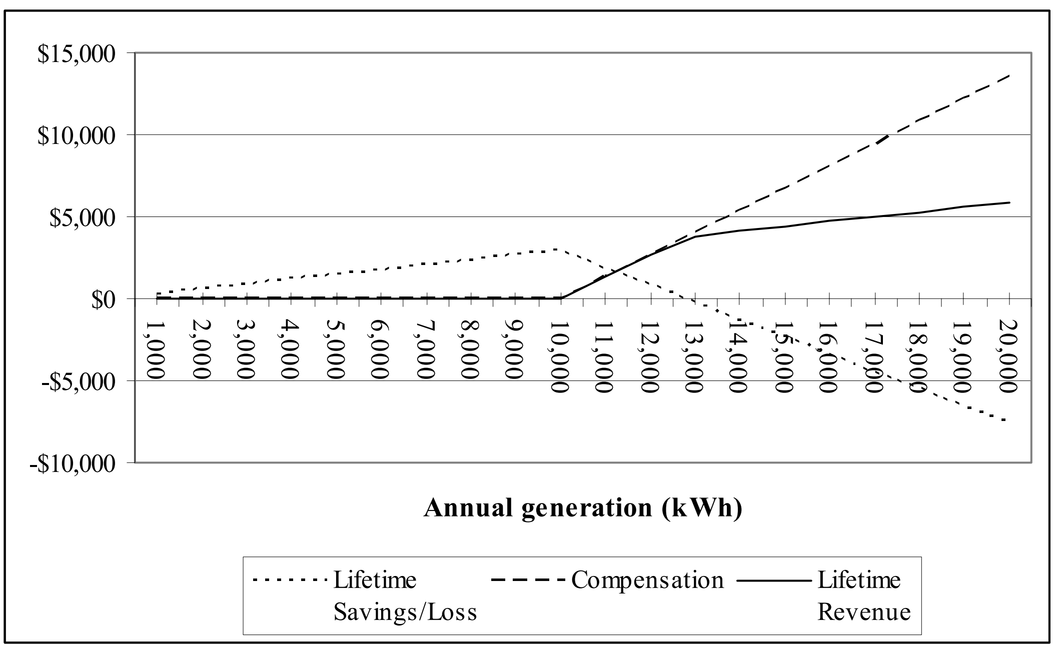

Figure 4: Lifetime revenue for net metering with buy-back

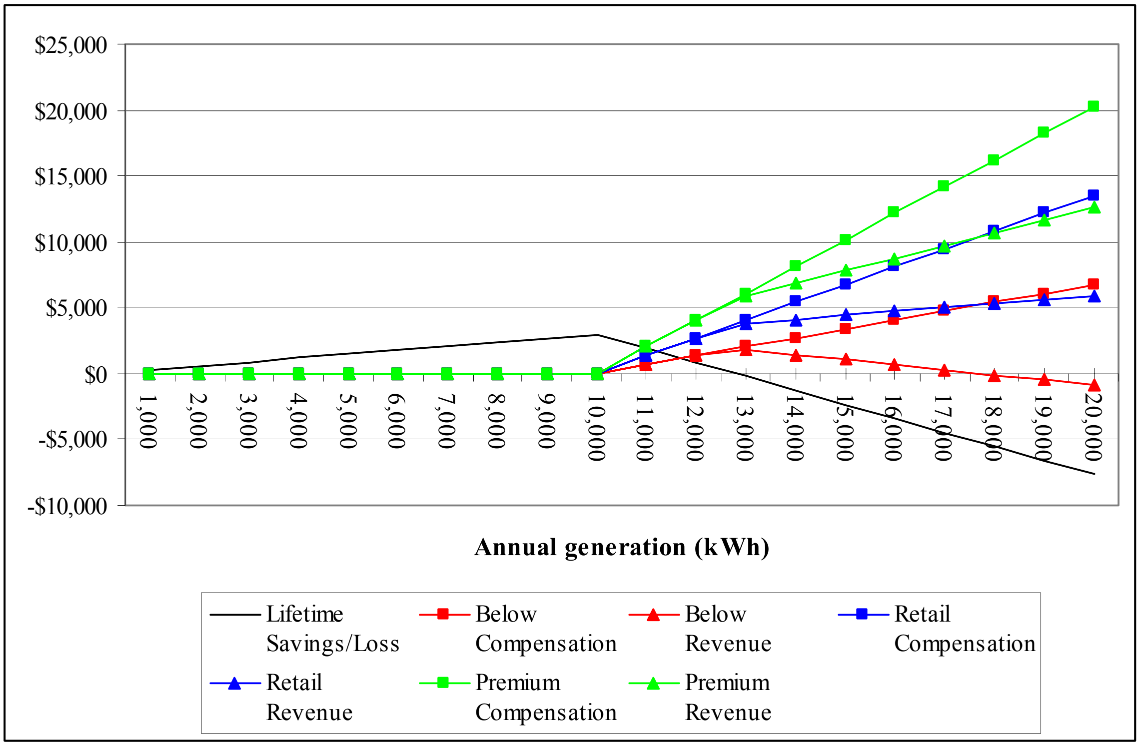

Figure 5: The effect of different buy-back rates