Effect of financial and fiscal incentives on the effective capital cost of solar energy technologies to the user

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Abstract

Development and dissemination of solar energy technologies in India has been aided by a variety of policy and support measures. One of the promotional measures is the provision of financial and fiscal incentives such as capital subsidy, low interest loan and accelerated depreciation related income tax benefits to the users on the purchase of solar energy technologies. In this study an attempt has been made to determine the effective capital cost of solar energy technologies to the user with the provision of financial and/or fiscal incentives. Results of exemplifying calculations for a domestic and an industrial solar water heating system, a solar home lighting system and a solar drying system have been presented and discussed.

Keywords: Financial and fiscal incentives; Effective capital cost; Solar energy technologies

1. Introduction

The Government of India has taken several initiatives for promotion of solar energy technologies in the country during the last two decades. A variety of policy measures have been adopted which include provision of financial and fiscal incentives to the potential users of solar energy technologies. The financial and fiscal incentives have varied with time and type of technology, the type of end users and even with the geographic location. Soft (low interest) loans under an interest subsidy scheme are provided for select renewable energy technologies through Indian Renewable Energy Development Agency (IREDA), a public sector company of the Ministry of Non-conventional Energy Sources (MNES), and through select nationalized banks and financial institutions for identified technology systems (MNES, 2001). Under the interest subsidy scheme, the difference between the normal lending rate of the bank and the rate of interest of the soft loan is borne by the Government. The normal lending rate is subject to the guidelines issued by the Reserve Bank of India.

The Government of India has been providing the following fiscal incentives for some renewable energy technologies

(a) income tax benefits i.e., accelerated depreciation claimed in the first year of installation of renewable energy systems (100% of investment costs deducted from the income in the first year itself);
Nomenclature

\( C_0 \) capital cost (Indian Rupees)  \( n \) number of loan repayment instalments in a year
\( C_{0\text{eff}} \) effective capital cost (Indian Rupees)  \( n_{\text{eff}} \) effective number of loan repayment instalments
\( d \) discount rate (fraction)  \( P \) number of months after the purchase and installation of the device when the income tax benefits are realized by the user
\( f_{\text{bl}} \) fraction of capital cost provided as commercial loan  \( T_l \) total loan repayment period (years)
\( f_{\text{eg}} \) fraction of capital cost paid out of capital gain  \( T_m \) moratorium period (years)
\( f_{\text{c}} \) fraction of capital cost provided as subsidy  \( k \) marginal income tax rate applicable to the user (fraction)
\( h \) fraction of balance of capital cost (after availing capital subsidy) provided as low interest loan  \( h \) marginal income tax rate applicable to the user on the income from capital gain (fraction)
\( i_{\text{bl}} \) commercial rate of interest charged by the bank (fraction)
\( i_{\text{g}} \) rate of interest charged by government financing institution (fraction)

Subscript

\( \text{th} \) threshold value

(b) exemption or reduction in excise duty (electricity generated from renewable energy sources is not subject to central government's excise tax);
(c) income tax holidays (income generated during the establishment of a new renewable energy facility in the first five year are not subject to the central income tax), and
(d) central sales tax and customs duty concessions on import of spare parts, peripheral materials components and other equipment used in renewable energy systems.

In order to make the potential users and other stakeholders aware of various incentives and to ensure its implementation at all levels, MNES issues guidelines to all state governments, state nodal agencies and implementing departments, NGOs and banks. States are urged by the MNES to announce the general policies for dissemination of renewable energy technologies, subsidies for promotion and dissemination, purchasing, wheeling and banking of power from all sources. In addition to the policy level decisions, the MNES at the national level and the implementing departments in various states, (such as Department of Agriculture, District Rural Development Agency, Khadi and Village Industries Commission, local governing bodies—Panchayat Boards, etc.) use media for publicity, pamphlets for dissemination of information about renewable energy programmes and technology alternatives as well as various relevant schemes of the government as announced from time to time.

Disbursement of financial subsidies follows the financing guidelines announced by the Reserve Bank of India and National Bank for Agriculture and Rural Development (NABARD) for domestic and rural programmes/technologies through notified and public sector banks. The detailed guidelines for financing are available with commercial and cooperative banks. In addition to above, training programmes, entrepreneurship awareness camps, regional seminars, manufacturers meet are conducted to take stock and review policies for dissemination of solar energy technologies (MNES, 2003).

2. Existing and proposed incentives

The financial and fiscal incentives provided are (a) capital subsidy (a portion of total capital cost is borne by the government), (b) low interest loan (the difference between commercial interest rate and that charged to the user being borne by the government), (c) accelerated depreciation related income tax benefits (profit making companies can claim 100% depreciation related income tax benefits on purchase and installation of solar energy technologies in the first year itself (IREDA, 2002), (d) relaxation in excise and import duties etc. (MNES, 2002).

In addition, the following potential incentives may also be provided: (a) capital gain investment related income tax benefits (users may be allowed to claim income tax rebate by investing capital gains for the purchase and installation of solar energy technologies), (b) income tax benefits provided to the user on the amount of interest paid on the loan availed for the purchase of solar energy technologies. Moreover, the facility of

\[ \begin{align*}
 C_0 &= \text{capital cost (Indian Rupees)} \\
 C_{0\text{eff}} &= \text{effective capital cost (Indian Rupees)} \\
 d &= \text{discount rate (fraction)} \\
 f_{\text{bl}} &= \text{fraction of capital cost provided as commercial loan} \\
 f_{\text{eg}} &= \text{fraction of capital cost paid out of capital gain} \\
 f_{\text{c}} &= \text{fraction of capital cost provided as subsidy} \\
 h &= \text{fraction of balance of capital cost (after availing capital subsidy) provided as low interest loan} \\
 i_{\text{bl}} &= \text{commercial rate of interest charged by the bank (fraction)} \\
 i_{\text{g}} &= \text{rate of interest charged by government financing institution (fraction)} \\
 n &= \text{number of loan repayment instalments in a year} \\
 n_{\text{eff}} &= \text{effective number of loan repayment instalments} \\
 P &= \text{number of months after the purchase and installation of the device when the income tax benefits are realized by the user} \\
 T_l &= \text{total loan repayment period (years)} \\
 T_m &= \text{moratorium period (years)} \\
 k &= \text{marginal income tax rate applicable to the user (fraction)} \\
 h &= \text{marginal income tax rate applicable to the user on the income from capital gain (fraction)} \\
 \text{th} &= \text{threshold value}
\end{align*} \]
accelerated depreciation related income tax benefits may be extended to individual users also.

A variety of combinations of the above mentioned existing and / or proposed incentives are practically feasible. The amount of investment required by the users availing such benefits is expected to affect the dissemination of solar energy systems to a large extent. Thus, the efficacy of financial and fiscal incentives can also be valued in terms of their role in reducing the effective capital cost to the user. It is with this objective that an attempt to study the effect of different financial and fiscal incentives and their combinations on the effective capital cost to the user has been made in this work. In order to facilitate a comparison among the various individual incentives and their combinations, expressions for the effective capital cost of the system to the user have been derived. In this section, some of the existing and proposed financial and fiscal incentives and their combinations have been briefly defined and explained.

(a) Capital subsidy. Under this incentive, a certain fraction of the capital cost of the system is borne by the government at the time of purchase itself. The balance amount is assumed to be invested by the user, which is the effective capital cost of the solar energy system to the user.

(b) Low interest loan (Interest subsidy). In this case the end users are provided a certain fraction of the capital cost as low interest loan by financing institutions. The balance amount is assumed to be invested by the user. The rate of interest charged on the loan is lower than the commercial rate charged by the banks and other financing institutions for commercial loans. The low interest loan is to be paid back in a specified period of time with a given number of loan repayment installments in a year. It is assumed that the user repays the loan with the interest accrued in equal periodic installments. Sometimes a moratorium period is allowed to the user during which loan repayment is not made though the interest is levied.

(c) Accelerated depreciation related income tax benefits. As mentioned earlier, it is proposed that income tax benefit due to accelerated depreciation may also be provided to the individuals i.e., the users can avail income tax benefit due to the provision of 100% depreciation of the solar energy equipment in the year of purchase itself. In this case it is assumed that the user invests the entire amount of capital cost.

(d) Income tax benefits on capital gain related investments. One of the possible mechanisms to attract relatively affluent users could be the provision of income tax benefits on the investments made out of capital gains for purchase and installation of solar energy systems. Potential users may be encouraged to invest a portion of the capital cost out of the capital gain(s) accrued to them and avail income tax benefits on the investments made.

(e) Income tax benefits on the interest paid on the loan availed for the purchase of solar energy system. A provision of tax benefits on the interest paid on a commercial loan taken for the purchase of a solar energy system can also motivate some of the potential users. In this case the user borrows a certain fraction of capital cost as a commercial loan. It is assumed that the user pays equal periodic installments during the loan repayment period.

(f) Capital subsidy and low interest loan. The user avails capital subsidy and is also given low interest loan on the purchase of solar energy system. The amount of low interest loan is assumed to be a certain fraction of the balance amount after deduction of capital subsidy from the initial capital cost.

(g) Capital subsidy and accelerated depreciation related income tax benefits. In this case it is assumed that, the user avails the facility of capital subsidy and also the income tax benefits due to 100% depreciation of solar energy system in the year of purchase itself. As the entire cost is assumed to be borne by the user, the same is considered in determining the income tax benefits due to accelerated depreciation.

(h) Low interest loan and accelerated depreciation related income tax benefits. The user avails the facility of low interest loan and accelerated depreciation related income tax benefits on the purchase and installation of the solar energy systems. In this case also the users avails income tax benefits on the entire capital cost.

(i) Accelerated depreciation related income tax benefits and income tax benefits due to capital gain investments. In this case it is assumed that the user invests the entire capital cost. However, a certain fraction of the capital cost is paid out of capital gains accrued to the user. It is assumed that the user does not pay any income tax on the investment made out of capital gain and, at the same time, the user is eligible for accelerated depreciation related income tax benefits as well.

(j) Capital subsidy, accelerated depreciation related income tax benefits and low interest loan. The end user avails capital subsidy, is provided low interest loan and also claims accelerated depreciation related income tax benefits on the purchase and installation of the solar energy system. While the amount of low interest loan is restricted to a certain fraction of the balance amount after capital subsidy, in the calculation of the income tax benefits due to accelerated depreciation also the amount of capital subsidy is excluded.

(k) Capital subsidy, low interest loan and income tax benefits due to capital gain related investments. The user avails capital subsidy, is provided with low interest loan and invests the balance amount out of capital gains (and thus also avails capital gain related income tax benefits).

(l) Capital subsidy, accelerated depreciation related income tax benefits and income tax benefits due to capital gain investments.
gain investments. The user gets capital subsidy and invests a certain fraction of the balance of the capital cost out of capital gains. The user avails income tax benefits due to accelerated depreciation of solar energy system as well as income tax benefits on the amount of investment made out of capital gain.

(m) Low interest loan, accelerated depreciation related income tax benefits and income tax benefits due to capital gain related investments. In this case a certain fraction of the capital cost is provided as low interest loan to the user and the user invests a fraction of the remaining balance out of the capital gains. The user avails income tax benefits due to accelerated depreciation and also on the investment made out of capital gains.

(n) Capital subsidy, low interest loan, income tax benefits due to accelerated depreciation and capital gain related tax benefits. The user avails capital subsidy on the purchase of the solar energy system and is also provided a fraction of the balance amount as low interest loan. The remaining balance is assumed to be invested by the user out of the capital gains. The user thus avails income tax benefits due to accelerated depreciation of solar energy system and also on the investment made out of capital gains.

Mathematical expressions for determining the effective present value of the capital cost to the end user in each of the above cases are presented in Appendix A. The corresponding compositions of the capital cost for these cases are presented in Table 1.

The framework presented in this paper can also be used to derive important policy related inferences about the relative superiority of one incentive (or a particular combination of incentives) over another incentive (or another combination of incentives). To facilitate such a comparison the expressions for the threshold values of relevant parameters for which a particular financial incentive would be preferred over another incentive are given in Appendix B for some of the cases considered in this study.

Table 1
Composition of the capital cost ($C_0$) for different combinations of financial and fiscal incentives

<table>
<thead>
<tr>
<th>Group no.</th>
<th>Individual/combined incentive(s)</th>
<th>Capital subsidy</th>
<th>Low interest loan</th>
<th>Personal investment</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Capital subsidy</td>
<td>$f_sC_0$</td>
<td>$1-f_sC_0$</td>
<td>$(1-f_s)C_0$</td>
<td>$f_s$: fraction of capital cost provided as capital subsidy</td>
</tr>
<tr>
<td>II</td>
<td>Low interest loan</td>
<td>$f_lC_0$</td>
<td>$1-f_lC_0$</td>
<td>$f_l$: fraction of capital cost provided as low interest loan</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Capital subsidy and low interest loan</td>
<td>$f_sC_0$</td>
<td>$(1-f_s)C_0$</td>
<td>$(1-f_s)(1-f_l)C_0$</td>
<td>$f_l$: fraction of balance of the capital cost (after capital subsidy) provided as low interest loan</td>
</tr>
</tbody>
</table>
3. Results and discussion

The effect of existing and some possible combinations of financial and fiscal incentives for solar energy technologies have been analyzed using the expressions derived in Appendix A. The base case values of different input parameters for the four solar energy technologies viz., a domestic solar water heating system, a solar home lighting system, an industrial solar water heating system and a solar drying system are presented in Table 2 (IREDA, 2002; Nagaraju et al., 1994; Palaniappan and Subramanian, 1994). The values of effective capital costs for different existing and possible combinations of financial and fiscal incentives are presented in Table 3. The following points emerge from an analysis of the results presented in this Table.

(a) For the prevailing values of input parameters as defined in Table 2, amongst the individual incentives, capital subsidy leads to the least value of the effective capital cost to the user. Thus for a domestic solar water heating system, 40% capital subsidy is much better than a provision of a loan (80% of the capital cost) at 5% for a period of five years.

(b) Potential users in 30% income tax range would, in fact, prefer the provision of 100% depreciation in the first year to the provision of low interest loan. Similarly, the users likely to pay 30% of their capital gains as income tax will also prefer the provision of income tax benefits on the investment made out of capital gains to the provision of low interest loan.

(c) The provision of income tax benefit on the amount of interest paid on a commercial loan taken for the purchase of a solar energy system is not at all financially attractive for the potential users.

(d) As expected, the value of effective capital cost is further lowered for a user availing more than one financial and/ or fiscal incentives. The combination of capital cost with 100% depreciation related income tax benefits and/ or with the capital gain related income tax benefits are more attractive than those with the provision of low interest loan.

Table 4 presents the effect of the interest rate charged by the financing institutions on the threshold value of fraction of capital subsidy (below which the capital subsidy would be less attractive to the user as compared to the provision of low interest loan). As an example, for the base values of other parameters as given in Table 2, the provision of low interest loan at 2% interest rate is equivalent to a capital subsidy of 14.32%. Therefore, a user would prefer a capital subsidy of 15% to a low interest loan at 2%. An increase in the interest rate to 4% lowers the equivalent capital subsidy to 10.89% and so on.

Table 5 presents some sample calculations based on Eq. (B.2) given in Appendix B for the threshold value of the marginal rate of income tax for the user while comparing the provision of capital subsidy with the income tax benefits due to accelerated depreciation. It may be noted that for a user with a marginal rate of income tax higher than 22%, the provision of income tax benefits due to 100% depreciation in the first year itself is more attractive than the provision of capital subsidy of 20%.

Similarly, the results of some calculations made on the basis of Equation (B.3) given in Appendix B for the

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base values of input parameters for solar energy systems considered in the study</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Domestic solar water heating system</th>
<th>Solar home lighting system</th>
<th>Industrial solar water heating system</th>
<th>Solar drying system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity/size of system</td>
<td>-</td>
<td>100 l per day</td>
<td>37 Wp Module, 29 V</td>
<td>100,000 l per day</td>
<td>500 m² collector area</td>
</tr>
<tr>
<td>C0</td>
<td>Rupees</td>
<td>22,000</td>
<td>17,000</td>
<td>12,800,000</td>
<td>16,24,000</td>
</tr>
<tr>
<td>d</td>
<td>Fraction</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>fs</td>
<td>Fraction</td>
<td>0.4</td>
<td>0.4</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>s</td>
<td>Fraction</td>
<td>0.8</td>
<td>0.8</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>eg</td>
<td>Fraction</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>h</td>
<td>Fraction</td>
<td>0.9</td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>h1</td>
<td>Fraction</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>k</td>
<td>Fraction</td>
<td>0.05</td>
<td>0.05</td>
<td>0.085</td>
<td>0.085</td>
</tr>
<tr>
<td>n</td>
<td>Number</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>n_eff (= T_e - T_m)</td>
<td>Number</td>
<td>20</td>
<td>20</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>h</td>
<td>Fraction</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>h1</td>
<td>Fraction</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>T_e</td>
<td>Years</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>T_m</td>
<td>Years</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

1 Euro = 54.66 Indian Rupees in April 2004.
Table 3
Effective capital cost of solar energy systems to the user availing financial and/or fiscal incentives

<table>
<thead>
<tr>
<th>Financial incentive(s)</th>
<th>Domestic solar water heating system</th>
<th>Solar home lighting system</th>
<th>Industrial solar water heating system</th>
<th>Solar drying system</th>
</tr>
</thead>
<tbody>
<tr>
<td>No financial incentive</td>
<td>22,000</td>
<td>17,000</td>
<td>12,800,000</td>
<td>1,624,000</td>
</tr>
<tr>
<td>Capital subsidy</td>
<td>13,200</td>
<td>10,200</td>
<td>9,600,000</td>
<td>1,218,000</td>
</tr>
<tr>
<td>Low interest loan</td>
<td>19,990</td>
<td>15,447</td>
<td>12,234,279</td>
<td>1,552,224</td>
</tr>
<tr>
<td>100% depreciation related income tax benefits</td>
<td>16,000</td>
<td>12,364</td>
<td>81,45,455</td>
<td>1,033,455</td>
</tr>
<tr>
<td>Capital gain investment related income tax benefits</td>
<td>16,600</td>
<td>12,827</td>
<td>9,658,182</td>
<td>1,225,382</td>
</tr>
<tr>
<td>Income tax benefit on the interest paid on the loan availed for the purchase of solar energy system</td>
<td>27,338</td>
<td>21,125</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Capital subsidy and low interest loan</td>
<td>11,994</td>
<td>9268</td>
<td>9,175,709</td>
<td>1,164,168</td>
</tr>
<tr>
<td>Capital subsidy and accelerated depreciation related income tax benefits</td>
<td>9600</td>
<td>7418</td>
<td>6,109,091</td>
<td>775,091</td>
</tr>
<tr>
<td>Low interest loan and accelerated depreciation related income tax benefits</td>
<td>13,990</td>
<td>10,810</td>
<td>7,579,733</td>
<td>961,679</td>
</tr>
<tr>
<td>100% depreciation related income tax benefits and capital gain related income tax benefits</td>
<td>10,600</td>
<td>8191</td>
<td>5,003,636</td>
<td>634,836</td>
</tr>
<tr>
<td>Capital subsidy, low interest loan and accelerated depreciation related income tax benefits</td>
<td>14,630</td>
<td>11,305</td>
<td>8,263,370</td>
<td>1,048,415</td>
</tr>
<tr>
<td>Capital subsidy, low interest loan and capital gain investment related income tax benefits</td>
<td>11,346</td>
<td>8767</td>
<td>8,822,254</td>
<td>1,119,324</td>
</tr>
<tr>
<td>Capital subsidy, accelerated depreciation related income tax benefits and capital gain tax benefits</td>
<td>6360</td>
<td>4915</td>
<td>3,752,727</td>
<td>476,127</td>
</tr>
<tr>
<td>Low interest loan, accelerated depreciation related income tax benefits and capital gain investment related income tax benefits</td>
<td>12,910</td>
<td>9976</td>
<td>7,108,461</td>
<td>901,886</td>
</tr>
<tr>
<td>Capital subsidy, low interest loan, accelerated depreciation related income tax benefits and capital gain investment related income tax benefits</td>
<td>7746</td>
<td>5985</td>
<td>5,331,322</td>
<td>676,412</td>
</tr>
</tbody>
</table>

1 Euro = 54.66 Indian Rupees in April 2004.

Table 4
Threshold value of capital subsidy, $f_{c,th1}$ (while comparing low interest loan with capital subsidy)

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Interest rate of financing institution (if)</th>
<th>$f_{c,th1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02</td>
<td>0.1432</td>
</tr>
<tr>
<td>2</td>
<td>0.04</td>
<td>0.1089</td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>0.0736</td>
</tr>
<tr>
<td>4</td>
<td>0.08</td>
<td>0.0373</td>
</tr>
</tbody>
</table>

Table 5
Threshold value of marginal rate of income tax, $t_{1,th1}$ (while comparing accelerated depreciation related income tax benefits with capital subsidy)

<table>
<thead>
<tr>
<th>S. no.</th>
<th>$f_{c1}$</th>
<th>$t_{1,th1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
<td>0.11</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>0.22</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
<td>0.33</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>0.44</td>
</tr>
</tbody>
</table>

threshold value of the rate of income tax levied on the capital gain investments while comparing this provision with capital subsidy (and using base values of other parameters as given in Table 2), are presented in Table 6.
Table 6
Threshold values of the rate of income tax on capital gain benefits, \( t_{\text{th1}} \) (while comparing income tax benefits on capital gain related investments with capital subsidy)

<table>
<thead>
<tr>
<th>S. no.</th>
<th>( \text{Interest rate (if)} )</th>
<th>( t_{\text{th1}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>2</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>3</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>4</td>
<td>0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>6</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>0.96</td>
</tr>
</tbody>
</table>

Table 7
Threshold value of rate of income tax on capital gains, \( t_{\text{th2}} \) (while comparing provision of income tax benefits on capital gain related investments with low interest loan)

<table>
<thead>
<tr>
<th>S. no.</th>
<th>( \text{Interest rate (if)} )</th>
<th>( t_{\text{th2}} )</th>
</tr>
</thead>
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<tr>
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<td>0.11</td>
</tr>
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</tr>
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</tr>
<tr>
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<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>6</td>
<td>0.10</td>
<td>0.00</td>
</tr>
</tbody>
</table>

It may be noted that if the capital gain related benefits are taxed at a rate of 41%, the provision of capital gain related income tax benefits to the user is more attractive for the user than a capital subsidy of 30%.

Results of calculations based on Eq. (B.6) given in Appendix B for the threshold value of income tax rate on capital gain related investments (while comparing provision of income tax benefits on capital gain investments with low interest loan) are presented in Table 7. It may be noted that the provision of income tax benefits on capital gain related investments is more attractive than provision of low interest loan at 5% provided the marginal rate of income tax on capital gains is more than 11%. With an increase in the rate of low interest loan the threshold value of marginal rate of income tax further reduces.

4. Concluding remarks

The paper presents a framework for studying the effect of several existing and proposed financial and fiscal incentives on the effective capital cost of solar energy systems to the end users.

(a) Capital subsidy. The effective capital cost, \( C_{0}\downarrow f_{\text{cs}} \), of the solar energy system with capital subsidy can be estimated as

\[
C_{0,\text{eff}} = C_{0} (1 - f_{\text{cs}}) \tag{A.1}
\]

where \( C_{0} \) represents the capital cost of the system and \( f_{\text{cs}} \) the fraction of capital cost provided as a capital subsidy by the government at the time of purchase itself.

(b) Low interest loan (Interest subsidy). The effective capital cost, \( C_{0}\downarrow f_{i} \), of the solar energy system with interest subsidy can be estimated as

\[
C_{0,\text{eff}} = (1 - f_{i})C_{0} + f_{i}C_{0} [\frac{(i_{f}/n)(1+i_{f}/n)^{n_{eff}}}{(1+i_{f}/n)^{n_{eff}} - 1} \frac{(1+d/n)^{n_{eff}} - 1}{(d/n)(1+d/n)^{n_{eff}}} - 1] \tag{A.2}
\]

where \( f_{i} \) represents the fraction of capital cost provided by financing institutions as low interest loan, \( i_{f} \) the rate of interest charged on the loan, \( T_{l} \) the loan repayment period, \( n \) the number of installments in a year, \( n_{eff} \) the effective number of total loan repayment installments, and \( d \) the discount rate.

(c) Accelerated depreciation related income tax benefits. The effective capital cost, \( C_{0}\downarrow f_{a} \), of solar energy system to the user with the accelerated depreciation related income tax benefits can be determined as

\[
C_{0,\text{eff}} = \frac{C_{0} (1 - f_{a})}{1 - \frac{f_{a}}{(1+d/n)^{n_{eff}}}} \tag{A.3}
\]

where \( f_{a} \) (fraction) represents the marginal income tax rate as applicable to the user. It is assumed that the income tax benefits accrue after \( p \) months of purchase of the solar energy device.

(d) Income tax benefits on capital gain related investments. The effective capital cost, \( Q_{0,\text{eff}} \), of the solar energy system with income tax benefits on capital gain related investments can be determined as

\[
Q_{0,\text{eff}} = C_{0} \left( 1 - \frac{f_{h}}{(1+d/n)^{n_{eff}} \sqrt[3]{1-\frac{n}{3}}} \right) \tag{A.4}
\]

Therefore, the possibility of motivating the potential users in the high income and upper-middle income category in the country through the provision of accelerated depreciation and/or capital gain investment related income tax benefits should be seriously explored.

Appendix A

The following expressions have been derived to study the effect of several existing and proposed financial and fiscal incentives on the effective capital cost of solar energy systems to the end users.

(a) Capital subsidy.

The effective capital cost,

\[
C_{0,\text{eff}} = \frac{C_{0} f_{\text{cs}}}{1 - f_{\text{cs}}} \tag{A.1}
\]

where \( C_{0} \) represents the capital cost of the system and \( f_{\text{cs}} \) the fraction of capital cost provided as a capital subsidy by the government at the time of purchase itself.

(b) Low interest loan (Interest subsidy). The effective capital cost,

\[
C_{0,\text{eff}} = (1 - f_{i})C_{0} + f_{i}C_{0} [\frac{(i_{f}/n)(1+i_{f}/n)^{n_{eff}}}{(1+i_{f}/n)^{n_{eff}} - 1} \frac{(1+d/n)^{n_{eff}} - 1}{(d/n)(1+d/n)^{n_{eff}}} - 1] \tag{A.2}
\]

where \( f_{i} \) represents the fraction of capital cost provided by financing institutions as low interest loan, \( i_{f} \) the rate of interest charged on the loan, \( T_{l} \) the loan repayment period, \( n \) the number of installments in a year, \( n_{eff} \) the effective number of total loan repayment installments, and \( d \) the discount rate.

(c) Accelerated depreciation related income tax benefits. The effective capital cost,

\[
C_{0,\text{eff}} = \frac{C_{0} (1 - f_{a})}{1 - \frac{f_{a}}{(1+d/n)^{n_{eff}}}} \tag{A.3}
\]

where \( f_{a} \) (fraction) represents the marginal income tax rate as applicable to the user. It is assumed that the income tax benefits accrue after \( p \) months of purchase of the solar energy device.

(d) Income tax benefits on capital gain related investments. The effective capital cost,

\[
Q_{0,\text{eff}} = C_{0} \left( 1 - \frac{f_{h}}{(1+d/n)^{n_{eff}} \sqrt[3]{1-\frac{n}{3}}} \right) \tag{A.4}
\]
where \( f_{cg} \) represents the portion of capital cost out of the capital gain(s) accrued to the user and \( \theta \) (fraction) the marginal income tax rate applicable to the user on the income from capital gains.

(e) Income tax benefits on the interest paid on the loan availed for the purchase of solar energy system. The effective capital cost, \( C_{0,\text{eff}}^{(e)} \), of the solar energy system with income tax benefits on the interest paid on the loan availed for the purchase of solar energy system can be determined as

\[
C_{0,\text{eff}}^{(e)} = C_0 (1 - f_{b}) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left[ \frac{1 + d/n}{d/n} \right] \right\} \]

where \( f_{b} \) represents the fraction of the capital cost as a commercial loan at an annual interest rate \( i_{b} \), \( T_l \) the loan repayment period, \( n \) the number of annual installments, and \( d \) the discount rate. The first term in the right-hand side of the above Equation (A.5) presents the up-front cost paid by the user, the second term presents the cumulative present worth of all loan repayment installments to be paid by the user, and the third term presents the cumulative present worth of income tax benefits provided to the user on the interest paid for the purchase of the system.

(f) Capital subsidy and low interest loan. In this case, the effective capital cost, \( C_{0,\text{eff}}^{(f)} \), of the solar energy system to the user can be expressed as

\[
C_{0,\text{eff}}^{(f)} = \left[ 1 - f_{b} \right] + \frac{f_{b}}{\frac{n\zeta}{\alpha} + 1} \left[ \frac{1 + d/n}{d/n} \right] \]

\[ \times \left[ \frac{1 + d/n}{d/n} \right] \]

\[ \times I_1 \left[ \frac{\alpha}{d/n} + \frac{d/n}{\alpha} \right] \]

A.5

(g) Capital subsidy and accelerated depreciation related income tax benefits. The effective capital cost of the solar energy system \( d^a \), in this case can be expressed as

\[
C_{0,\text{eff}}^{(g)} = C_0 \left( 1 - f_{a} \right) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left[ \frac{1 + d/n}{d/n} \right] \right\} \]

\[ \times \left[ \frac{1 + d/n}{d/n} \right] \]

\[ \times \frac{1}{\frac{\alpha}{d/n} + \frac{d/n}{\alpha}} \]

A.7

(h) Low interest loan and accelerated depreciation related income tax benefits. In this case, the effective capital cost, \( C_{0,\text{eff}}^{(h)} \), can be determined using the expression

\[
C_{0,\text{eff}}^{(h)} = C_0 \left( 1 - f_{a} \right) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left[ \frac{1 + d/n}{d/n} \right] \right\} \]

\[ \times \left[ \frac{1 + d/n}{d/n} \right] \]

\[ \times \frac{1}{\frac{\alpha}{d/n} + \frac{d/n}{\alpha}} \]

A.8

(i) Accelerated depreciation related income tax benefits and income tax benefits due to capital gain investments. In this case, the effective capital cost of the solar energy system, \( C_{0,\text{eff}}^{(i)} \), to the user can be calculated as

\[
C_{0,\text{eff}}^{(i)} = C_0 \left[ \frac{1 - f_{a} + f_{b}}{\left[ \frac{\alpha}{\alpha} \right]} \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \right] \]

\[ \times \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \]

\[ \times \frac{1}{\frac{\alpha}{\alpha} + \frac{\alpha}{\alpha}} \]

A.9

(j) Capital subsidy, accelerated depreciation related income tax benefits and low interest loan. In this case, the effective capital cost of the solar energy system, \( C_{0,\text{eff}}^{(j)} \), can be expressed as

\[
C_{0,\text{eff}}^{(j)} = C_0 \left( 1 - f_{a} \right) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left[ \frac{1 + d/n}{d/n} \right] \right\} \]

\[ \times \left[ \frac{1 + d/n}{d/n} \right] \]

\[ \times \frac{1}{\frac{\alpha}{d/n} + \frac{d/n}{\alpha}} \]

A.10

(k) Capital subsidy, low interest loan and income tax benefits due to capital gain related investments. The effective capital cost, \( C_{0,\text{eff}}^{(k)} \), in this case, can be expressed as

\[
C_{0,\text{eff}}^{(k)} = C_0 \left[ \frac{1 - f_{a} + f_{b}}{\left[ \frac{\alpha}{\alpha} \right]} \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \right] \]

\[ \times \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \]

\[ \times \frac{1}{\frac{\alpha}{\alpha} + \frac{\alpha}{\alpha}} \]

A.11

(l) Capital subsidy, accelerated depreciation related income tax benefits and income tax benefits due to capital gain investments. The effective capital cost of the solar energy system, \( Q^{1,4}_{\alpha} \), to the user in this case can be expressed as

\[
C_{0,\text{eff}}^{(l)} = C_0 \left( 1 - f_{a} \right) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left[ \frac{1 + d/n}{d/n} \right] \right\} \]

\[ \times \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \]

\[ \times \frac{1}{\frac{\alpha}{d/n} + \frac{d/n}{\alpha}} \]

A.12

(m) Low interest loan, accelerated depreciation related income tax benefits and income tax benefits due to capital gain related investments. The effective capital cost, \( C_{0,\text{eff}}^{(m)} \), of the solar energy system to the user in this case can be expressed as

\[
C_{0,\text{eff}}^{(m)} = C_0 \left( 1 - f_{a} \right) + f_{b} \left\{ \frac{\alpha}{n} \left[ \frac{1 + d/n}{d/n} \right] \right. \\
\left. \times \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \right\} \]

\[ \times \left( \frac{\alpha}{\alpha} \right) \frac{\alpha}{\alpha} - 1 \]

\[ \times \frac{1}{\frac{\alpha}{\alpha} + \frac{\alpha}{\alpha}} \]

A.13

\]
(n) Capital subsidy, low interest loan, income tax benefits due to accelerated depreciation and capital gain related tax benefits.

The effective capital cost, \(C_0(1 + \text{ef}_c)\), of the solar energy system to the user in this case can be expressed as

\[
C_0^{[13]} = C_0 \left[ (1 - f_{is}) \right] + f_{is} \left[ \frac{\left( \frac{1}{n} \right) (1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}}}{(1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}} - 1} \right] \left( 1 + \frac{d}{n} \right)^{\frac{\text{nr}}{2}} - 1
\]

\[
\frac{1}{(1 + df)^{\frac{n}{2}}} \left\{ t_u + (1 - f_u) t_2 f_{is} \right\}
\]

\[
\delta A13x
\]

\[
\Delta A13x
\]

Appendix B

Some of the expressions derived for the threshold values of several important parameters are presented below.

(a) The threshold value of \(f_{cs}\) (while comparing capital subsidy with low interest loan)

\[
f_{cs,th1} = 1 - \left[ \frac{\left( \frac{1}{n} \right) (1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}}}{(1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}} - 1} \right] \frac{nT_i}{(1 + \frac{d}{n})(\frac{1 + d}{n})^{\frac{\text{nr}}{2}} - 1}
\]

\[
\delta A14x
\]

From the above expression it may be noted that the value of \(f_{cs,th1}\) is independent of the capital cost of the technology.

(b) Threshold value of marginal rate of income tax (while comparing capital subsidy with income tax benefits due to 100% depreciation in the first year itself)

\[
t_{1,th1} = f_{is} (1 + d)^{\frac{\text{nr}}{2}}
\]

\[
\delta A14x
\]

It may be noted that for \(p = 0\), \(t_{1,th1} = f_{cs}\), i.e., if the income tax benefits are accrued to the user at the time of purchase itself, the threshold value of the income tax rate would be the same as the fraction of capital cost provided as subsidy.

(c) Threshold value of income tax rate on capital gain (while comparing capital subsidy with the provision of income tax benefits on the investment made out of capital gains)

\[
t_{2,th1} = \frac{f_{cs} (1 + d)^{\frac{\text{nr}}{2}}}{t_{eg}}
\]

\[
\delta A14x
\]

\[(B.3)\]

i.e., if the entire capital cost is borne out of capital gain and the corresponding income tax benefits accrue to the user at the time of purchase, the threshold value of the income tax rate would be the same as the value of \(f_{cs}\).

(d) Threshold value of \(f_{cs}\) (while comparing the provision of capital subsidy with the provision of income tax benefits on the loan taken for the purchase of a solar energy system)

\[
f_{cs,th2} = b_f \sim b_l f_{is} \left[ \frac{\left( \frac{1}{n} \right) (1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}}}{(1 + \frac{i_s}{n})^{\frac{\text{nr}}{2}} - 1} \right]
\]

\[
\times \left[ \frac{(\frac{1 + d}{n})^{\frac{\text{nr}}{2}} - 1}{(1 + d)(\frac{1 + d}{n})^{\frac{\text{nr}}{2}} - 1 - nT_i} \right] + nT_i \left[ \frac{\left( \frac{1 + d}{n} \right)^{\frac{\text{nr}}{2}} - 1}{(1 + d)(\frac{1 + d}{n})^{\frac{\text{nr}}{2}} - 1 - nT_i} \right]
\]

\[
\times \left( \frac{1}{1 + df} \right)
\]

\[
\delta A14x
\]

\[(B.4)\]

From the above expression it may be noted that the value of \(f_{cs,th1}\) is independent of the capital cost of the technology.

References


