ABSTRACT

Energy demand for primary processing of rice in India has been assessed and feasibility of two renewable energy supply options evaluated. A model for obtaining least cost energy supply mix for a rice mill has been proposed.

KEYWORDS

Rice processing, energy demand, energy supply options, least cost energy supply mix.

INTRODUCTION

Rice is a major food grain in India accounting for over 40% of production and over 30% of cropped area. Primary processing of rice basically involves removal of husk and the underlying bran layers from paddy in major rice milling systems-hullers, shellers and modern mills. It is estimated that 50% of paddy processed in India is parboiled by using various methods of parboiling (Kapur et al., 1994). Drying is mostly done in the open sun. While parboiling and drying operations mainly require thermal energy the milling operations need mechanical energy. An attempt has been made in the present work to assess the energy demand for primary processing of rice and to evaluate some of the renewable energy supply options.

ENERGY DEMAND

Energy demand for rice processing depends on the quantity of paddy produced/processed in the country, the proportionate distribution of this quantity amongst various methods/processes of parboiling/drying, their energy intensities and efficiencies of energy conversion devices involved (Kapur et al., 1996a). Using the annual paddy production data for the period 1971-72 to 1991-92, the least square regression fit, \( P = (61 + 0.142T + 0.54T^3) \times 10^6 \), was obtained. Here \( P \) represents annual paddy production (t) and \( T \) the time in years with 1971 72 as the reference (\( T = 0 \)).

ENERGY CONSERVATION POTENTIAL OF ENERGY EFFICIENT MOTORS

The mechanical energy requirement of rice processing is generally met by electric motors. Thus one
of the immediate demand management measures could be the replacement of the standard motors by their energy efficiency counterparts. The annual energy saving potential of energy efficient motors (Kapur et al., 1995) in rice mills of various capacities having different annual operating hours is shown in Fig. 2.

**RENEWABLE ENERGY SUPPLY OPTIONS**

The feasibility of using rice husk for meeting mechanical energy demand through gasification-dual fuel engine-generation route (Kapur et al. 1996b) and that of solar systems for heating water for soaking during parboiling (Kapur et al., 1996c) were assessed. The variation of unit cost of electricity (UCE) obtained through gasification route for different power ratings is shown graphically in Fig. 3 alongwith UCE from diesel generator sets as well as the grid electricity rates. Time variation of the unit cost of useful thermal energy is shown in Fig. 4 for systems based on rice husk (at different initial unit costs), and also for systems based on coal, furnace oil, and solar energy.

**LINEAR PROGRAMMING MODEL**

The following objective function was used (Kapur et al., 1996d) to obtain the least cost energy supply mix for a rice mill:

\[
\text{Min} \left[ \sum_{\ell} \sum_{m} \sum_{n} (RU_{\ell mn} \times CV_{\ell mn} \times \eta_{\ell mn}) \times UC_{\ell mn} \right]
\]

where \( \ell \) represents the energy resource, \( m \) the technology for its utilisation, \( n \) the end use form of energy, \( RU_{\ell mn} \) represents the quantity of primary energy resource utilised through a path \( \text{lmn} \) in a year, \( CV_{\ell} \) the calorific/energy value of \( \ell \)th fuel, \( \eta_{\ell mn} \) the overall efficiency of conversion of the primary energy resource to useful energy through path \( \text{lmn} \) and \( UC_{\ell mn} \) the unit cost of useful energy obtained through path \( \ell mn \). The results indicate that as long as grid electricity is available at lower prices, it is unlikely that any other energy conversion path would be used to power the rice mill. For meeting the thermal energy demand, husk would continue to be used till it is available as a free resource. Once more profitable uses of rice husk come into practice, use of coal, if available locally, or even solar energy may be financially viable.

**ACKNOWLEDGEMENT**

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**REFERENCES**


Table 1. Energy demand of rice processing operations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Operation</th>
<th>System/Method</th>
<th>Energy Demand, MJ/t</th>
<th>Raw</th>
<th>Parboiled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Milling*</td>
<td>Huller</td>
<td>144</td>
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<td></td>
<td></td>
<td>Sheller</td>
<td>108</td>
<td>123</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Modern mill</td>
<td>79.2</td>
<td>90</td>
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<tr>
<td>2.</td>
<td>Parboiling*</td>
<td>Single steaming</td>
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<td>241</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Double steaming</td>
<td></td>
<td>391</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open drum</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Hot soaking and steaming</td>
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<td>425</td>
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<tr>
<td></td>
<td></td>
<td>Pressure parboiling</td>
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</tr>
<tr>
<td>3.</td>
<td>Drying*</td>
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<td></td>
<td>827</td>
<td></td>
</tr>
</tbody>
</table>

* Demand is for mechanical energy indicated in terms of electricity i.e. MJ/ tonne of paddy
# Demand indicated is useful thermal energy demand in terms of MJ/ tonne of paddy; In addition, mechanical energy @ 28.8 and 86.4 MJ/t may be required for material handling during parboiling and drying operations respectively.

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**Fig. 1. Annual energy saving potential (esp) of energy efficient motors as a function of rice mill capacity.**

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Fig. 2. Variation of unit cost of electricity (UCE) with power rating at 2400 annual operating hours.

Fig. 3. Time variation of unit cost of useful thermal energy (UCTE) with annual fuel cost escalation @ 10%.