# Renewable Energy

# Curriculum Design

# for Schools

## Potato Cooking as Science Education
## For Primary and Secondary Schools

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## ABSTRACT

A training module providing an example of a school curriculum in the area of energy conservation in households by comparing three different cooking methods for potatoes. The exercise can be undertaken in the classroom or as homework. By undertaking the exercise at home, the families of the students will also be involved and obtain direct practical knowledge. Lower cooking energy needs in rural areas has an important positive gender impact. Through participatory and real case demonstration, primary schoolchildren learn about the different amounts of energy used for different cooking methods. Secondary school students can use the same analysis, but more precise calculations and better understanding of kitchen energy can be developed. The methodology can be replicated for other types of cooking, such as for rice, beans and traditional dishes.

**Note:**
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# INTRODUCTION

In Nepal, firewood for cooking is energy requirement number one, especially in the rural areas. Energy for cooking food accounted for over 95% of all energy consumed in Nepal[1] in 2000. That energy use is estimated to be: 77% from firewood, 6% animal dung cakes, 4% agricultural residues and about 8% kerosene fuel and gas (LPG and biogas). It is usually the woman's task to collect large quantities of firewood, often from afar, to meet their cooking energy needs. This task demands an ever increasing effort and cost, often needing more than 20 hours hard labour per week. In addition, poor quality stoves cause respiratory diseases among women and children sharing the kitchen area.

Cultural behaviours are passed along from parent to child and in doing so become embedded as accepted practices in the daily life. For that reason they are very difficult to change. Methods of food preparation and eating customs are strongly embedded habits and traditions, learned at an early age, and are prevalent in the society as a whole. For this reason schoolchildren need to learn better methods at an early age and the reasoning needs to be properly explained. This is best done in a practical and demonstrative way, by which the students can realise the study themselves.

Traditional energy resources are reducing with deforestation. With the continuous increase in the cost of other non-renewable fuels (imported kerosene, LPG), we seriously need to look at our food preparation and eating habits in order to save some energy. Each reduction in the amount of firewood used implies less work for the women. In urban areas, decreasing cooking time means savings in cost of kerosene or bottled LPG.

This training module provides an example of a school curriculum in the area of energy conservation in households by comparing three different cooking methods for potatoes. The exercise can be undertaken in the classroom or as homework. By undertaking the exercise at home, the families of the students will also be involved and obtain direct practical knowledge. It provides an insight into the differences in energy consumption associated with different cooking methods, and how this can be communicated to students.

**Doing is Learning**

Through participatory and real case demonstration, primary schoolchildren learn about the different amounts of energy used for different cooking methods. By measuring in a simple way the different energy quantities consumed in food preparation, students may better understand how energy can best be used. By making the learning exercise fun to do, the students will be more apt to remember the lesson. The training module provides some basic experience on research and helps students to look critically at their own environment. With changing times and economics, some habits need to change to adjust to the economy of our daily life.

Students can draw some simple lessons from the exercise. For secondary school students the module can be expanded with more advanced energy calculations and by putting the figures into a national context. Educationalists can use the present module as a model to develop other curricula based on the daily needs of people, covering various aspects of household technology and energy use. The method can be replicated for other types of cooking, such as for rice or beans.

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[1] Statistics Ministry of Energy and Water Resources, year 2000/2001. Total residential consumption was 301,410 x 1000GJ, with total energy consumption being 339,015 x 1000GJ

# PART I ~ PRIMARY SCHOOLS

## 1. ORGANISATION

Many schools in developing countries do not have science laboratories nor a science education programme. Yet science education can be practical and beneficial for the lifetime of the students.

When this module was first proposed for use in a Nepali primary school, several problems arose:

a. The activity was considered extracurricular because the existing educational programme did not include this kind of practical science education.
b. The activity was time consuming, considering preparation, implementation and cleaning up.
c. The activity required use of a fire inside the classroom, boiling water and sharp knives; all elements that may be considered dangerous.
d. The activity requires the use of a pressure cooker. Although almost every family in Nepal (with a large population living above 1500m altitude) owns a pressure cooker, these are in the current situation not allowed to be transported[2].
e. There is a substantial shortage of teaching staff.
f. Schools often have financial problems of buying small supplies for teaching purposes.

After reviewing this training module, the teacher of one primary school discussed the idea with the students of the highest class and proposed to do the exercise at home. Some of the students volunteered and took the instructions home to try the different tests in their own kitchen.

The special advantage of this innovative teaching method is that the families of the students also become involved, providing immediate dissemination of the ideas and creating the desired energy impact with the application of low-energy cooking methods.

When presenting and discussing the results in the classroom, the selected students benefit additionally by learning how to do a presentation in front of a group of peers. The other students hear real case studies of their classmates and not a theoretical story. When five different students from five different households recount the same energy reduction effect of the applied method, other students will accept the idea and recount the story at home. This can result in the immediately application of new cooking habits in the households of the other students.

In order to motivate the students to realise the experiment in their own kitchen, the teacher should first do the experiment him/herself at home. This way it will not be a theoretical exercise from a book, but a replication of a personal experience of the teacher.

With the teacher's own experience, other products can be tested, such as determining the most energy efficient method of cooking rice and beans, a staple food for many Nepalese. The use of the thermo storage box (hay box) and other energy-saving methods can follow suit.

The training module can become a first unit in a new form of home economics teaching.

[2] From the beginning of the Maoist insurgency, pressure cookers were used for making bombs. This caused the central government to ban the sale of pressure cookers outside the capital. When security personnel find a person on the street in possession of a pressure cooker, problems can arise.

## 2. PREPARATION

To allow ample participation, the best training is conducted for a group of 12-16 students. Larger groups should be split in two. If the students do not participate, their learning experience will be far less than when they actually undertake an activity by themselves. The teacher who is presenting the training exercise needs to ensure that the following technical implements are ready the day before:

- A well ventilated classroom in which one or more gas stoves can be lighted. Safety measures: the gas stove should stand firmly on the floor or on a stable table. An LPG gas stove should be used, not a kerosene burner[3].
- The gas stove should have a medium-size flame, not a large flame; otherwise too much heat will escape along the sides of the cooking pot.
- When the testing process needs to be speeded up, three similar gas stoves can be utilized.
- The classroom should have a sink with a running water tap. Alternatively two buckets are required; one filled with water, the other empty for the waste water. The potatoes need to be washed after peeling. Water is also needed for cooking and washing hands.
- A large pail is required for washing several kilograms of peeled potatoes.
- 3.5 kg potatoes all of the same sort and freshness, including several large 10cm (4") potatoes.
- A small knife and a potato peeler (thin-peeler). Potato peelers are sometimes available in household appliances shops.
- Two cooking pots of similar material and thickness (4 litres each). The cooking pots should have a good closing lid.
- One pressure cooker having a volume of 4 litres.
- A transparent liquid measuring cup of minimal one litre.
- One precise kitchen scale with a 1-gram division. The electronic kitchen scales are best. If a kitchen scale with a 10-gram division is used, the measurements will be substantially less accurate, but will still be demonstrative.
- Clock or watch with a second hand for precise time measuring.
- Matches for lighting the stove.
- Potholders.
- A blank copy of the record table (see annexe).


The teacher can organise having the students bring most of the above items to school, thereby increasing the participation of both the students and their parents. The classroom needs to be organised in such a way that students can have a good view of what is happening and can hear the explanations.

When the exercise is done at home, accurate measurements need to be assured.

[3] The kerosene burner needs to be pumped regularly, causing excessive fluctuations in the gas flow and heat output of the flame.

# 3. ORGANISATION OF THE ACTIVITY

The group can be divided into two groups, the cooks and the observers. The observers' task is to write down the quantities, weights, times, etc. The teacher can assist them in providing the following table for them to fill out.

| Description | Knives | Peelers A | Peelers B |
|---|---|---|---|
| Total weight of all potatoes supplied | gram | gram | gram |
| Net potato weight after peeling | gram | gram | gram |
| Net weight of potato peels | gram | gram | gram |
| Percentages of peels calculated | % | % | % |
| Peeling time in minutes | minutes | minutes | minutes |
| Percentages of time calculated | % | % | % |
| **Activity** | **Pot Large Potatoes** | **Pot Small Potatoes** | **Pressure Cooker** |
| Net weight of potatoes in each pot | gram | gram | gram |
| Net weight of water in each pot | gram | gram | gram |
| Cooking time in minutes high gas | minutes | minutes | minutes |
| Cooking time in minutes low gas | minutes | minutes | minutes |
| Standing time with pressure | xxxxxxxxxxxxx | xxxxxxxxxxxxx | minutes |
| Percentages of cooking time | 100 % | % | % |
| Net weight of water after boiling | gram | gram | gram |
| Net amount of water used in boiling | | | |
| Percentages of water used in boiling | % | % | % |

When filling the pot of potatoes with water, the top of the water should be equal to the top of the potatoes. Keeping the lid on the pot will ensure that all potatoes will be cooked evenly.

During the cooking process the gas flame should be lowered if the content has come to the boiling point. This should also be done at home, otherwise the water will bubble out of the pot. Keeping the lid on the pot while cooking is important.

For precise measurements, the difference of gas flow/consumption between high and low gas should be known. In the annexed table, this is estimated at 60%.

For primary schools, the differences between the cooking times are to be noted and discussed. The difference in gas use is the difference in energy use and cost.

More advanced calculations and activities can be developed by the teacher for secondary school students. In such a case the weight of the cooking pots and the temperature of the water before and after cooking needs to be measured as well.

# 4. THE COOKING EXCERCISE

The activity should be explained to the students before the exercise is performed – what has to be done and why. After the activity the implications of the measurements are to be explained. For example: in primary schools the function and operation of the pressure cooker should be explained and why using a potato peeler is more economic than a knife.

In secondary schools the understanding of calculating in Joules or kcal needs to be explained. The importance of taking accurate measurements before and after cooking needs to be stressed, as well as the water and pot temperatures. The influence of measuring tolerances can be elaborated upon.

In a large or well equipped school laboratory, the three tests can be realised simultaneously. In a house it may take two or three weeks before the different test are completed, especially when potatoes are not eaten daily.

After cooking, the consistency (softness) of the potatoes in the two pots and the pressure cooker needs to be the same. This requires some experience to obtain. If in one pot (after cooking) the potatoes are still firm and in the other pot the potatoes are boiled to mush, the comparative study becomes invalid. This requirement of a similar end cooking result also demands that all the potatoes are the same sort[4] and freshness.

The example exercise table at the end of this paper gives an idea about the different cooking times. Especially with the pressure cooker, some pre-testing may need to be realised because checking the consistency of the potatoes during the pressure cooking period cannot be made.

A practical quantity for the tests is about 1 kg of peeled potatoes per 4-litre cooking pot. For three tests about 3.5 kg potatoes are needed, allowing for the loss weight of the peels.

4.1 Peeling Exercise

After measuring the total weight of potatoes available (≈ 3.5 kg), the whole portion is split in two. One group of students peels the potatoes using ordinary knives, while the other group uses the potato peelers (thin peelers). The peels from each group are to be kept separated. By peeling the potatoes in two different ways, the differences can be observed and commented upon[5]. At this point, the potatoes are only peeled, not cut into smaller pieces. Once completed, the peels of each group are weighted. The time it took in peeling the potatoes can also be recorded. The weight of the two different groups of peels, as well as the peeling time, are noted down. All the potatoes are now washed.

4.2 Make Three Portions

The potatoes are separated into three portions, each having about the same weight (3 x ≈1 kg). One portion of the largest potatoes is placed into one of the cooking pots; these potatoes are kept whole (≈1 kg). The second two portions of potatoes are cut into pieces or cubes measuring about 2-2.5cm (1") in thickness (2 x ≈1 kg). Half of the small pieces (cubes) are placed into a second cooking pot (≈1 kg), and the other half into the pressure cooker (≈1 kg). The exact weight of the potatoes in each pot are measured and noted down.

[4] There exist many different type of potatoes in the world, some become mushy and others dry and crumbling after cooking. If students need to bring potatoes to the classroom for a test, these should be all from the same type. The colour of the potatoes can be used for identification.

[5] With a potato peeler (thin-peeler), less peels are produced than with a common knife. By precisely measuring each portion of potatoes before and after peeling, a good insight can be obtained about the economy of a potato peeler.

4.3 Measure the Added Water

Fill the liquid measuring cup with exactly one litre of water. Water is added to each of the three cooking pots. The water level should just cover the potatoes. Once the water is added to one pot, calculate the volume. The large potatoes may require about one litre to cover, while the small pieces may require about half a litre for coverage. The pressure cooker requires only 50-100cc water, being one teacup or half a mug of water.

4.4 Size of Gas Flame

During the three cooking tests, the flame height should be exactly the same, otherwise the differences in time do not reflect the differences in gas used. For this reason the kerosene or petroleum burner (primus) should not be used, because here the apparatus needs to be pumped up regularly, changing the size of the flame and its temperature. The differences in time are best measured with a moderate gas flame. When two levels of gas flame are used (a lower gas flame after the water comes to the boil), the two times should be measured. The students need to know that cooking on a low flame, which remains under the pot, is more energy efficient than a wide flame which goes up alongside the pot.

4.5 Keep the Lid On

The two pots with large and small cut potatoes are cooked with the lid on the pot. Always cook with the lid on the pot as less energy is lost in this way. For this reason the flame must not be very high because it will cause the water to boil over.

4.6 Cooking Time

The exact cooking time required until the potatoes in the pots are soft is recorded. Once the pressure cooker has come to full pressure (the weight is dancing with steam escaping), it needs to stay on full pressure (steam) for about three or four minutes. The time it takes to come up to full pressure, plus the three or four extra minutes should be noted down. The pressure cooker is then taken off the heat to cool off. This may take about five minutes. The cooking process continues inside the pressure cooker due to the pressure, but it does not use gas. The pressure cooker is left untouched until the over-pressure is fully down.

4.7 Pressure Cooker and Thermo Box

When the pressure cooker has come to full pressure (steam), it can immediately be placed inside a thermo box (hay box)[6] for keeping warm. Alternatively, the hot pressure cooker can be wrapped in a thick blanket immediately after it is taken from the fire. In both cases the additional three or four minutes are not required. The additional cooking period of the potatoes is extended because of the insulation (the pressure goes down very slowly).

4.8 Testing the Consistency

Test the consistency of the potatoes with a fork or knife. The centre of the large potatoes must have the same softness as the smaller cubed potatoes. It is estimated that the small cut potatoes take about 10 minutes, while the large potatoes take about 20 minutes to cook. After cooking to the right softness, the remaining boiled water is drained into a measuring cup and the amount recorded[7].

4.9 Serving

The cooked potatoes are served to the students, which will increase the pleasure of the exercise. Butter or other dressings can be added for taste.

4.10 Cleaning Up

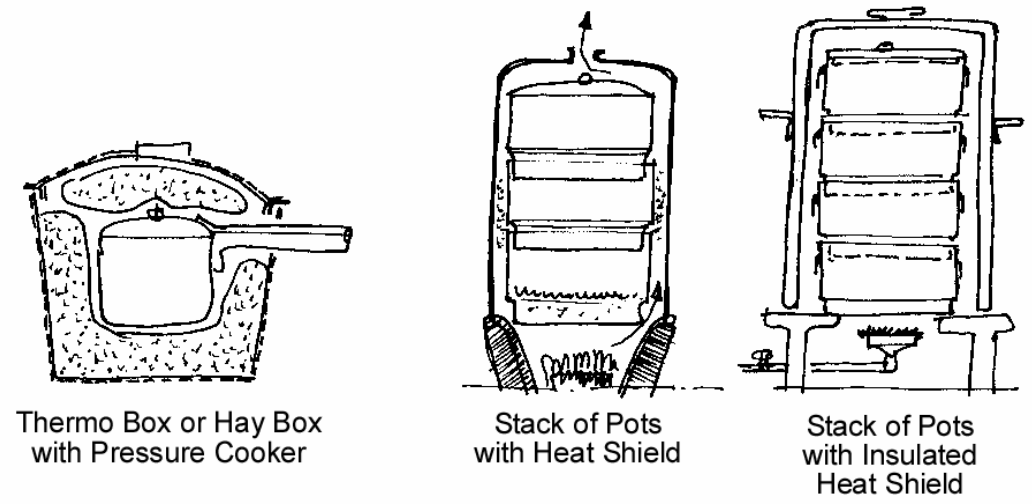
[6] The thermo box or hay box principle can be explained in the classroom.

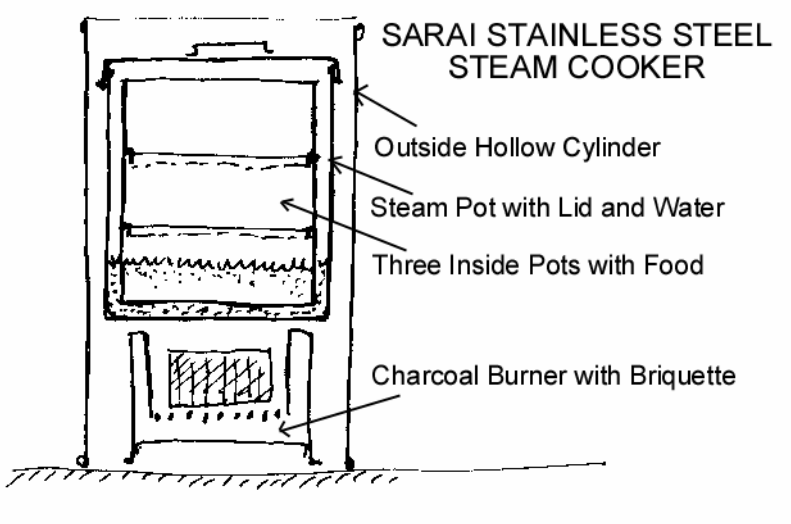
[7] The amount of water from the pressure cooker will be very small and can be used as a basis for making a sauce. This way no water containing possible nutrients will be lost with the pressure cooker process.

4.11 Class Discussion

The different aspects of the exercise should be discussed with the students:

- ◊ What is the difference in peeling time and weight of the peels when normal knives and potato peelers[8] are used?
- ◊ What is the difference in cooking times of the different sizes of potatoes?
- ◊ What energy conservation measurements can be taken at home?
- ◊ What implications does this have for cooking in general?
- ◊ In what other types of dishes can this knowledge be applied?
- ◊ What did you like about the exercise?
- ◊ What other methods exist in reducing the energy used for cooking?
- ◊ Why are Chinese dishes often cut into little pieces?




The Sarai cooker has been designed by Appropriate Rural Technology Institute (ARTI), Pune, India. The steam pot is filled with 150ml water and the cooking pots inserted. Because of the hollow cylinder, the steam pot is heated on all sides. This design makes cooking very efficient.

[8] In many communities the potatoes are cooked with the skin, thus saving more edible material.

# PART II ~ SECONDARY SCHOOLS

For secondary schools the curriculum can be extended with more complex measurements and scientific calculations[9].

The following table is extended with some energy measurements, for which the conversion factors can be discussed in science or mathematic classes.

- Cost calculations can be done in economics class.
- The macro-economic implications for the entire country can be assessed.
- Cost and energy reductions can be calculated if pre-heated water from a Solar Water Heater is being used instead of cold tap water.

| Description | Knives | Peelers A | Peelers B |
|---|---|---|---|
| Total weight of all potatoes supplied | gram | gram | gram |
| Net potato weight after peeling | gram | gram | gram |
| Net weight of potato peels | gram | gram | gram |
| Percentages of peels calculated | % | % | % |
| Peeling time in minutes | minutes | minutes | minutes |
| Percentages of time calculated | % | % | % |
| **Activity** | **Pot Large Potatoes** | **Pot Small Potatoes** | **Pressure Cooker** |
| Net weight of potatoes in each pot | gram | gram | gram |
| Net volume of water in each pot | cc | cc | cc |
| Net weight of water in each pot | gram | gram | gram |
| Percentages of water calculated | 100 % | % | % |
| Temperature of start water | Celsius | Celsius | Celsius |
| Caloric value of start water | cal | cal | cal |
| Cooking time in minutes high gas | minutes | minutes | minutes |
| Cooking time in minutes low gas | minutes | minutes | minutes |
| Total gas used in gram | gram | gram | gram |
| Standing time with pressure | xxxxxxxxxxxxx | xxxxxxxxxxxxx | minutes |
| Percentages of time calculated | 100 % | % | % |
| Amount of energy used Joule | Joule | Joule | Joule |
| Net volume of water after boiling | cc | cc | cc |
| Net weight of water after boiling | gram | gram | gram |
| Percentages of water calculated | 100 % | % | % |
| Temperatures of exit water | Celsius | Celsius | Celsius |
| Caloric value of exit water | cal | cal | cal |
| Amount of energy used in Joule | Joule | Joule | Joule |
| Weight of metal cooking pot | gram | gram | gram |
| Temperature cooking pot start | Celsius | Celsius | Celsius |
| Temperature cooking pot end | Celsius | Celsius | Celsius |
| Caloric value added to cooking pot | cal | cal | cal |
| Efficiency comparison per method | 100% | % | % |
| Cost calculations of energy. | NRs | NRs | NRs |

The annexed table can be analysed and some preliminary conclusions drawn.

[9] See the following website and its linkages for more detailed information on how to perform cooking tests: www.hedon.info/goto.php/MeasuringEfficiency.

# OTHER CURRICULUM DEVELOPMENT

Following the above model, several energy-related training modules can be developed for both primary and secondary schools.

A similar exercise can be done with cooking rice, having the following options:

- Normal, uncooked (but washed) rice on a gas stove.
- Pre-cooked rice on a gas stove, comparing costing and time economics.
- Using an electric rice cooker, with and without an insulated body.
- Cooking rice and using a hay-box or thermal insulation box.
- Cooking rice in a parabolic solar cooker or solar cooking box.
- The use of stacked cooking pots and an insulated cylinder over the stack of pots[10].

When we compare the differences of beans we can add the following tests:

- Beans cooked (for Daal-Bhaat) directly from the package into the pot.
- Beans first soaked for one night in water before cooking.
- Beans first soaked and, after bringing to cooking temperature, placed in the thermo box.

The economic implications of solar cookers and solar cooking boxes in combination with insulation boxes (hay-box) can be studied and the suitability in the rural areas or high altitude areas analysed.

Advantage points are that high altitude areas often have more (and more intense) sun radiation, whereas the availability of firewood is less. Firewood collection results in faster local deforestation at high altitudes and also aggravates soil erosion.

[10] The principle of a stack of pots and a metal (stainless steel or aluminium) cylinder closely (½-1cm gap) around the stack of pots has been used in Europe in times of energy shortage. See page 7.

Disadvantage points of solar cookers and solar cooking boxes are that these require sun during midday, need adequate space and must stand shielded from strong winds. In addition, cooking cannot be done in the kitchen. These cooking devices are useful for some types of cooking, but less suitable for other types[11].

Discussion point: How can the advantages be exploited and how can the disadvantages be reduced?

**Science Education Related to Own Environment**

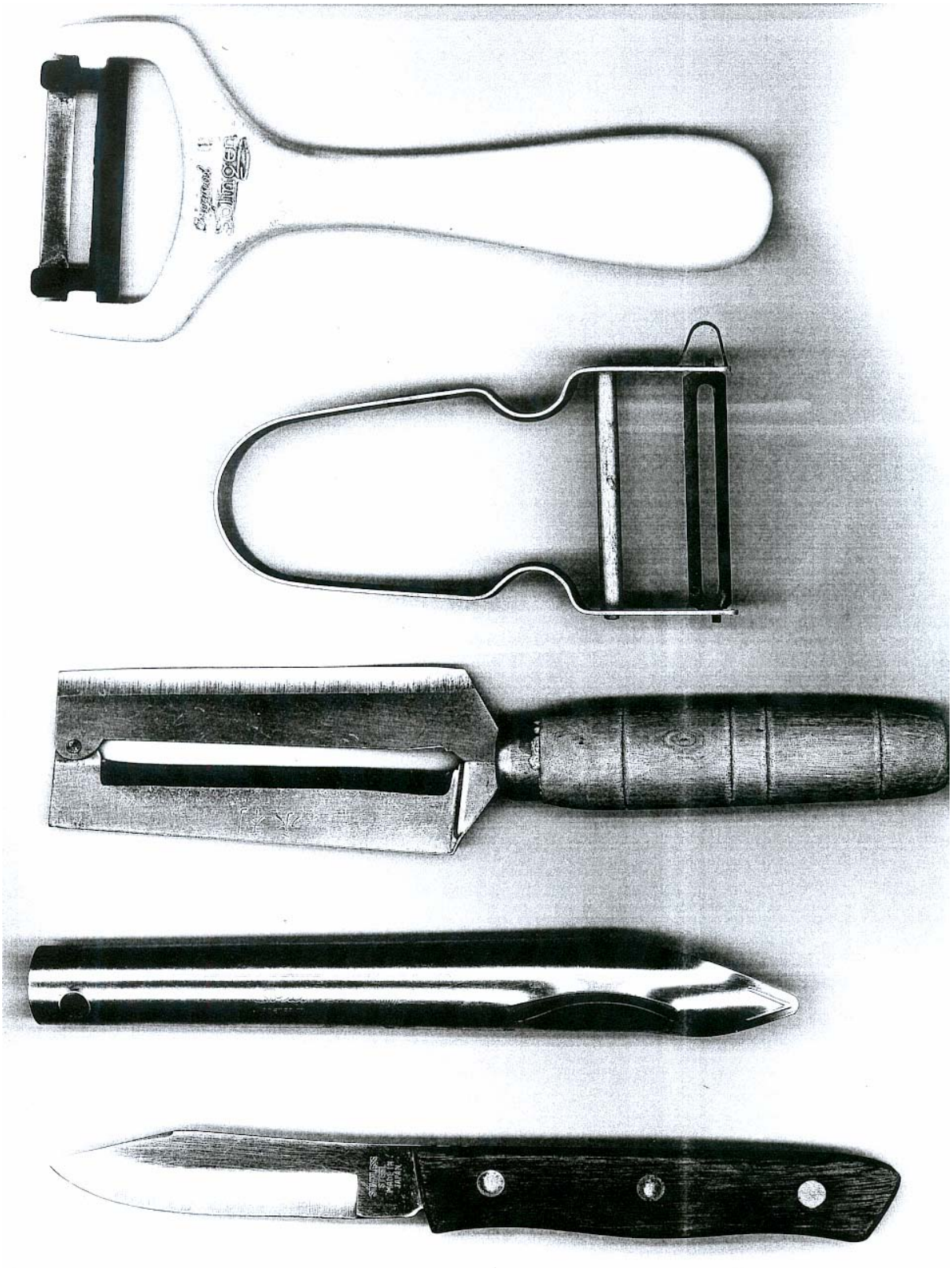
There may be a difference in science education between high and low altitude areas (the Hills or Terai). In high altitude areas the need for firewood may be greater than at low altitudes because forests grow slower. On the other hand, the population is larger in lower altitudes, requiring more energy as a whole.

Educational material should be developed which is closely related to the direct environment of the students. If you are living in a boat surrounded by water, it is useful to learn how to swim. If you are living in cold, high mountains, it is useful to learn how to stay warm.

[11] The solar cooker is very useful for pre-heating water in good quantities, as well as for slow cooking of a number of dishes. Dependent on the sun during the right hours, solar cooking can in sunny countries provide cooking energy for 30% or more of the cooking requirements. For frying, higher energy sources or better solar cookers are required.

# ANNEXE

Example of potato cooking exercise (Excel file, page 1 and 2).



Different types of potato peelers and one ordinary knife.

## HOUSEHOLD COOKING ENERGY ~ POTATO COOKING EXERCISE

Version: 25-05-2004

weight measured in grammes | formula | peel ratio is peels/gross weight in % | food/gas ratio is weight of food/gas in minutes

Starting temperature about 15 degrees Celsius | Cooking or process time in minutes

| Test number and sizes of cuttings in cm | Gross weight gram | Peels weight gram | Net weight gram | Water weight gram = CC | Pot and cover weight gram | Total weight pot and contents | Heating to boiling point | Heating to top pressure point | Continue boiling on 60% gas | Thermo box storage | Total minutes gas used | Weight drained water gram | Net weight of used water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *TEST 1 - Pressure Cooker* | | | | | | | | | | | | | |
| **2-3 cm pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCLUSION: | | | | | | | | | | | | | |
| *TEST 2 - Pressure Cooker* | | | | | | | | | | | | | |
| **2-3 cm pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCUSION: | | | | | | | | | | | | | |
| *TEST 3 - Pot with Lid* | | | | | | | | | | | | | |
| **Large pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCLUSION: | | | | | | | | | | | | | |
| *TEST 4 - Pot with Lid* | | | | | | | | | | | | | |
| **Large pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCLUSION: | | | | | | | | | | | | | |
| *TEST 5 - Pot with Lid* | | | | | | | | | | | | | |
| **2-3 cm pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCLUSION: | | | | | | | | | | | | | |
| *TEST 6 - Pot with Lid* | | | | | | | | | | | | | |
| **3-4 cm pieces** | | | 0 | | | 0 | | | | | 0 | | 0 |
| Results | peel ratio % | #DIV/0! | | | | | | | food / gas ratio | | #DIV/0! | | |
| CONCLUSION: | | | | | | | | | | | | | |