# BHUTAN

## ECOOKBOOK

## CLOSING THE GAP ON CLEAN COOKING


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Ministry of Energy and Natural Resources

MECS
Modern Energy
Cooking Services

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Data from: Bhutan Kitchen Laboratory CCT Report (2023)

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# ABBREVIATIONS

| | |
|---|---|
| **AEAS** | – Annual Environmental Accounts Statistic |
| **BLSS** | – Bhutan Living Standard Survey |
| **CCT** | – Controlled Cooking Test |
| **EPC** | – Electric Pressure Cooker |
| **G** | – Gram |
| **KPT** | – Kitchen Performance Test |
| **LPG** | – Liquified Petroleum Gas |
| **MECS** | – Modern Energy Cooking Services Programme |
| **MJ** | – Megajoule |
| **ML** | – Millilitre |
| **MT** | – Metric Ton |
| **NDC** | – Nationally Determined Contribution |
| **RGOB** | – Royal Government of Bhutan |
| **ToE** | – Ton of Oil Equivalent |
| **TSP** | – Teaspoon |
| **UNCDF** | – United Nations' Carbon Development Fund |
| **UNESCAP** | – UN Economic & Social Commission for Asia & the Pacific |
| **WBT** | – Water Boiling Test |

# ACKNOWLEDGEMENTS

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We would also like to express our appreciation to **UNESCAP** and **MECS** for leading this study with its focus on narrowing the clean cooking gap in Bhutan and offering recommendations to the government. The study is important in marking the potential of electric technologies to address indoor air pollution – that causes serious hazards to public health – and outlining the potential for long-term pollution free, zero-carbon and climate resilient development.

Finally, we would like to thank **Mr. Lam Dorji** of Kunfen Consult, Thimphu, for his consulting inputs and conscientious efforts in putting together this report.

# EXECUTIVE SUMMARY

This eCookBook records dishes that are typically cooked in Bhutan and presents data on energy consumption and cost, to set a benchmark of energy expectations and associated costs. This eCookbook was developed with **UNESCAP**, in collaboration with the **Modern Energy Cooking Service Programme** (MECS) and supported by the **Royal Government of Bhutan**.

For this study, nine local dishes - **3 meat, 3 cheese, and 3 vegetable dishes** – were selected, covering many popular dishes across different ethnic groups, and reflecting the wide Bhutanese palate. LPG, infrared, and induction cook stoves were considered for the **Controlled Cooking Tests** (CCT), based on testing common popular cooking technologies used by the Bhutanese population. An Electric Pressure Cooker (EPC) was also used to test its versatility and performance in cooking two energy intensive local meat dishes.

At the end of the CCTs, a comparative analysis of the data was carried out and the findings were:

1. All dishes cooked **faster on LPG (30-40% less time)** than electric stoves. But in terms of energy consumption and cooking cost, **LPG stoves were observed to be most fuel inefficient and least cost-effective.**

2. **Induction stoves were found to be 70% more energy efficient than LPG stoves and about 43% more than infrared stoves.** Using a stove-top pressure cooker with an induction stove can substantially reduce energy usage and cooking time. However, this **efficiency can be affected by the steel grade of the outer layer of the bottom of the pot**. It is recommended to use 430 grade stainless steel to maximise efficiency.

3. The EPC took 27 – 35 minutes more time to cook meat than on the other stoves but the EPC was **60 percent more energy efficient, over 40 percent cheaper than the two electric stoves, and 2x cheaper than an LPG stove**. The **EPC was most cost effective when cooking dishes that require a long cooking process (big energy savings on boiling).** Although it has a range of functions, dishes which require deep frying were not possible to cook using the device.

4. The cost sensitivity analysis results also showed that **even with an increase of the electricity tariff to BTN 7.75/kWh, from the current level of BTN 2.678/ kWh, it is still more cost-effective to use an induction stove or EPC than LPG**.

5. Time taken to cook was directly affected by (a) **the power rating of the burner** (high power shortens cooking time; low power takes longer cook), (b) **efficient heat transfer to the pan** depends on the size of the pan used compared to the size of the flame/heating surface, and (c) **quantity of the dish cooked**. For the electric stoves, it was observed however, that **irrespective of the burner power rating, the cooking energy consumption patten** remains the same (change in burner power ratings do not alter the actual energy consumption pattern).

The CCT results show **shifting from LPG to electricity as a primary cooking fuel is efficient and cost effective for the Bhutanese populace.** Shifting to electric cooking will help Bhutan: **(a) reduce reliance on imports;** and **(b) move towards a greener energy regime** and towards its commitment to remain carbon neutral.

# BHUTAN

## ELECTRICITY ACCESS & CLEAN COOKING OVERVIEW

Bhutan has near universal access to electricity, a surplus of generation, and 100% of its electricity comes from renewable sources.

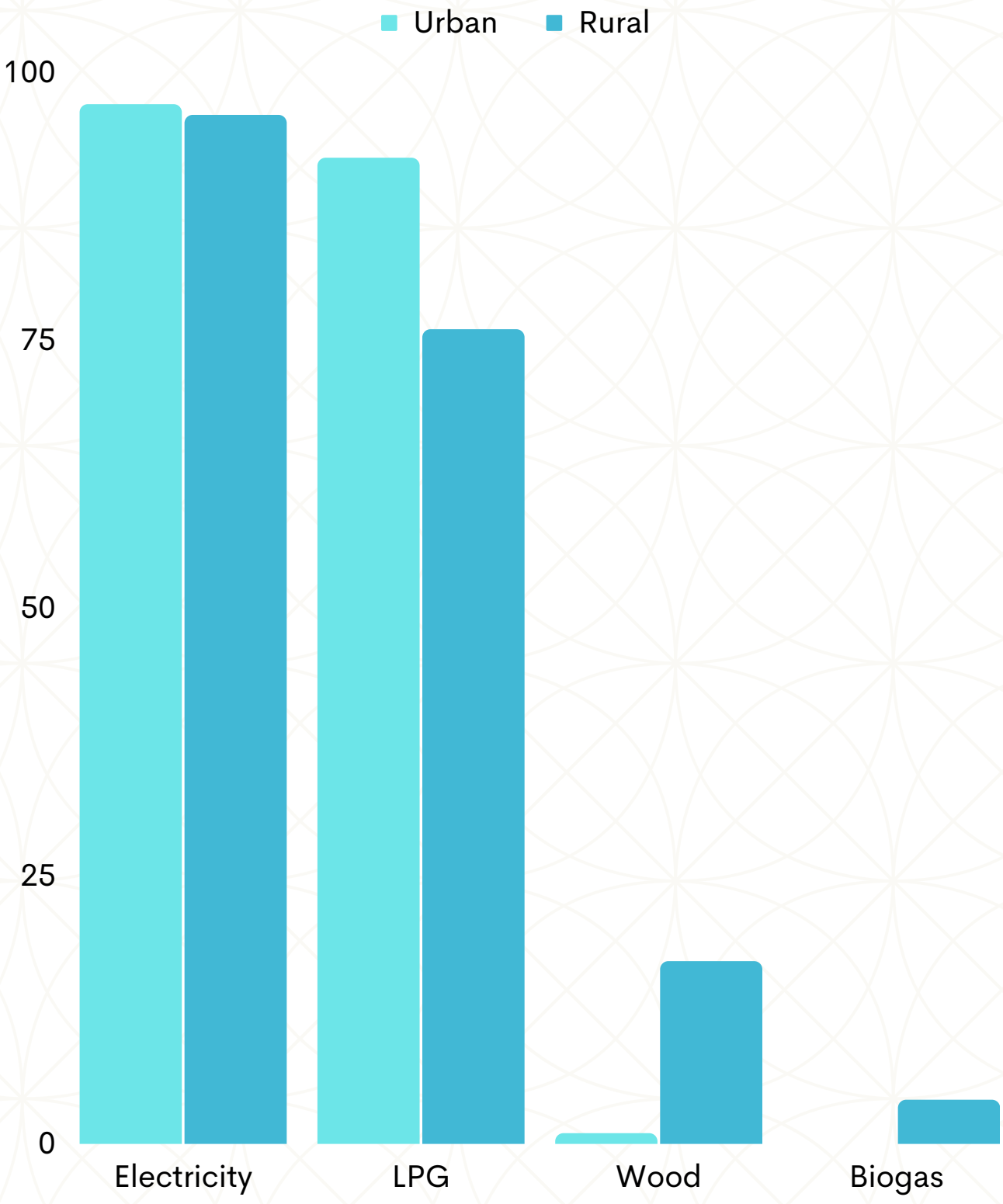
Access to clean cooking fuels has reached over 80%.

**20%** Gap between access to clean cooking and those with access to electricity (almost 100% access to electricity, 80% clean cooking).

Promoting clean cooking stoves, despite a higher up-front cost, has been the number one priority of the Government in order to achieve 100% access to clean cooking by the end of this decade.

# COMMON COOKING FUELS

Fuel stacking with electricity and LPG is common in Bhutan. Wood is used almost exclusively in rural areas. Few people use other fuels such as biogas and rarely, if ever, dung or coal.



# ELECTRICITY

**Electricity is the most widely used source of energy for cooking in both urban (97.0%) and rural (95.9%) households**. Under Bhutan's "Electricity for All" initiative, all urban households have access to electricity, and 99.5 percent of rural households have access to electricity.

# LPG

**A high proportion of urban households use LPG (92.1%) as a source of energy for cooking** although it is less commonly used in rural households (75.96%). Bhutan has no petroleum nor natural gas reserves so fossil fuels are imported from India, for all domestic consumption. Bhutan imports an average nearly 10,000 metric tonnes of LPG per year. **Issues such as refilling and distribution persist in rural areas.**

# WOOD

Households in remote rural areas, like in Lunana Gewog, under Gasa Dzongkhag, depend heavily on firewood for cooking and heating, where grid electricity and LPG supply and distribution facilities are not available. **On average, each household consumes about 2.9 tonnes of firewood annually.** Firewood is a scarce resource and it can take one day to walk to-and-from with horses to collect the firewood. **A significant amount of women's time is spent on collecting firewood.**

# COMMON TYPES OF COOKSTOVES

Three types of cookstoves are commonly available in domestic markets and households:

## GAS/LPG STOVE

**uses a burner and LPG to create flames & cook food.**

- ▲ Not dependent on an electricity connection
- ▲ Good for Bhutanese food
- ▲ No specific utensil requirements
- ▼ Lower energy efficiency than electric stoves
- ▼ Imported fuel

## INDUCTION STOVE

**uses electricity & the magnetism of steel to directly heat cooking vessels.**

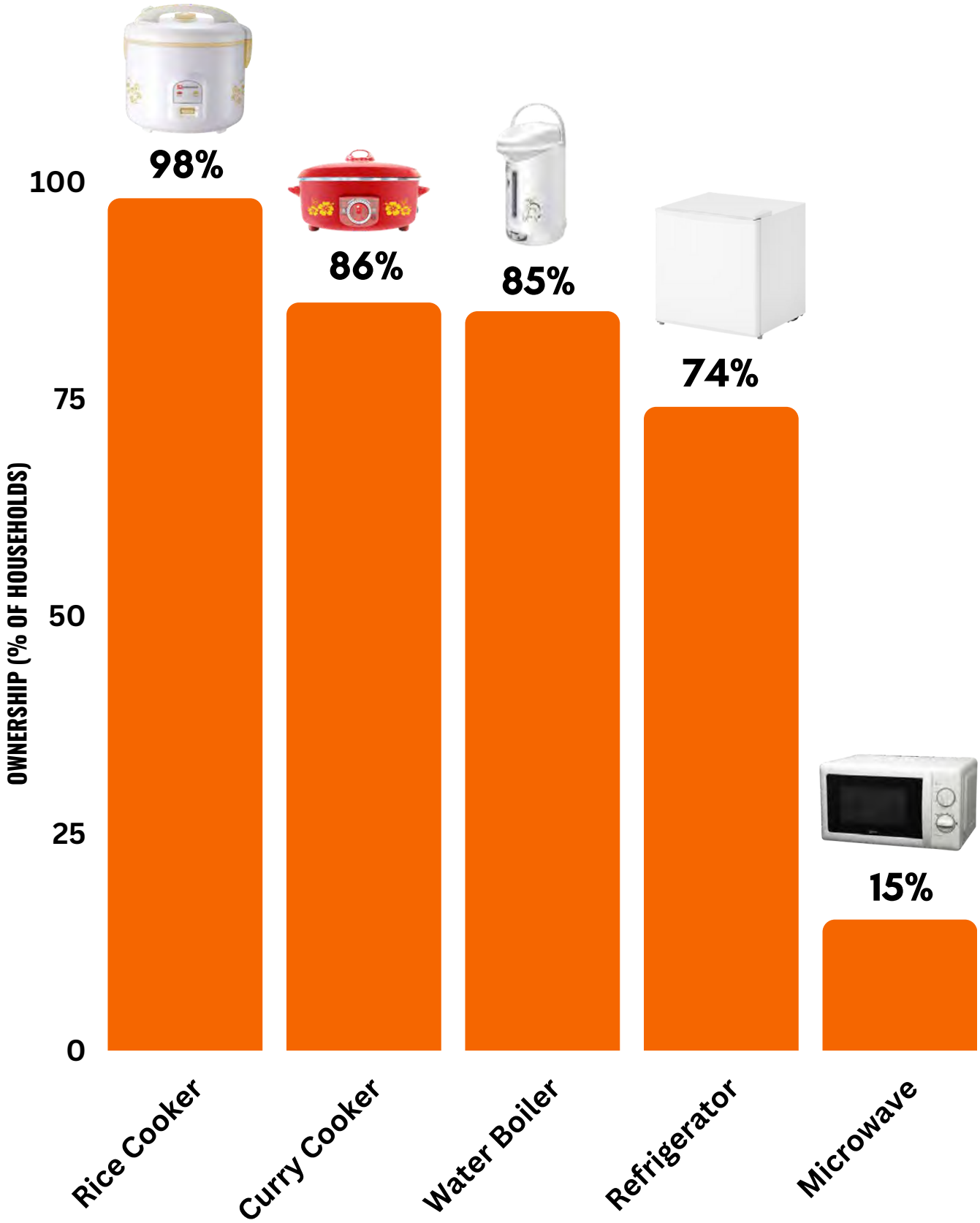
- ▲ No flames or red-hot elements
- ▲ Highly energy efficient (70% v LPG stoves)
- ▲ Heats vessel in contact and reduces injury
- ▼ Only compatible with ferromagnetic metals

## INFRARED STOVE

**uses electricity to generate heat and cook food with a resistance coil.**

- ▲ More energy efficient than gas stoves and more economical
- ▲ Releases less heat to surroundings
- ▼ Can cause burns when touched
- ▼ Needs flat surface utensils

# POPULAR KITCHEN DEVICES IN BHUTAN




*Data from Bhutan Living Standard Survey 2022, National Statistical Bureau

# BHUTANESE FOOD

Bhutan is known for being a tranquil land that is **rich in natural beauty and biodiversity.** This aura of exotic allure is reflected in its cuisine.

Like the country itself, **Bhutanese cuisine is unique**.

Local produce forms the basis of the cuisine and the prevailing characteristic of Bhutanese cuisine is spiciness: **chillies are a crucial ingredient in almost all dishes.** Bhutanese cuisine is dominated by ingredients such as red rice, buckwheat, and maize and local staples include dried beef, pork, lamb, yak meat, and various soups and stews.

To understand cooking cultures and energy consumption in Bhutan a variety of dishes were chosen; **3 meat dishes, 3 plain vegetable dishes, and 3 cheese dishes; covering staple and popular dishes across ethnic groups, reflecting the larger Bhutanese palate.**

These dishes were broadly grouped in 3 categories based on their cooking processes and food category to enable comparing cooking energy consumption pattern. **Recipe and energy consumption data is in the following pages...**

## MEAT DISHES

PHAGSA PAA
NORSHA PAA
JASHA PAA

## VEGETABLE DISHES

COPI TSHOEM
LA-PHU-MAB TSHOEM
MIX VEGETABLE

## CHEESE DISHES

EMA DATSI
SHAMO DATSI
KEWA DATSI

# KITCHEN LABORATORY

This e-CookBook is developed using Controlled Cooking Tests* (CCTs). **A CCT is a standard test methodology in the clean cooking sector that measures stove performance** when a cook prepares a pre-determined local meal. It is designed to assess stove performance in a controlled setting with local cooks, foods, pots, practices and fuels.

In May and June 2023, **three Bhutanese cooks** prepared selected dishes for a family size (4 people) testing **LPG, infra-red, and induction stoves** repeatedly (3x minimum). The **EPC** was also used to cook a few long-cooking dishes for comparison purposes. Detailed recipes capturing ingredients and cooking processes were recorded along with energy consumption and the time consumed cooking the dishes on different cook stoves. Additionally, observations of convenience, taste, safety, and usability were also recorded.

Most Bhutanese dishes' recipes can be cooked on different cook stoves without much difficulty. **Past studies showed that conventional cooking techniques waste energy in the cooking process, creating opportunities for modern appliances to reduce energy consumption.**

Bhutanese people are well aware of the benefits of using a stove-top pressure cooker with cooking stoves. They commonly cook - pork, beef, etc - that usually take far longer to cook in a conventional pot.

For these tests, pork and beef were cooked using a stove-top pressure cooker on all cook stoves in the kitchen lab, while other dishes were cooked in a pot with lid. An electric pressure cooker (EPC) was also used to cook these two meat dishes.

## Assumptions for CCTs

The **per-unit (kWh) cost of electricity used to calculate the cost of cooking is assumed as Nu.2.68** (BPC Power Data 2022).For electric cookers, an energy meter was used to measure electric consumption.

**For LPG, per-unit (kg) cost of Nu.71.13 was used**. A 14.2 kg weight cylinder LPG cost Nu.1,010 as per the Bhutan Oil Distributor outlet, Thimphu (June 2023). The equivalent electric consumption for LPG fuel was converted using its calorific conversion factors as:

**1 kg of LPG = 46.1MJ**
**1 kWh of electricity = 3.6MJ**

Comparative analysis of the cooking time, energy and cost data was undertaken and the findings are presented in the following pages.

**Electric Stove Power ratings:**
Infrared stove: 2200 - 2500W
Induction stove: 2000W
EPC: 900-1100W

*The CCT methodology used is detailed in "MECS Controlled Cooking Test (CCT) Protocol: version 1.2 May 2023", prepared by Dr. Jon Leary and Jacob Fodio Todd. Available online: www.mecs.org.uk


Weight
POWER
EUT
KWh
Surface remains hot after use, do not touch!
COOK

# MEAT

## NORSHA PAA
## PHAGSA PAA
## JASHA PAA

# PHAGSHA BAZUM

## (PORK GRAVY)

*Paa is a curry with gravy or a meaty stew. Phaksha Paa highlights a favorite item of the Bhutanese people – pork. This dish is made of pork slices stir-fried with whole dry red chilies or green chillies.*

| | |
|---|---|
| **290g** | **Pork fillet (cut into strips)** |
| **260g** | **Onions** |
| **270g** | **Tomatoes** |
| **250g** | **Fresh Green Chilies** |
| **1 tsp** | **Chili power** |
| **¼ cup** | **Vegetable Oil** |
| **2 tsp** | **Salt** |
| **500 ml** | **Water** |

*Preparation Time: 5 mins | Cooking Time: 28-39 mins | Serves 4*

**Prepare ingredients**

Wash the pork fillet and cut into strips // Chop onion, tomatoes and green chillies into quarters // Remove some of the seeds from the chilies for less heat, if desired.

**Cook pork fillet**

Add the pork strips, onion, tomato, a pinch of salt and water into the pressure cooker, turn on the heat and cook under pressure // Wait until the cooker whistles 10 times and then turn off the heat and release the pressure OR let it cool naturally till pressure cooker is de-pressurized.

**Finish stew**

Continue cooking with the lid open and wet fry the pork in its own oil till it is tender // Render out some of the fat oil if found excessive. Throw in garlic, green chilies & chilli powder (optional) into the pork and simmer over low heat till green chillies wilt // Can also add bok choy, works well!



**Serve**

Add handful of coriander leaves roughly chopped on top of the dish.

# NORSHA PAA

## (BEEF, GREEN BEANS & CHILLI)

*A famous meat dish in Bhutan cooked in a similar fashion to pork paa. The meat is always cut bigger or longer in size and it is cooked mostly with vegetables like radish, spinach, cabbage, potatoes, beans or just with lots of chilies. It is served with a little gravy.*

| | |
|---|---|
| **205g** | **Fresh Beef** |
| **70g** | **Onions** |
| **30g** | **Tomato** |
| **22g** | **Green Beans** |
| **50g** | **Fresh Green Chilies** |
| **2 tsp** | **Chilli power** |
| **¼ cup** | **Vegetable Oil** |
| **3 tsp** | **Salt** |
| **700ml** | **Water** |

*Preparation Time: 5 mins | Cooking Time: 37 mins | Serves 4*

**Prepare ingredients**

Rinse the tomato, beans and chilies // Cut tomatoes into slices and half the beans and chilies lengthwise // Rinse the beef, pat dry and cut into slices //

**Pressure cook**

Transfer beef into pressure cooker, add onion, salt, oil, water and pressure cook till we hear ten whistles or about 15 minutes // Turn off flame and wait till all the pressure from the pressure cooker is released/out (to be able to open the lid) //

**Finish stew**

Add tomatoes and beans and cook (do not pressure cook) till beans are semi-cooked // Add green chilies and cook for 5 more minutes, toss gently in between. Reduce flame to low and simmer while tossing //

**Serve**

Adjust the seasoning (salt) and serve.

# JASHA PAA

## (CHICKEN WITH CHILLIES)

*A famous Bhutanese dish prepared using on-the-bone chicken, garlic, onion, ginger, chilli and tomato. The dish is quite spicy (hot) as most Bhutanese dishes usually are.*

| | |
|---|---|
| **333g** | **On-the-bone chicken** |
| **68g** | **Onion** |
| **44g** | **Tomato** |
| **4 cloves** | **Garlic** |
| **70g** | **Fresh Green Chilli** |
| **3 tsp** | **Vegetable Oil** |
| **3 tsp** | **Salt** |
| **400ml** | **Water** |

*Preparation Time: 5 mins | Cooking Time: 30-38 mins | Serves 4*

**Prepare ingredients**

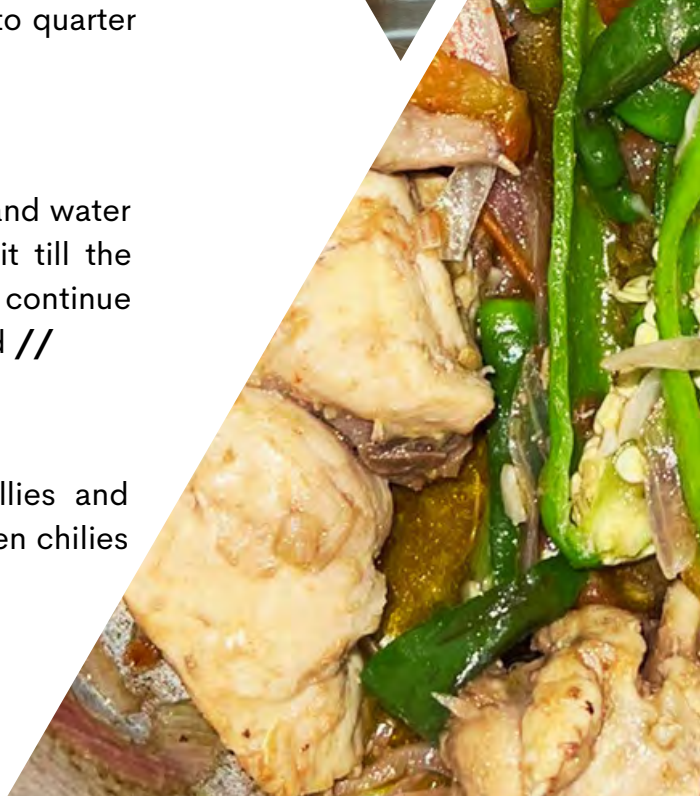
Chop chicken into cubes // Cut tomatoes into thin slices // Chop onion into slices // Cut green chilies into quarter // Smash the garlic //

**Cook meat**

Add the cut chicken, chopped onion, garlic, salt and water into the pot, turn on the heat and cook // Wait till the chicken is half-cooked // Then add tomatoes and continue till the chicken is soft and tomato has disintegrated //

**Wet Fry**

Once the chicken is soft, add fresh green chillies and simmer on low heat till the water dries up and green chilies skin partial burns // The dish is ready to serve //



# MEAT DISHES ENERGY CONSUMPTION

## PHAGSHA BAZUM (PORK GRAVY )

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 28 | 0.054 kg | 3.90 | 0.604 |
| Infrared | 39 | 0.611 kWh | 1.62 | 0.671 |
| Induction | 41 | 0.694 kWh | 1.84 | 0.732 |
| EPC | 69 | 0.439 kWh | 1.17 | 0.791 |

## JASHA PAA (CHICKEN WITH CHILLIES)

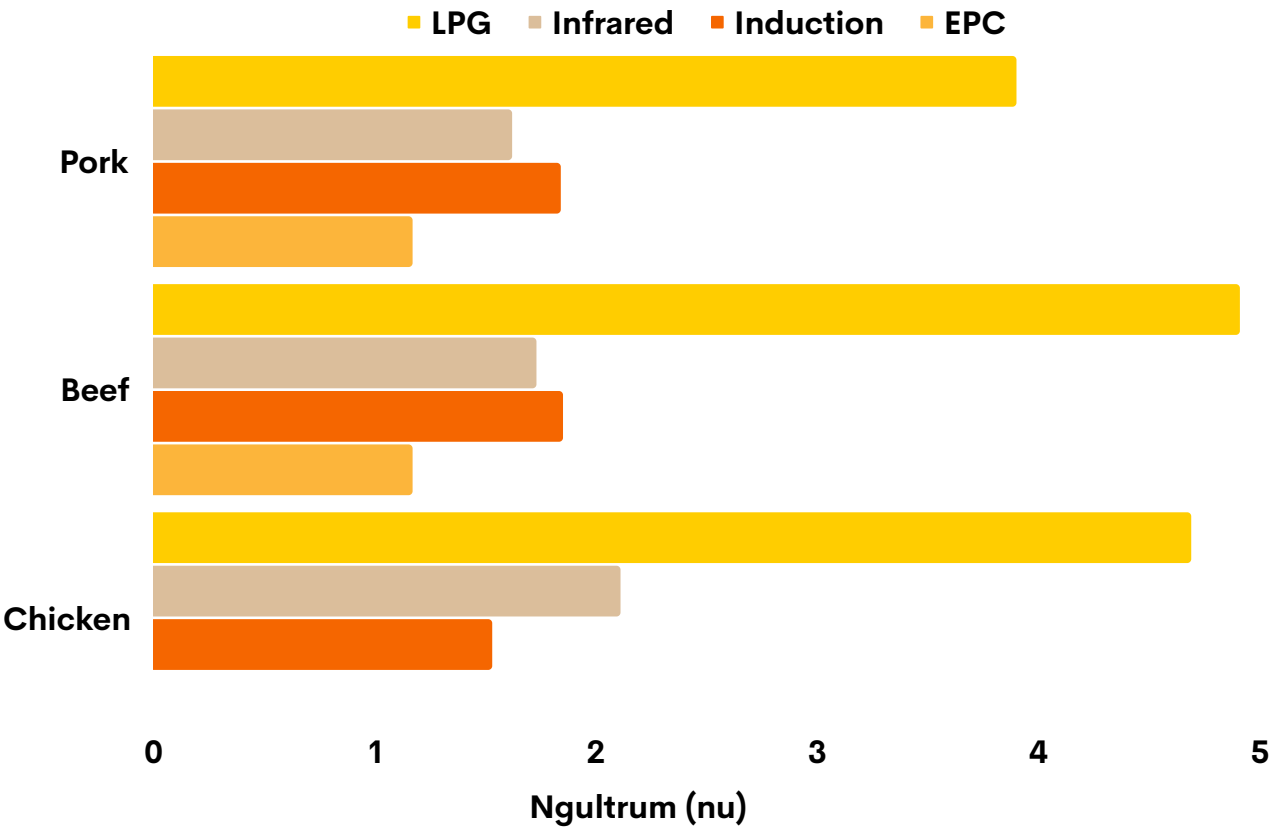
| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 30 | 0.066 kg | 4.69 | 0.440 |
| Infrared | 38 | 0.795 kWh | 2.11 | 0.347 |
| Induction | 29 | 0.576 kWh | 1.53 | 0.334 |

## NORSHA PAA (FRESH BEEF WITH BEANS AND CHILLIES)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 37 | 0.069 kg | 4.91 | 0.483 |
| Infrared | 42 | 0.649 kWh | 1.73 | 0.621 |
| Induction | 39 | 0.696 kWh | 1.85 | 0.652 |
| EPC | 66 | 0.431 kWh | 1.17 | 0.429 |

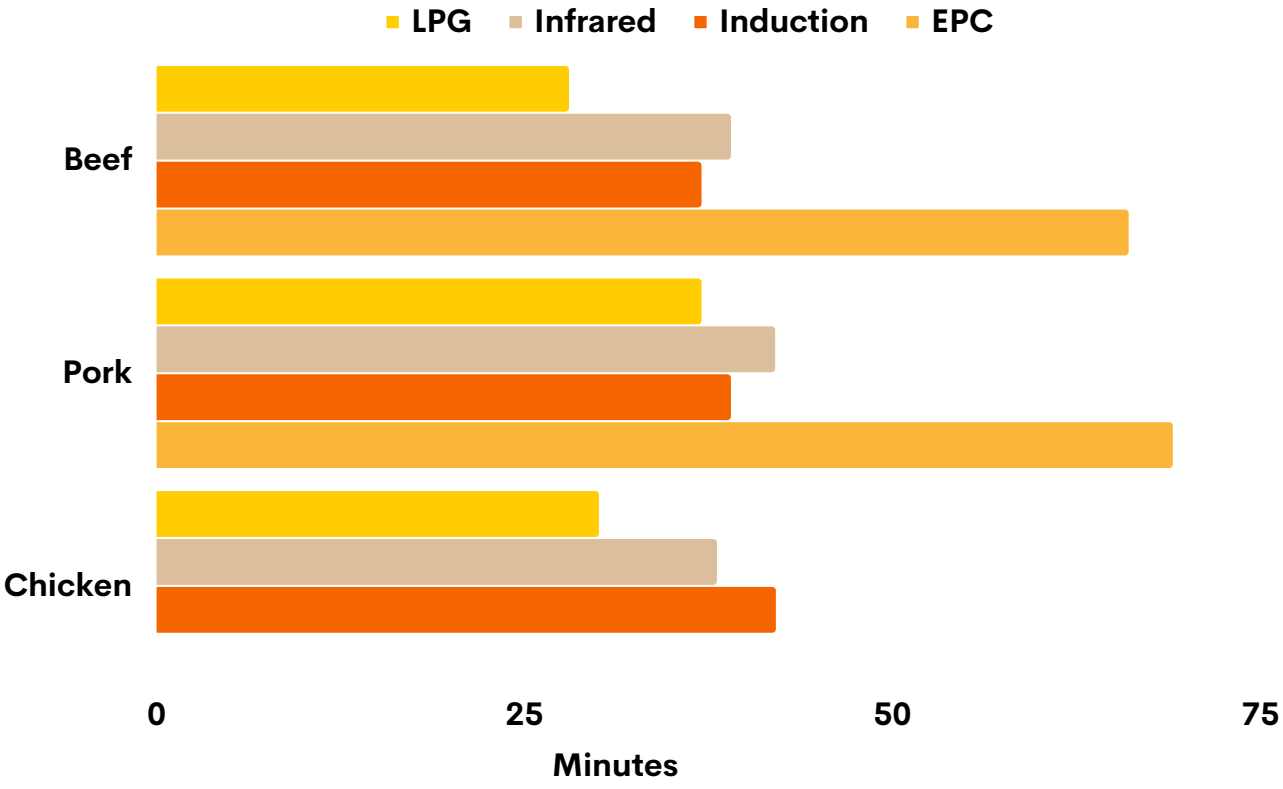
# COST OF COOKING COMPARISON - MEAT DISHES

*The energy savings of using an EPC, over stove-top pressure cookers, is demonstrated below with the pork and beef dishes which were part cooked under pressure. Greater time and energy savings could be made by maximising pressure cooking and minimising frying.*



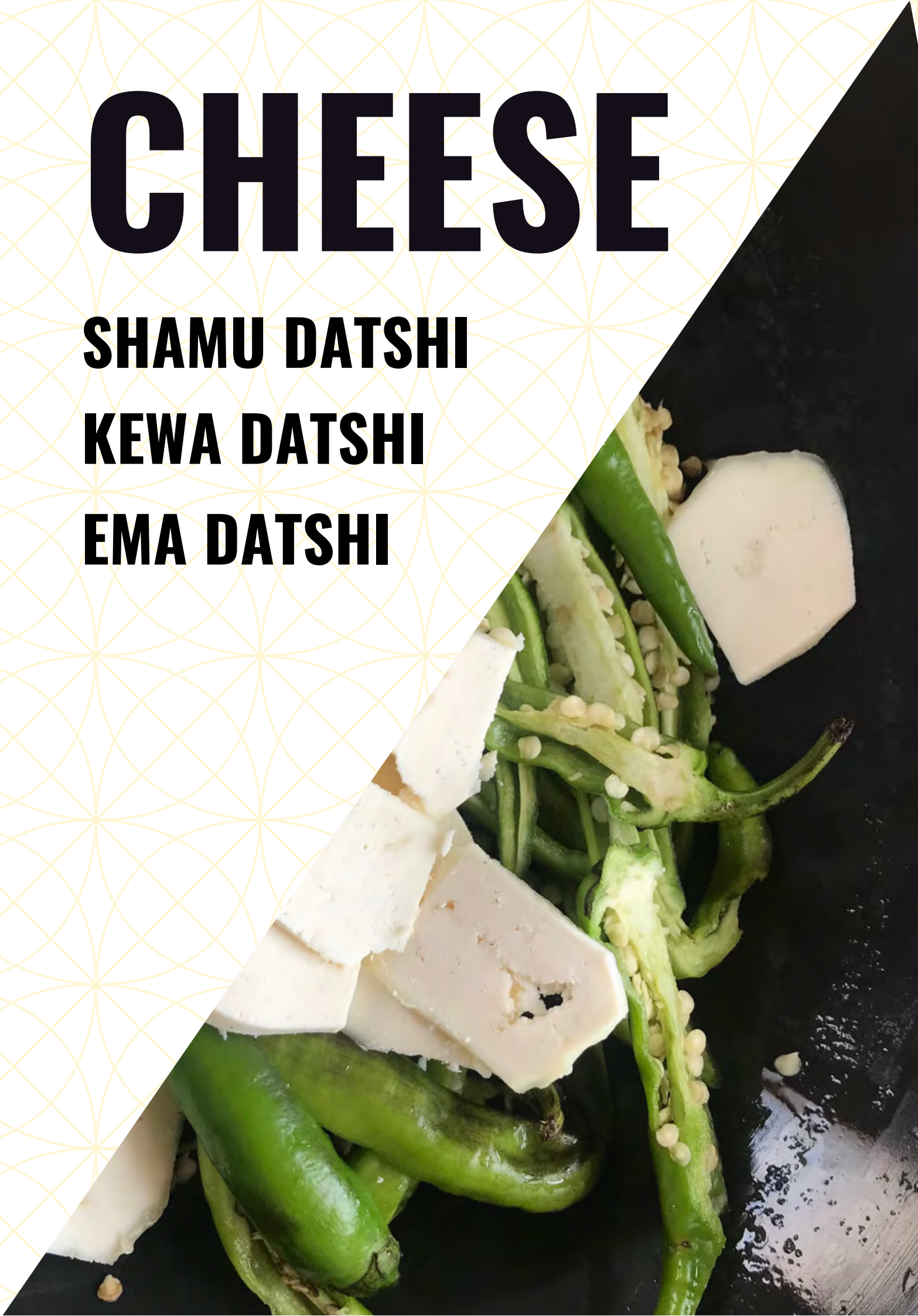

# COOKING TIME COMPARISON - MEAT DISHES

*The pork and beef dishes were part cooked using a stove-top pressure cooker on different stoves. These recipes were also tested using a EPC. However, a large part of the cooking process was with the lid open (see recipes), negating the time benefits of pressure cooking.*



# CHEESE

## SHAMU DATSHI
## KEWA DATSHI
## EMA DATSHI

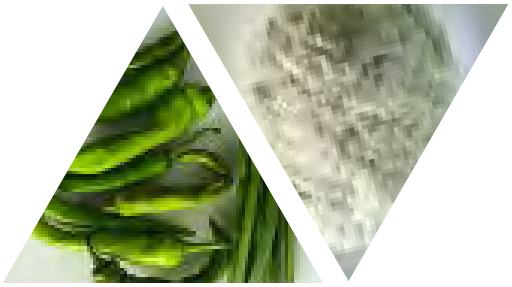


# EMA DATSHI

## (SPICY CHILLIES & CHEESE)

*The national dish of Bhutan is known as Ema Datshi. It is eaten throughout the country and is a fundamental part of most meals. Ema" means "chillies" and "datshi" means "cheese" in the local language, Dzongkha. The chillies, which can be either fresh green or dry red chillies are sliced lengthwise and cooked with datshi, and plenty of butter for good measure. The more you eat ema datshi, the more you'll realize that no two ema datshis are the same: every cook has their own version, some being lighter or more watery, others being richer and more sticky with cheese.*

| | |
|---|---|
| **120** | **Fresh Green Chilies** |
| **32g** | **Spring Onions** |
| **140g** | **Farm Cheese** |
| **25ml** | **Vegetable Oil** |
| **6g** | **Salt to taste** |
| **40ml** | **Water** |



*Preparation Time: 4 mins | Cooking Time: 6-10 mins | Serves 4*

**Prepare ingredients**

First thing first, rinse the chillies, onion or spring onion, and garlic // Cut the chillies in half lengthwise. Remove some of the seeds from the chilies for less heat, if desired // Chop the onion or spring onion & garlic into thin slices

**Cook ingredients**

Now, add all ingredients into a pot, along with one-quarter cup of water. Bring it to a simmer, cover and cook over low heat until the chili ingredients are cooked //

**Finish Ema Datshi**

Add butter (optional) and the cheese cubes by placing on top of the other ingredients // Cover the pot and simmer until the cheese has melted // Remove the lid and stir until combined // Check for salt, which will vary depending on how salty your cheese is //



**Serve**

Serve hot // If you are a spice lover, you could use more chillies //

# SHAMU DATSHI

## (MUSHROOM & CHEESE )

*Bhutan is precious with natural forests, home to different species of mushrooms. Locals go into the forest and collect garden-fresh varieties of mushroom especially during spring and summer.*

*Shamu Datshi is widely popular in Bhutan, not just because of its taste, but also because of its health benefits. Shamu is "Mushroom" and Datshi is "Cheese". This meal is extremely similar to Ema Datshi and is prepared similarly, except the primary ingredient is mushroom.*

| | |
|---|---|
| **85g** | **Mushroom Shitaki** |
| **30g** | **Fresh Green Chili** |
| **40g** | **Cheese** |
| **25ml** | **Vegetable Oil** |
| **5g** | **Salt to tase** |
| **300ml** | **Water** |

*Preparation Time: 4 mins | Cooking Time: 10-14 mins | Serves 4*

**Prepare ingredients**

Rinse the mushrooms and green chillies // Ensure the water is completely squeezed from the mushroom // Cut mushrooms in half (big size mushroom again into half) // Cut green chilies into half lengthwise //

**Cook ingredients**

Transfer all the cut mushrooms, green chillies, water, oil and salt together in a pot // Cover and cook on high heat till the mushrooms are half cooked // Add cheese, cover again and cook until the cheese begins to melt //

**Serve**

Without mixing, turn off the heat and let it sit for 2-3 minutes // Finally mix well, check salt and add more if needed. Garnish dish with coriander leaves //

# KEWA DATSHI

## (POTATO & CHEESE )

*Kewa Datshi is one of the famous dishes in Bhutanese cuisine. This dish is easy to prepare, requires very few ingredients and is delightfully testy.*

*The potatoes are typically sliced into thin pieces, then sauteed down with cheese and lots of butter or oil. Sometimes cooks will toss in a few chillies and tomatoes, but usually this is Bhutanese dish that's pretty mild, and focuses on potatoes and cheese.*

| | |
|---|---|
| **280g** | **Potato** |
| **10g** | **Fresh Green Chili** |
| **20g** | **Cheese** |
| **25 ml** | **Vegetable Oil** |
| **5g** | **Salt to taste** |
| **2.5 cups** | **Water** |
| **25g** | **Onion** |
| **40g** | **Tomato** |

*Preparation Time: 4 mins | Cooking Time: 10-14 mins | Serves 4*

**Prepare ingredients**

Peel the skin of the potatoes and wash // Cut the potato, onion & tomato, into thin slices // Cut green chilies into slices //

**Cook potato**

Put potatoes, onions & tomatoes together in a pot and add water and oil // Cover the pot with a lid and cook the potato on high heat until it is half cooked // Give a quick mix to prevent sticking to the pot and then add green chilies, cheese and salt // Cover again and continue cooking at high heat without mixing them until cheese is melted well //

**Serve**

Turn off the heat and let the dish sit for 1-2 minutes // Give a good mix and garnish it with chopped spring onion green leaves or coriander //

# CHEESE DISHES ENERGY CONSUMPTION

## SHAMU DATSHI (MUSHROOM & CHEESE)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 10 | 0.028 kg | 1.99 | 0.383 |
| Infrared | 14 | 0.303 kWh | 0.81 | 0.316 |
| Induction | 14 | 0.299 kWh | 0.79 | 0.323 |

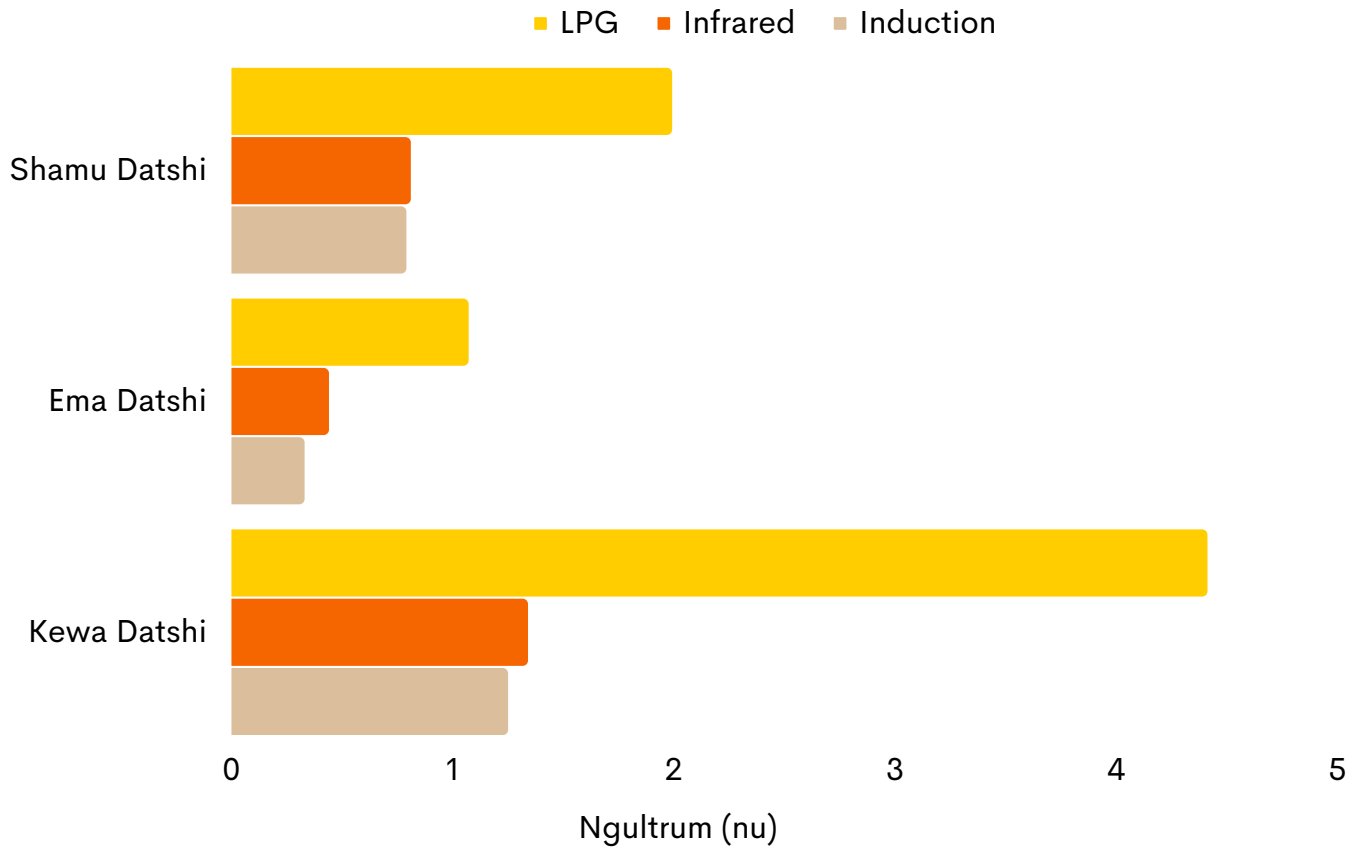
## EMA DATSHI (SPICY CHILLIES & CHEESE)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 6 | 0.015kg | 1.07 | 0.208 |
| Infrared | 10 | 0.165 kWh | 0.44 | 0.250 |
| Induction | 7 | 0.123 kWh | 0.33 | 0.228 |

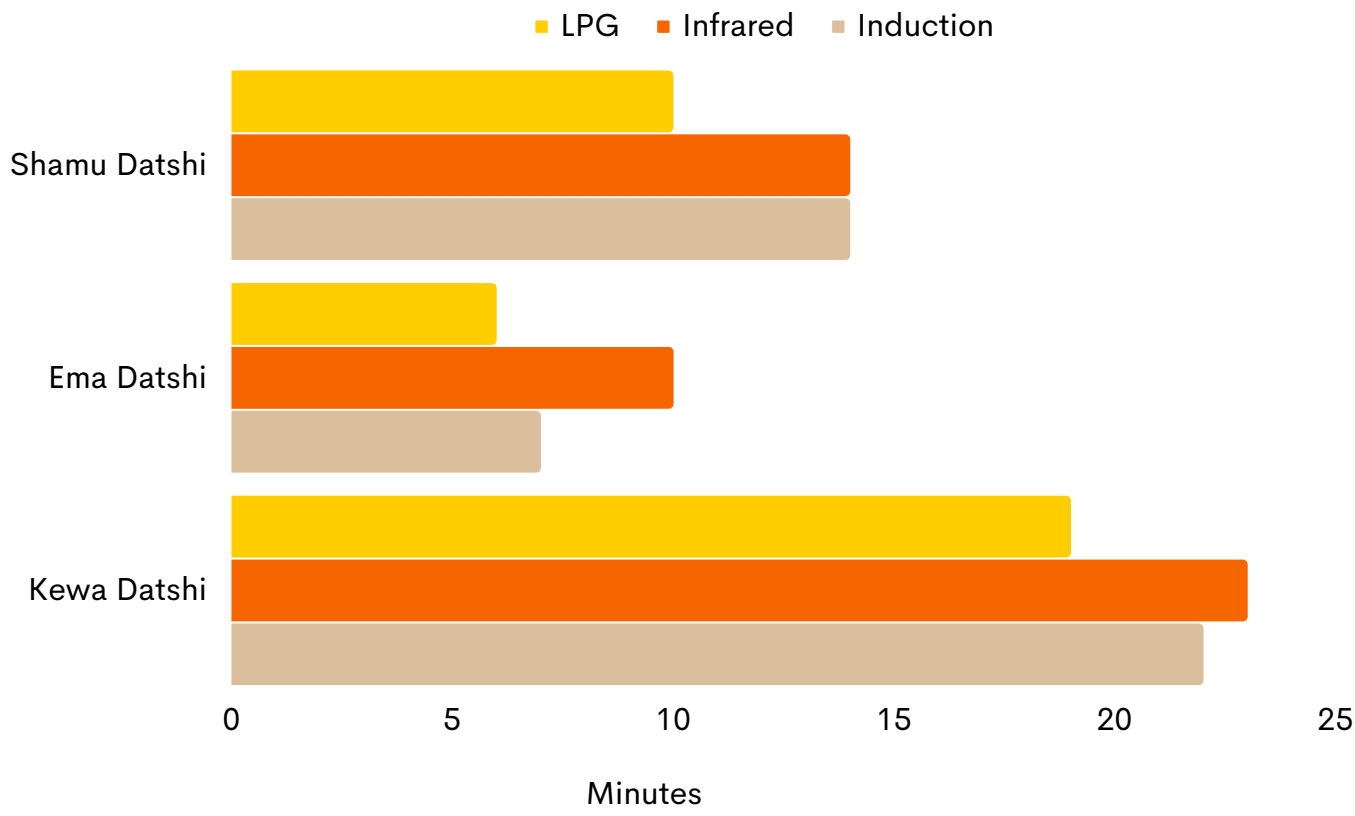
## KEWA DATSHI (POTATO & CHEESE STEW)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 19 | 0.062 kg | 4.41 | 0.677 |
| Infrared | 23 | 0.506 kWh | 1.34 | 0.510 |
| Induction | 22 | 0.471 kWh | 1.25 | 0.617 |

# COST OF COOKING COMPARISON - CHEESE DISHES




# COOKING TIME COMPARISON - CHEESE DISHES



# VEGETABLES

## LA-PHU-MAB TSHOEM

## COPI TSHOEM

## MIX VEG

# COPI TSHOEM

## (CAULIFLOWER CURRY)

*Copi is "cauliflower" and Tshoem is "curry". This simple dish is easy to prepare with fresh cauliflower and fresh chilies.*

| | |
|---|---|
| **129g** | **Cauliflower** |
| **55g** | **Fresh Green Chilies** |
| **50g** | **Onion** |
| **44g** | **Tomato** |
| **25 ml** | **Vegetable Oil** |
| **5g** | **Salt to tase** |
| **250 ml** | **Water** |
| **1 tsp** | **Turmeric power** |

*Preparation Time: 5 mins | Cooking Time: 16-22 mins | Serves 4*

**Prepare ingredients**
Wash and cut the cauliflower into bite-sized pieces (you can use the stem and the florets, cut off the ends and the tough parts and cut into pieces) **//** Wash again and keep aside **//** Cut the tomato and onion roughly and cut the chilies diagonally **//**

**Soften vegetables**
Heat oil on a medium heat **//** Then add onion, chillies and tomato **//** Stir well and fry the mixture until it turns soft **//** Add salt **//**

**Cook cauliflower**
Next add cauliflower, stir and add a teaspoon of turmeric powder **//** Stir again, put the lid on and cook for 5-7 minutes until the cauliflowers turn tender **//** Remove from heat, add sliced green chillies, ginger & garlic paste and stir **//** Add water, put on the lid and cook on medium heat till the cauliflower is cooked **//** Taste and adjust salt **//** If you prefer dry curry, cook on a slightly higher heat.

**Serve**
Add chopped coriander leave //

# MIX VEGETABLES

## (BHUTANESE STYLE VEG)

*The mix vegetable dish is easy to prepared and requires very few spices. The dish can be prepared from collecting all kind of left-over vegetables.*

| | |
|---|---|
| **180g** | **Carrot, cauliflower & broccoli** |
| **40g** | **Fresh Green Chilies** |
| **45g** | **Onion** |
| **40g** | **Tomato** |
| **125 ml** | **Water** |
| **25 ml** | **Vegetable Oil** |
| **3 tsp** | **Salt to tase** |
| **1 tsp** | **Turmeric power** |

*Preparation Time: 7-8 mins | Cooking Time: 19-24 mins | Serves 4*

**Prepare ingredients**

Collect whatever leftover vegetables are on the shelf and wash // Cut them into bite-size pieces and wash again // Cut the tomato and onion into slice and cut the chilies diagonally //

**Cook vegetables**

Heat oil in pan on a medium heat // Then add onion, chilies and tomato // Stir well and fry the mixture until it turns soft // Add salt // Add mixed vegetables // Fry on a medium high heat for 2 – 3 minutes // Pour over ¾ cup of hot water and give a good mix. Cover and cook on a low to medium heat until vegetables are fork tender // Add chillies & when vegetables are soft cooked, taste and adjust salt // If you prefer dry curry, cook on a slightly higher heat //

**Serve**

With chopped coriander or spring onion leaves //

# LA-PHU-MAB TSHOEM

## (CARROT CURRY)

*Carrot curry is a simple, healthy and delicious dish made with fresh carrots, spices, onion, tomatoes. The carrot curry is a basic version and is made much the same way as any other curry.*

| | |
|---|---|
| **290g** | **Pork fillet (cut into strips)** |
| **270g** | **Onions** |
| **270g** | **Tomatoes** |
| **250g** | **Fresh Green Chilies** |
| **1 tsp** | **Chili power** |
| **¼ cup** | **Vegetable Oil** |
| **2 tsp** | **Salt** |
| **500 ml** | **Water** |

*Preparation Time: 5 mins | Cooking Time: 28-39 mins | Serves 4*



**Prepare ingredients**

Wash the carrots and chilies // Skin and cut the carrot into thin slices // Cut the tomato and onion and cut the chilies diagonally //

**Cook base**

Heat oil in a pan/pot on a medium heat. Then add onion, chillies and tomato // Stir well and fry the mixture until it turns soft // Add salt //

**Cook carrot**

Next add sliced carrots and fry on a medium high heat for 2-3 minutes // Pour over 2 cups of hot water and give a good mix // Cover and cook on medium heat until the carrots are half cooked // Add green chilli and continue cooking till the carrot is soft // Taste and adjust the salt // Cook on a slightly higher heat to evaporate the moisture if a dry curry is preferred //

# VEGETABLE DISHES ENERGY CONSUMPTION

## COPI TSHOEM (CAULIFLOWER CURRY)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 16 | 0.049 kg | 3.48 | 0.926 |
| Infrared | 22 | 0.404 kWh | 1.07 | 0.763 |
| Induction | 21 | 0.269 kWh | 0.69 | 0.951 |

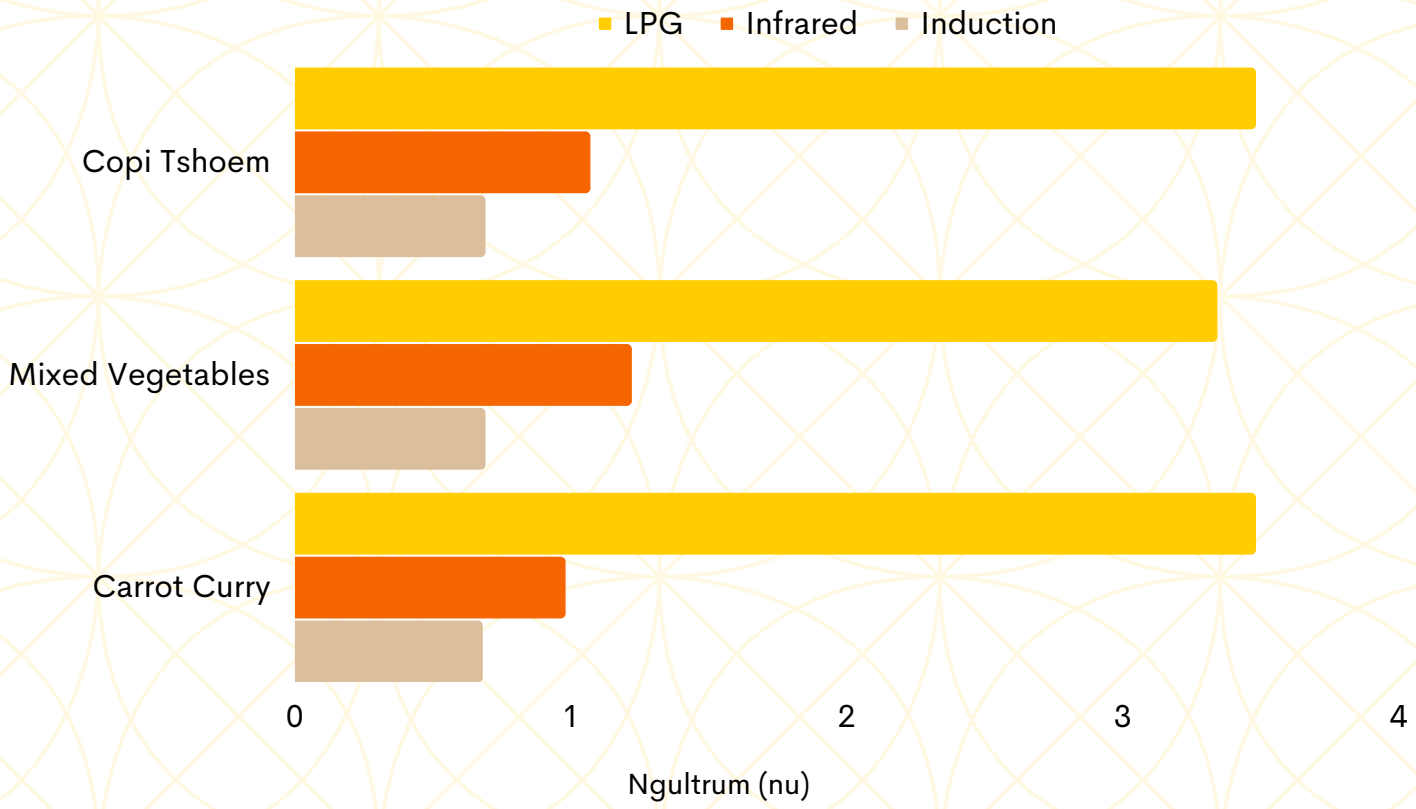
## MIXED VEGETABLES BHUTANESE STYLE

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 19 | 0.047 kg | 3.34 | 0.883 |
| Infrared | 24 | 0.457 kWh | 1.22 | 0.923 |
| Induction | 19 | 0.262 kWh | 0.69 | 0.903 |

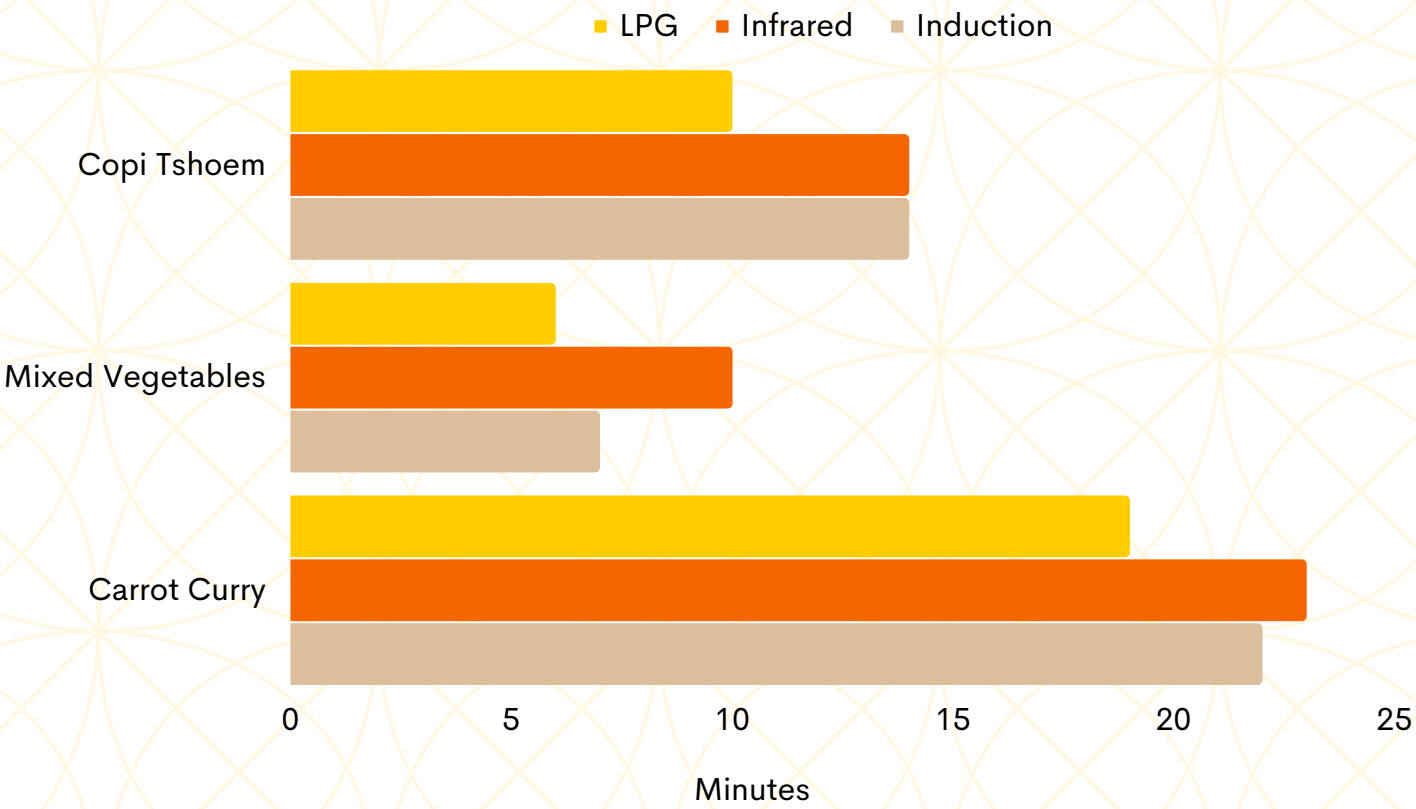
## LA-PHU-MAB TSHOEM (CARROT CURRY)

| Fuel | Time (minutes) | Energy Consumed | Cost (Nu) | Dish Weight (kg) |
|---|---|---|---|---|
| LPG | 12 | 0.049 kg | 3.48 | 0.905 |
| Infrared | 19 | 0.368 kWh | 0.98 | 0.878 |
| Induction | 19 | 0.258 kWh | 0.68 | 0.941 |

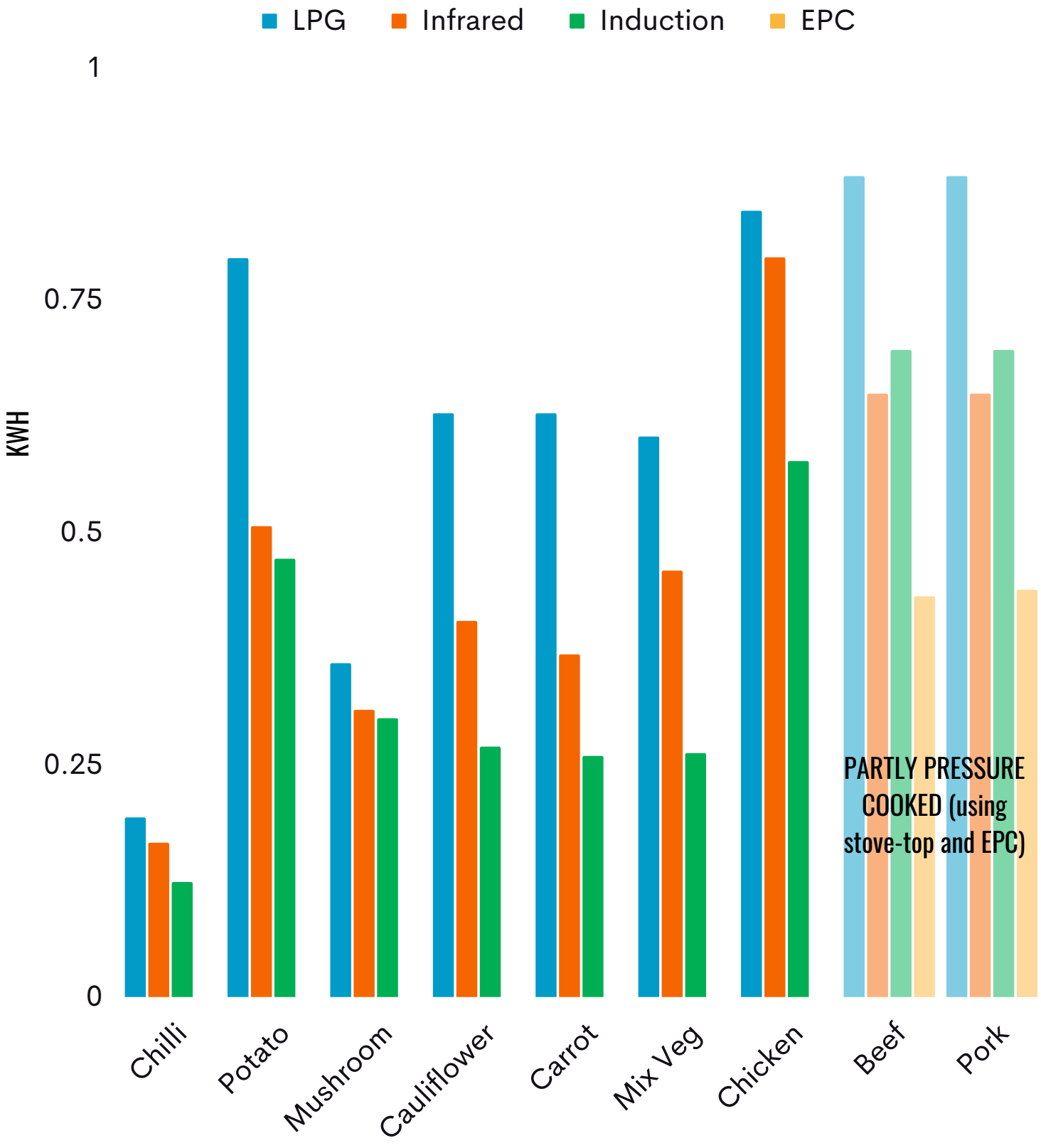
# COST OF COOKING COMPARISON - VEGETABLE DISHES




# COOKING TIME COMPARISON - VEGETABLE DISHES



# ENERGY CONSUMPTION - OVERALL




For electric cookstoves, a plug-in energy meter was used to record or measure the electricity consumption. The quantity of LPG used to cook each dish was measured taking differences of the weight of the LPG cylinder before and after cooking.

The calculated net weight of LPG was then converted to equivalent electric (kWh) consumption using calorific values of LPG for comparison purpose.

# ENERGY CONSUMPTION ANALYSIS

## EPC & INDUCTION STOVE MOST ENERGY-EFFICIENT

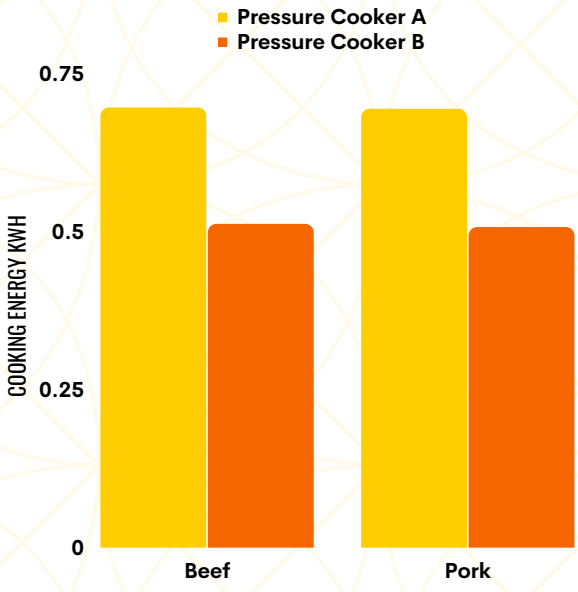
The **EPC was the most efficient when it was used** (2 dishes). For the other dishes (7), the **induction stove was the most energy-efficient stove and LPG stove the least**. The lower efficiency of LPG is due to flames and hot gases from the burner escaping up the sides of the pot. Within the selected cook stoves, when cooking vegetable dishes, the CCT data showed the induction stove was on average **135% more efficient than the LPG stove and was 30-55% more efficient when compared with the infrared electric stove.**

## EPC 60% MORE EFFICIENT AT PRESSURE COOKING

With long-cooking meat dishes (e.g pork and beef) the **EPC was up to 60% more energy efficient** than an infrared stove with a stove-top pressure cooker and an induction stove with a stove-top pressure cooker and many times more efficient than LPG.

## GREATEST EFFICIENCIES WITH LONG COOKING DISHES

The energy consumption gap was small (about 20%) between LPG and electric stoves for the dishes that require quick cooking and the gap increases significantly (up to 1.3 times) for the dishes that require long cooking process (boiling and steaming).

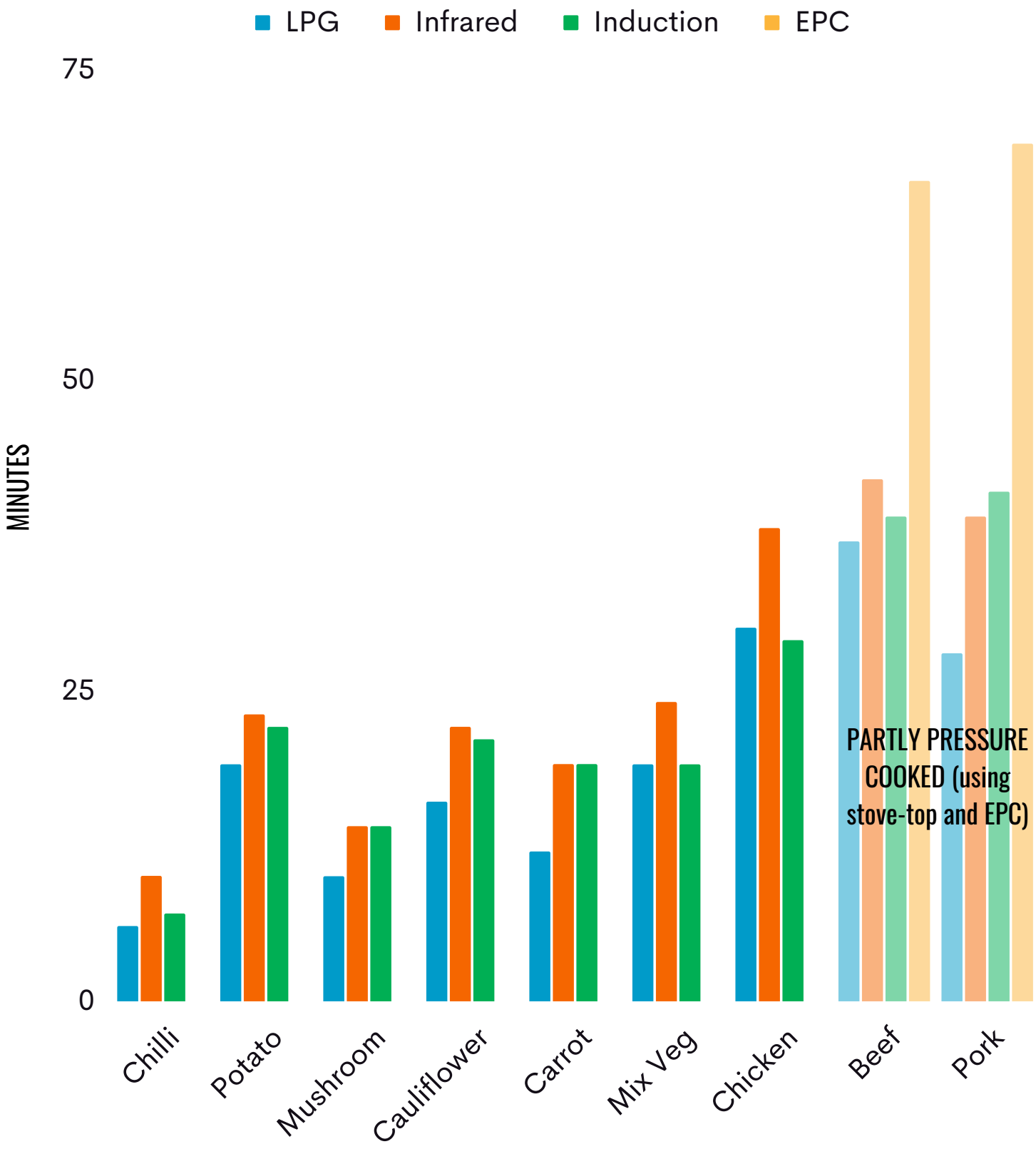



## COOKING POT MATERIAL IMPORTANT

Cooking meat dishes with different types of pressure cookers affects the cooking time and the energy consumption. Tests showed different energy consumption patterns, see graph comparing Pressure Cookers A + B. This concludes that selecting the correct steel grade for the outer layer of the outer layer of the bottom of the pot is key to achieving the maximum energy efficiency when cooking on an induction stove.

Pressure Cooker A: 3L anti-bulge induction base pressure cooker, TTK Prestige
Pressure Cooker B: 3L hard anodized induction bottom pressure cooker , Kitchen Essentials

# COOKING TIMES - OVERALL




The total cooking time was calculated from the point electric devices were switched to "ON" or when "LPG stove was lit", and measured till the dishes were fully cooked and removed from the stoves.

# COOKING TIME ANALYSIS

## LPG STOVES COOKED FOOD FASTEST

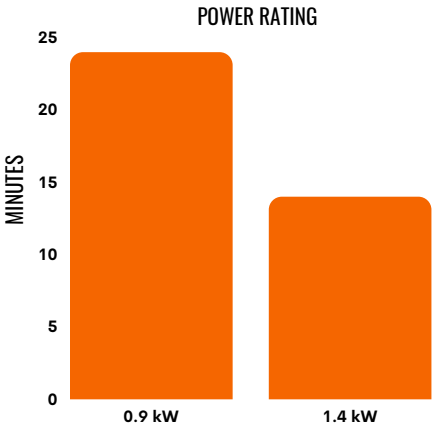
The LPG stove cooked 34 – 40% faster than the electric stoves. However, the size of the pan used compared to the size of flame and quantity of dish cooked also affected the cooking time. However, they were by some way the least energy-efficient.

## STOVE-TOP PRESSURE COOKERS COOK FAST

Two meat dishes cooked on EPC took 27–35 minutes, more than the infrared, induction and LPG stoves using a stove-top pressure cooker. However, much of the cooking was open-lid frying, not pressure cooking, the EPC had a lower electric power rating.

## INDUCTION STOVE FASTEST ELECTRIC STOVE

The infrared stove took slightly longer to cook dishes in an open pan with a lid (unpressurized) than the induction stove. The time delay in infrared stove was caused as it first need to heat its own element. With induction stoves such a time difference is not observed.



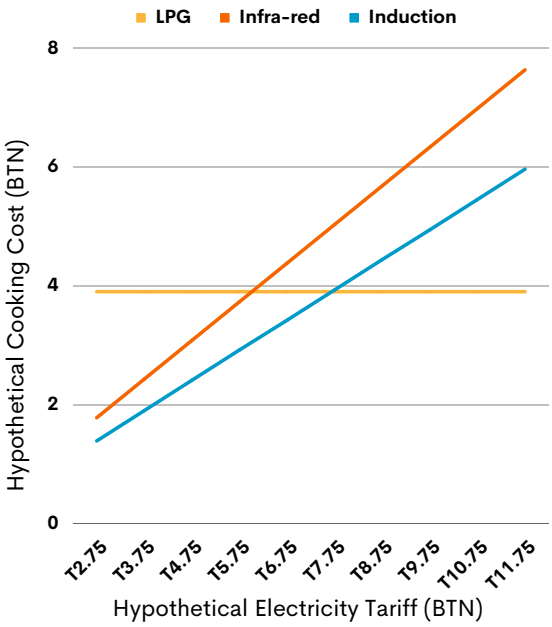

## POWER RATING IMPACTS COOKING TIME

When cooking on electric stoves, the CCT data showed the cooking time was affected by the power rating of the hob. For instance, when the mushroom dish was cooked on a 0.9kW hob, it took 24 minutes to cook the dish completely. When the same quantity of dish was cooked on a 1.4kW burner, it took only 14 minutes. The quantity of food being cooked also greatly effects the cooking time.

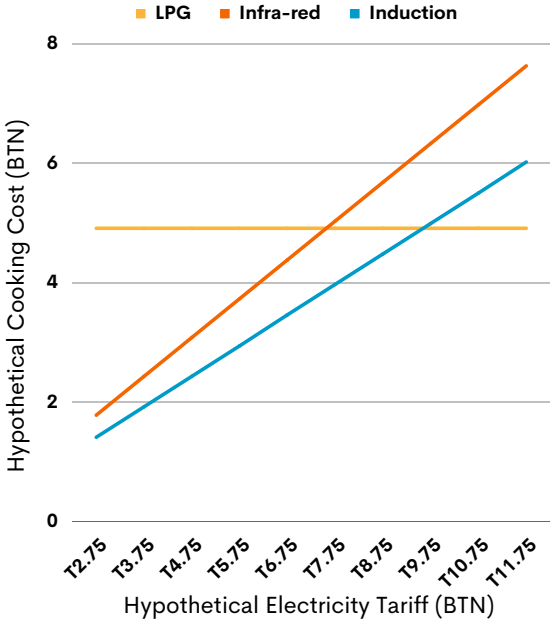
# COST SENSITIVITY ANALYSIS

Currently, **the cost of electricity, at BTN2.68/kWh is very low in Bhutan** compared to other tariffs in the region. The sensitivity analysis of electricity tariff to cooking cost is carried out below for four selected dishes assuming a few hypothetical incremental electricity tariff changes. **The analysis is benchmarked against LPG cost,** which remains constant. The horizontal axis (T2.75, T3.75, ..etc...) represents the hypothetical electricity tariff.

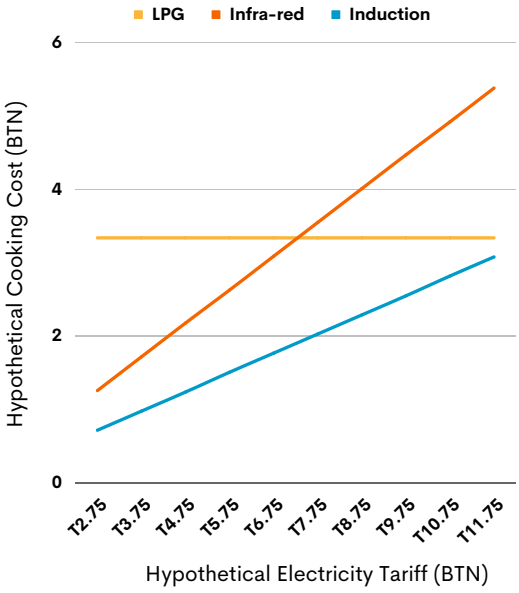
## PORK DISH



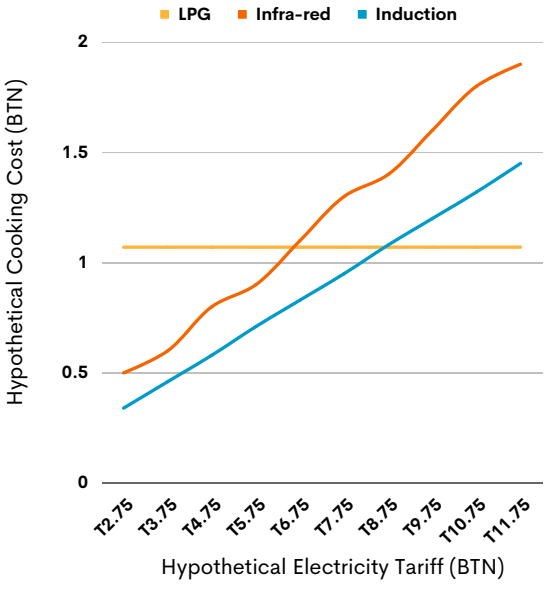

## BEEF DISH




## MIXED VEGETABLE DISH




## CHILLI DISH




- The results show **cooking chili, mix vegetable, pork & beef dishes on infra-red stove is cost effective even the electricity tariff increases to BTN6.5/kWh** compared to LPG.

- If households choose induction stoves as their primary cooking stoves to cook their daily dishes, it is found **still cost-effective even if the tariff is increased to around BTN8/kWh**.

- **This cost sensitivity analysis also supplements the previous finding that induction stoves are energy efficient and cost-effective to use as primary cooking stove.**

# THE COOKING EXPERIENCE

The cooks were asked to list their experiences when preparing the dish with different stoves and quality of cooking experiences observed which are listed below.

## LPG STOVE

**(i)** The cooks were very familiar cooking with LPG stoves and they did not face any challenges cooking all types of dishes. They do not require to learn how to operate.

**(ii)** It was very easy to start the fire and easy to control the heat using knob. As soon as the burner was lit, started heating the dish, thus cooked the dish very fast.

**(iii)** Commonly available cookware can be used with this stove.

**(iv)** When heat is put off after cooking, can continue keeping the dish on the burner and does not change the dish status and taste as well.

**(v)** It does not require fans to cool the burner after cooking. If safety was not kept in mind, flames escaping from side of the pot can cause burns.

## INDUCTION

**(i)** Initially, need to learn how to operate the functions of the stove and frequently need to refer to stove manual causing inconvenience during cooking. However, it improved overtime because users eventually got used to it.

**(ii)** The induction stove reduces heat losses by convection up the sides of the pot. Thus, do not feel heat on the face.

**(iii)** The commonly available cookware cannot be used on this stove. Needed magnetic ferrous pots, that are highly efficient.

## INFRARED

**(i)** It has multi functions to select which automatically sets the rated power of the burner to cook the dish. Can also adjust the heat input manually.

**(ii)** Commonly available cookware can be used with this stove.

**(iii)** It takes time to heat up the plate and takes longer time than expected to cook the dish.

**(iv)** After cooking, the dish had to be immediately removed from the burner, else it continues and over cook the dish and may even burn it.

**(v)** At the end of cooking activities, the stove fan continued running and was noisy.

**(vi)** Cannot immediately clean the stoves after cooking. Can burn fingers if in contact when hot.

## EPC

**(i)** EPC's insulating body reduces heat loss, increase efficiency and keeps food warm for a long time.

**(ii)** Although it is multi-functional, some dish which require deep frying were not possible to cook.

**(iii)** Excels at boiling and steaming. Big energy saving on boiling.

**(iv)** No extra utensils were required.

**(v)** EPC was fully automatic and users needed to learn to operate its functions.

# CONCLUSIONS

i. 

The induction stove was **70% more energy efficient than the LPG stove and about 43% than the infrared electric stove**. This efficiency can be affected by the selection of the steel grade of the bottom of the pot. 430 grade stainless steel performed best. The material grade also affects the cooking time.

ii. 

All Bhutanese dishes tested cooked faster on the **LPG stove** than on the electric stoves, but in terms of energy consumption and cooking cost, it was observed to be the **most fuel inefficient and least cost-effective. Consumers also need to factor in the price of LPG cylinders & the national burden of import costs.**

iii. 

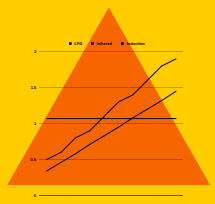
**Despite taking longer to cook, the EPC was found to be 60% more energy efficient and over 40% cheaper than the two electric stoves and twice as much cheaper than using an LPG stove.** The use of EPC was most cost effective when cooking dishes that requires long cooking processes (big energy savings on boiling).

iv. 

The cooking test data showed the time taken to cook was directly affected by **(a)** the electric power rating of the burner (high power shortens cooking time; low power takes longer to cook), **(b)** efficient heat transfer depends on the size of the pan used compare to the size of the flame/heating surface, and **(c)** the quantity of the dish cooked. **Irrespective of the electric burner power capacity, the cooking energy consumption pattern remains the same** (change in burner capacity do not alter the actual energy consumption pattern) for electric stoves.

v. 

**An induction stove and stove-top pressure cooker combined can substantially reduce energy losses and the cost of cooking.** Induction stove technology reduces the amount of heat lost by convection up the side of the pot. Cooking with a lid reduces the cooking time and reduces evaporation.

vi. 

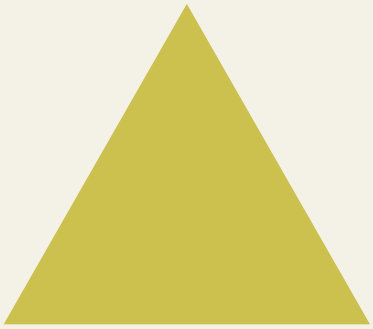
The cost sensitivity analysis results also supplements the findings that an **induction stove is a versatile, energy efficient and cost-effective device to use as a primary cooking stove.**

# RECOMMENDATIONS

## REDUCE THE RELIANCE ON LPG IMPORTS

With 84% LPG penetration in 2021, **Bhutan pays a huge cost for importing LPG**. Bhutan is an **electricity surplus nation** and exports electricity to India. **Replacing LPG with electricity would drastically reduce the on reliance and the cost of imports for Bhutan.**

## A GREENER ENERGY REGIME FOR COOKING



**Replacing LPG with electricity would help Bhutan move towards a greener energy regime and towards its commitment to remain carbon neutral.** LPG consumption contributes about 9,809 ToE annually. Meanwhile Bhutan generates **100% of its electricity through renewable sources** and this capacity increases periodically.

## EMBRACE E-COOKING COST EFFICIENCIES

Early CCT results, displayed in this eCookbook, show **using increasing use of electricity as a primary cooking fuel in Bhutan would be cost efficient and cost effective for both consumers and the Bhutanese government.** Green cooking energy is now possible because of the wide availability of cheap electricity from hydropower.