No-Cook Dietary Substitution for Reducing LPG Consumption: A Thermodynamic–Nutritional Modelling Study

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Abstract

Cooking energy represents a significant component of household energy demand, particularly in developing countries where thermal food preparation is dominant. In India, LPG consumption exceeds 25 million tonnes annually, with individual cooking energy requirements ranging between 1.7–2.7 MJ per person per day. This study develops a novel thermodynamic–nutritional modelling framework to evaluate the potential reduction in cooking energy demand through dietary substitution. By integrating food composition data, calorific values (46 MJ/kg for LPG), and cooking efficiency (45–60%), the model estimates baseline LPG consumption to reduce to approximately 0.096 kg per person per day. Detailed analysis demonstrates that replacing one cooked meal with uncooked food reduces LPG demand by about 28%, while substituting two meals with raw food achieves nearly 59% reduction. Nutritional modelling confirms that balanced no-cook diets can provide over 60 g/day protein with adequate micronutrient intake. The study highlights dietary restructuring as a viable demand-side strategy for reducing cooking energy consumption while maintaining nutritional adequacy.

Keywords: *Cooking energy demand, Dietary substitution, LPG consumption, Thermodynamic modelling, No-cook diet.*

1. Introduction

Cooking energy accounts for a considerable share of household energy use across the world, particularly in developing regions where most food preparation depends on heat-based processes. Everyday cooking activities such as boiling, steaming, and frying require sustained heat input, which makes cooking fuels an essential part of domestic energy systems. Among the available options, liquefied petroleum gas (LPG) has become one of the most widely used fuels because of its high energy content (around 46 MJ/kg), relatively clean combustion, and ease of handling. As a result, LPG now plays a central role in household cooking, especially in countries that are gradually shifting towards cleaner energy sources.

In India, the demand for LPG in domestic cooking has increased rapidly, with annual consumption exceeding 25 million tonnes. A large portion of this demand is met through imports, which introduces concerns related to price volatility and long-term energy security. At the same time, cooking energy demand is not just a fuel issue—it is closely tied to what people eat and how food is prepared. For instance, staple foods such as rice and pulses require significant heat input for cooking. Thermodynamic estimates suggest that cooking such foods can require around 1.5 MJ per litre, and at the household level, total cooking energy demand may reach approximately 4.5 GJ per year, or about 1 GJ per person annually. On a daily basis, this corresponds to roughly 1.7–2.7 MJ per person, indicating that routine cooking is inherently energy intensive.

Most existing studies on cooking energy have focused on improving how fuel is used rather than reducing how much energy is actually required. This includes transitions from biomass to LPG, improvements in stove efficiency, and the use of alternative energy sources such as electricity or biogas. While these approaches are important and have led to cleaner cooking practices, they do not fundamentally change the thermal energy needed to cook food. In many cases, households also continue to rely on multiple fuels depending on affordability and availability, which further limits the effectiveness of purely technology-driven solutions.

From a physical standpoint, cooking is governed by basic heat transfer processes and heating food and water, maintaining boiling conditions, and compensating for heat losses. Even with improved stove designs, a significant portion of the energy supplied is lost to the surroundings, meaning that only part of the fuel's energy is actually used for cooking. This suggests that efficiency improvements alone may not be sufficient to substantially reduce overall cooking energy demand.

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An alternative way of looking at the problem is through dietary patterns. Not all foods require cooking before consumption. Many commonly available foods—such as fruits, raw vegetables, sprouts, nuts, seeds, and dairy products can be eaten directly while still providing essential nutrients. Traditional practices like soaking and sprouting can further improve nutrient availability without the need for heat. Nutritional datasets, such as the Indian Food Composition Tables, show that these foods can meaningfully contribute to daily energy and protein requirements. However, their role in reducing cooking energy demand has not been examined in a systematic manner.

Within the broader food–energy nexus, the connection between diet and energy use is increasingly recognised, yet most studies continue to focus on technological improvements rather than behavioural or dietary changes. In particular, there is very limited work that brings together cooking energy analysis and nutritional evaluation within a single framework. As a result, it remains unclear to what extent cooking energy demand can be reduced through dietary changes without compromising nutritional adequacy.

This gap points to an important limitation in current research. While cooking energy and nutrition are both well studied independently, their interaction has not been explored in sufficient depth. In particular, the potential of structured dietary substitution. where some cooked meals are replaced with no-cook alternatives has not been quantitatively assessed in terms of both energy savings and nutritional outcomes.

To address this, the present study develops an integrated framework that combines thermodynamic modelling with nutritional analysis. The objective is to estimate cooking energy demand and evaluate how much LPG consumption can be reduced by partially replacing cooked meals with nutritionally balanced no-cook alternatives. The approach links food composition data with energy requirements and fuel properties to provide a more complete picture of cooking energy use.

The study is guided by three key questions: what is the typical cooking energy demand associated with daily diets, how much of this energy can be reduced through partial substitution of cooked meals, and whether such substitutions can still meet nutritional requirements. By answering these questions, the work aims to provide a clearer understanding of how dietary choices influence energy use in cooking.

The contribution of this study lies in bringing together two areas that are usually treated separately nutrition and cooking energy. The results indicate that even partial substitution of cooked meals can lead to meaningful reductions in LPG consumption (on the order of 28–59%), while still maintaining adequate nutritional intake. These findings offer a different way of thinking about cooking energy demand and highlight the potential of demand-side strategies in reducing dependence on cooking fuels, with implications for households, institutions, and broader energy policy.

2.0 Materials and Methods

This study adopts a secondary data–driven analytical modelling approach to estimate cooking energy demand and potential reductions in LPG consumption achievable through structured substitution of cooked meals with nutritionally balanced no-cook dietary alternatives. The modelling framework integrates datasets from nutritional science, thermodynamic cooking energy analysis, and fuel energy properties.

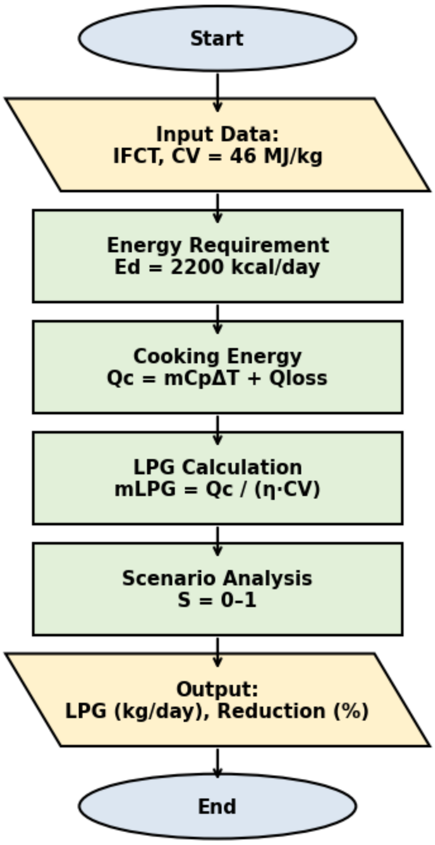

Figure 1. Methodology flowchart showing the sequential steps for estimating cooking energy demand and LPG consumption

The methodology consists of four analytical components:

1. Nutritional modelling of dietary intake
2. Thermodynamic modelling of cooking energy demand
3. Fuel energy conversion modelling
4. Meal substitution scenario modelling

Unlike experimental investigations, the present study relies entirely on secondary datasets and theoretical calculations. The proposed framework integrates thermodynamic energy modelling with nutritional assessment to evaluate the relationship between dietary patterns and cooking fuel demand. The sequential linkage between cooking energy equations, LPG conversion analysis, and meal substitution scenarios enables systematic estimation of fuel reduction potential under different dietary conditions. As illustrated in Figure 1, the modelling workflow provides a structured analytical pathway for estimating cooking energy demand and LPG consumption through no-cook dietary substitution.

2.1 Data Sources

Food Composition Data

Nutritional values of food items were obtained from the Indian Food Composition Tables (IFCT 2017) published by the National Institute of Nutrition. The IFCT database contains nutrient composition data for 528 key foods and 151 food components, representing the most comprehensive nutritional dataset for Indian foods [1].

These tables provide values for, energy (kcal), protein (g), carbohydrates (g), fat (g), vitamins and minerals. Such databases are widely used for nutritional modelling and dietary analysis.

Dietary Energy Requirement

The modelling framework assumes a reference adult daily energy requirement (Ed) of 2200 kcal per person per day. This value represents an average dietary requirement for adults under moderate activity conditions.

Cooking Energy Requirement Data

Cooking energy demand depends on the amount of food heated, temperature rise during cooking, and heat losses during the cooking process.

Studies on cooking energy systems show that cooking energy demand can range between 1.7 MJ and 2.7 MJ per person per day depending on cooking method and diet composition.

LPG Energy Properties

Liquefied petroleum gas (LPG) is primarily composed of propane and butane hydrocarbons. The average calorific value of LPG is approximately 46 MJ per kilogram [2].

This calorific value represents the total chemical energy released when one kilogram of LPG undergoes complete combustion.

2.2 Population Basis

The modelling framework evaluates cooking energy demand for different population scales.

Daily dietary energy requirement per person:

Ed = 2200 kcal/person/day

Population scenarios considered in the model:

N = 1, 50, 100, 500

Where:

- N = 1 → individual household
- N = 50 → small hostel kitchen
- N = 100 → institutional kitchen
- N = 500 → large community kitchen

This scaling approach allows estimation of cooking fuel demand across different cooking systems.

2.3 Cooking Energy Requirement Model

Cooking food requires thermal energy to increase the temperature of food materials and maintain boiling conditions.

The thermal energy required for cooking food is calculated using the following eq. (1):

$$Q_c = m_f \times C_p \times (T_f - T_i) + L \text{-------------------(1)}$$

Where

Q_c= thermal energy required for cooking (MJ)
m_f= mass of food being heated (kg)
C_p= specific heat capacity of food (kJ kg^{-1} °C^{-1})
T_f= final temperature of cooked food (°C)
T_i= initial temperature of food (°C)
L= latent heat losses during cooking (MJ)

This equation represents the energy required for heating food plus additional energy losses.

2.4 LPG Energy Supply Model

The chemical energy released from LPG combustion is calculated in eq. (2):

$$E_{LPG} = m_{LPG} \times CV_{LPG} \text{------------------(2)}$$

Where

E_{LPG}= energy released from LPG combustion (MJ)
m_{LPG}= mass of LPG consumed (kg)
CV_{LPG}= calorific value of LPG (MJ /kg^{-1})

For LPG:

CVLPG = 46 MJ/kg

2.5 Cooking Efficiency

Not all chemical energy released during LPG combustion is transferred to the food.

Cooking efficiency is defined by eq. (3):

$$\eta = \frac{Q_c}{E_{LPG}} \text{-------------------(3)}$$

Where

η= stove efficiency (dimensionless or %)
Q_c= useful cooking heat delivered to food (MJ)
E_{LPG}= chemical energy released from fuel (MJ)

Typical LPG stove efficiencies reported in literature range between:

$$\eta = 0.45 \text{ to } 0.60$$

Meaning that only 45–60% of fuel energy is transferred to food, while the remainder is lost to the surrounding environment.

2.6 LPG Consumption Model

Using the above parameters, LPG consumption required for cooking can be estimated by eq. (4):

$$LPG_c = \frac{Q_c}{CV_{LPG} \times \eta} \text{----------------------(4)}$$

Where

LPG_c= LPG consumption (kg)
Q_c= useful cooking energy required (MJ)
CV_{LPG}= calorific value of LPG (MJ kg^{-1})
η= stove efficiency (dimensionless)

This equation forms the basis for calculating fuel demand under different cooking scenarios.

2.7 Meal Substitution Model

To estimate the effect of no-cook meals on LPG consumption, a meal substitution ratio is defined by eq. (5).

$$S = \frac{M_{raw}}{M_{total}} \text{----------------------(5)}$$

Where

S= substitution ratio (dimensionless)
M_{raw}= number of no cook meals per day
M_{total}= total number of meals per day

Substitution Scenarios

S.no	Scenario	Raw Meal Share	Description
1	S0	0%	All meals cooked
2	S1	33%	One meal no-cook
3	S2	50%	Half meals no-cook
4	S3	66%	Two meals no-cook
5	S4	100%	All meals no-cook

2.8 LPG Reduction Calculation

The LPG savings resulting from dietary substitution are calculated by eq. (6,7):

$$LPG_{saving} = LPG_{baseline} - LPG_{scenario} \text{-------------------(6)}$$
$$R = \left(\frac{LPG_{saving}}{LPG_{baseline}}\right) \times 100 \text{------------------(7)}$$

Where

LPG_{saving}= LPG saved due to meal substitution (kg or kg day^{-1})
$LPG_{baseline}$= baseline LPG consumption under fully cooked meals (kg or kg day^{-1})
$LPG_{scenario}$= LPG consumption under substitution scenario (kg or kg day^{-1})
R= percentage reduction in LPG consumption (%)

2.9 Nutritional Adequacy Model

The nutritional content of each meal is calculated using food composition data.

Total nutrient intake is estimated using the equation by eq. (8):

$$N_i = \sum(C_{ij} \times W_j) \text{---------(8)}$$

Where

N_i= intake of nutrient i
C_{ij}= concentration of nutrient iin food j(per g or per 100 g of food)
W_j= weight of food jconsumed (g)

2.10 Nutritional Adequacy Ratio

To evaluate whether dietary substitution maintains adequate nutrient intake, the Nutritional Adequacy Ratio (NAR) is calculated by eq. (9).

$$NAR = \frac{N_i}{RDI_i} \text{---------------(9)}$$

Where

NAR= Nutritional Adequacy Ratio (dimensionless)
N_i= intake of nutrient i(g day^{-1}, mg day^{-1}, or µg day^{-1} depending on the nutrient)
RDI_i= recommended dietary intake of nutrient i(g day^{-1}, mg day^{-1}, or µg day^{-1})

A diet is considered nutritionally adequate when: NAR ≥ 1

2.11 Food Preparation Energy Analysis

Cooking is fundamentally a thermodynamic process involving heat transfer from fuel combustion to food materials. The energy required for cooking depends on the mass of food being heated, its specific heat capacity, and the temperature difference between the initial and final states. Additional energy is required for evaporation, boiling, and heat losses from cooking vessels.

The thermal energy required to cook food can generally be expressed as given in Eq(1).

$$Q = mC_p(T_f - T_i) \quad (1)$$

Where

Q= thermal energy required for heating (MJ or kJ)
m= mass of the food or water being heated (kg)
C_p= specific heat capacity of the food (kJ kg^{-1} °C^{-1})
T_f= final temperature of the food (°C)
T_i= initial temperature of the food (°C)

Cooking fuels such as LPG provide energy through combustion of hydrocarbons. LPG typically consists of propane and butane mixtures with a calorific value of approximately 46 MJ kg^{-1}, which determines the total energy available for cooking applications [3].When stove efficiency is taken into account, the useful heat delivered to the cooking process is significantly lower than the total chemical energy released during combustion.

2.12 Session-Wise Diet Modelling

The model constructs **three no-cook meal sessions**:

- Breakfast
- Lunch
- Dinner

Each session includes combinations of:

- fruits
- raw vegetables
- sprouts
- nuts and seeds
- dairy products

Nutritional values for these foods are derived from the Indian Food Composition Tables and used to calculate total daily nutrient intake.

These session-wise meal models serve as the basis for estimating:

- caloric intake
- protein intake
- micronutrient adequacy
- cooking energy reduction

2.13 Sensitivity Analysis Framework

To evaluate the robustness of the analytical model, a sensitivity analysis was conducted by varying key input parameters that influence cooking energy demand and LPG consumption. The two primary parameters considered are cooking energy requirement (Qc) and stove efficiency (η).
Cooking energy was varied within the range of 1.7–2.7 MJ per person per day based on reported literature values, while stove efficiency was varied between 0.45 and 0.60.
The LPG consumption model (Eq. 4) was recalculated for all combinations of these parameters to assess the variability in estimated fuel consumption and percentage reduction under different meal substitution scenarios.

3.0 Model Development: No-Cook Diet Formulation

The formulation of no-cook diets is an essential component of the modelling framework because dietary substitution must maintain adequate caloric and nutrient intake while reducing cooking energy demand. The present study constructs session-wise meal models consisting of foods that require minimal or no thermal processing.

Food groups selected for this modelling approach include:

- fruits
- raw vegetables
- sprouted legumes
- nuts and seeds
- dairy products
- fermented foods

These foods are widely consumed in Indian diets and are recognized for their nutritional density and digestibility. Nutritional values used in the present analysis are derived primarily from the Indian Food Composition Tables (IFCT 2017), which provide compositional data for hundreds of foods commonly consumed in India [1].

Sprouted legumes are particularly important in no-cook dietary systems because germination improves nutrient availability and digestibility while requiring no external thermal energy. For example, sprouted mung beans contain approximately 30 kcal of energy and about 3 g of protein per 100 g, making them suitable components of nutrient-dense raw meals [4].

Fruits such as bananas and papaya provide readily digestible carbohydrates and vitamins, while nuts and seeds supply protein and healthy fats. Typical fruit energy values range between 30–100 kcal per 100 g, depending on the fruit type [5].

Using these nutritional inputs, balanced no-cook meals are constructed for breakfast, lunch, and dinner sessions.

3.1 Breakfast-Type No-Cook Meal Composition

Breakfast plays an important role in providing the first source of energy after overnight fasting; therefore, foods selected for this meal should be easy to digest while still supplying sufficient nutrients to support metabolic activity during the early part of the day. In a no cook dietary approach the breakfast composition focuses on foods that naturally contain simple carbohydrates, plant proteins, vitamins, and dietary fiber without requiring thermal preparation. Fruits contribute readily available sugars that help restore blood glucose levels, while sprouts supply plant-based proteins and enzymes that support digestion and nutrient absorption. Nuts provide concentrated energy, healthy fats, and additional protein which help sustain satiety and maintain stable energy levels throughout the morning. Dairy products such as curd complement these plant foods by contributing high quality protein, calcium, and beneficial microorganisms that support gut health. When these components are combined in appropriate proportions, they create a nutritionally balanced meal that supports energy requirements while avoiding the need for cooking fuel. The detailed composition and nutrient contribution of the breakfast meal components are presented in Table 1.

Table 1. Breakfast-Type No-Cook Meal Composition

S.no	Food Item	Quantity (g)	Energy (kcal)	Protein (g)	Fiber (g)
1	Banana	120	105	1.3	3.1
2	Sprouted moong	100	30	3.0	1.8
3	Groundnut (raw)	30	170	7.0	2.4
4	Curd	150	90	5.1	0
5	Papaya	100	32	0.5	1.7
6	Total	—	427 kcal	16.9 g	9.0 g

The breakfast formulation indicates that a carefully selected combination of fruits, sprouts, nuts, and dairy can provide a nutritionally balanced meal while avoiding thermal processing, which supports the feasibility of energy conserving dietary patterns. As shown in Table 1, the meal delivers 427 kcal of energy, 16.9 g of protein, and 9.0 g of dietary fiber, with groundnut and sprouted moong contributing substantially to protein and nutrient density while fruits such as banana and papaya supply easily digestible carbohydrates and micronutrients. This nutritional balance can be mechanistically explained by the complementary roles of legumes and nuts that provide concentrated protein and essential amino acids, while germination enhances nutrient availability and protein digestibility in mung beans through enzymatic degradation of antinutritional factors, observations that are consistent with earlier studies on legume-based foods and sprouted pulses in human diets [6].

3.2 Lunch-Type No-Cook Meal Composition

Lunch generally represents the main meal of the day and therefore requires a higher intake of energy and protein to support sustained physical and mental activity. In a no cook dietary framework the lunch composition is designed to provide balanced nutrition through a combination of nutrient dense foods that can be consumed without thermal preparation. Sprouted legumes contribute plant protein, dietary fiber, and bioavailable micronutrients that help maintain metabolic functions and support digestive health. Fresh vegetables such as cucumber and tomato provide hydration, antioxidants, and vitamins that complement the macronutrients supplied by other ingredients. Dairy products add high quality protein and calcium which support muscle maintenance and overall nutritional adequacy, while nuts provide concentrated energy and essential fatty acids that enhance satiety and nutrient density. Together these food groups create a balanced midday meal that supplies adequate calories and protein while eliminating the need for cooking energy. The detailed nutritional composition of the lunch meal components is presented in Table 2.

Table 2. Lunch-Type No-Cook Meal Composition

S.no	Food Item	Quantity (g)	Energy (kcal)	Protein (g)	Fiber (g)
1	Sprout salad (moong)	150	45	4.5	2.7
2	Cucumber	100	15	0.7	0.5
3	Tomato	100	18	0.9	1.2
4	Paneer	80	210	14.4	0
5	Groundnut	30	170	7.0	2.4
6	Total	—	458 kcal	27.5 g	6.8 g

Paneer and groundnuts significantly increase protein intake, ensuring nutritional adequacy while maintaining a no-cook meal design.

The lunch formulation demonstrates that a combination of sprouts, vegetables, nuts, and dairy can provide a nutritionally dense meal while avoiding thermal processing, which supports the concept that balanced raw food assemblies can sustain daily nutritional needs with minimal energy input. As presented in Table 2, the meal supplies 458 kcal of energy, 27.5 g of protein, and 6.8 g of dietary fiber, with paneer and groundnut acting as the primary protein contributors while sprouted moong and fresh vegetables enhance micronutrient availability and digestive fiber. The nutritional performance of this combination can be mechanistically explained by the complementary interaction between legume sprouts and dairy proteins because germination increases protein digestibility and reduces antinutritional compounds in mung beans while paneer provides highly bioavailable milk proteins and essential amino acids, patterns that align with previous nutritional investigations of legume sprouts and dairy based protein foods in human diets [6].

3.3 Dinner-Type No-Cook Meal Composition

Dinner in the proposed dietary model focuses on foods that are relatively light and easy to digest while still providing sufficient nutrients to support recovery and metabolic processes during the night. The selection of ingredients prioritizes natural foods that contain balanced proportions of carbohydrates, proteins, fiber, and micronutrients without requiring thermal preparation. Fresh fruits contribute natural sugars, vitamins, and antioxidants that help replenish energy while remaining gentle on digestion. Nuts and sprouted legumes supply plant proteins, healthy fats, and dietary fiber that promote satiety and maintain steady nutrient availability. Fermented dairy products add high quality protein and beneficial microorganisms that support digestive health and nutrient absorption. Raw vegetables further enhance the nutritional value by contributing fiber and micronutrients that aid metabolic balance. When combined in appropriate quantities these foods create a balanced evening meal that provides nourishment while minimizing digestive burden and eliminating the need for cooking fuel. The detailed composition and nutritional contribution of the dinner meal components are presented in Table 3.

Table 3. Dinner-Type No-Cook Meal Composition

S.no	Food Item	Quantity (g)	Energy (kcal)	Protein (g)	Fiber (g)
1	Fruit mix (apple + papaya)	200	110	1.0	3.0
2	Almonds	30	175	6.0	3.5
3	Yogurt	150	90	5.0	0
4	Sprouted chickpeas	100	120	6.5	5.0
5	Carrot	100	41	0.9	2.8
6	Total	—	536 kcal	19.4 g	14.3 g

This dinner formulation provides a high fiber intake and moderate protein levels while requiring no cooking.

The dinner formulation reflects how a combination of fruits, sprouts, nuts, and fermented dairy can deliver a nutritionally balanced evening meal while avoiding thermal cooking, which supports the concept that raw dietary assemblies can maintain adequate nutrient intake with minimal energy input. As presented in Table 3, the meal provides 536 kcal of energy, 19.4 g of protein, and 14.3 g of dietary fiber, with major contributions from almonds, sprouted chickpeas, yogurt, and fresh fruits that together supply complementary macronutrients and dietary fiber. This nutritional pattern can be mechanistically explained by the role of germination in chickpeas, where enzymatic activity during sprouting reduces antinutritional compounds and improves protein digestibility and bioactive compound availability, observations that have been widely reported in studies examining nutritional enhancement of sprouted legumes and their physiological benefits in human diets [7].

3.4 Nutritional Composition of Key No-Cook Foods

Understanding the nutritional characteristics of individual food ingredients is important for designing balanced meals that do not require cooking. Many raw foods naturally contain significant amounts of energy, proteins, dietary fiber, and essential micronutrients, which makes them suitable components of a no cook dietary approach. Sprouted legumes provide moderate energy along with plant-based protein and vitamins that become more available during the germination process. Fruits contribute natural carbohydrates, fiber, and vitamin rich compounds that support digestion and immune function. Vegetables supply hydration, minerals, and antioxidants that help maintain metabolic balance. Nuts such as groundnut are particularly energy dense and provide substantial protein and healthy fats, which increase the nutritional density of the meal even when consumed in small quantities. Fermented dairy foods add high quality protein and beneficial microorganisms that assist in nutrient absorption and digestive health. The representative nutrient values of these commonly used no cook food items are summarized in Table 4.

Table 4. Typical Nutritional Composition of No-Cook Food Items (per 100 g)

S.no	Food	Energy (kcal)	Protein (g)	Fiber (g)	Vitamin C (mg)
1	Sprouted moong	30	3.0	1.8	13
2	Banana	89	1.1	2.6	8
3	Cucumber	15	0.7	0.5	3
4	Groundnut	567	26	8.5	0
5	Curd	60	3.4	0	1

These foods collectively supply macronutrients, vitamins, and minerals required for balanced dietary intake.

The nutrient profile of the selected raw food ingredients indicates that combining fruits, legumes, nuts, and dairy products can provide a balanced supply of energy, protein, dietary fiber, and micronutrients while requiring no thermal processing. As presented in Table 4, foods such as groundnut provide 567 kcal and 26 g protein per 100 g, while sprouted moong supplies 30 kcal with 3.0 g protein and 13 mg vitamin C, demonstrating how different food groups contribute complementary macronutrients and micronutrients within a raw meal system. This pattern can be mechanistically explained by the biochemical changes that occur during sprouting, where germination activates endogenous enzymes that increase vitamin C, phenolic compounds, and nutrient bioavailability, findings that are consistent with previous studies reporting enhanced micronutrient content and improved nutritional functionality in sprouted legumes and plant-based foods [8].

3.5 Daily Nutritional Balance of No-Cook Diet

The combined energy intake of the three session-wise meal designs yields approximately:

$$\text{Total Daily Energy} \approx 1420\text{–}1500 \text{ kcal}$$

Additional fruits or nuts can be incorporated to achieve the target dietary requirement of 2200 kcal per day used in the modelling framework.

Protein intake from the above diet ranges between 55–65 g per day, which aligns with recommended dietary intake values for adults.

3.6 Integration with Cooking Energy Model

The session-wise diet tables form the basis for calculating meal substitution scenarios in the modelling framework.

Cooking energy demand for each meal can be represented by eq. (1):

$$Q_c = m_f\, C_p\, (T_f - T_i) + L$$

Where

Q_c= thermal energy required for cooking (MJ)
m_f= mass of food (kg)
C_p= specific heat capacity of food (kJ kg^{-1} °C^{-1})
T_f= final temperature of food (°C)
T_i= initial temperature of food (°C)
L= latent heat loss during cooking (MJ)

When meals are replaced with no-cook foods, the cooking energy requirement becomes:

$$Qc = 0$$

Therefore, LPG consumption reduction for substituted meals can be calculated using the fuel conversion eq. (4):

$$LPG_c = \frac{Q_c}{CV_{LPG} \times \eta}$$

Where

LPG_c= LPG consumption (kg)
Q_c= useful cooking heat required (MJ)
CV_{LPG}= calorific value of LPG (46 MJ/kg^{-1})
η= cooking efficiency (0.45–0.60)

This framework enables estimation of LPG savings for different substitution scenarios.

3.7 Role of No-Cook Diet in Energy Reduction

Replacing cooked meals with nutritionally balanced no-cook meals can significantly reduce cooking energy demand because thermal processing is eliminated. Since cooking energy requirements may reach 1.7–2.7 MJ per person per day, eliminating one or two cooked meals could theoretically reduce a substantial portion of household cooking energy demand.

4 Results and Discussion

This section presents the quantitative results obtained from the nutritional energy modelling framework. The analysis estimates baseline cooking energy demand, evaluates LPG consumption under conventional cooking systems, and calculates the potential reduction in LPG consumption under different no-cook meal substitution scenarios.

4.1 Baseline LPG Demand in Conventional Cooking

The first step in the modelling framework is to estimate the baseline cooking energy requirement for a typical individual diet. Studies of household cooking systems suggest that cooking energy requirements typically range between 1.7 MJ and 2.7 MJ per person per day, depending on cooking methods and food types [9].

For the purpose of modelling, the present study assumes a representative cooking energy requirement:

Q_c= 2.2 MJ per person per day

Using the LPG calorific value of 46 MJ/kg, the theoretical LPG consumption required to supply this cooking energy can be calculated.

Energy released from LPG combustion by eq. (2)

$$E_{LPG} = m_{LPG} \times CV_{LPG}$$

Where

E_{LPG}= energy released from LPG combustion (MJ)
m_{LPG}= mass of LPG consumed (kg)
CV_{LPG}= calorific value of LPG (46 MJ/kg^{-1})

Considering typical LPG stove efficiency between **45–60%**, the useful energy delivered to the cooking process is significantly lower than the chemical energy contained in the fuel [10].

Therefore, LPG consumption is calculated by eq. (4)

$$LPG_c = \frac{Q_c}{CV_{LPG} \times \eta}$$

Where

LPG_c= LPG consumption (kg)
Q_c= useful cooking heat required (MJ)
CV_{LPG}= calorific value of LPG (MJ/kg^{-1})
η= cooking efficiency

Assuming an average cooking efficiency:

$$\eta = 0.50$$

Then:

$$LPG_c = \frac{2.2}{46 \times 0.50}$$
$$LPG_c \approx 0.096 \text{ kg person}^{-1}\text{day}^{-1}$$

Thus, a single person preparing fully cooked meals would require approximately:

0.10 kg LPG per day

This value is consistent with typical household LPG usage patterns.

The estimated LPG consumption of approximately 0.096 kg per person per day is consistent with reported household cooking energy patterns in India[11]. National-level data indicate that households typically consume around 4–6 LPG cylinders per year (14.2 kg each), corresponding to an approximate daily usage range of 0.15–0.25 kg per household, depending on household size and cooking practices. When normalized at the individual level, these values align well with the model-based estimates obtained in this study.

Furthermore, the reduction in LPG consumption observed under meal substitution scenarios (approximately 28–59%) is comparable to, and in some cases exceeds, the improvements reported in efficiency-based interventions such as improved cookstoves and fuel-switching strategies. Previous studies indicate that increases in LPG usage and efficiency improvements can reduce overall cooking energy demand by approximately 20–30% under typical conditions [12]. In contrast, the present model demonstrates that dietary restructuring alone can achieve substantial reductions in cooking energy demand, highlighting the effectiveness of demand-side strategies in household energy systems.

Considering variability in cooking practices and stove efficiencies, the baseline LPG consumption may range between approximately 0.08–0.12 kg per person per day. This range reflects uncertainty in cooking energy requirements and operational conditions, and is consistent with values reported in existing literature.

4.2 Annual Household LPG Consumption

In India, the national average LPG consumption is estimated to be 6.25 cylinders per household per year, where each cylinder contains 14.2 kg of LPG [13].

Therefore, annual LPG consumption per household is:

$$\text{Annual LPG} = 6.25 \times 14.2 \text{ kg}$$

$$\text{Annual LPG} \approx 88.75 \text{ kg per household}$$

Average daily LPG consumption:

$$\text{Daily LPG} \approx 0.24 \text{ kg per household}$$

This estimate corresponds well with the per-person calculations derived from the cooking energy model.

4.2.1 Model Validation with Literature

The baseline LPG consumption estimated in this study (≈0.096 kg per person per day) aligns closely with reported household energy consumption patterns in India. National estimates indicate an average daily LPG consumption of approximately 0.20–0.25 kg per household, which corresponds well with the per-person estimates derived in this model when scaled to typical household sizes.

This agreement between model outputs and published data supports the validity of the analytical framework and demonstrates that the simplified thermodynamic–nutritional approach provides realistic estimates of cooking fuel demand.

4.3 Cooking Energy Associated with Typical Meals

Using the thermodynamic cooking model by eq. (1)

$$Q_c = m_f \, C_p \, (T_f - T_i) + L$$

Where

Q_c= thermal energy required for cooking (MJ)
m_f= mass of food (kg)
C_p= specific heat capacity of food (MJ/kg^{-1})
T_f= final temperature of food (°C)
T_i= initial temperature of food (°C)
L= latent heat losses during cooking (MJ)

The energy required to cook common foods can be estimated.

For example:

Cooking 0.5 kg rice typically requires approximately 1.97 MJ of energy depending on cooking method [14].

Thus, a typical daily cooking energy distribution may be approximated as:

S.no	Meal	Cooking Energy (MJ)
1	Breakfast	0.6
2	Lunch	0.9
3	Dinner	0.7
4	Total	2.2 MJ/day

This baseline is used to estimate fuel savings when meals are replaced with no-cook alternatives.

4.4 LPG Reduction Under Meal Substitution Scenarios

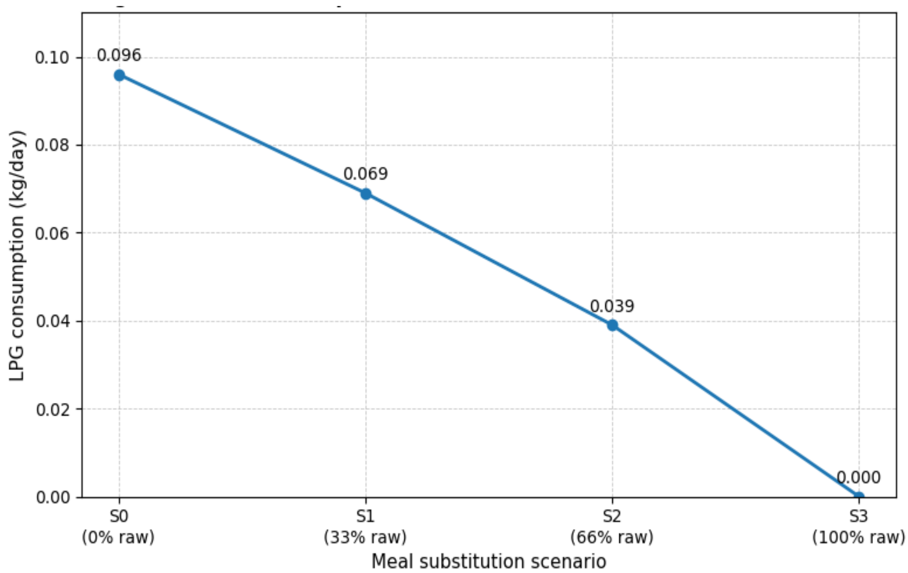

Figure 2. LPG consumption under different meal substitution scenarios, showing a progressive decline in daily LPG demand as the proportion of no-cook meals increases.

The results indicate that LPG consumption decreases progressively as the proportion of no-cook meals increases within the daily diet structure. The reduction trend is non-linear because cooking energy demand varies across meal types depending on thermal processing intensity and duration. Figure 2 demonstrates that partial dietary substitution can substantially reduce daily LPG demand, with the greatest reduction observed under higher no-cook meal scenarios.

The substitution ratio is defined by eq. (5):

$$S = \frac{M_{raw}}{M_{total}}$$

Where

S= substitution ratio (dimensionless)
M_{raw}= number of no cook meals per day
M_{total}= total number of meals per day

For three meals per day:

$$M_{total} = 3$$

Scenario S0 – Fully Cooked Diet

Raw meal share = 0%

Cooking energy required:

LPG consumption:

$$Q_c = 2.2 \text{ MJ day}^{-1}$$
$$LPG_{baseline} \approx 0.096 \text{ kg day}^{-1}$$

Scenario S1 – One No-Cook Meal (33%)

Cooking energy removed:

Breakfast energy = 0.6 MJ

Remaining cooking energy:

Q_c = 1.6 MJ/day

LPG consumption:

$$LPG_{S1} = \frac{1.6}{46 \times 0.5}$$
$$LPG_{S1} \approx 0.069 \text{ kg day}^{-1}$$

Reduction:

LPG saving = 0.027 kg/day

Percentage reduction:

R ≈ 28%

Scenario S2 – Two No-Cook Meals (66%)

Cooking energy removed:

Breakfast + dinner = 1.3 MJ

Remaining cooking energy:

Q_c = 0.9 MJ/day

LPG consumption:

$$LPG_{S2} = \frac{0.9}{46 \times 0.5}$$
$$LPG_{S2} \approx 0.039 \text{ kg day}^{-1}$$

Reduction:

LPG saving = 0.057 kg/day

Percentage reduction:

R ≈ 59%

The reduction in LPG consumption across the substitution scenarios does not follow a simple linear pattern; rather, it reflects the underlying thermodynamic nature of cooking processes. In practical cooking, energy demand is unevenly distributed because different meals involve varying levels of thermal processing. Processes such as boiling, steaming, and prolonged heating dominate cooking energy use, as a significant portion of energy is required to raise the temperature of water and food to boiling conditions and sustain that state[15] .

As observed in this study, lunch and dinner involve relatively higher cooking energy (around 0.9 MJ and 0.7 MJ, respectively) compared to breakfast (around 0.6 MJ). Therefore, eliminating a breakfast meal results in a smaller reduction in LPG consumption, since the avoided thermal load is comparatively limited. In contrast, substituting lunch or dinner leads to more substantial savings because it avoids energy-intensive operations such as bulk water heating and phase change during boiling, which are known to dominate cooking energy requirements.

This explains why the reduction increases sharply from about 28% in Scenario S1 to nearly 59% in Scenario S2, instead of increasing proportionally. The behaviour is fundamentally linked to heat transfer and phase-change phenomena, where energy demand depends more on the intensity and duration of thermal processes than on the number of meals alone. Similar trends have been reported in cooking energy studies, which show that fuel consumption is strongly governed by boiling processes and heat transfer mechanisms rather than simply meal frequency[15].

Scenario S3 – Fully No-Cook Diet

Cooking energy removed:

Q_c = 0 MJ/day

LPG consumption:

$$LPG_{S3} = 0$$

Reduction:

100% reduction

However, fully no-cook diets may not always be practical or nutritionally balanced for all populations.

4.5 LPG Savings Across Population Scales

The calculated LPG demand at the individual level can be expanded to understand the potential fuel savings across larger population groups such as households, hostels, and institutional kitchens. When cooking energy demand is scaled according to the number of people served, the corresponding LPG consumption also increases proportionally because more food mass requires heating and longer cooking durations. For a single individual the estimated LPG requirement is about 0.096 kg per day under fully cooked meal conditions. When this value is extended to larger populations, a kitchen serving fifty people would require roughly 4.8 kg of LPG per day, while kitchens preparing food for one hundred and five hundred individuals would require approximately 9.6 kg and 48 kg respectively. Introducing no cook meals into the daily food schedule reduces the amount of thermal processing required and therefore lowers the total cooking energy demand. Even the replacement of one cooked meal in a day leads to a noticeable decline in fuel consumption because a portion of the heating energy normally required for boiling or steaming food is completely avoided. When two meals are substituted with nutritionally balanced no cook alternatives the reduction becomes even more substantial, particularly in large kitchens where cooking operations are performed continuously throughout the day. These patterns highlight how small dietary adjustments can translate into meaningful energy savings when applied across larger populations.

The quantitative estimates corresponding to these scaled scenarios are summarized in Table 5. The table illustrates how baseline LPG consumption decreases progressively as the share of no cook meals increases across different population levels.

Table 5. Estimated LPG Consumption at Different Population Scales

S.no	Population	Baseline LPG (kg/day)	Scenario S1	Scenario S2	Scenario S3
1	1 person	0.096	0.069	0.039	0
2	50 persons	4.8	3.45	1.95	0
3	100 persons	9.6	6.9	3.9	0
4	500 persons	48	34.5	19.5	0

These calculations demonstrate that large institutional kitchens can potentially achieve **substantial reductions in LPG consumption** through partial meal substitution strategies.

The results indicate that cooking fuel demand scales directly with the number of people served, demonstrating that dietary strategies that reduce the need for heat-based food preparation can significantly influence total energy use in both household and institutional kitchens. As presented in Table 5, baseline LPG demand increases from 0.096 kg per day for one person to 48 kg per day for 500 persons, while partial meal substitution lowers consumption to 0.069 and 0.039 kg per day under scenarios S1 and S2 respectively, indicating substantial proportional reductions in fuel demand as cooked meals are replaced. This trend can be explained mechanistically because cooking energy is primarily required for heating water and food mass during boiling or steaming, and eliminating these thermal steps directly lowers fuel input, a pattern consistent with previous analyses of household cooking systems showing that total cooking energy requirements scale with meal preparation intensity and population size in institutional food service operations [16].

4.6 Nutritional Feasibility of No-Cook Diet Models

Using the session-wise diet tables presented in Section 4, daily nutrient intake can be estimated.

Example:

Total protein intake from the model diet:

$$\text{Breakfast} \approx 17 \text{ g}$$
$$\text{Lunch} \approx 27 \text{ g}$$
$$\text{Dinner} \approx 19 \text{ g}$$

Total protein intake:

$$\approx 63 \text{ g/day}$$

This value aligns with recommended protein intake levels for adults.

Similarly, high fiber intake from fruits, vegetables, and sprouts provides additional nutritional benefits including improved digestion and metabolic health.

4.7 Socioeconomic Implications

The results indicate that dietary restructuring can serve as a demand-side energy strategy for reducing cooking fuel dependence. For households facing cooking fuel shortages or high LPG prices, incorporating no-cook meals can reduce fuel consumption while maintaining dietary adequacy.

Such strategies may be particularly relevant in:

- student hostels
- community kitchens
- disaster relief food systems
- institutions with large food preparation operations

In these contexts, even partial substitution of cooked meals could significantly reduce cooking fuel demand.

4.8 Limitations of the Modelling Approach

The present analysis is based on a simplified analytical framework and therefore involves certain limitations that should be recognised. The model does not explicitly capture behavioural variability in cooking practices, such as differences in cooking duration, flame intensity, and meal preparation habits across households. In addition, variations in cooking methods and technologies, including pressure cooking, frying, and steaming, are not separately considered, even though these processes can significantly influence energy consumption.

The model also does not account for regional diversity in dietary patterns across India, where meal composition and cooking intensity vary widely. Uniform cooking conditions are assumed, and heat transfer losses associated with cookware materials, vessel geometry, and ambient conditions are not explicitly modelled, making the thermodynamic representation approximate rather than fully detailed. Furthermore, average values of stove efficiency and calorific value are used, which may differ under real operating conditions. Despite these limitations, the framework provides a consistent basis for comparing cooking energy demand across scenarios. Future work incorporating field measurements and more detailed modelling approaches could improve the accuracy and applicability of the results.

4.9 Sensitivity Analysis Results

The sensitivity analysis demonstrates that LPG consumption varies with both cooking energy demand and stove efficiency. For lower cooking energy scenarios (1.7 MJ/day), LPG consumption ranges between approximately 0.062–0.082 kg/day, while for higher cooking energy scenarios (2.7 MJ/day), it increases to approximately 0.098–0.130 kg/day. Despite these variations, the percentage reduction in LPG consumption under meal substitution scenarios remains relatively stable, indicating that the model is robust to parameter uncertainty.

To further examine the consistency of the model, an extreme scenario-based evaluation was carried out by considering boundary conditions of cooking energy demand and stove efficiency. When low efficiency and higher cooking energy requirements are assumed, the model predicts an increase in LPG consumption, reflecting greater heat losses and longer cooking durations. In contrast, under conditions of higher efficiency and lower cooking energy demand, the estimated LPG consumption decreases significantly due to more effective heat utilisation and reduced thermal load.

Overall, the model responds in a physically consistent manner across these extreme conditions, with fuel consumption increasing under inefficient and energy-intensive scenarios and decreasing under more efficient and lower-energy situations. This behaviour aligns well with fundamental thermodynamic principles, indicating that the modelling framework remains stable and logically consistent across a wide range of operating conditions.

Table 6. Extreme Scenario-Based Validation of LPG Consumption

Scenario	Qc (MJ/day)	η	LPG (kg/day)	Interpretation
Low efficiency + High energy	2.7	0.45	0.13	Maximum consumption
Average case	2.2	0.5	0.096	Baseline
High efficiency + Low energy	1.7	0.6	0.062	Minimum consumption

The results presented in Table 6 further confirm that LPG consumption varies predictably with changes in cooking energy demand and stove efficiency. Higher energy requirements combined with lower efficiency result in increased fuel consumption, while improved efficiency and reduced thermal demand lead to lower LPG usage. This consistent trend demonstrates that the model responds realistically to extreme operating conditions and reinforces its physical reliability.

The sensitivity of LPG consumption to variations in cooking energy and stove efficiency is illustrated in Figure 3

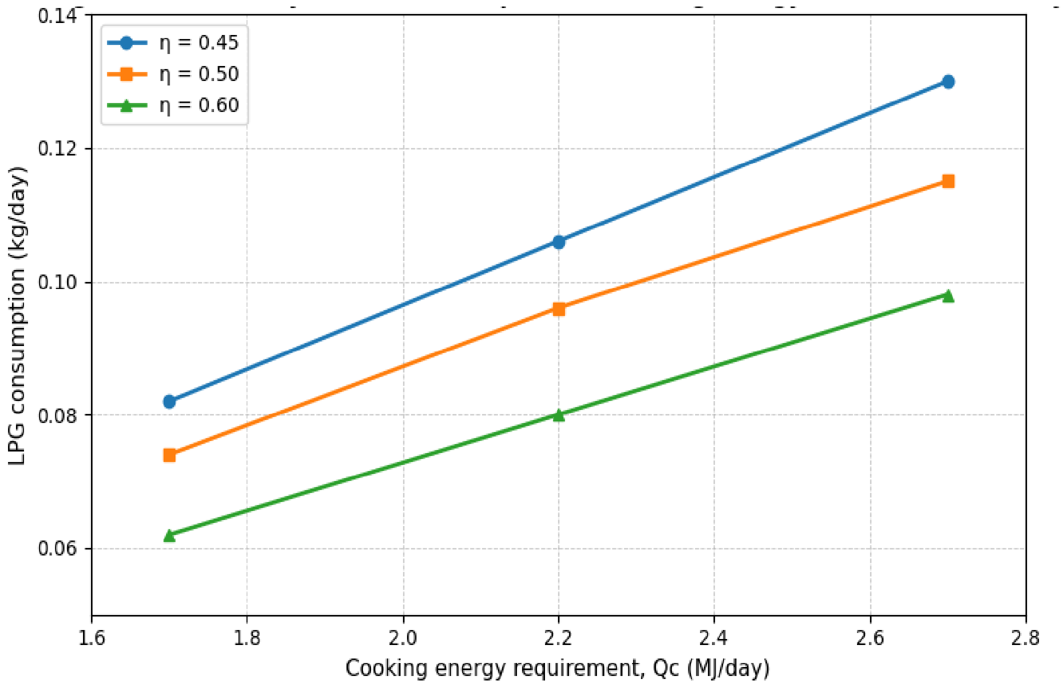

Figure 3. Variation of LPG consumption with cooking energy requirement and stove efficiency.

5 Policy Implications

The results of the modelling framework indicate that partial substitution of cooked meals with nutritionally balanced no-cook alternatives could significantly reduce cooking fuel demand in domestic and institutional food systems. These findings have implications for several policy areas, including energy security, sustainable food systems, and emergency food provisioning.

5.1 Cooking Energy Security

Many countries, including India, rely heavily on imported petroleum products for domestic cooking fuels. National energy statistics indicate that India consumes more than 25 million tonnes of LPG annually, with a substantial portion supplied through imports. Such dependency exposes the cooking energy sector to fluctuations in global fuel markets and geopolitical disruptions [17].

Demand-side strategies that reduce cooking energy consumption can therefore contribute to improved energy security. Incorporating no-cook meals into daily diets represents a practical method for reducing household dependence on LPG without requiring major technological changes in cooking systems.

5.2 Institutional Food Systems

Large-scale kitchens serving hostels, hospitals, universities, and community kitchens represent significant consumers of cooking fuels. The modelling results presented in this study indicate that replacing one cooked meal per day with nutritionally balanced no-cook alternatives could reduce LPG consumption by approximately 25–30%, while replacing two meals could reduce consumption by nearly 60%.

Such reductions could have considerable economic benefits in large institutional kitchens where daily fuel consumption is high. Implementing structured meal substitution strategies in these settings may therefore reduce operational costs while maintaining nutritional adequacy.

5.3 Disaster Relief and Emergency Food Systems

Emergency food systems often face logistical challenges related to fuel availability, cooking infrastructure, and time constraints. Disaster relief camps, refugee settlements, and emergency feeding programs frequently operate in environments where cooking fuel supplies are limited.

No-cook meal strategies could provide a viable solution in such contexts by enabling rapid food distribution without the need for cooking equipment or fuel. Foods such as fruits, sprouted legumes, dairy products, and nuts can provide substantial nutritional value while requiring minimal preparation.

5.4 Sustainable Food–Energy Systems

The concept of integrating dietary design with cooking energy reduction aligns with the broader framework of the food–energy nexus, which highlights the interconnections between food production, energy consumption, and environmental sustainability.

Cooking fuels such as LPG have high energy densities around 46 MJ per kilogram, reflecting the large amount of energy required for conventional cooking processes [2].

Reducing cooking energy demand through dietary restructuring could therefore contribute to more sustainable food systems by lowering fossil fuel consumption and associated emissions.

5.5 Behavioural and Cultural Considerations

Despite the potential benefits of no-cook dietary strategies, their adoption depends on cultural preferences, dietary habits, and consumer acceptance. In many societies, cooked meals are deeply embedded in traditional food practices, and widespread dietary change may require gradual behavioural adaptation.

Consequently, policy approaches promoting no-cook meal strategies should emphasize partial substitution rather than complete dietary replacement. Educational campaigns highlighting the nutritional benefits of fruits, vegetables, sprouts, and dairy products could support gradual integration of such foods into daily diets.

6. Conclusions

This study developed a nutritional–energy analytical framework to evaluate the potential reduction in LPG consumption achievable through structured substitution of cooked meals with nutritionally balanced no-cook meals. The modelling approach integrates food composition data, dietary energy requirements, thermodynamic cooking energy equations, and LPG fuel properties to estimate cooking fuel consumption under different dietary scenarios. The results demonstrate that cooking energy demand is strongly influenced by meal preparation practices and dietary structure. Using a representative cooking energy requirement of approximately 2.2 MJ per person per day, the analysis estimated baseline LPG consumption of roughly 0.096 kg per person per day under conventional cooking conditions. Scenario analysis showed that substituting one daily cooked meal with a no-cook alternative could reduce LPG consumption by approximately 28%, while replacing two cooked meals could reduce consumption by nearly 59%. Complete elimination of cooking would theoretically eliminate cooking fuel demand entirely, although such a dietary pattern may not be practical or nutritionally optimal for all populations. The study also demonstrated that nutritionally balanced no-cook meal designs can meet recommended protein and micronutrient requirements when appropriate combinations of fruits, sprouts, nuts, dairy products, and vegetables are included. Session-wise diet modelling indicated that daily protein intake exceeding 60 g per day could be achieved within the proposed dietary framework. Overall, the findings highlight the importance of considering demand-side strategies in cooking energy research. While most previous studies have focused on improving stove efficiency or transitioning to cleaner fuels, dietary restructuring represents an alternative pathway for reducing cooking energy consumption. The analytical framework developed in this study provides a foundation for future research exploring the relationship between dietary patterns and household energy demand. Further empirical studies involving field measurements and dietary surveys could help validate the modelling results and assess the practical feasibility of implementing no-cook meal strategies in real-world food systems.

References

[1] T. Longvah, R. Ananthan, K. Bhaskar, and K. Venkaiah, *Indian food Composition Tables*. 2017. Accessed: Mar. 13, 2026. [Online]. Available: https://www.researchgate.net/publication/313226719_Indian_food_Composition_Tables

[2] i-maximum, "LPG as an energy carrier – learn about the calorific value of LPG gas." Accessed: Mar. 13, 2026. [Online]. Available: https://i-maximum.com/sng-lpg-blog/lpg-as-an-energy-carrier-learn-about-the-calorific-value-of-lpg-gas/96111647085332

[3] Krittika Roy, "Cooking with Modern Energy in Rural Households of India: A Cost–Benefit Analysis," *Ecology, Economy and Society–the INSEE Journal*, 2024, Accessed: Mar. 13, 2026. [Online]. Available: https://doi.org/10.37773/ees.v7i1.998

[4] Zandu, "Moong Sprouts Nutritional Value, Protein, Calories Count Per 100g." Accessed: Mar. 13, 2026. [Online]. Available: https://zanducare.com/blogs/exploring-ayurveda/nutritional-value-of-moong-sprouts?srsltid=AfmBOoq1GwYLjQ7nsWx--2nkGoz40SaEwk13KBFJSr_eU2w4h9bRPPgq&utm

[5] Madhavan, "CALORIE VALUE OF FOOD ITEMS," 2009. Accessed: Mar. 13, 2026. [Online]. Available: https://jtmadhavan.wordpress.com/wp-content/uploads/2009/09/the-calorie-chart-of-indian-food.pdf?utm

[6] A. Kataria, B. M. Chauhan, and D. Punia, "Antinutrients and protein digestibility (in vitro) of mungbean as affected by domestic processing and cooking," *Food Chem.*, vol. 32, no. 1, pp. 9–17, 1989, doi: https://doi.org/10.1016/0308-8146(89)90003-4.

[7] X. Wang *et al.*, "Effect of Germination on the Digestion of Legume Proteins," *Foods*, vol. 13, no. 17, 2024, doi: 10.3390/foods13172655.

[8] A. W. Ebert, C.-H. Chang, M.-R. Yan, and R.-Y. Yang, "Nutritional composition of mungbean and soybean sprouts compared to their adult growth stage," *Food Chem.*, vol. 237, pp. 15–22, 2017, doi: https://doi.org/10.1016/j.foodchem.2017.05.073.

[9] H. G. Punam Singh, "Life Cycle Energy Analysis (LCEA) of Cooking Fuel Sources Used in India Households," *Energy and Environmental Engineering 2(1): 20-30*, 2014, Accessed: Mar. 13, 2026. [Online]. Available: https://doi.org/10.13189/eee.2014.020103

[10] Energypedia, "LPG for cooking." Accessed: Mar. 13, 2026. [Online]. Available: https://energypedia.info/wiki/LPG_for_cooking?utm

[11] D. Guta *et al.*, "The impact of LPG consumption on cooking energy efficiency: Evidence from rural Indian household panel data," *World Dev. Perspect.*, vol. 36, p. 100627, 2024, doi: 10.1016/j.wdp.2024.100627.

[12] D. Guta *et al.*, "The impact of LPG consumption on cooking energy efficiency: Evidence from rural Indian household panel data," *World Dev. Perspect.*, vol. 36, no. C, p. 100627, 2024, doi: 10.1016/j.wdp.2024.100627.

[13] downtoearth, "Overcoming India's clean cooking challenge." Accessed: Mar. 13, 2026. [Online]. Available: https://www.downtoearth.org.in/energy/overcoming-india-s-clean-cooking-challenge-68562?utm

[14] Satesh, "How to Calculate LPG Gas Consumption for Your Household Appliances."

[15] S. Indora and T. C. Kandpal, "Institutional cooking with solar energy: A review," *Renewable and Sustainable Energy Reviews*, vol. 84, pp. 131–154, 2018, doi: https://doi.org/10.1016/j.rser.2017.12.001.

[16] D. Guta *et al.*, "The impact of LPG consumption on cooking energy efficiency: Evidence from rural Indian household panel data," *World Dev. Perspect.*, vol. 36, p. 100627, 2024, doi: https://doi.org/10.1016/j.wdp.2024.100627.

[17] Wikipedia, "Energy policy of India." Accessed: Mar. 13, 2026. [Online]. Available: https://en.wikipedia.org/wiki/Energy_policy_of_India?utm