Thermal performance of gasifier cooking stoves: A systematic literature review [version 2; peer review: 1 approved, 1 approved with reservations]

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Abstract
A systematic literature review was conducted to summarize the overall thermal performance of different gasified cooking stoves from the available literature. For this purpose, available studies from the last 14 years (2008 to 2022) were searched using different search strings. After screening, a total of 28 articles were selected for this literature review. Scopus, Google Scholar, and Web of Science databases were used as search strings by applying “Gasifier cooking stove” AND “producer gas cooking stove” AND “thermal performance” keywords. This review uncovers different gasified cooking stoves, cooking fuels, and fabrication materials besides overall thermal performances. The result shows that the overall thermal performance of different gasified cooking stoves was 5.88% to 91% depending on the design and burning fuels. The premixed producer gas burner with a swirl vane stove provided the highest overall thermal performance range, which was 84% to 91%, and the updraft gasified stove provided the lowest performance, which was 5.88% to 8.79%. The result also demonstrates that the wood pellets cooking fuel provided the highest thermal performance and corn straw briquette fuel provided the lowest for gasified cooking stoves. The overall thermal performance of wood pellets was 38.5% and corn straw briquette was 10.86%.

Keywords
Gasified cooking stoves, thermal performance, cooking fuels and literature review.
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Amendments from Version 1

In this new version (version 2), some major modifications have been done based on the suggestions and comments of the reviewers. The number of stoves and fuels identified from literature in the Abstract section added in the abstract section. The design, working principal and reason of performance for different identified gas stoves have been added in results and discussion section. Table 2 and Figure 3 have been removed upon suggestions from reviewer. Short description has been provided for all cases presented in Tables 3, 4 and 5. The phenomena behind the performance of cooking stoves and cooking fuels are also included. Six new figures (Figure 3 to Figure 8) have been included to present the design and working principle of different cooking stoves.

Any further responses from the reviewers can be found at the end of the article

Introduction

One of the largest energy-consuming sectors in developing nations is the cooking sector, and this sector requires a large amount of energy and effort as it is a commonplace daily activity. Biomass fuel, natural gas, oil, and coal are the predominant sources of energy for cooking sector, and the majority of the inhabitants in developing countries rely on conventional fuels, typically wood and agricultural residues. Approximately three billion people worldwide, 41% of households, rely on solid biomass fuels (biomass such as wood, crop residues, animal waste, charcoal, and coal) for cooking due to the affordability or availability of these fuels, especially in developing countries in Asia and sub-Saharan Africa (Bonjour et al., 2013). The majorities of the conventional cooking are perpetrated over open flames, which burn inefficiently and result in significant emissions. It is worth to be mentioned that, in 2010, about 3.5 million premature deaths globally were caused by household air pollution (Lim et al., 2012), and it also contributed to outdoor air pollution, which resulted in an additional 370,000 deaths and 9.9 million disability-adjusted life worldwide (Chafe et al., 2014). Furthermore, household emissions can stimulate lung cancer, chronic obstructive pulmonary disease and chronic bronchitis, cardiovascular diseases, low birth weight, stillbirth, and acute lower respiratory infections (Amegah & Jaakkola, 2016). Excessive uses of solid fuels have pernicious effects on human health, regional environment, and global climate (Smith et al., 2004). Due to the pernicious impact on human health that results in sophisticated diseases, global temperature rise, hazardous gas emissions, and excessive time waste in conventional cooking, the advancement of heat generation techniques in cooking stoves become significant.

To concoct an improved cooking stove, it must requires substantial improvements in combustion efficiency as well as increased fuel efficiency compared to conventional stoves (Venkataraman et al., 2010). In the first decade of the 1940s, the development of biomass-based cooking stoves commenced in India, and these stoves were known as improved mud cooking stoves. Then another study (Raju, 1954) reported the development of the upgraded multi-pot mud cooking stoves for Indian rural households. Afterwards, an upsurge in better cooking stoves appeared due to the world’s focus shifted to environmental concerns and energy conservation measures. These cooking stoves were created and built using engineering principles, making them more effective and long-lasting than the conventional open fired cooking stove. Investigators are currently attempting to design cooking stoves that are more ecologic and sustainable as well as more energy and thermally efficient. To date, several different types of improved cooking stoves have been designed and investigated, i.e. katsari cooking stoves (Cynthia et al., 2005), mirt cook stove (Dresen et al., 2014), gasifier cook stove (Carter et al., 2014), wick stove (Dinesha et al., 2019), pellet stoves (Boman et al., 2011), radiant stoves (Pantangi et al., 2011), etc. From the above verities, gasifier cook stove is one of the potential energy efficient and environment friendly cook stove.

The process of transforming solid or liquid feed stocks into usable gaseous or other chemical fuels that may be combusted to produce thermal energy is known as gasification. Fuel with a small amount of air is delivered into a closed container so that the fuel can be partially combusted to generate the required heat for gasification. The fundamental idea of gasification is that it is a thermochemical process that uses the reactions of drying, pyrolysis, oxidation, and reduction to turn solid fuel into a combustible gas (producer gas) (Basu, 2010). In a gasifier cook stove, biomass is gasified in the reactor to generate syngas, thereafter, syngas is burned in the burner in order to obtain producer gas flame (Susastriawan et al., 2021). On the contrary, biomass is directly combusted with the presence of excess air and produced heat and flue gas.

Due to the eclectic amount of highly appealing characteristics of gasifier cook stoves, including high efficiency, smoke-free safe combustion, uniform and steady flame, simplicity of controlling the flame, and operational capability for long periods (Raman et al., 2014), the advancement of gasifier cooking stoves became significant. Therefore, to date, several research studies had been performed on the design and development of gasifier cooking stoves with the goal of increasing efficiency and dwindling emission such as producer gas stove with bluff-body shape in burner (Susastriawan et al., 2021), producer gas stove (Panwar et al., 2011; Punnarapong et al., 2017), Chinese gasifier stove (Carter et al., 2014), natural-draft gasifier cook stoves (Hailu, 2022; Tryner et al, 2014), fixed bed advanced micro-gasifier cook stowe (Sakthivadivel & Iniyan, 2017), inverted downdraft gasifier (Narnaware & Pureek, 2016; Ojolo et al., 2012; Osei et al., 2020), biomass
gasifier cook stove (Panwar & Rathore, 2015), top-lit updraft gasifier cook stove (Scharler et al., 2021), advance micro-gasifier stove (Sakthivadivel et al., 2019; Wamalwa et al., 2017), rice husk gas stove (Ndindeng et al., 2019), natural and force draft gasifiers stove (Getahun et al., 2018), and natural cross draft (Nwakaire & Ugwuishiwu, 2015). However, to the authors’ best knowledge, no proper systematic reviews have already been conducted on the overall thermal performance of gasifier cook stoves, with an emphasis on types of gasifier stoves, cooking fuels, location of investigation, and materials to fabricate stoves. Therefore, in this study, a systematic review has been performed to consolidate all the technical works published on the thermal performance of gasifier cooking stoves as well as further analyse the areas on which additional studies should be focused for future research trajectory.

Methods
A typical research methodology steps for systematic review of Tranfield et al. (2003) are considered which are given in Figure 1 wherein the 1st stage is known as “Define” which is subdivided by steps as “Identification of need for a literature review” and “Development of a literature review protocol”. The 2nd stage known as “Collect and Select” which is also consist of two steps: “Identification of documents” and “Selection of relevant documents”. Simultaneously, the 3rd stage is “Analyse” which is categorized as documents and Data extraction steps. Meanwhile, the final stage is “Result” indicates the last steps “Documents Finding” wherein collected all documentation are reviewed significantly for extracting knowledge from gathered information.

Search and selection strategy
A literature search was conducted to cover the period from January 2008 to August 2022. Scopus, Web of Science, Google Scholar and Science Direct databases were selected as search strings. Boolean operators “AND” and “OR” between Keywords and database searching fields. The searching keywords were gasified cooking stoves, producer gas cooking stove thermal performance and cooking fuels. The gasified cooking stove also called as producer gas cooking stove therefore both of the terms used as keywords. EndNote X 9.0 software was used to exclude duplicates from searched data. The protocol of the review discussed in Table 1.

Data extraction and analysis
To conduct this study, the author, date, name and types of study, study location, stoves types, material used, fuels/energy sources, thermal performances and emission of pollutants were reported by using Microsoft Excel.

Results and discussion
A total of 1153 articles initially identified. After removing duplicates, checking title, abstract and full text, 28 were found eligible based on the predetermined exclusion and inclusion criteria for this study. Among the 28 selected articles, all conducted their investigation on gasified cooking stoves experimentally and only 3 articles performed numerical/computational analysis beside experimental study.

Figure 1. Summary of study selection design.
**Table 1. Protocol of review.**

<table>
<thead>
<tr>
<th>Items</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keywords</td>
<td>Gasifier cooking stove, producer gas cooking stove, thermal performance and emission of pollutants</td>
</tr>
<tr>
<td>Boolean Operators</td>
<td>“AND” between Keywords; “OR” between Database search fields.</td>
</tr>
<tr>
<td>Search Fields</td>
<td>Abstract; Title; Keywords;</td>
</tr>
<tr>
<td>Exclusion Criteria</td>
<td>Household survey study, review article, articles that did not determine thermal performance or emission of pollutants</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
</tr>
<tr>
<td>Publication Type</td>
<td>Article</td>
</tr>
<tr>
<td>Time Window</td>
<td>January 2008 to August 2022</td>
</tr>
<tr>
<td>Searching Keywords</td>
<td>Gasified cooking stoves, producer gas cooking stove thermal performance, cooking fuels</td>
</tr>
</tbody>
</table>

**Figure 2. Year wise publications percentages.**

Publication year
The publications year of the selected articles is summarized in Figure 2, which was obtained from Table 2. The figure shows that the selected articles were published in 2022, 2021, 2020, 2019, 2017, 2016, 2015, 2014, 2012 and 2008. The result also highlights that the highest amount of research on gasified cooking stoves was conducted in 2019 at 18% and the lowest amount of research was conducted in 2012 at only 4%. From the beginning to the mid of the current year 2022 almost 14% studies were identified from the selected literature which reflects that the investigation demand on gasified cooking stoves is recently also a high priority to researchers.

Identified gasified cooking stoves
From the literature search, this review identified different types of gasified cooking stoves wherein modification and improvement were applied. Based on the findings from Table 2 the identified gasified cooking stoves are summarized in few categories, which are:
<table>
<thead>
<tr>
<th>Authors</th>
<th>Material used</th>
<th>Fuel/energy source</th>
<th>Gasified stove types</th>
<th>Study locations</th>
<th>Study types</th>
<th>Study types locations</th>
<th>Thermal efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hailu, 2022</td>
<td>Steel sheet or cast iron</td>
<td>Eucalyptus, bamboo, and sawdust-cow animal waste briquettes</td>
<td>Natural draft</td>
<td>Not mentioned</td>
<td>Experimental and computational</td>
<td>India</td>
<td>29.85%, 28.43% and 23.76% for eucalyptus, sawdust-cow animal waste briquettes</td>
</tr>
<tr>
<td>Gutierrez, et al., 2022</td>
<td>Not mentioned</td>
<td>Forced draft with separate secondary and primary air fans</td>
<td>General gasified</td>
<td>Not mentioned</td>
<td>Experimental and Computational</td>
<td>China</td>
<td>41.43%</td>
</tr>
<tr>
<td>Varunkumar, et al., 2012</td>
<td>Not mentioned</td>
<td>General gasified</td>
<td>General gasified</td>
<td>Not mentioned</td>
<td>Experimental and Computational</td>
<td>China</td>
<td>41-43%</td>
</tr>
<tr>
<td>Schaller, et al., 2021</td>
<td>Not mentioned</td>
<td>Top-lit updraft</td>
<td>Top-lit updraft</td>
<td>Not mentioned</td>
<td>Experimental and Numerical</td>
<td>Indonesia</td>
<td>45 - 47%</td>
</tr>
<tr>
<td>Sussastrian, et al., 2020</td>
<td>Not mentioned</td>
<td>Producer gas stove with bluff body shape in burner</td>
<td>Updraft</td>
<td>Not mentioned</td>
<td>Experimental and Numerical</td>
<td>Indonesia</td>
<td>42%</td>
</tr>
<tr>
<td>Andika and Nawiwan, 2020</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental and Numerical</td>
<td>China</td>
<td>17.6%</td>
</tr>
<tr>
<td>Osei, et al., 2020</td>
<td>Cassava peel</td>
<td>Cassava peel</td>
<td>Cassava peel</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Ghana</td>
<td>5.88 to 8.79%</td>
</tr>
<tr>
<td>Ahmad, et al., 2019</td>
<td>Peanut shell pellets, corn cobs, wood chips</td>
<td>Top-lit updraft (TLUD) with remote burner and fuel</td>
<td>Top-lit updraft</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>31.4 ± 1.2 for peanut shell pellets, 27.1 ± 0.9% for corn cobs and 23.3 ± 0.7% for wood chips</td>
</tr>
<tr>
<td>Desale, 2019</td>
<td>Neem stalk</td>
<td>Inverted downdraft</td>
<td>Forced draft</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Ethiopia</td>
<td>30.5-38.1%</td>
</tr>
<tr>
<td>Geethun, et al., 2018</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Sub-sahara africa</td>
<td>22.7% and 25% for natural draft and forced draft respectively</td>
</tr>
<tr>
<td>Ndindeng, et al., 2019</td>
<td>Rice husk</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Natural and forced draft</td>
<td>Nigeria</td>
<td>11% for MY gasifier and 30% for PO150 and 26% for other stoves</td>
</tr>
<tr>
<td>Susastriawan, et al., 2021</td>
<td>Stainless steel</td>
<td>Producer gas stove with bluff body shape in burner</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Indonesia</td>
<td>11%</td>
</tr>
<tr>
<td>Andika and Nawiwan, 2020</td>
<td>Stainless steel</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>11%</td>
</tr>
<tr>
<td>Nusrin et al., 2019</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>11%</td>
</tr>
<tr>
<td>Desale, 2019</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>11%</td>
</tr>
<tr>
<td>Osei, et al., 2020</td>
<td>Cassava peel</td>
<td>Cassava peel</td>
<td>Cassava peel</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Ghana</td>
<td>5.88 to 8.79%</td>
</tr>
<tr>
<td>Ahmad, et al., 2019</td>
<td>Peanut shell pellets, corn cobs, wood chips</td>
<td>Top-lit updraft (TLUD) with remote burner and fuel</td>
<td>Top-lit updraft</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>31.4 ± 1.2 for peanut shell pellets, 27.1 ± 0.9% for corn cobs and 23.3 ± 0.7% for wood chips</td>
</tr>
<tr>
<td>Desale, 2019</td>
<td>Neem stalk</td>
<td>Inverted downdraft</td>
<td>Forced draft</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Ethiopia</td>
<td>30.5-38.1%</td>
</tr>
<tr>
<td>Geethun, et al., 2018</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Natural and forced draft</td>
<td>Sub-sahara africa</td>
<td>22.7% and 25% for natural draft and forced draft respectively</td>
</tr>
<tr>
<td>Ndindeng, et al., 2019</td>
<td>Rice husk</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Not mentioned</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>11% for MY gasifier and 30% for PO150 and 26% for other stoves</td>
</tr>
<tr>
<td>Authors</td>
<td>Gasified stove types</td>
<td>Study types</td>
<td>Study locations</td>
<td>Material used</td>
<td>Fuel/energy source</td>
<td>Thermal efficiency</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------</td>
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<td>-----------------</td>
<td>---------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Sakthivadivel et al., 2019</td>
<td>Advanced micro</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Carbon steel</td>
<td>Coconut shells, tamarind pellet and Prosopis juliflora</td>
<td>36.7 ± 0.4%, 37 ± 0.4% and 38 ± 0.4%, for coconut shells, Prosopis juliflora and tamarind seed pellets, respectively.</td>
<td></td>
</tr>
<tr>
<td>Punnarapong et al., 2017</td>
<td>Premixed producer gas burner with a swirl vane</td>
<td>Experimental</td>
<td>Thailand</td>
<td>Steel sheet and Ceramic fiber</td>
<td>Charcoal</td>
<td>84 – 91%</td>
<td></td>
</tr>
<tr>
<td>Sakthivadivel and Iniyan, 2017</td>
<td>Fixed bed advanced micro</td>
<td>Experiment</td>
<td>India</td>
<td>Carbon steel</td>
<td>Biomass fuels like coconut shells, prosopis Juliflora and wood pellets</td>
<td>36.7%, 36% and 38.5% for coconut shell, Prosopis Juliflora and wood pellets, respectively</td>
<td></td>
</tr>
<tr>
<td>Wamalwa et al., 2017</td>
<td>Micro</td>
<td>Experimental</td>
<td>Kenya</td>
<td>Not mentioned</td>
<td>Saw dust pellets</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Ahmad et al., 2016</td>
<td>Top lit up-draft (TLUD)</td>
<td>Experimental</td>
<td>China</td>
<td>Not mentioned</td>
<td>Wood char, rice husk, corn cob, nut shell pellets and corn straw briquette</td>
<td>17.8%, 16.47%, 14.38%, 12.38% and 10.86% for woodchar, rice husk, corncob, and nut shell pellets and corn straw briquette, respectively.</td>
<td></td>
</tr>
<tr>
<td>Chen et al., 2016</td>
<td>Chinese three forced-draft</td>
<td>Experimental</td>
<td>China</td>
<td>Not mentioned</td>
<td>Pellets made with cornstalk and cow animal waste</td>
<td>16% to 43%</td>
<td></td>
</tr>
<tr>
<td>Narnaware and Pareek, 2016</td>
<td>Downdraft</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Mild steel</td>
<td>Mango (magnifera indica), babul (prosopis juliflora) and nim (azadirachta indica) wood</td>
<td>36 to 39%</td>
<td></td>
</tr>
<tr>
<td>Panwar and Rathore, 2015</td>
<td>General gasified</td>
<td>Experimental</td>
<td>India</td>
<td>Mild steel</td>
<td>Biomass (Prosopis juliflora)</td>
<td>36.38%</td>
<td></td>
</tr>
<tr>
<td>Balakumar et al., 2015</td>
<td>Forced draft micro</td>
<td>Experimental</td>
<td>India</td>
<td>Not mentioned</td>
<td>Juliflora wood and Coconut shell</td>
<td>for high power hot and cold start 28% and 30% for coconut shell and 27% and 28% for juliflora wood.</td>
<td></td>
</tr>
<tr>
<td>Kumar et al., 2015</td>
<td>Chinese model (HX-20) updraft institutional</td>
<td>Experimental</td>
<td>Nepal</td>
<td>Not mentioned</td>
<td>Wood chips, rice husk and pellet</td>
<td>17.76%, 15.51% and 19.91% for wood chips, rice husk and pellet</td>
<td></td>
</tr>
<tr>
<td>Nwakaire and Uguwuhiwu, 2015</td>
<td>Natural cross draft</td>
<td>Experimental</td>
<td>Sub-saharan africa</td>
<td>Mild steel</td>
<td>Rice husk briquette</td>
<td>21.10%</td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>Gasified stove types</td>
<td>Study types</td>
<td>Study locations</td>
<td>Material used</td>
<td>Fuel/energy source</td>
<td>Thermal efficiency</td>
<td></td>
</tr>
<tr>
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<td>------------------------</td>
<td>-------------------------------</td>
<td>-------------------</td>
<td></td>
</tr>
<tr>
<td>Carter et al., 2014</td>
<td>Chinese general gasified</td>
<td>Experimental</td>
<td>China</td>
<td>Not mentioned</td>
<td>Processed (pelletized) biomass</td>
<td>22 to 33%</td>
<td></td>
</tr>
<tr>
<td>Shahi et al., 2014</td>
<td>General gasified</td>
<td>Experimental</td>
<td>Nepal</td>
<td>Not mentioned</td>
<td>Pinus roxburghii (Salla) wood</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td>Tryner et al., 2014</td>
<td>Natural-draft semi</td>
<td>Experimental</td>
<td>Not mentioned</td>
<td>Steel sheet</td>
<td>Corn cobs and wood pellets</td>
<td>42%</td>
<td></td>
</tr>
<tr>
<td>Ojolo et al., 2012</td>
<td>Inverted downdraft</td>
<td>Experimental</td>
<td>Nigeria</td>
<td>Not mentioned</td>
<td>Biomass wood shaving</td>
<td>10.6%</td>
<td></td>
</tr>
<tr>
<td>Panwar and Rathore, 2008</td>
<td>General gasified</td>
<td>Experimental</td>
<td>India</td>
<td>Mild steel</td>
<td>Babul wood and gas</td>
<td>26.5%</td>
<td></td>
</tr>
</tbody>
</table>


3. Downdraft gasified stove: Downdraft gasifier and biomass downdraft.

4. Natural draft gasified stove: Natural draft and natural cross draft.

5. Forced draft gasified stove: Forced draft, forced draft pellet-fed semi gasifier, and forced draft with separate secondary and primary air fans.


7. Others: Producer gas stove with bluff-body shape in burner, rice husk gasifier stove, etc.

From the table it can be seen that most of the studies worked on general gasified cooking stoves while lowest number of studies worked on micro, and other gasified cooking stoves. Due to the easy design consideration and fabrication, most of the studies considered general gasified cooking stoves for their investigation. A short description of the categorized cooking stoves are as follows:

**General gasified cooking stove**
Few published articles have focused on gasified cooking stoves, but have not mentioned any particular type. These stoves are generally referred to as 'general gasified cooking stoves' in the literature. Biomass, Chinese, and biochar are identified as general gasified cooking stoves in literature. A bio-char general gasified cooking stove of Shahi et al. (2014) is presented in Figure 3. The stove mainly consists of outer cylinder ad inner cylinder. Inside the inner cylinder the combustion and then gasification occurs. The working procedure of these stoves depend on two processes. Firstly, charcoal and hydrocarbon-containing gases are combined with solid biomass in the gasification process. Second, a clear (smokeless) flame is used to burn the gases. At this stage, the stove's operation is halted when making charcoal, and the charcoal is taken out as a residue. For gasification, a primary air flow is necessary, and to help the gas ignite, a secondary air flow is added to the hot gas above the fuel.

**Updraft gasifier cook stove**
Updraft gasifier cook stoves are a type of biomass stove that produce a clean and efficient flame through a process of partial combustion and gasification of the fuel. The basic principle of the updraft gasifier cook stove is to burn the fuel in

**Figure 3. Bio-char general gasified cooking stoves (Shahi et al., 2014).**
an oxygen-limited environment, creating a syngas consisting of hydrogen, carbon monoxide, and other combustible gases. This gas is then burned cleanly in a secondary combustion chamber, producing a hot and efficient flame.

Figure 4 illustrates the schematic diagram of a Top-Lit Up Draft (TLUD) gasifier cook stove (Scharler et al., 2021). The TLUD, known as the reverse downdraft gasifier, is a highly popular cook stove technology due to its ease of use and flexibility. It offers the same level of adaptability as the updraft gasifier, but with the added advantage of the downdraft gasifier: volatiles, including tar, produced during pyrolysis are partially decomposed and burned as they pass through the hot char bed above. This TLUD, as shown in Figure 4, enhances its flame efficiency by utilizing external fans or blowers. However, the TLUD stove can also be used by natural draft flow (Tryner et al., 2014).

**Downdraft gasified stove**

A downdraft gasified stove is a type of cooking stove that operates by burning wood or other biomass in a closed chamber, which produces a gas that is then burned in a secondary combustion chamber to generate heat. The downdraft design of the stove allows for more efficient and complete combustion, resulting in lower emissions and higher energy efficiency compared to traditional open fire cooking.

The downdraft gasifier involves introducing biomass feedstock into the top of the gasifier, where it undergoes a series of processes including drying, pyrolysis, oxidation, and reduction as it moves downwards through the gasifier, as depicted in Figure 5 (Susastriawan & Saptoadi, 2017). The gasification process produces a gas called producer gas which exits the gasifier through an outlet at the bottom. Producer gas is typically composed of both combustible gases, including CO, H₂, and CH₄, and non-combustible gases like CO₂ and N₂.

**Natural draft gasified stove**

The gasifier stoves are built from sheet metals using basic mechanical techniques, and they include a fuel chamber for loading biomass residue, air inlets for partial combustion, and a pot stand for holding cooking utensils. This particular gasifier stove is natural, so it does not require any external power source to drive the primary and secondary air into the stove, unlike other gasifier stoves that rely on electricity. Figure 6 illustrates a schematic diagram of natural up draft gasifier stove. This stove is constructed by Hailu (2022) from mild steel sheet metal and can hold a maximum of 0.0005 m³ (500 gm) of fuel for effective gasification. Secondary air enters the stove through the gap between the external cylinder and the internal gasifier chamber. The study suggests that the heat generated by the gasifier chamber’s surface plays a crucial role in the combustion process. Specifically, this heat warms up the secondary air by means of conduction and...
convection, creating optimal conditions for combustion at the top of the gasifier chambers exterior. Due to this efficient process, the gasifier is able to function effectively and produce the desired output.

**Forced draft gasified stove**

A forced draft gasified stove is a type of cook stove that uses a fan to introduce air into the combustion chamber at a higher pressure than the surrounding air. This results in a more efficient combustion process, with fuel burned more completely and at a higher temperature. Forced draft stoves also often include features such as insulation and preheated air supplies, which further optimize the combustion process and minimize heat loss.

Figure 7 depicts a forced draft gasified stove with two separate fans to supply primary and secondary air (Himanshu *et al.*, 2022). According to their study, the primary air was fed from a grate located below the fuel bed, which facilitated gasification, while the secondary air was introduced from the top of the cook stove and utilized to burn the volatiles released during biomass pellet gasification. The design also included an annulus chamber that preheated the secondary air before it entered the combustion chamber, minimizing heat loss and leading to a more efficient, cleaner combustion process. Overall, the study found that these measures were highly effective in optimizing the cook stove's performance. By providing a steady supply of preheated air and facilitating optimal gasification and combustion processes, the cook stove was able to produce the desired results while minimizing waste and reducing its environmental impact.

Forced draft gasified stoves have the potential to greatly reduce fuel consumption and minimize indoor air pollution, particularly in developing countries where traditional cooking methods can be both inefficient and harmful to human health. Further research and development in this area may lead to even more effective and sustainable cook stove technologies.
Micro gasified stove
A micro gasified stove is a small and portable stove that converts solid biomass fuel into a clean-burning gas. Figure 8 illustrates an experimental setup of an advanced micro-gasifier cook stove, built by Sakthivadivel and Iniyan (2017). The working principle of a micro gasified stove involves the partial combustion of solid biomass fuel in a low-oxygen environment. As the fuel heats up, it releases volatile gases, which are then burned in a separate combustion chamber to produce a clean-burning gas. This gas can be used to cook food or heat water, providing a convenient and efficient source of energy. The velocity of the air determines the rate of flame propagation of biomass fuel in fixed bed micro-gasifiers. The combustion air velocity, combustion process, and heat transfer all have an impact on the flame propagation, and are influenced by various fuel properties such as size, density, thermal conductivity, moisture content, ash content, and calorific value. Additionally, parameters such as bed porosity, peak temperature of the combustion chamber, and heat losses from the reactor can also affect flame propagation.
Investigation location

Most of the identified articles on different gasified gas stoves are conducted in Asian and African continents as due to energy security and crisis people in these continents for which people of these continents mainly depend on the biomass fuel driven cooking system. Country wise identified published articles from Table 2 are presented in Figure 9. Among the selected articles 71% mentioned their study location. The figure shows 11 different countries from Asian and African continent where the investigation on gasified cooking stoves were conducted. The figure also highlights that 21% published articles performed their studies in India, which is the highest while the lowest study was performed in Thailand, which was only 3%. The design, configuration and burning fuels for any cooking stoves usually develop and investigate based on the geographical locations, climate, environment and materials availability. Therefore, this finding may help researchers, organizations and government to investigate and implement this type of cooking stoves based on the geographical location so that the adoption rate of the research can increase.

Materials to fabricate stoves

Cast iron, mild steel, metal, ceramic fiber, steel sheet, carbon steel and stainless steel were mainly used to manufacture the gasified cooking stoves. Among the selected articles for the current review, only 60% articles addressed the materials they used to fabricate their experimental gasified stove. From Table 2 it can be said that various types of steel were the main materials for manufacturing the body of the gasified cooking stoves among those mild steel was applied mostly. The availability of mild steel in the investigated locations and higher thermal properties of stainless steel for cooking devices are the key reasons for applying it in production. In some studies, cast iron was used with steel for manufacturing purposes due to the cost effectiveness of cast iron and better mechanical wear resistance property. Additionally, ceramic fiber and wool were used for insulation purposes for updraft type and Premixed producer gas burner with a swirl vane type gasified cooking stoves.

Cooking fuels

The fuels used in the cooking stoves are categorized in four types from the Table 2 and presented in Figure 10. The categories are wooden fuel, animals manure, cereals, charcoal and others. However, wooden fuels are classified in seven types, which are pellets, cassava peel, coconut shell, sized, shavings, chip and sawdust. Among the fuels wooden pellets fuels were used maximum. Peanut shell, cornstalk and cow animal waste, from pine patula, saw dust pellets, tamarind pellet, wood pellets and rice hull pellets are identified as wooden pellets fuels from selected articles. Moreover, Babul wood (Prosopis Juliflora), mango (magnifera indica), babul (prosopis julifera) and nim (azadirachta indica) wood, eucalyptus, bamboo and pinusroxburgii (Salla) wood are identified as sized wooden fuels. The rice husk, wheat straw and corncobs are categorized as cereal fuels while gas and briquettes are categorized in other types. In briquette fuels rice husk, sawdust-cow animal waste and corn straw are identified. This finding highlights the potential fuels to run a gasified cooking stove through which general people and research will be benefited.

Thermal performance of different gasified cooking stoves

The overall thermal performance of different gasified cooking stoves from Table 2 is identified 5.88% to 91% depends on the design and burning fuels. The thermal performances of the cooking stoves usually determine by using three approaches named water-boiling test, control cooking test and kitchen performance test. The overall thermal performance of different gasified cooking stoves obtained from selected studies is presented in Figure 11 and Table 3. Figure 11 shows that natural draft semi gasified cooking stove provide the highest overall thermal performance which was 42% while Mayon rice husk gasified stoves shows the lowest performance which was 11%. This overall thermal performance of the
stoves usually varied due to the design and fuels applied in the experimental tests. In the meantime, the overall thermal performance of some gasified stoves was presented as range in the literature therefore those performance is not presented in Figure 11, which can only find in Table 3. Table 3 shows that premixed producer gas burner with a swirl vane stove provided the highest overall thermal performance range which was 84% to 91% and updraft gasified stove provided the lowest performance which was 5.88% to 8.79%. Swirl vanes use in stoves usually a flame retardant device that highlight

**Figure 10.** Cooking fuels based on published articles.

**Figure 11.** Overall thermal performance of different gasified cooking stoves.
the recirculation zone formation to improve the mixing of flame stabilization and reactants compared to other stoves. Due to the improve in flame stabilization and reactants mixture, the performance and efficiency of the stoves are increased compared to other stoves.

Due to the different mechanical properties such as fuel consumption rate, calorific value, heating rate and fire point different cooking fuels provided different thermal performance presented in Table 2. To understand the insight of the thermal performance of different stoves for different cooking fuels a summarization table is created. The Table 4 presents the overall thermal performance for some cooking fuels that are directly mentioned in Table 2. From Table 4 it can be seen that wood pellets provided the highest thermal performance and corn straw briquette provided the lowest. The overall thermal performance of wood pellets was 38.5% and corn straw briquette was 10.86%. Due to the thermal, physical and biomass characteristics including burning rate, heat capacity, proximate analysis and energy content, wood pellets provided the better perform compared to corn straw briquette.

<table>
<thead>
<tr>
<th>Cooking Fuel</th>
<th>Overall thermal performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut shell</td>
<td>36.70%</td>
</tr>
<tr>
<td>Prosopis Juliflora</td>
<td>36-37.4%</td>
</tr>
<tr>
<td>Wood pellets</td>
<td>38.50%</td>
</tr>
<tr>
<td>Tamarind seed pellets</td>
<td>38±0.4%</td>
</tr>
<tr>
<td>Eucalyptus</td>
<td>29.85%</td>
</tr>
<tr>
<td>Sawdust-cow animal waste briquette</td>
<td>28.43%</td>
</tr>
<tr>
<td>Bamboo</td>
<td>23.76%</td>
</tr>
<tr>
<td>Peanut shell pellets</td>
<td>31.4±1.2%</td>
</tr>
<tr>
<td>Corn cobs</td>
<td>12% to 28%</td>
</tr>
<tr>
<td>wood chips</td>
<td>17.76% to 24%</td>
</tr>
<tr>
<td>Wood char</td>
<td>17.80%</td>
</tr>
<tr>
<td>Rice husk</td>
<td>15.51% to 16.47%</td>
</tr>
<tr>
<td>Nut shell pellets</td>
<td>12.38%</td>
</tr>
<tr>
<td>Corn straw briquette</td>
<td>10.86%</td>
</tr>
<tr>
<td>Pellet</td>
<td>19.91%</td>
</tr>
</tbody>
</table>

The recirculation zone formation to improve the mixing of flame stabilization and reactants compared to other stoves. Due to the improve in flame stabilization and reactants mixture, the performance and efficiency of the stoves are increased compared to other stoves.

Thermal performances of cooking fuels for gasified cooking stoves
Due to the different mechanical properties such as fuel consumption rate, calorific value, heating rate and fire point different cooking fuels provided different thermal performance presented in Table 2. To understand the insight of the thermal performance of different stoves for different cooking fuels a summarization table is created. The Table 4 presents the overall thermal performance for some cooking fuels that are directly mentioned in Table 2. From Table 4 it can be seen that wood pellets provided the highest thermal performance and corn straw briquette provided the lowest. The overall thermal performance of wood pellets was 38.5% and corn straw briquette was 10.86%. Due to the thermal, physical and biomass characteristics including burning rate, heat capacity, proximate analysis and energy content, wood pellets provided the better perform compared to corn straw briquette.
Conclusion
In this current literature review the overall thermal performance of different gasified cooking stoves were explored. For this purpose, available literature from past 14 years from 2008 to 2022 were search by using different search strings and after screening a total of 28 articles were selected for this literature review. The key findings from the review are as follows:

- Maximum studies on gasified cooking stoves were conducted on 2019, which was 18%, and the least minimum researches were conducted on 2012, which was only 4%. From the beginning to the mid of the current year 2022 almost 14% studies were identified from the selected literature which reflects that the investigation demand on gasified cooking stoves is recently also in high priority to researcher.

- The identified gasified cooking stoves from literature are classified in six groups named downdraft, updraft, natural draft, forced draft, micro, general gasified and others whereas the maximum articles worked on general gasified cooking stoves, which was 23%.

- 21% published articles on gasified cooking stoves performed their studies in India, which is the highest while the lowest study was performed in Thailand, which was only 3%.

- 15% published articles used mild steel to make gasified stove, which is the highest while only 3% used, ceramic fiber, which is the lowest.

- The identified cooking fuels for gasified stoves are classified in four group which are wooden fuel, animals’ manure, cereals, charcoal and others whereas wooden fuel was applied most of the studies.

- The overall thermal performance of different gasified cooking stoves was 5.88% to 91% depends on the design and burning fuels. The premixed producer gas burner with a swirl vane stove provided the highest overall thermal performance range, which was 84% to 91%, and the updraft gasified stove provided the lowest performance, which was 5.88% to 8.79%.

- Among the coking fuels, the wood pellets provided the highest thermal performance and corn straw briquette provided the lowest for gasified cooking stove. The overall thermal performance of wood pellets was 38.5% and corn straw briquette was 10.86%.

The review recommends to analysis the impact of pollution rate of the identified gasified stove on women and children health. Moreover, the adoption rate among general, economic sustainability and lifecycle analysis of the identified gasified stoves can be more valuable for our community.

Data availability
Underlying data
All data underlying the results are available as part of the article and no additional source data are required.

Reporting guidelines

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

References


Reference Source


Getahun E, Tessema D, Gabbie N: Design and development of household gasifier cooking stoves: natural versus forced draft. International Conference on Advances of Science and Technology. Cham: Springer; 2018; (pp. 298–314).


Open Peer Review

Current Peer Review Status: ✔️ ?

Version 2

Reviewer Report 11 July 2023

https://doi.org/10.5256/f1000research.145661.r184649

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✔️ Shabnam Konica
  Brown University, Providence, RI, USA

Ok to index.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Mechanical Engineering, Solid Mechanics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 10 February 2023

https://doi.org/10.5256/f1000research.139347.r161509

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❓ Nawshad Arslan Islam
  Aerospace Center, The University of Texas at El Paso, El Paso, TX, USA

The review focuses on gasifier stoves and their thermal performances. I applaud the hard work of the authors, however there are significant improvements required.

Although the literature may be limited due to the technology being limited to use in certain parts
of the world, a wide range of technical resources can be found based on gasification process and biomass power generation. The review fails to merge the scientific relations between such processes and hence does not provide any technical information behind statistical data? For example, the article states wood pellet shows better efficiency but fails to analyze the reason behind it.

Although a review article, it should necessarily go over adequate amount of technology description. For example the article provides no background on how thermal performances are measured, what experiments are usually performed, examples of such set ups. For a small review of 28 literatures, it was possible to have in depth discussion of some of the technical aspects and design aspects.

In addition, the review focuses a lot on how the articles were searched and geological location of research and how often research was published. However, I do not think these are relevant and provide any scientific merit to the work.

I have several recommendations for the authors, if followed will greatly improve the quality of the article. My recommendations are listed below-

1. Abstract should not contain how articles were searched, this is irrelevant for technical paper review. It should focus on how many types of stoves you reviewed, how many fuels (feeds) reviewed, some of the technical challenges, methods used to calculate efficiency and a few line summary of why some setups and fuels perform better than others.

2. In introduction it would be better to talk about biomass fuel types. There is a broader category of fuel types based on source - Agricultural, Forest, Animal Residue, Solids and Plastic Waste, MSW. And then by constituent of organic matter - Lignin, lignocellulosic, cellulosic, hemi-cellulosic etc. Author may want to define the types based such technical norms and then set up the review based on such fuel types. Otherwise the comparisons will not have any common variable. for example woodchip always performs better while agricultural waste will always perform worse due to organic constituent. Thus comparing two different types over several types of stoves will not provide much technical understanding

3. Instead of Dung authors may want to write Animal Waste. It covers a broader area.

4. The Methods section is completely irrelevant to the technical purpose of the article. If it is not required by the Journal Guideline, it is best to remove this section.

5. Review papers do not contain Results and Discussion. Since authors are describing what is already published in brief.

6. Instead of Methods and Results and discussion sections, authors may want to have sections as Stove Types - overviewing different stoves and their design and challenges. Types of Experiments Conducted to measure efficiency. Efficiency by fuel type and how it changes, reasoning behind and how stove design influences it.

7. Similar to the reasons stated above, Figure 1-4, 6 and Table 1 and 2 does not have any meaningful technical contribution and thus should be removed if not required by Journal
8. In addition, the data for figure 2-6 are questionable. Since the author filters a lot of literatures, such numbers do not reflect actual scenario. Thus it is best to avoid it.

9. There is a tremendous scope to add technical reasoning for this review. For example, each type of cooking stove efficiency should be backed up by how it was measured and what setup was used and how to calculate it.

10. Similar reasoning should also be used to describe efficiency issues for fuels

11. Why was swirl vane producer gas burner not included in gasified stoves comparison in figure 7. Essentially Gasification or Gasified process results in producer gas?

12. Why does the premixed producer gas with swirl vane have a very high efficiency compared to other technologies? Please describe

13. Similarly why does wood pellets perform better than corn straw? Please describe

14. Similar descriptions should be provided for all cases presented in Table 3, 4 and 5

I wish the authors best of luck with their future work.

**Are the rationale for, and objectives of, the Systematic Review clearly stated?**
Partly

**Are sufficient details of the methods and analysis provided to allow replication by others?**
No

**Is the statistical analysis and its interpretation appropriate?**
Not applicable

**Are the conclusions drawn adequately supported by the results presented in the review?**
No

**Competing Interests:** No competing interests were disclosed.


I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.
Md Insiat Islam Rabby

Thank you very much for reviewing the manuscript. The paper has been revised according to the reviewer suggestions and comments. The responses for reviewer comments are as follows:

1. Abstract should not contain how articles were searched. This is irrelevant for technical paper review. It should focus on how many types of stoves you reviewed, how many fuels (feeds) reviewed, some of the technical challenges, methods used to calculate efficiency and a few line summary of why some setups and fuels perform better than others.

Response: Thank you for the concern. This is actually a systematic literature review paper not a technical review paper. Therefore, reviewer might me confused on about the current review. Authors maintained PRISMA systematic literature review process, which was provided by the journal to make a good systematic literature review. In published other systematic review papers it is common to mention how articles were searched and how many articles were selected for review.

However, authors added the number of stoves and fuels identified from literature in the Abstract section.

2. In introduction it would be better to talk about biomass fuel types. There is a broader category of fuel types based on source - Agricultural, Forest, Animal Residue, Solids and Plastic Waste, MSW. And then by constituent of organic matter - Lignin, lignocellulosic, cellulosic, hemi cellullosic etc. Author may want to define the types based such technical norms and then set up the review based on such fuel types. Otherwise the comparisons will not have any common variable. for example woodchip always performs better while agricultural waste will always perform worse due to organic constituent. Thus comparing two different types over several types of stoves will not provide much technical understanding.

Response: Thank you for the nice suggestion. As this study, mainly focus on revising gasified cooking stoves and its thermal performance therefore in the introduction section talk about fuel types is beyond the scope of the review. The main focus of the literature review is gasified cooking stoves and thermal performance not fuel types. Even those published articles we reviewed from literature they also did not discuss on fuel types and physical characteristics of fuels. Therefore, authors want to keep the arrangement of introduction section as it is. However, authors added working principal and design of different gasified cooking stoves in results and discussion section to make the review more standard.

3. Instead of Dung authors may want to write Animal Waste. It covers a broader area.

Response: Thank you so much for the suggestion. Authors changed dung to animal waste.

4. The Methods section is completely irrelevant to the technical purpose of the article. If it is...
not required by the Journal Guideline, it is best to remove this section.

Response: This is actually a systematic literature review paper not a technical review paper. Therefore, reviewer might me confused on about the current review. Authors maintained PRISMA systematic literature review process, which was provided by the journal to make a good systematic literature review. In published all systematic review papers reviewer can easily find method section. It is a mandatory part for systematic literature review according to PRISMA guideline. Therefore, authors added this section otherwise it will not be a systematic review.

5. Review papers do not contain Results and Discussion. Since authors are describing what is already published in brief.

Response: This is actually a systematic literature review paper not a technical review paper. Therefore, reviewer might be confused about the current review. Authors maintained PRISMA systematic literature review process, which was provided by the journal to make a good systematic literature review. In published all systematic review papers reviewer can easily find result and discussion section. It is a mandatory part for systematic literature review according to PRISMA guideline. Therefore, authors added this section otherwise it will not be a systematic review.

6. Instead of Methods and Results and discussion sections, authors may want to have sections as Stove Types - overviewsing different stoves and their design and challenges. Types of Experiments Conducted to measure efficiency. Efficiency by fuel type and how it changes, reasoning behind and how stove design influences it.

Response: This is actually a systematic literature review paper not a technical review paper. Therefore, the reviewer might be confused about the current review. Authors maintained PRISMA systematic literature review process, which was provided by the journal to make a good systematic literature review. In published all systematic review papers reviewer can easily find result and discussion sections. It is a mandatory part for systematic literature review according to PRISMA guidelines. Therefore, authors added this section otherwise it will not be a systematic review.

However, the authors added a subsection on different cooking stoves according to reviewer’s suggestion where design and working principles were discussed.

7. Similar to the reasons stated above, Figure 1-4, 6 and Table 1 and 2 does not have any meaningful technical contribution and thus should be removed if not required by Journal guideline.

Responses: Authors removed Table 2 and Figure 3. The authors want to keep others’ figures and tables to maintain the systematic review protocol.

8. In addition, the data for Figure 2-6 are questionable. Since the author filters a lot of literature, such numbers do not reflect the actual scenario. Thus it is best to avoid it.
**Responses:** Authors want to keep these figure and tables to maintain systematic review protocol. As the search and article selection protocol maintained a systematic method therefore the presented scenario is actual.

9. There is a tremendous scope to add technical reasoning for this review. For example, each type of cooking stove efficiency should be backed up by how it was measured and what setup was used and how to calculate it.

**Response:** The measurement process of efficiency and setup were not scope of the review. Authors working on a general technical review on cooking stoves where these will be added.

10. Similar reasoning should also be used to describe efficiency issues for fuels

**Response:** The measurement process of efficiency and setup was not the scope of the review. Authors working on a general technical review on cooking stoves where these will be added.

11. Why was swirl vane producer gas burner was not included in gasified stoves comparison in figure 7. Essentially Gasification or Gasified process results in producer gas?

**Responses:** Thank you for the comment. The performance of swirl vane producer gas burner was identified as range (84% to 91%) in literature therefore it was not included in Figure 7. In Figure 7, only those stoves' performance that was not in range was plotted. However, in discussion, the performance of swirl vane producer gas burner is included.

12. Why does the premixed producer gas with swirl vane have a very high efficiency compared to other technologies? Please describe

**Response:** Thank you for the suggestions. The reason has been included in “Thermal performance of different gasified cooking stoves” section. The added part is as follows:

“Swirl vanes use in stoves are usually a flame retardant device that highlights the recirculation zone formation to improve the mixing of flame stabilization and reactants compared to other stoves. Due to the improvement in flame stabilization and reactants mixture, the performance and efficiency of the stoves are increased compared to other stoves”

13. Similarly why do wood pellets perform better than corn straw? Please describe

**Response:** Thank you for the suggestions. The reason has been included in the “Thermal performances of cooking fuels for gasified cooking stoves” section.

14. Similar descriptions should be provided for all cases presented in Tables 3, 4 and 5
Response: Short description has been provided for all cases presented in Tables 3, 4 and 5

Competing Interests: No competing interests were disclosed.

Reviewer Report 07 February 2023

https://doi.org/10.5256/f1000research.139347.r161508

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Shabnam Konica
Brown University, Providence, RI, USA

This work presents a statistical review of the thermal performance of gasifier cooking stoves. While the content of this article is important to understand the aspects of designing and energy performance evaluation of gas stoves for the countries where this type of stoves are still in use, it does not have a clear conclusion or future recommendations regarding how to improve the performance in terms of energy efficiency and environmental pollution. There should be more concise action words to address this issue. Below are some of my concerns:

1. I am against putting Table-2 altogether. Everyone knows how to search, and it should not be on the table. The references are included, which should suffice the explanation of the search method.

2. What are the authors' conclusions about the different types of cooking stoves? Which design is better and why? More explanations are necessary. Also, I advise including their design and working principles.

3. The authors mention, "this finding will help researchers, organizations and government to investigate and implement this type of cooking stoves based on the geographical location so that the adoption rate of the research can increase." If these stoves are already in use in those locations, it is unclear why the government should implement them. They are already in use.

4. The authors talk about different materials. While it is clear why steel stoves are widely used for fabricating gas stoves, I am not clear why other materials are there. Do those materials improve the design and efficiency? More explanation is necessary.

5. For each fuel, there should be sufficient research on the health impact and environmental pollution. The authors should conduct a review in these areas and add it to this work, and it should not be left for future recommendations.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

**Are sufficient details of the methods and analysis provided to allow replication by others?**
Partly

**Is the statistical analysis and its interpretation appropriate?**
I cannot comment. A qualified statistician is required.

**Are the conclusions drawn adequately supported by the results presented in the review?**
No

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Mechanical Engineering, Solid Mechanics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 17 Apr 2023

**Md Insiat Islam Rabby**

Thank you very much for reviewing the manuscript. The paper has been revised according to the reviewer suggestions and comments. The responses for reviewer comments are as follows:

1. I am against putting Table-2 altogether. Everyone knows how to search, and it should not be on the table. The references are included, which should suffice the explanation of the search method.
   
   **Response:** Thank you for the suggestion. The table has been removed.

2. What are the authors' conclusions about the different types of cooking stoves? Which design is better and why? More explanations are necessary. Also, I advise including their design and working principles.
   
   **Response:** Thank you for the suggestion and advice. Authors added the design, working principal and reason of performance for different identified gas stoves.

3. The authors mention, "this finding will help researchers, organizations and government to investigate and implement this type of cooking stoves based on the geographical location so that the adoption rate of the research can increase." If these stoves are already in use in those locations, it is unclear why the government should implement them. They are already in use.
   
   **Response:** This review only summarized the articles those are experimentally conducted in laboratory by different researchers and identified thermal performances. Authors did not
get any evidence from the literature that those are implanted and used in big scale in those geographical areas therefore authors mentioned that statement based on the findings from literature. However, for readers continence authors made the following revisions: “this finding may help researchers, organizations and government to investigate and implement this type of cooking stoves based on the geographical location so that the adoption rate of the research can increase”

4. The authors talk about different materials. While it is clear why steel stoves are widely used for fabricating gas stoves, I am not clear why other materials are there. Do those materials improve the design and efficiency? More explanation is necessary.

**Response:** Thank you for looking on it. During discussing materials authors missed some points therefore this section seems unclear. For manufacturing stoves steel was used in all studies, while other mentioned materials usually used for insulation purposes. Authors revised the “Materials to fabricate stoves” section accordingly.

5. For each fuel, there should be sufficient research on the health impact and environmental pollution. The authors should conduct a review in these areas and add it to this work, and it should not be left for future recommendations.

**Response:** Thank you for the valuable suggestion. Authors also believe that health impact and environmental pollution are very concerning factors for cooking stoves. However, the current systematic literature review only limited to thermal performance of gasifier cooking stoves. Health impact and environmental pollution are not scope of this review. Therefore, authors only showed the relationship between fuels and thermal performances for gasified cooking stoves. This is a systematic literature review, which was structured and maintained according to the guidelines of a typical systematic review followed by “PRISMA Diagram & Checklist - Systematic Reviews”. Additionally, most of the identified literature for this review did not discuss health impact and environmental pollution are not scopes of this review. Therefore, it will be now very difficult for authors to add health impact and environmental pollution, which were not the scopes for this review. Authors are now writing another critical review article on cooking stoves wherein health impact and environmental pollution are considered and given priority, therefore authors do not want to include health impact and environmental pollution in this systematic review.

**Competing Interests:** No competing interests were disclosed.
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