Be clever or be cold: repurposed ovens for space heating following global catastrophic infrastructure loss

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Abstract

Global catastrophic infrastructure loss (GCIL) would disrupt energy supply networks, prohibiting heating in houses reliant on electricity or piped natural gas. Cold climates would require alternative heating methods, as space heating is critical to survival. This work assesses the viability of converting household appliances to wood-burning stoves, and the scalability of such conversions. A standard Simpson-brand electrical oven was converted to a wood-burning stove, using tools and materials likely to be readily available following a GCIL event, and tested by burning pine wood in the fire laboratory at the University of Canterbury. The conversion was successful, with average useful heat output of 2.6 kW, showing the viability of ovens as wood-burning stoves for space heating. It is expected such conversions could be completed in less than one day, given sufficient availability of tools, materials, and labour. Global supplies of ovens, tools, materials, and fuel are expected to be sufficient for widespread conversion of ovens to wood-burning stoves, assuming international collaboration. However, international collaboration may be limited following GCIL, so countries should develop individual response plans accounting for this limitation, and knowledge should be disseminated ahead of time or backup communication systems put in place.

Highlights

- Heating would be disrupted following global catastrophic infrastructure loss (GCIL).
- Ovens could be converted to wood-burning stoves to meet basic heating needs.
- A prototype conversion had useful heat output of 2.6 kW from wood combustion.
- Supplies are sufficient for large-scale conversion, with international collaboration.
- Further testing would inform generalisability, safety, and component lifetimes.

Keywords: global catastrophic infrastructure loss; global catastrophic risk; energy systems; alternative heating; catastrophe resilience; existential risk

Word count: 5248 (excluding references)

1 Introduction

In the event of global catastrophic infrastructure loss (GCILs) resulting from events such as extreme solar storms, cyber-attacks, high-altitude electromagnetic pulses (HEMPs), or pandemics (resulting from people's inability or unwillingness to report to work at critical industries), modern society could face a severe disruption in electricity and fossil fuel production [1]. These disruptions would cause cascading collapses of industrial civilisation, affecting food, water, and other needs. Such collapses could also contribute to an unrecoverable collapse of civilisation, thus constituting an existential risk [2]. Previous work has analysed interventions in GCIL scenarios to provide food [3], [4], and water [5]; less studied is the resilience of space heating to GCIL, which would prohibit the use of heating methods dependent on electricity or gas networks. This loss would pose a threat to human survival, especially in cold climates where heating is essential for survival.

The majority of heating in developed countries, such as New Zealand [6] and the United States [7], relies on electricity natural gas supply networks, which would not function in a GCIL scenario, and many other space heaters also have electric controls. Available heating methods not requiring electricity or piped gas typically involve combustion of wood or kerosene [8], but these heating methods are found in few homes [6], [9], [10]. Furthermore, kerosene production could be halted in a GCIL scenario, so may not be a viable long-term post-GCIL heating solution.

Some short-term interventions exist for mitigating heat loss immediately following a GCIL event, including the use of warm clothing and sleeping bags, shared mattresses for retention of bodily warmth, and consolidation in better-insulated areas of the home. High performance sleeping bags are rated to ambient temperatures as low as -20 °C [11] and a combination of these techniques is likely to approach similar levels of effectiveness.

Medium-term interventions could involve consolidating families into a smaller number of buildings, which would provide more self-heating. Salvaged insulation could be added to exterior walls of these full houses, and building insulation consolidated to better insulate a smaller number of rooms. Unused rooms could then be closed off, windows and pipes insulated, and thermal curtains installed to reduce heat loss [12].

However, these methods do not provide viable long-term solutions, as the short-term interventions are highly restrictive, and the medium-term interventions would still require a heat source in cold climates. Additionally, increased housing density can increase the rate of viral transmission [13] and would thus be unviable in the event of pandemics. Thus, longer-term heating solutions would be required to ensure survival in cold climates in GCIL scenarios.

During periods in which gas and/or electricity infrastructure has been limited in cold climates, such as during war, heating has been limited primarily to fireplaces and wood-burning stoves, such as potbelly stoves [14], [15]. While burning wood would provide a long-term solution to heating following GCIL events, most modern homes do not contain fireplaces or wood-burning stoves [6], [9], [10]. However, some common household appliances, such as ovens, share key characteristics with fireplaces, such as the ability to withstand high temperatures [16], so it could be possible to convert household appliances to simple wood-burning stoves.

This paper investigates the feasibility of converting household appliances to wood-burning stoves. A methodology is presented for the repurposing of an oven to function as a wood-burning stove, and calculations are presented to assess the scalability of such a conversion.

2 Background and appliance characteristics

Fireplaces heat buildings by burning wood or other combustible material. The dominant mode of heat transfer from fireplaces is thermal radiation, which travels in straight lines from the fireplace, and objects intersecting the flow path will absorb some or all of the thermal energy [17]. However, most of the heat from a fireplace does not heat the room, instead travelling up the chimney as smoke, limiting the thermal efficiency (the proportion of heat from the fireplace entering the room) of typical fireplaces [18]. Thermal efficiency can be increased with changes to fireplace design, such as double-shell fireboxes, adjustable dampers, and glass doors [19].

In contrast to fireplaces, wood-burning stoves (hereafter “stoves”) are separate from walls, allowing more heat to enter the room. A good stove efficiently transfers heat, is safe for indoor use, minimises smoke and particulate emissions, and is constructed from readily available materials. Conversely, fireplaces often require extensive structural modifications to houses, which would be impractical in emergency situations.

Multiple household appliances were considered as candidates for conversion to stoves, including clothes dryers, clothes washers, dishwashers, and ovens. Ovens were considered the best candidates as they can tolerate higher temperatures than other appliances and can be easily modified with a flue for smoke expulsion.

Wood burns at 593 °C during second-stage combustion, and at higher temperatures once charcoal is produced during third-stage combustion [20]. Many log-burning fireplaces have doors with tempered glass, which is heat resistant to 200 °C, relying on the doors being far enough from flames to remain below these temperatures [21]. Oven interiors are typically made of steel, with an enamel lining able to withstand temperatures up to 480 °C [22]. However, while most oven components can withstand sufficient temperatures, glass oven doors are not rated to combustion temperatures [21] and may require replacement with temperature-resistant materials, such as sheet metal.

Oven ownership varies worldwide, with high rates in Argentina (92%), Brazil (91%), and Europe (~85%), and lower rates in Asian countries, such as Japan (50%), mainland China (47%) and South Korea (36%) [23], likely due to cultural differences in cooking methods [24]. Thus, the conversion of ovens to wood-burning stoves may not be uniformly viable.

3 Methods

3.1 Oven conversion

A used freestanding Simpson-brand oven and galvanised tie wire (16 gauge – 1.6 mm diameter) were purchased locally in Christchurch, New Zealand. Corrugated iron was obtained from the scrap metal bin at the Mechanical Engineering Department at the University of Canterbury. All tools were supplied by the Mechanical Engineering Workshop at the University of Canterbury: tin snips, pliers with wire cutters, screwdrivers, hammer, and nails.

In a GCIL scenario, sheet metal, could be salvaged from fences, roofs, or the sides of an oven, and bent into a circular flue, then secured using tie wire through holes punched with a hammer and nail. A typical woodstove chimney has a diameter of at least 12 cm, with a double wall required at junctions, such as where the chimney passes through a wall, ceiling or window. This diameter could be achieved by using the sheet metal from the two sides of an oven, with an approximate length of 50 cm, giving a chimney diameter of roughly 15 cm, and a second inner chimney could be made to a diameter of roughly 12 cm.

For the prototype conversion, outer sheet metal and insulation were removed from the oven to increase heat transfer, and a flue was fabricated for smoke expulsion. Mechanical cutting methods requiring no electricity were employed, using tin snips and a chisel and hammer to modify metal parts and create a flue hole. Inner glass in the oven's glass door was replaced with sheet metal to withstand higher temperatures, which was secured between the inner and outer faces of the oven door.

The flue for the converted oven was constructed from double-layered corrugated iron, and holes were punched in the bottom of the oven with a hammer and nails to provide draft. The flue was then connected to the oven by cutting a hole in the back of the oven, with a diameter equivalent to the inner pipe of the chimney.

The door of the oven was hinged at the bottom, so opening the door during operation would have caused undesired ventilation of smoke into the building. To minimise smoke ventilation, a cover was constructed with sheet metal removed from the back of the oven, which hooked over the top lip of the oven opening and covered the top half of the opening to minimise smoke released during stoking.

A diagram of the converted oven in its installed location is shown in Figure 1.

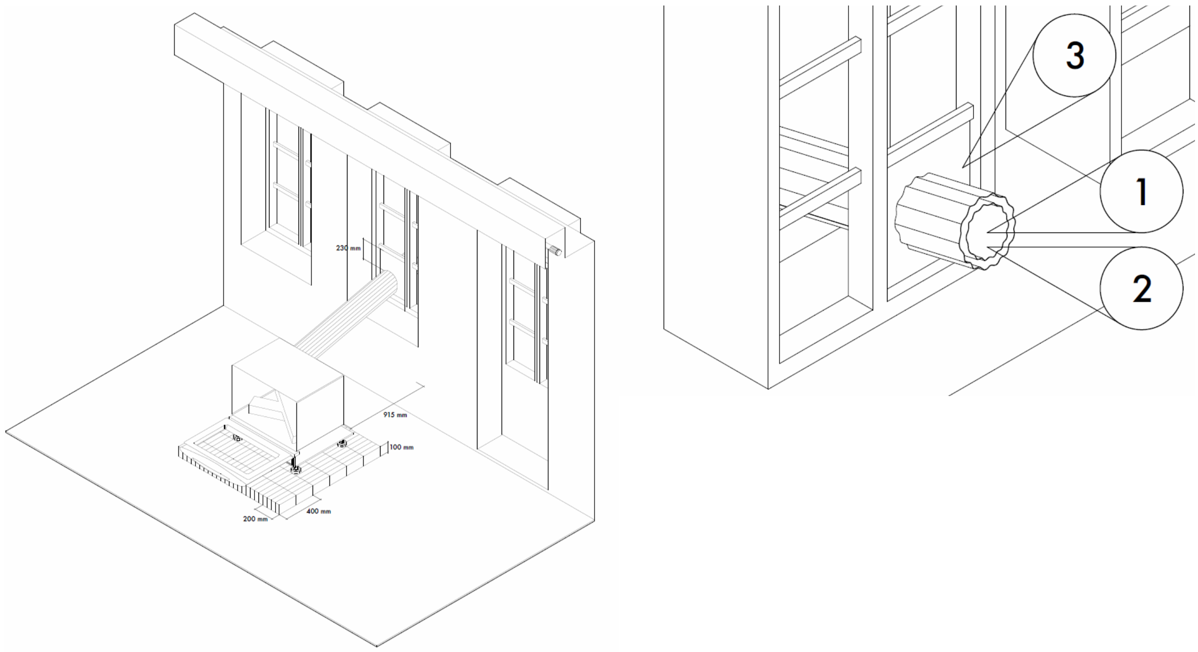

Figure 1. Diagram of stove installation (L) and locations of the thermocouples on the chimney flue outlet during testing (R).

3.2 Combustion and efficiency testing

The converted oven was tested in the University of Canterbury's Fire Laboratory. Three tests were conducted, which are summarised in Table 1:

1. Burning with the oven door closed.
2. Burning with the door open and a sheet metal cover placed over part of the door opening.
3. Burning with the door closed and drafts sealed.

Table 1. Oven configurations and masses of wood used in the three tests.

Test number	Configuration	Pine wood mass (kg)	Kindling mass (kg)
1	Door closed, holes open	2.78	0.17
2	Door open, holes open	2.99	0.17
3	Door closed, drafts sealed	3.05	0

Three pieces of pine wood and some kindling, with wood masses shown in Table 1, were placed in the oven for each test, and a gas blowtorch used to set the wood alight. Testing location was chosen to simulate the flue being placed through a window, with the glass replaced with sheet metal to determine whether the edge of the metal would heat up enough to damage a PVC window frame with a maximum temperature rating of 60 °C. Three thermocouple locations were used for the first two tests: (1) at the end of the flue in the middle to measure the flue gas temperature; (2) on the outer flue pipe near the window-flue interface; and (3) on a piece of sheet metal with the flue through it. The locations of these thermocouples are shown in Figure 1. For test 3, flue gas velocity was also measured, and the final mass of wood was recorded.

3.2.1 Efficiency calculations

Efficiency of combustion was calculated using the following equations, which are adapted from those developed for the condensation of flue gases in boilers [25]. The lower heating value of a fuel, CV [$kJkg^{-1}$], can be calculated using the Mendeleyev formula, where C, H, O, S, and W are the weight percentages of carbon, hydrogen, oxygen, sulphur, and moisture content in the fuel, respectively:

$$CV = 338C + 1256H - 109(O - S) - 25(H+W) \quad (1)$$

Heat of the flue gas, Q_g [$kJkg^{-1}$], can be estimated by separately calculating the heat of the water vapour and the dry flue gases. For the dry flue gas, this is equivalent to the sensible heat, where m_g is the mass of dry flue gases [kg], $C_{p,g}$ is the specific heat of water vapour (1.08 $kJkg^{-1}K^{-1}$), T is the measured temperature of flue gases [°C], and T_{ref} is the reference temperature, which is set to the ambient temperature, as it is assumed the useful heat of the flue gas would be recovered from cooling it from its initial temperature to room temperature:

$$Q_g = m_g C_{p,g}(T - T_{ref}) \quad (2)$$

The mass of dry flue gas, m_g [kg], can be calculated, where m_{fuel} is the mass of fuel burned [kg], Φ is the excess air percentage, V_0 is the volume of air required for combustion [m^3], and m_{H2O} is the mass of water vapour [kg]:

$$m_g = m_{fuel}(1 + (1 + \Phi)V_0 - m_{H2O}) \quad (3)$$

The volume of air required for combustion, V_0 [m^3] and the mass of water vapour, m_{H2O} [kg], can be calculated, where V_{H2O} is the volume of water vapour formed by combustion [m^3], and ρ_{H2O} is the density of water vapour (0.804 kgm^{-3}):

$$V_0 = 0.89(C + 0.37S) + 0.265H - 0.33O \quad (4)$$

$$m_{H2O} = V_{H2O}\rho_{H2O} \quad (5)$$

The volume of water vapour formed by combustion, V_{H2O} [m^3], can be calculated:

$$V_{H2O} = 0.111H + 0.0124W + 0.0161(1 + \Phi/100)V_0 \quad (6)$$

Heat from the water vapour is calculated by the sum of the sensible heat to cool the vapour to the dew point temperature, the latent heat to condense the vapour, and the sensible heat to cool the liquid water to its final temperature. The sensible heat for the vapour and liquid, $Q_{s,H2O,vap}$ and $Q_{s,H2O,liq}$ [$kJkg^{-1}$], can be calculated, where $C_{p,H2O,vap}$ and $C_{p,H2O,liq}$ are the specific heat of water vapour and liquid water (1.865 and 4.18 $kJkg^{-1}K^{-1,}$ respectively), T is the measured temperature of the flue gases [°C], T_{dp} is the dew point temperature of the water vapour [°C], and T_{ref} is the reference temperature, which is set to the ambient temperature:

$$Q_{s,H2O,vap} = m_{H2O}C_{p,H2O,vap}(T - T_{dp}) \quad (7)$$

$$Q_{s,H2O,liq} = m_{H2O}C_{p,H2O,liq}(T - T_{ref}) \quad (8)$$

The total latent heat from the water $Q_{L,H2O}$ [$kJkg^{-1}$] is given:

$$Q_{L,H2O} = m_{H2O}L_{H2O} \quad (9)$$

In test 3, a MKS Baratron® Type 223B Pressure Transducer was used to measure the velocity in the centre of the end of the chimney. The average velocity across the cross-section at the end of the chimney, v_{avg} [ms-1], was calculated, where v_{ctr} is the velocity at the centre of the chimney [ms^{-1}] and f is a unitless friction factor (0.045):

$$v_{avg} = v_{ctr} / (1 + 1.33f^{0.5}) \quad (10)$$

The average temperature was assumed to be the temperature halfway between the centre of the cross-section and the edge, which was measured directly using a thermocouple, as shown in Figure 1. Heat out of the top of the chimney at each timestep was calculated using air density and the specific heat of air, and this result integrated to find the total heat released through the chimney.

4 Results

4.1 Oven conversion

A photograph of the final converted oven is shown in Figure 2 The full conversion, including gathering of materials and tools, took 10 days. However, if the materials and tools were readily available and at least two people were available for labour, it is estimated the conversion could be completed within one day.

Figure 2. Photograph of the repurposed oven, showing the door opening, sheet metal chimney, and door with the inner glass pane replaced with sheet metal.

4.2 Combustion and efficiency testing

During testing, most of the visible smoke travelled out the flue. A photograph of the converted oven during testing is shown in Figure 3, and maximum temperature readings are shown in Table 2. The ambient temperature was measured as 12 °C.

Figure 3. Igniting the fire in the converted oven for test 3.

Table 2. Maximum temperatures (°C) of parts of the converted oven and surroundings during testing.

Part of Furnace	Flue Gas Centre	Flue Gas Between Centre and Edge	Outside Surface of Flue	Edge of Window
Test 1: Door closed	394.5		95	19.5
Test 2: Door open, cover on	364.5		84.5	17.5
Test 3: Door closed, more sealing	147	129.5		

The high temperatures of the flue gas in tests 1 and 2 indicate much of the heat from combustion was lost through the flue. The additional sealing of gaps for test 3 slowed air flow and combustion, increasing time for heat transfer through the walls into the room. The double layering of the flue was effective, with the edge of the window remaining below 20 °C, well below PVC's 60 °C temperature limit.

Temperature profiles at the three measured locations for Tests 1 and 2 are shown in Figures 4 and 5. While temperature profiles were similar, overall temperatures were lower with the door closed (test 2).

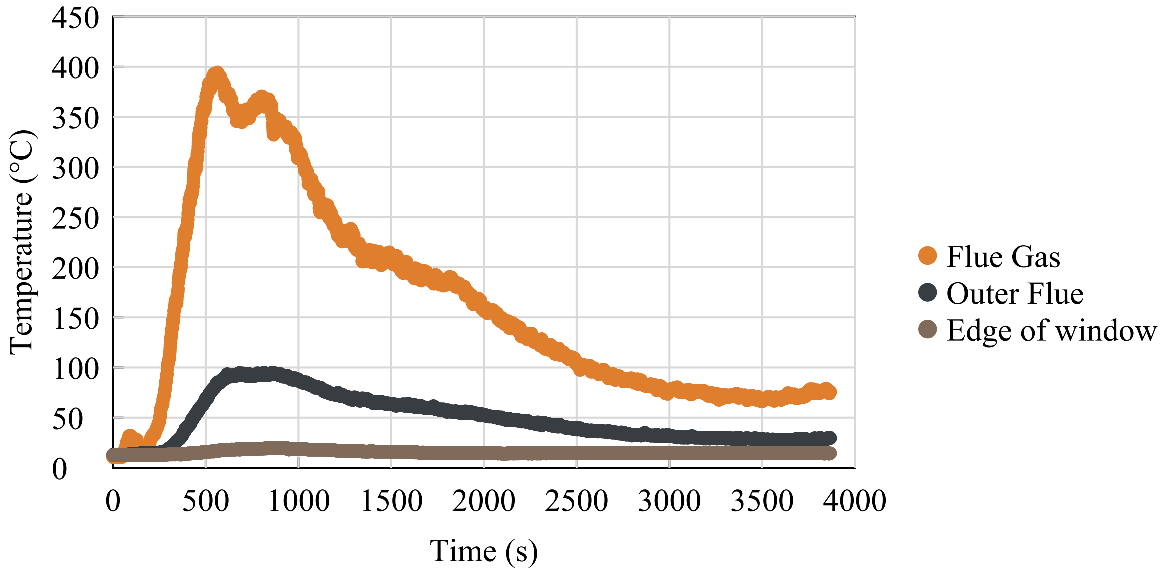

Figure 4. Temperature readings during test 1 (burning with the door closed).

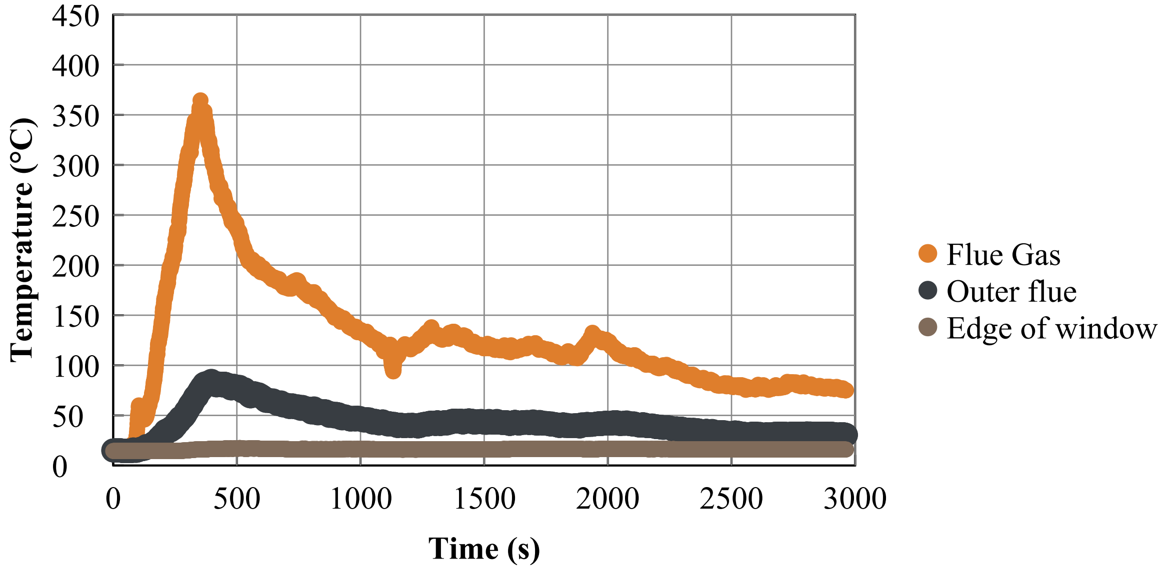

Figure 5. Temperature readings during test 2 (burning with the door open and the door opening covered).

Figure 6 shows the temperatures over time for test 3, in which gaps were filled to reduce unwanted ventilation during combustion. The burning time of test 3 was longer than tests 1 and 2, and the exhaust temperature was lower, as shown in Table 2.

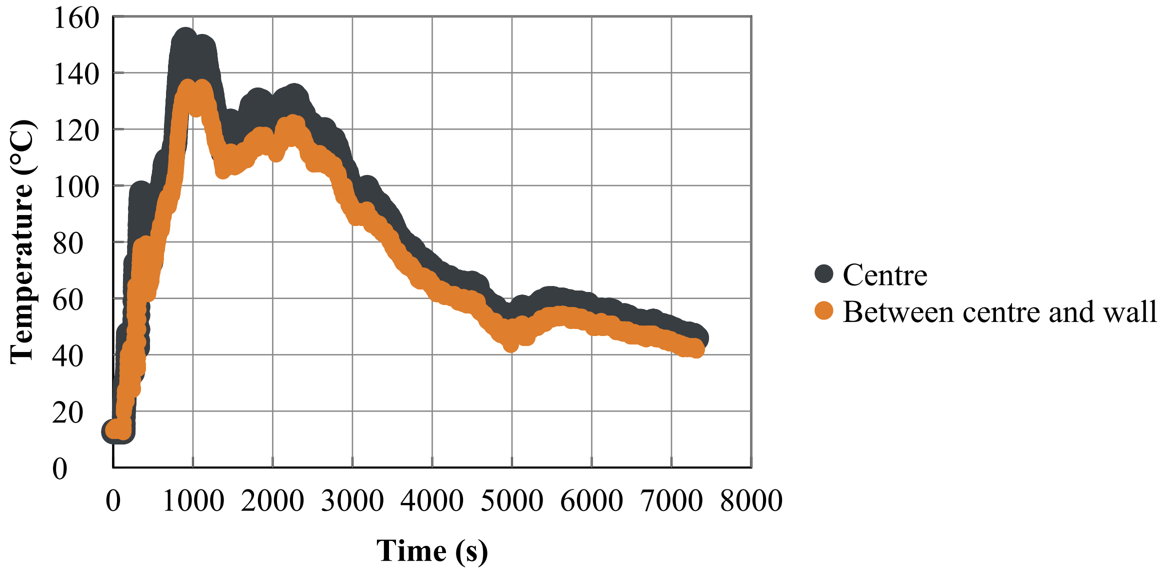

Figure 6. Temperature readings for test 3 (increased sealing), in which 1.48 kg of the 3.05 kg of wood was burned.

Total heat released through the chimney during test 3 was calculated as 6.2 MJ, representing 22% of the heat of combustion. Typically, 10% of the initial energy is released in the form of soot, carbon monoxide, and other particles in smoke [26]. Thus, the overall useful efficiency of the converted oven in test 3 was calculated to be 68%. Since test 3 took 122 minutes to burn and 1.48 kg of wood, with an average energy content of 19 MJ/kg [27] consumed in combustion, total heat energy produced was 28 MJ (3.8 kW average). With an efficiency of 68%, this yields an average of 2.6 kW useful heat.

5 Discussion

The successful conversion of an oven to a wood-burning stove indicates such conversions may be a viable solution to mitigate the effects of heating loss in a GCIL scenario. While wood was successfully burned in all three tests, the additional sealing of gaps for test 3 increased the viability of the converted oven for space heating. With reduced ventilation, less oxygen entered the oven, allowing for a longer burning time, increasing the efficiency and overall usefulness of the converted oven as a wood-burning stove.

Average useful heat released to the room in test 3 was 2.6 kW. The average area of a house in the USA is approximately 232 m^2 [28] and average heat required to maintain the entire house at a comfortable temperature in cold climates is over 30 kW [29], which is much larger than the heating capacity of the converted oven. However, many households, particularly those with limited ability to afford heating, do not heat their entire homes and opt instead to heat a single room only [6]. Thus, mitigating the effects of heating infrastructure loss in a GCIL event with converted ovens will require a combination of lower indoor temperatures, consolidation of household activities to areas near the stove, and/or consolidation of households and stoves into fewer houses.

5.1 Design safety

Biomass combustion can release harmful substances, including particulate matter, carbon monoxide, nitrogen and sulphur oxides, and polycyclic organic compounds, which can lead to health problems including asthma [30], respiratory infections [31], cancer [32], and premature death [33]. Adequate ventilation is required to prevent build-up of these substances from the operation of wood-burning stoves inside buildings [34]. While in catastrophic scenarios, these health concerns may be considered of secondary importance to the provision of heat, further research would be useful to determine whether the operation of converted ovens indoors is likely to pose health risks, and how these can be mitigated.

Additionally, wood-burning stoves can pose fire risks to buildings, and standards exist to minimise these risks, including NFPA 211: Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances [35]. The safe and proper operation of a wood-burning stove depends on its contact points and clearances from combustible materials. Safe operation of fireplaces includes ensuring sufficient insulation material or distance between combustible materials and the stove. If the floor is made of concrete, non-combustible materials with a fire-rating of 2 hours or more, or properly stabilized earth, then it is safe to set stoves directly on the ground [35]. However, if the floor is made of combustible materials, a non-combustible surface must be placed on top, the thickness and material of which depend on the leg height of the stove.

While the converted oven does not have legs and thus is recommended not to be operated on a combustible floor, even with non-combustible masonry underneath, there is a drawer underneath the oven, which would raise the combustion chamber approximately 12 cm above the surface on which it rests (which, at this height, should be at least 4 inches (10.2 cm) of masonry [35]). Thus, if no non-combustible floors are present in a building requiring heating, the stove may be able to be safely operated on combustible floors if other sufficient fire safety precautions are taken. Additionally, while many conventional ovens have drawers, legs could be added to ovens without drawers for fire safety. If the addition of legs is not possible, four bricks could be substituted for legs in dire circumstances, if the stove were operated on a stable surface and carefully monitored for fire safety.

5.2 On the scalability of oven conversion

The results from previous sections show a household oven can be successfully repurposed to function as a wood-burning stove. However, the effectiveness of replacing conventional residential heating in a GCIL scenario depends on the scalability of such a conversion, which could be limited by the number of ovens or the availability of tools or materials. This section estimates these resources' availability to inform the feasibility of widespread conversion of residential ovens following a GCIL scenario.

With a total global population of approximately 8.1 billion people [36] and average household size of 3.45 people per household [37], the number of households worldwide is approximately 2.3 billion. Oven ownership varies widely between regions, with over 95% and under 15% of households owning an oven in the USA [38] and Africa [39], respectively. Using ownership rates of different regions [37] - [40], the population-weighted rate of oven ownership is estimated as 0.45 ovens per household, globally. Thus, the total number of ovens available for repurposing is estimated to be approximately 1.1 billion.

Construction of the flue for this converted oven required 0.55 m^2 of sheet metal. In a GCIL, new sheet metal supply is not expected to be sufficient to build flues for 1.1 billion ovens, so additional sheet metal may be required from roofs. Houses with metal roofs comprise 18% of the housing stock [42] and the average house has a roof area of 200-250 m^2 [28], [43], so the total area of sheet metal in residential roofs is approximately 100 billion m^2. While the use of roofing metal for oven conversion would likely be undesirable to most homeowners, heating requirements in cold climates may outweigh this undesirability.

Many households have access to a hammer, nails, screwdrivers, and a ruler, and local sharing of these tools is expected to provide sufficient supply for oven conversions. However, tin snips and wire cutters, which would also be required, are less common. With a global market for tin snips of 460 million USD per year [44], an average cost of 45 USD [45], and an average lifetime of around 10 years [46], the total number of tin snips globally is calculated to be approximately 100 million. Similarly, with a global market for wire cutters of 800 million USD [47], average cost of 30 USD, and an average lifetime of around 10 years [48], the total number of wire cutters globally is calculated to be approximately 260 million.

With a transition of residential heating from electricity and gas to wood, global wood supply may be a limiting factor in the feasibility of converted ovens for residential heating. In test 3, the oven produced average heat of 2.6 kW. With a duty cycle of 10% (i.e., assuming heating is operational for a total of 10% of the year, as is typical [6]) and a total of 1.1 billion ovens, annual wood consumption for converted wood-burning stoves would be approximately 0.67 billion dry tons per year. Current global wood production is 2 billion dry tons per year [49], so the additional demand from converted ovens would represent a considerable, but likely manageable, increase. However, with a GCIL affecting other systems, such as food production, global demand for wood may increase in other areas, such as for wood gasification to power cars and heavy machinery.

Overall, large-scale conversion of ovens to wood-burning stoves is expected to be feasible, with the potential to mitigate the effects of heating loss in a GCIL scenario. However, such an undertaking would require effort across multiple areas of society, including the sharing of tools, acquisition of materials, coordination of labour, and provision of fuel to those in need. Furthermore, distribution of the tools and materials required for the conversion, and the fuel required for the operation, of stoves, varies between countries and regions.

International cooperation would be required for large-scale conversion to, and operation of, ovens as stoves, and advanced planning will increase the likelihood of success. However, it is important to note GCIL could stem from international hostility, such as state-sponsored cyber-attacks, engineered pandemics, or the intentional detonation of high-altitude electromagnetic pulses (HEMPs), in which the likelihood of international cooperation would be reduced. Thus, while plans for international cooperation in GCIL events should be considered a top priority, individual countries should also prioritise national-level plans, such as investing in resilient or backup communications systems.

Potential backup systems include shortwave or high frequency radios [50] and satellites resilient to EMP that could communicate directly to cellular phones.

5.3 Limitations and future work

In this work, the converted oven was tested in laboratory conditions, without measure of direct heat output or indoor pollution levels. While direct heat was not measured in these experiments, the equations used to calculate heat output from flue gas velocity and temperatures have been used in other peer-reviewed literature [25], [51] and their results should be considered representative of those expected if direct heat output were measured instead. However, further research should investigate the use of converted ovens in real houses, with measurements of indoor temperatures and pollution levels.

Only one oven model, an electric Simpson-brand oven, was converted to a wood-burning stove and tested in this work. Thus, the generalisability of these results to other oven models, including those fuelled by propane or natural gas, is unknown. The oven model used in this work was chosen due to its simple design, which shares key characteristics with a wide range of other common oven models, so it is expected the conversion process presented in this work would be widely applicable and testing results would be representative of a range of oven models. However, further research on conversion of other common oven models to wood-burning stoves would provide greater understanding of the generalisability of such conversions.

In this work, three tests were conducted, with a total burning time of approximately 3.8 hours. While no material degradation or other damage from burning was observed during or after these tests, the burning period before onset of degradation and the replacement intervals for converted ovens are unknown. Thus, the long-term viability of converted ovens for space heating is unknown. However, as no degradation was visible after the three tests conducted, it is expected the majority of converted ovens would be suitable for emergency space heating after a GCIL event, until the establishment of more permanent heating infrastructure, such as the re-instatement of electricity and/or natural gas supply networks or the fabrication of more durable stoves (e.g., stoves with thicker metal walls).

6 Conclusions

This work investigates the repurposing of household ovens into wood-burning stoves as a heating solution following GCIL events, such as extreme solar storms, cyber-attacks, high-altitude electromagnetic pulses, or pandemics, which may result in widespread and prolonged disruptions to energy supply. A used Simpson-brand common oven was converted to a wood-burning stove through the removal of insulation and outer casing, and the fabrication of chimneys using readily available materials. The converted oven effectively transferred heat from burning logs to the interior of a testing room, with average useful heat output of 2.6 kW. With approximately 1.1 billion ovens worldwide, sufficient materials, tools, and fuel are expected to be available for large-scale conversion of ovens to wood-burning stoves for space heating, provided international collaboration allows for provision of supplies to regions most in need. However, while converted ovens provide a practical, scalable solution to widespread disruption of heating infrastructure, their heating capacity is lower than that required to heat the whole of a standard house. Thus, it may be necessary to consolidate households in single buildings and/or prioritise the heating of single rooms. While these results show the viability of converting a common type of electrical oven to a wood-burning stove, further research is required to inform the generalisability of such a conversion to other oven types and the replacement intervals of components in the resultant stoves. Additionally, further testing should assess the operation of converted ovens in real households, rather than laboratory conditions, measuring indoor temperatures and pollution levels.

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