The Clean Cook: The Value of Induction Stovetops

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ABSTRACT

Building electrification and reductions in greenhouse gases due to climate change are increasingly important goals for some energy efficiency program administrators (PAs). As programs look to electrification as sources of energy and greenhouse gas savings, PAs should also consider the non-energy impacts (NEIs) of replacing gas stovetops with induction stovetops, particularly health impacts associated with improved indoor air quality (IAQ).

NMR has recently completed a study that estimated NEIs associated with a residential initiative to replace gas stovetops with induction stovetops in Massachusetts. The study team conducted a systematic and extensive literature review, which included articles that did not directly monetize NEIs but did provide information that could be used as inputs for monetization.

This paper identifies and monetizes several participant NEIs that can be attributed to induction stovetops displacing fossil fuel stovetops, which included:

- Increased childhood asthma prevention
- Reduction in childhood asthma symptoms
- Reduction in adult asthma symptoms
- Reduction in lower respiratory tract symptoms
- Reduction in COPD-related hospitalizations
- Increased costs associated with new cookware purchases

The paper will provide detailed NEI values for induction stovetops, and will detail additional NEIs that were identified but were not monetized, such as potential risk associated with pacemakers, fires, and methane leakage.

Introduction

Research from the medical community has increasingly indicated that the elevated levels of NO_2 resulting from cooking with a natural gas or propane stovetop can increase the risk of asthma development and can exacerbate asthma symptoms (Belanger et al. 2013; U.S. EPA. 2016; Lin, Brunekreef, Gehring 2013; Knibbs et al. 2018). The Massachusetts Medical Society issued an official resolution in December 2019 that stated it, "Recognizes the association between the use of gas stoves, indoor NO_2 levels, and asthma" ("Informing Physicians" 2019). While proper ventilation can mitigate these effects, ventilation alone does not appear to eliminate the risks of indoor cooking on gas stovetops (Knibbs et al. 2018).

The author and co-authors were involved in prior research to the induction stovetop study discussed in this paper, which examined the non-energy impacts (NEIs) associated with residential new construction, including electrification of end-uses. The prior study, the Residential New Construction (RNC) NEI Quick Hit Assessment Study, was conducted for the Massachusetts energy efficiency program administrators (PAs) and identified and monetized new NEIs associated with the reduction in risks to asthma patients posed by gas combustion

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stovetops. These NEIs are associated with improvements in indoor air quality (IAQ) by eliminating byproducts of combustion stovetops, including NO_2, $PM_{2.5}$, CO, and others. Increased levels of $PM_{2.5}$ and CO from combustion stovetops are associated with negative health outcomes, such as damage to respiratory systems (Seals and Krasner 2020; Tianchao, Singer, & Logue 2012). As a follow-up to the RNC NEI Quick Hit Assessment Study, the Massachusetts PAs asked the study team to examine potential NEIs associated with converting residential gas stovetops to electric induction stovetops.

This paper presents a selection of the final results from the *Residential Gas-to-Induction Stovetop Study* (MA22X03-E-GSCNEI). The Cross-Cutting Non-Energy Impacts evaluation team, led by NMR Group, Inc., with the support of Three[3] and DNV, prepared this final report for the Massachusetts PAs.[1] This study examined the NEIs associated with the replacement of gas stovetops with electric induction stovetops. We leveraged the previous research conducted as a part of the RNC NEI research, adjusting the findings from that study with new literature and based on considerations of just replacing the stovetop rather than a full stovetop and oven. We also reviewed existing literature to identify and monetize any potential new health and safety NEIs, specifically non-asthma indoor air quality health impacts, fire and burn risks, greenhouse gas impacts, and pacemaker risks.

The focus of the research presented in this paper is on participant-level impacts. This means that the research did not look at or monetize impacts that were considered societal impacts. This distinction is important, as there are NEIs that can straddle the line between impacts that directly benefit the participant or those that extend to the broader society. For example, a reduction in indoor air quality pollutants has direct benefits to the participant may also result in some level of societal air quality benefits, but these societal benefits are not considered in this research. Additionally, direct societal benefits such as reduced greenhouse gas emissions, while they can impact participants, were not monetized due to study design and program constraints for claiming only participant-level impacts.

Key Terms

COPD	Chronic Obstructive Pulmonary Disease
CPI	Consumer Price Index
EPA	Environmental Protection Agency
EUL	Effective Useful Life
GHG	Greenhouse Gas
GWP	Global Warming Potential
IAP	Indoor Air Pollutants
IAQ	Indoor Air Quality
LRT	Lower Respiratory Tract
NEI	Non-Energy Impacts
PAF	Population Attributable Fraction
PM	Particulate Matter
RNC	Residential New Construction
RPP	Regional Price Parities

[1] The PAs comprise Berkshire Gas, Cape Light Compact, Eversource, Eversource Gas of Massachusetts, Liberty Utilities, National Grid, and Until.

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TRM	Technical Resource Manuals
UFP	Ultra-Fine Particles
VOC	Volatile Organic Compounds
VSL	Value Of A Statistical Life

Methods

The study team gathered evidence on potential outcomes from replacing natural gas or propane stovetops with induction electric stovetops from a literature review and secondary data.

The study team expanded upon the literature review conducted in previous research for the Massachusetts PAs, including the RNC NEI Quick Hit Assessment study (MA20X14-B-RNCNEI) (NMR and Three[3]. 2021), the Residential Heat Pump NEIs study (MA21X21-E-RHPNEI) (NMR and Three[3]. 2022), and the RNC Electrification Barriers study (MA21R44) (NMR. 2023). We aimed to identify and monetize NEIs that could potentially be claimed by the PAs from the replacement of combustion stovetops with induction electric stovetops. Besides utilizing previously collected literature from various studies, the team conducted targeted semi-structured searches for each NEI topic outlined in the study plan to identify any relevant new articles and secondary data sources.

The targeted semi-structured literature and data search utilized consistent search terms, for example applying consistent variations and usage of terms like “gas stove” or “gas cooker” and “premature mortality” were defined prior to reviewing articles. The search terms were then applied across multiple research databases such as Google Scholar, PubMed, University of Tennessee Libraries, and Boston College libraries. Articles were selected based on their relevant titles and descriptions, followed by a review of the abstract and a brief examination of the methods, results, and conclusions to determine their relevance to the research objectives for a given NEI category. The team also remained vigilant for any additional potential NEIs identified within targeted NEI categories during the literature review. In addition, the study team reviewed articles that were referenced in the literature identified through the research databases.

The articles reviewed did not directly monetize any of the NEIs. However, they did offer valuable information that served as inputs for monetization. The review focused on the following potential NEIs:

- Asthma related NEIs, with a detailed examination of asthma-related algorithms and insights from the RNC NEI Quick Hit Assessment study, with an assessment of whether updates were necessary based on recent literature.
- Health-related impacts not specifically linked to asthma
- Avoided fires and burns
- Negative impacts associated with individuals with pacemakers and the use of induction stovetops
- Potential decrease in greenhouse gas emissions resulting from the transition from combustion stovetops to induction electric stovetops, as well as potential gas leaks discovered in homes

The following Tables summarize each phase of the study team’s review process and outline the number of articles ultimately reviewed and referenced in this study. Each NEI

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category had a slightly different criteria used to examine the literature, focusing on whether articles:

1. Provided or refuted evidence of the existence of an NEI.
2. Offered information demonstrating the relationship of the measure to the impact, such as odds ratios or risk ratios for health impacts.
3. Provided information useful in understanding the financial implications of the NEI.

Articles were rejected if, upon initial review, they did not provide quantitative or implementable data, the results could not be tied to monetizable outcomes, or the study lacked sufficient sample size (e.g., anecdotal data compared to experimental).

Table 1 presents the number of articles reviewed related to IAQ, premature death, and non-asthma health articles, Table 2 presents the number of articles reviewed related to fire risk, Table 3 presents the number of articles reviewed related to burn risk, and Table 4 presents the number of articles reviewed related to cookware saturation.

Table 1. Number of IAQ, premature death, and non-asthma health articles reviewed

Status	Number of Articles
Total number of articles pulled based on title	48
Number of articles rejected based on abstract	23
Number of articles kept and reviewed	25
Articles reviewed from reference sections	11
Articles reviewed from previous research	5

Table 2. Number of fire risk-related articles reviewed

Status	Number of Articles
Total number of articles pulled based on title	17
Number of articles rejected based on abstract	11
Number of articles kept and reviewed	6

Table 3. Number of burn risk-related articles reviewed

Status	Number of Articles
Total number of articles pulled based on title	11
Number of articles rejected based on abstract	11
Number of articles kept and reviewed	0

Table 4. Number of induction cookware saturation articles reviewed

Status	Number of Articles
Total number of articles pulled based on title	10

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Number of articles rejected based on abstract	9
Number of articles included	1

Results: Monetized Induction Stovetop NEIs

This paper presents a summary of some of the new NEIs monetized as part of the *Residential Gas-to-Induction Stovetop Study*. The subsequent subsections focus on the monetization algorithms and compilation of information from various sources to derive a monetized estimate of the impact associated with replacing combustion stovetops with induction stovetops. Additionally, we present additional findings associated with the non-monetized NEIs included in the scope of this research.

Indoor Air Quality

Non-Asthma Health NEIs

The Team compiled and reviewed academic literature, governmental reports, and evaluation materials to describe the relationships between: 1) gas stovetops and non-asthma health impacts; 2) gas stovetops and premature death; 3) gas stovetops and indoor air pollutants (IAP); and 4) IAP and the aforementioned health issues and premature death. The literature on these topics is broad and complex. The study team highlighted key articles and studies along with the evidence-level for each potential causal pathway from gas stovetops to poor health and mortality.

The literature suggests that the strongest evidence is for impacts of gas stovetops on respiratory infections and COPD exacerbations. Evidence linked the presence of gas stovetops to an increased risk of respiratory symptoms and infections, particularly among children, women, and individuals with pre-existing respiratory condition such as COPD or bronchopulmonary dysplasia. Gas stoves have also been linked to lower respiratory tract (LRT) infections and symptoms (Chauhan and Johnston 2003; Ostro 1993).

Table 5 presents the monetized impacts associated with removal of gas stovetops and the reduction in LRT symptoms and associated medical costs (in the form of a doctor's office visit). Note that the focus is solely on stovetops, not stovetops and ovens, and costs have been adjusted accordingly to account for only the stovetop. The table describes the variable included in the algorithm and the associated input value. The study team developed a pathway to monetize the NEI by using various sources of evidence and creating an algorithm that linked the intervention to the outcome. The overall algorithm that monetizes the NEI is shown in Row S of Table 5.

Table 5. Lower respiratory tract symptom reduction from replacing propane or natural gas stovetops with induction stovetops in existing homes – NEI algorithm

	Variable	Input Value	Notes/Source
A	*Odds ratio (OR) of developing lower respiratory tract (LRT) symptoms when gas stove is present in home versus absence of gas stove*	1.23	Chauhan, A. J., & Johnston, S. L. (2003). Air pollution and infection in respiratory illness. British Medical Bulletin, 68(1), 95–112. https://doi.org/10.1093/bmb/ldg022

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B	*Percent of the study population exposed to gas stoves*	80%	Ostro, Lipsett, M. J., Mann, J. K., Krupnick, A., & Harrington, W. (1993). Air Pollution and Respiratory Morbidity among Adults in Southern California. American Journal of Epidemiology, 137(7), 691–700. https://doi.org/10.1093/oxfordjournals.aje.a116729
C	*Population attributable fraction (PAF)*	16%	The PAF is a measure used in epidemiology to estimate what portion of cases can be attributed to the given exposure. In this calculation, we rely on the common heuristic that an odds ratio can be substituted for relative risk in the PAF equation if it is considered a small odds ratio or close to 1. PAF = **B***(**A**-1) / (**B***(**A**-1)+1)
D	*Portion of stove NO_2 emissions attributable to the stovetop*	40%	See footnote #2 in this paper.
E	*Percent of symptoms attributable to gas stovetop (not including oven)*	6.4%	**C * D**
F	*Average number of children (under 18) per household*	0.52	Massachusetts population in occupied homes, U.S. Census
G	*Average number of adults per household*	2.10	Massachusetts population in occupied homes, U.S. Census
H	*Average cost of care for LRT symptoms (office-based visit) (US $2020)*	$257	Agency for Healthcare Research and Quality. Mean expenditure per event by event type and census region, United States, 2020. Medical Expenditure Panel Survey.
J	*Average cost of care for LRT symptoms (office-based visit) (MA $2020)*	$276	Regional Price Parities (RPP), All Items[2]
K	*Percent of medical costs paid out of pocket*	9%	Agency for Healthcare Research and Quality. Mean expenditure per event by source of payment and census region, United States, 2020. Medical Expenditure Panel Survey.
L	*Average missed days of school due to respiratory infection*	0.80	McLean, H. Q., Peterson, S. H., King, J. P., Meece, J. K., & Belongia, E. A. (2017). School absenteeism among school-aged children with medically attended acute viral respiratory illness during three influenza seasons, 2012-2013 through 2014-2015. Influenza and other respiratory viruses, 11(3),220–229. https://doi.org/10.1111/irv.12440
M	*Cost of a day of missed school ($2015 US)*	$106	EPA's Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP)[3]
N	*Cost of a day of missed school, adjusted for inflation and cost of living in MA (2020)*	$126	Consumer Price Index (CPI), All Items[4] and Regional Price Parities (RPP), All Items[5]
P	*Average missed days of work due to respiratory infection*	3.00	Van Wormer, J. J., King, J. P., Gajewski, A., McLean, H. Q., & Belongia, E. A. (2017). Influenza and Workplace Productivity Loss in Working Adults. *Journal of Occupational and Environmental Medicine*, 59(12), 1135–1139. https://doi.org/10.1097/JOM.0000000000001120
Q	*Cost of a day of missed work ($2015 US)*	$173	EPA's Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP)
R	*Cost of a day of missed work, adjusted for inflation and cost of living in MA (2020)*	$205	Consumer Price Index (CPI), All Items and Regional Price Parities (RPP), All Items
S	***Annual NEI estimate per home***	**$88.26**	**E * ((F + G) * J * K + (F * L * N) + (G * P * R))**

[2] https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=8#reqid=70&step=1&isuri=1
[3] https://www.epa.gov/sites/default/files/2015-04/documents/benmap-ce_user_manual_march_2015.pdf
[4] https://data.bls.gov/cgi-bin/surveymost?cu
[5] https://apps.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=8#reqid=70&step=1&isuri=1

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Asthma-Related NEIs

The study team also updated asthma-related NEIs associated with reducing risks to asthma patients posed by gas combustion stoves. After examining asthma-related input values and algorithms used in the RNC NEI Quick Hit Assessment Study, the team applied several adjustments to estimate NEI values for existing households replacing combustion stovetops with induction stovetops. The adjustments made by the study team include:

1. Applying an adjustment factor to apply the NEI value only to stovetops.[6]
2. Updating the cost of illness valuation for new onset asthma using 2022 federal guidance and removing discount factors (Belova et al. 2020).
3. Implementing inflation and cost-of-living adjustments specific to Massachusetts.
4. Incorporating productivity losses.
5. Updating the measure's effective useful life (EUL) from 25 to 16 years.

While asthma-related NEIs are not the primary focus of this paper, they do contribute to the overall impact for replacing gas stovetops with induction stovetops. Table 6 highlights the asthma-related NEIs that were ultimately monetized based on these updates. Additional details about the methods and algorithms used to monetize asthma-related impacts are available in the *Residential Gas-to-Induction Stovetop Study* (MA22X03-E-GSCNEI) final report.

Table 6. Asthma-related NEIs from replacing propane or natural gas stovetops with induction stovetops in existing homes (2020 $)

Non-Energy Impact	Value Suggested
Childhood asthma prevention, occupant lifetime	$4.73 per home per year
Adult asthma symptom reduction	$51.45 per home per year
Childhood asthma symptom reduction	$49.77 per home per year
Total	$105.95 per home per year

Cookware Replacements

Only cookware made from specific materials is compatible with induction stovetops. Cookware must be made from magnetic material, such as cast iron, stainless steel, and carbon steel, allowing the stovetop to induce a magnetic field to generate heat. Additionally, there are products known as induction interface disks, which enable non-magnetic cookware like aluminum pans to function with induction stovetops, although they are generally less efficient than using cookware made of magnetic materials.

[6] According to a proposed rule by DOE on 12/14/2020 re: Energy Conservation Standards for Consumer Conventional Cooking Products, a standard gas cooktop uses about 1,443 kBtu/year whereas a standard conventional gas oven uses between 1,960 and 2,093 kBtu/year. So, of the combined cooktop/oven energy consumption for a home, about 40% is for the cooktop and 60% is for the oven. https://www.federalregister.gov/documents/2020/12/14/2020-26874/energy-conservation-program-energy-conservation-standards-for-consumer-conventional-cooking-products. It is common practice to assume a linear relationship between NO_2 exposure and respiratory impacts (Huangfu, P., & Atkinson, R. (2020). Long-term exposure to NO_2 and O_3 and all-cause and respiratory mortality: A systematic review and meta-analysis. *Environment international*, *144*, 105998. https://doi.org/10.1016/j.envint.2020.105998).

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In addition to reviewing existing literature and secondary data sources, the team compiled the costs of five separate induction cookware sets from seven online retailers to understand the potential one-time cookware replacement costs that participants may be incur when replacing incompatible cookware (Table 7). Table 8 presents the average prices of induction interface disks from top retailers.

- The average cost of a new induction-compatible cookware set (about 6 cookware pieces) is about $536 for all seven retailers, with an average price per cookware piece of about $84.
- The average cost of a new induction-compatible cookware set among the four lowest-cost items is about $256, with an average price per cookware piece of about $43.
- The lowest-cost induction stovetop set is $45.98, with an average cost of $15.33 per pot/pan.
- The average cost of an induction interface disc is about $50, but these discs have the potential to reduce the efficiency of induction stovetops.

Table 7. Average induction-compatible cookware set and individual pot/pan prices for the top 7 retailers

Retailer	Average Cookware Set Price	Average Price per Pan
Retailer 1	$375.99	$57.67
Retailer 2	$888.00	$133.00
Retailer 3	$1,202.98	$207.66
Retailer 4	$942.00	$446.62
Retailer 5	$197.99	$30.21
Retailer 6	$349.38	$61.41
Retailer 7	$100.95	$20.89
Average cost – all retailers	***$579.61***	***$96.28***
Average cost – four lowest cost retailers	***$256.08***	***$43.04***

Table 8. Average induction interface disk prices for the top retailers

Retailer	Average Induction Interface Disk Price
Retailer 1	$105.00
Retailer 2	$34.79
Retailer 3	$55.29
Average cost	**$50.49**

The study team could not identify a clear estimate of the percentage of household cookware that would need replacement for a typical household, nor was there an estimate of the proportion of homes that would need to purchase new cookware. Most articles suggested that while some households would need to replace cookware, many already have at least some compatible cookware.

Ultimately, to monetize the cookware NEI, the study team and stakeholders agreed on an assumption that 15% of households would require partial cookware replacements and 15% of

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households would require full cookware replacements. Additionally, the team applied the average cost from the four-lowest cost retailers to estimate the one-time cost for participants. Since this is an additional cost on the participants, both the impact and costs are considered negative, as they decrease the cost-effectiveness of the measure. However, given this was an assumption, the study team recommended future research to refine these estimates.

Non-monetized Induction Stovetop NEIs

The study team explored several additional possible NEIs through publicly available literature that had inconclusive results or were not suggested to be monetized for a variety of reasons. Detailed below are the NEI categories that were researched by the team but were not suggested to be monetized for various reasons that are outlined below.

Avoided fires. Avoided fires were explored by the team using the National Fire Incident Reporting System (NFIRS) dataset to review the causes of fires in Massachusetts and the severity of resulting injuries and property damage. The team found that traditional electric resistance, such as coils, cause more fires in Massachusetts than gas stovetops. However, the NFIRS data did not differentiate between electric resistance stovetops and induction stovetops, making it challenging to determine if fire incidents were associated with induction stovetops.

While some sources suggested that induction stovetops are a safer alternative to traditional stovetops (both gas and electric), other evidence pointed to certain features in induction stovetops that may pose fire risks not observed in traditional stovetops. These features include quick heating speeds, faulty safety mechanisms, constraints related to cookware compatibility, and potential operational difficulties. Induction stovetops lack an open flame and a constant heat source, which might reduce fire risk. However, there is insufficient evidence in the literature to conclude whether induction stovetops decrease or increase fire risk compared to electric resistance and gas stovetops.

Avoided burns. One potential positive NEI resulting from installations of induction stovetops is a reduction of burn injuries in the home. Induction stovetops are believed to reduce burn risk because they lack an open flame and do not generate heat without cookware on the surface. The team assessed burn risks associated with electric and gas stovetops using data from the National Electronic Injury Surveillance System (NEISS). Electric resistance stovetops cause a significantly higher number of burn injuries compared to gas stovetops, although gas stovetops tend to cause more severe burns. However, similar to the NFIRS data, the data on stovetop burns does not differentiate between electric resistance stovetops and induction stovetops. While existing literature suggests that the risk of burns should be minimal due to the absence of a flame and constant heat source, it did not provide clear evidence that induction stovetops reduce the risk of burn injuries compared to electric resistance or gas stovetops.

Pacemakers. One potential negative NEI associated with induction stovetops is the risk they may pose to individuals with pacemakers. Induction stovetop manufacturers publish warnings about potential impacts the devices may have due to magnetic fields emitted during operation, which could cause electromagnetic interference in sensitive electronics such as pacemakers. However, the evidence base reviewed by the team suggests that there is minimal risk posed by induction stovetops to individuals with pacemakers. The most severe consequence observed in the literature was based on a 'worst-case' scenario leading to a temporary interruption of pacemaker service, quickly resolved by the device itself. None of the articles reviewed provided evidence of any long-term health impacts, injuries, or deaths caused by induction stovetops in individuals with pacemakers. However, the team noted that many articles on this

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topic were dated and also did not account for advancements made in induction stovetops or pacemakers, especially regarding advancements in protecting against electromagnetic interference.

Methane leaks. The team investigated the impacts of methane, a primary component of natural gas and a potent greenhouse gas (GHG) - up to 84 times more powerful than carbon dioxide (CO2) over the first 20 years after release into the atmosphere. Natural gas stovetops in homes can release methane through post-meter leaks and incomplete combustion. Recent research on natural gas stovetops found that they emit 0.7-1.2% of the gas they use as unburned methane, with over three-quarters of these methane emissions occurring when the stovetop is turned off (Lebel et al. 2022). Both methane GHG emissions and associated air pollutants such as benzene, a known carcinogen, can result from indoor natural gas leakage, all of which have potential health impacts (Michanowicz et al. 2022). However, the benefits of methane emission reduction are societal impacts and were not considered for monetization in this study. The team recommended that evaluations assessing societal impacts consider reductions in methane from gas pipe leakage in homes that replace gas stovetops with induction stovetops.

Maintenance costs. The team found no evidence providing data on the frequency of repairs and maintenance and other associated costs for induction stoves.

Electrical upgrade costs. The team did not find any academic research, evaluations, or Technical Reference Manuals (TRMs) that systematically detailed either the costs or frequencies of electrical upgrades needed to enable installation of an induction stovetop.

Conclusions, Recommendations, and Considerations

The team ultimately recommended the monetization of seven NEIs as a result of this study. Table 9 includes the monetized values derived from the research of the study. These values can be applied to cost-effectiveness tests for programs that replace gas stovetops with induction stovetops or used to support the incremental cost of replacing a gas stovetop with an induction stovetop. It should also be noted that while induction stovetops are more efficient than their traditional electric resistance stovetop counterparts, switching from gas to electric increases electricity usage and potentially increased costs for the homeowner (as gas rates are typically lower than electric rates). While the team did find evidence of additional potential NEIs, they could not be monetized at this time due to limited or lack of evidence, limited information on financial implications a participant may experience, or they may not qualify as an NEI that the participant directly benefits from.

The recommended NEI values include the adjusted NEI value for the asthma-related NEIs that were initially developed in the RNC NEI Quick Hit Assessment study for electric stoves (both stovetop and ovens), which are shown with the adjustments to NEI values made in this study (Table 9). The new NEIs that resulted from this research include lower tract respiratory symptom reduction, COPD-related hospitalization reduction, and one-time costs associated with replacement of cookware. While the values presented below represent average benefits for a participant, it should be noted that there is inherent uncertainty when calculating NEI values such as those presented below and, in reality, certain households may experience greater benefits than others. In addition, the values themselves may be impacted or updated as additional research is available.

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Table 9. Recommended NEIs per home per year from replacing propane or natural gas stovetops with induction stovetops in existing homes (2020 $)

Non-Energy Impact	Final value recommended (2024 and after)
Childhood asthma prevention, occupant lifetime (annual)	$4.73
Childhood asthma symptom reduction (annual)	$51.45
Adult asthma symptom reduction (annual)	$49.77
Lower respiratory tract symptom reduction (annual)	$88.26
COPD-related hospitalization reduction (annual)	$0.28
Total *annual* NEIs per home	**$194.49**
NEI for partial cookware replacements (one-time)	-$19.37
NEI for full cookware replacements (one-time)	-$38.41
Total *one-time* NEIs per home	**-$57.78**

In addition to the recommended NEI values, the study team provided an additional recommendation for future research and several additional considerations arising from the study. The team recommended that the PAs conduct further research to gather information on the costs and frequencies of participants requiring replacement cookware and electrical upgrades among initial program participants. Electrical upgrades may represent a hidden cost that is associated with the installation of induction stovetops. To address this, determining the labor and materials costs would help fill in missing cost data gaps.

Additional considerations included conducting primary research to measure $PM_{2.5}$ emissions from cooking on induction stovetops and comparing them with $PM_{2.5}$ emissions from gas and propane stovetops. According to one estimate, indoor $PM_{2.5}$ from cooking was responsible for 5,500 deaths in New England in 2012 (Azimi and Stephens 2020). Hypotheses suggesting that induction stovetops could produce less $PM_{2.5}$ compared to gas stovetops are based on shorter cook times and cleaner cooking surfaces (Jhatial 2021; Microsoft 2022). Although there was not sufficient evidence that induction stovetops lower fire and burn risk relative to standard electric or combustion stovetops, future research may be worthwhile as more literature on induction stovetops becomes available.

The team also included some more programmatic considerations as a part of this research, including offering free cookware replacements with the installation of induction stovetops for low- and moderate-income households to reduce barriers to broader market adoption of the technology. Additionally, the PAs may consider including uncombusted methane emissions from gas stovetops in future studies that look at societal impacts from GHG emissions.

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