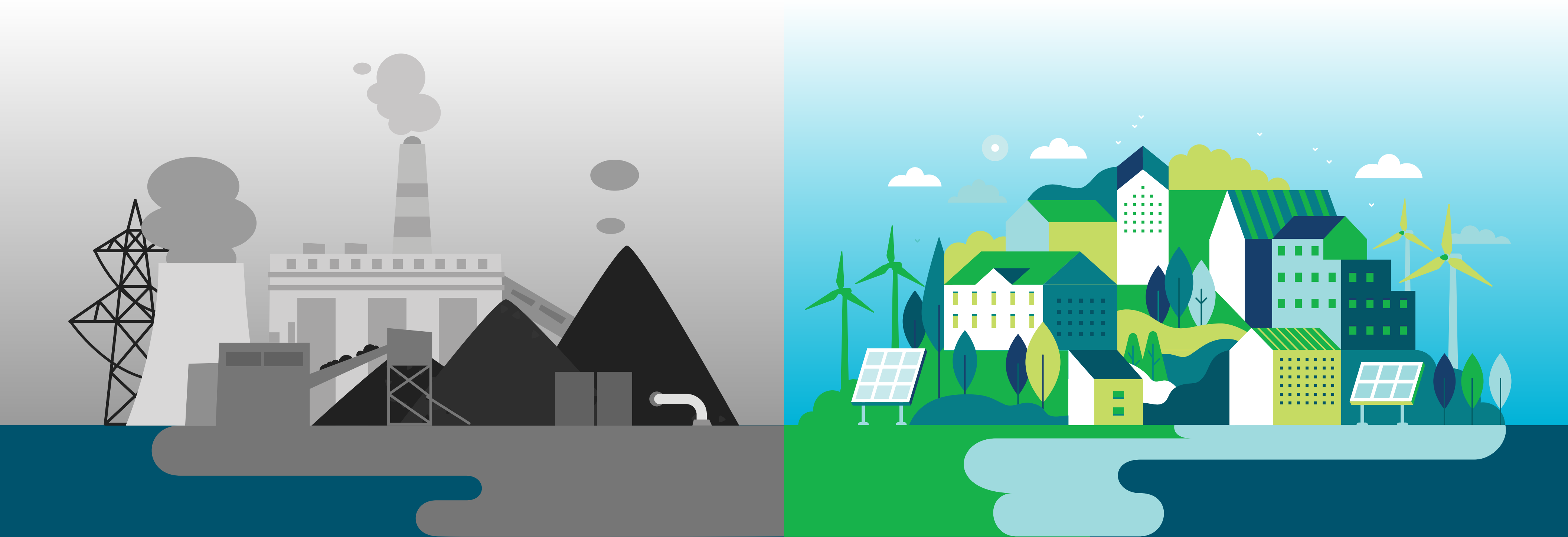

THE BUILDING DECARBONIZATION PRACTICE GUIDE

A Zero Carbon Future for the Built Environment

Google | Microsoft | Energy Foundation | UL | AIA California | WRNS Studio | Building Decarbonization Coalition | Guttmann & Blaevoet | Urban Fabrick | William J Worthen Foundation

VOLUME 5:

All-Electric Kitchens: Residential + Commercial

VOLUME 5 CONTENT LEADERSHIP

- **Rachelle Boucher,** Kitchens to Life
- **Chef Christopher Galarza,** Forward Dining Solutions, LLC
- **Steven Guttmann,** PE, BCxP, LEED Fellow, Guttmann & Blaevoet
- **Teresa Jan,** AIA, LEED AP, WELL AP, Multistudio
- **Pauline Souza,** FAIA, LEED Fellow, WELL AP, LEED AP BD+C, LFA, WRNS Studio

VOLUME 5 ADVISORS

- **Steve Gross**
- **David Kaneda**
- **Chef Tu David Phu**
- **Brett Rosenberg**

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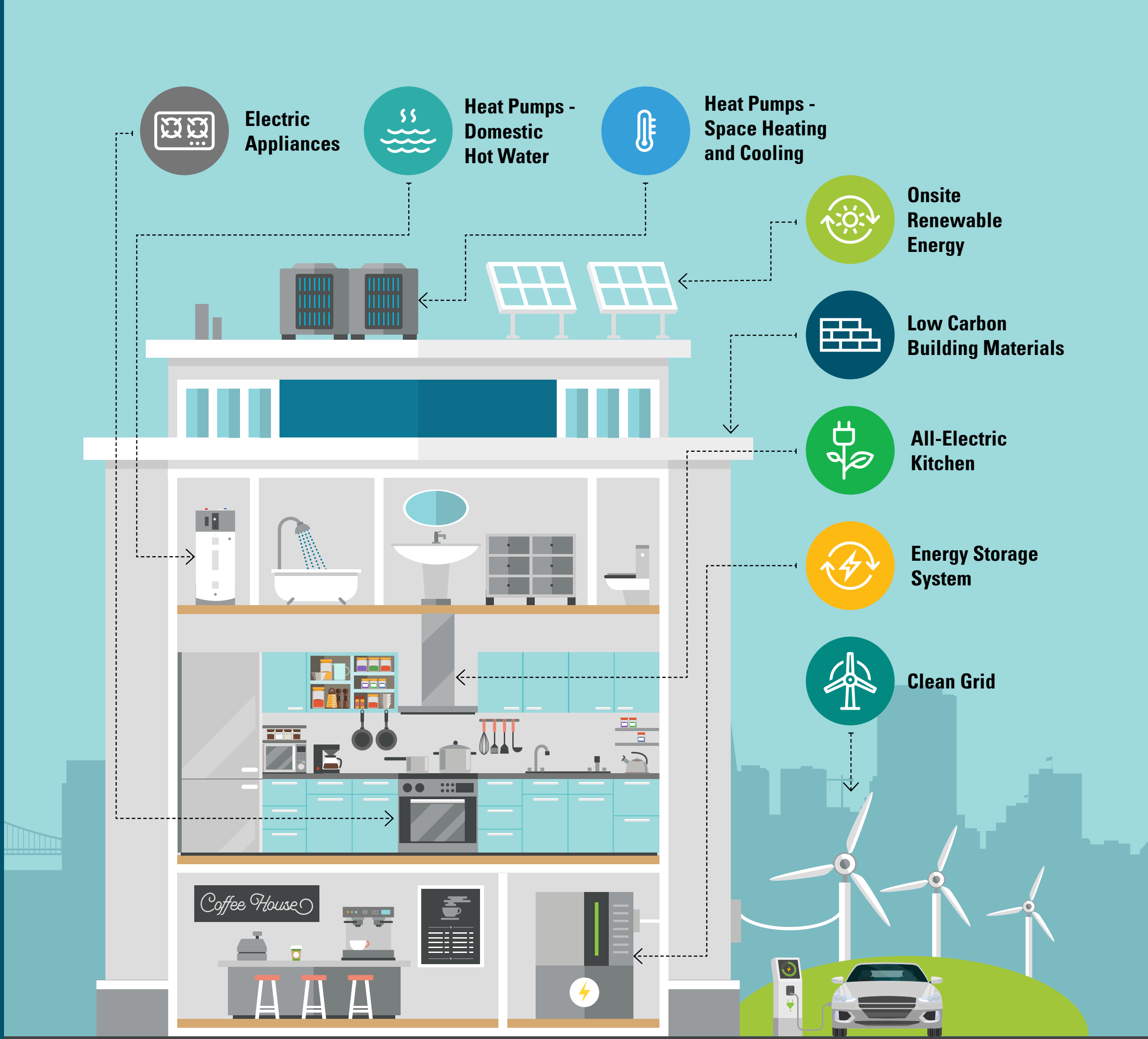

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VOLUME 5

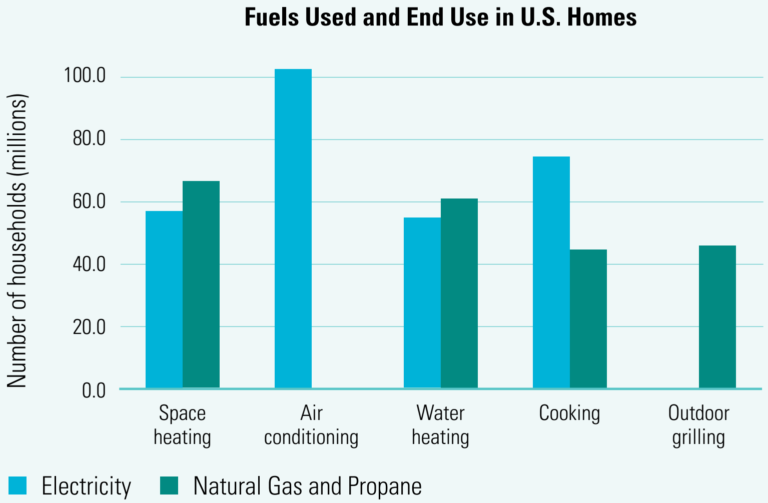
All-Electric Kitchens: Residential + Commercial

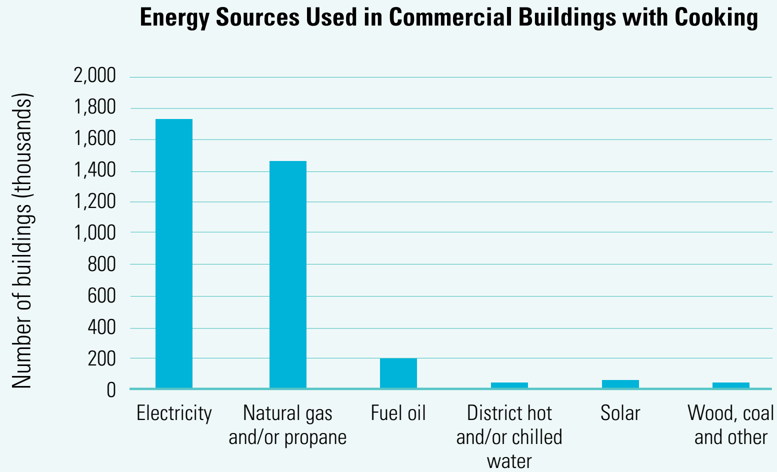
5.0_All-Electric Kitchens: Residential + Commercial

A traditional 20th century kitchen typically contains a combination of natural gas and electric appliances. This is true of kitchens at restaurants, in multifamily residential buildings and in large commercial operations. But an all-electric kitchen — one that reflects the goals of decarbonization — is one with no natural gas or other fossil fuel-based energy source. Kitchens are the last place that the post WWII myth of "better living through gas" has been hard to overcome; this Volume explains why this is a myth and how to design a better kitchen — both residential and commercial — in an all-electric paradigm.

This Volume focuses strictly on kitchens, which is still a source of natural gas use within a significant number of residential and commercial buildings (See Figure 5.1A), and is responsible for perhaps as much as 13% of total US greenhouse gas emissions from buildings (see Figure 5.1B). Kitchens present superb opportunities for decarbonization since electric cooking technology has advanced considerably in the past ten years and costs are becoming more competitive due to increased market penetration.

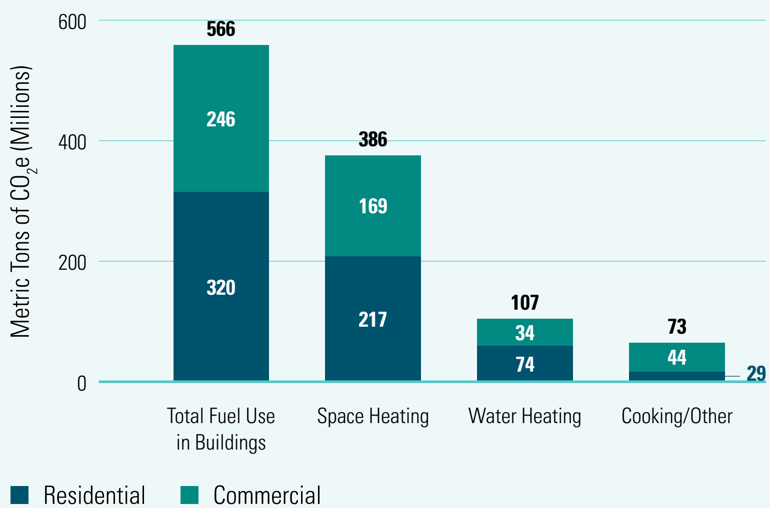
FIGURE 5.1A: PREVALENCE OF NATURAL GAS AND PROPANE USE IN RESIDENTIAL BUILDINGS, AND IN COMMERCIAL BUILDINGS WITH COOKING





Source: 2015 Residential Energy Consumption Survey Data, U.S. Energy Information Administration (https://www.eia.gov/consumption/residential/data/2015/index.php?view=characteristics) and 2018 CBECS Survey Data (https://www.eia.gov/consumption/commercial/data/2018/index.php?view=characteristics#b22-b33)

FIGURE 5.1B: CARBON EMISSIONS OF FOSSIL FUEL END USES IN U.S. BUILIDINGS (2015)



Source: The Economics of Electrifying Buildings, RMI 2018

The challenges, however, include overcoming the inertia of the construction industry as well as dealing with the impacts on the dwindling number of natural gas users from having to carry an ever greater burden of the cost of stranded gas assets.[1] Perhaps most challenging, however, is overcoming cultural preferences for gas cooking as well as educating the public about modern induction and other high efficient electric cooking sources.

In an effort to synthesize information and help designers, architects, and engineers make more enlightened building decisions, this Volume presents both the pros and cons of electric kitchen technologies. It looks at questions of performance, health benefits, and greenhouse gas reductions, and it presents design considerations for all-electric kitchens in multifamily residential and commercial projects. Throughout, cost considerations are woven into the discussion.

> "What Winston Churchill once said of architecture — *'First we shape our buildings, and then they shape us'* — might also be said of cooking. First we cooked our food, and then our food cooked us."
>
> Source: Michael Pollan, *Cooked: A Natural History of Transformation*

5.1_Electric Kitchen Technology

Cooking over an open flame is perhaps the oldest means of preparing edible food. Watch any house hunting or celebrity chef program on TV, and it's easy to assume that the luxury gas ranges/cooktops will continue indefinitely. Unfortunately, cooking over a flame, whether indoors or outdoors, often means cooking with gas. Electric coil cooktops and electric resistive cooktops are slow to heat up, respond poorly to temperature adjustments, and continue to be seen as inferior for serious chefs. Given some of these perceptions, this electric cooking technology hasn't accelerated the all-electric kitchen approach, and gas appliances remain the top choice for performance, quality, and luxury. Fortunately, induction cooking and other recent technology advances in modern electrical cooking appliances have expanded the range of options and the effectiveness for all-electric residential and commercial kitchens. As many multifamily

1 https://www.edf.org/sites/default/files/documents/Managing%20the%20Transition_1.pdf

residential developments and well-respected restaurants — including Michelin starred establishments — install induction cooking equipment to prepare fabulous and innovative meals, the paradigm that cooking with gas is the best option is undergoing a significant shift.

All-electric kitchens, especially when outfitted with induction equipment, do in fact allow for precision-temperature cooking for authentic cuisine. Additionally, they result in a healthier environment for the people who cook in commercial and residential kitchens.According to the US EPA, Americans spend an average of 90% of their time indoors and that indoor air quality is often considerably worse than outdoor air quality.[2] Given this reality, indoor air quality should be a significant public health concern especially given how vulnerable so many people are to respiratory disease and chronic respiratory problems.

A COMMON LANGUAGE

For clarity when researching residential cooking appliance options, it is helpful to know a few terms. While the term "stove" or "stove top" is still used, it is outdated and not very specific.

Cooktop: a drop-in gas, electric or induction unit without an attached oven

Oven: a cooking chamber with no attached cooktop.

Convection oven: ovens with built-in fans to circulate heat.

Range: a cooktop and oven combination. Can be gas, electric or dual fuel and can be a built-in or a slide-in style.

Rangetop: similar to cooktops, but they are often more powerful (higher BTU) and wrap around the front of the counter with controls on the front.

2 https://www.epa.gov/report-environment/indoor-air-quality

5.1.1_DO ELECTRIC KITCHENS PROVIDE COST SAVINGS?

The transition to modern all-electric kitchens is still in its infancy. While the cost of certain appliances still exceeds more conventional kitchen equipment, one can be certain that the cost of appliances will continue to fall as this transition accelerates and market share increases. Moreover, there is ample evidence that the new generation of all-electric kitchens can be built at a no- or low-cost premium. This is due to many of the savings discussed below.

Gas Infrastructure Savings
All-electric kitchens save a significant amount of money in new construction projects by eliminating the need for gas utility connections and indoor gas plumbing systems. For retrofits, some cost will be associated with capping off the existing gas main, but future costs for gas infrastructure maintenance will be avoided. In all-electric multi-family residential projects, significant space and cost savings can also be realized from eliminating the multiple gas meters that would otherwise be required.

Energy and Utility Savings
Electric kitchens are cooler because of reduced heat loss to the environment. This is particularly beneficial in hot climates where air conditioning use may be reduced, saving on overall energy costs. Furthermore, as discussed in Volume 2, section 2.5.1.3.3, the future cost of gas may further tilt the scale in favor of reduced operating costs for all-electric kitchens.

Labor Savings
In commercial kitchens, induction cooking increases productivity and allows for a faster throughput. Furthermore, less time is required for scrubbing and clean-up of cooking appliances, pots and pans, hoods and ventilation. This offers the added benefit of increasing the revenue-per-labor-hour ratio in commercial kitchens, or simply reduced cleaning time in residential kitchens.

Longer Life of Cookware
The violent nature of fire tends to alter the structure of pans, degrading and warping the metal over time. Induction, however, works within the molecular structure of cookware to more efficiently introduce a large amount of heat energy without adverse impacts.

5.1.2_ALTERNATIVES TO ALL-ELECTRIC KITCHENS: ELECTRIC-READY KITCHENS

Many municipalities that have adopted all-electric ordinances have exceptions that allow the use of gas appliances in exchange for designing an electric-ready kitchen. Thus, the decision to maintain the use of gas appliances is often made due to a reluctance to let go of well-established practices. Until perceptions change and costs come into alignment, future-proofing a building for both gas and electric-ready will likely cost more in the short term.

While not strictly aligned with the ideals of full decarbonization, when a project cannot justify an all-electric kitchen, electric-ready kitchen designs can at least set a project on the path to decarbonization.

An electric-ready kitchen may run on gas at first but is designed and wired so that gas equipment could be easily replaced with electric appliances, and gas infrastructure can be easily dismantled and removed sometime after the original kitchen installation. This helps mitigate the long-term effects of a costly future retrofit.

There are at least two important considerations when planning an electric-ready kitchen:

» Try to incorporate electric kitchen equipment to replace any and all gas equipment that would have an open flame. Equipment that uses open flame is the greatest contributor to poor indoor air quality and has the biggest risk of causing kitchen fires. Open flame equipment also contributesto the degradation of the cookware that regularly sits on the flame.

» For commercial kitchens, identify the equipment with the largest gas usage and replace it with an electric/induction counterpart.

5.2_Induction Technology and Other Electric Equipment

Of all the electric cooking options, induction cooktops are often the most discussed but perhaps the least understood. Relatively new in American kitchens, modern induction cooktops have significant benefits over electric coil, electric ceramic, and gas cooktops (see Figure 5.2). They also offer superior culinary performance, energy efficiency, and labor efficiency, as well as improved safety. Though there has been much advancement with induction cooking technologies, a lingering misperception persists that induction cooktops are either the same as or will perform just like traditional electric coil or electric resistive ceramic cooktops. Given this misunderstanding, a brief overview of cooktop technologies is in order.

FIGURE 5.2: COOKTOP HEAT SOURCES: THREE WAYS OF PROVIDING A HEAT SOURCE ON A COOKTOP: ELECTRIC COIL, GAS, AND INDUCTION

Source: https://factorybuilderstores.com/compare-electric-gas-induction-cooktops/

5.2.1_TRADITIONAL COOKTOPS VERSUS INDUCTION HOBS

A gas burner heats food by creating a flame that is controlled by the mix of oxygen and natural gas applied to the outside of a pot. This is heating the food via convection. However, much of the heat wicks off the pot and thus ends up in the exhaust hood or throughout the kitchen. This results in unhealthy air quality, an uncomfortable thermal environment, and a great deal of lost energy.

Electric coil cooktops are constructed of spiral steel tubing that houses a heating element powered by electricity. Heat is thus transferred by conduction from the coils to the pot. The temperature is adjustable, but the temperature will rise and fall with a significant time lag. Coils also radiate heat downward and to the sides, reducing their efficiency.

Electric ceramic cooktops appear similar to induction cooktops but function quite differently. The coiled metal elements under tempered ceramic glass are electrically heated to the desired temperature. The coil transfers heat to the pot via a combination of convection/conduction (from the coil, to the air under the glass, to the glass, to the pot) and radiation (from the coil to the bottom of the pot). Due to the unit having to convert the electrical energy into heat, electric ceramic cooktops are slower and less energy efficient than induction, and heat spreads over the entire ceramic top. One quick way to differentiate a ceramic cooktop from induction is that the coil heating elements can be seen glowing under the ceramic glass plate when in use. Currently, electric ceramic is cheaper than induction, but it does not perform as precisely and efficiently.

An induction hob contains a coil of copper wire underneath a tempered ceramic glass plate. An alternating electric current is passed through it, resulting in a magnetic field. When ferrous cookware is placed in the magnetic field, it produces an eddy current. The resistance to the eddy current flowing through the metal creates heat in the pot. To visualize this, we need to understand two things:

1. How metal is structured: metal has a linear molecular structure that makes it a great conductor of heat and electricity.
2. How a microwave works: a microwave works by using the aforementioned "microwaves" to excite the water molecules in the food to oscillate at such a high rate of speed that the friction on a molecular level creates the heat that cooks/heats the food from inside out.

Both of these physical phenomena are used in induction cooking. As the magnetic current generated in the coils of the induction unit is created, that current is excited and oscillates the magnetic molecules in the metal of the pan exactly the same way the water is excited in the microwave. Due to the linear structure of the metallic molecules, this allows for the easy flow of energy into the pan and thus creates the heat. Figure 5.3 presents how induction works.

In an induction hob, unlike the other cooktops, the energy is transferred directly from the coil into the pot — and only the pot. Therefore, the cooking surface and surrounding area remain relatively cool, safe, and user friendly. Only the surface directly under the pot becomes hot, from heat transferred back out of the pot to the ceramic glass. This means that more of energy is transferred directly into the food, thus speeding up cook times and creating a kitchen with much cleaner air and a more comfortable thermal environment.

Similarly, induction cooktops are more efficient than gas, transferring heat to the food with an 80% efficiency rate, vs 30–35% heat transfer efficiency for gas. Furthermore, induction cooktops are among the top rated by Consumer Reports and have received many positive reviews by professional chefs.[3]

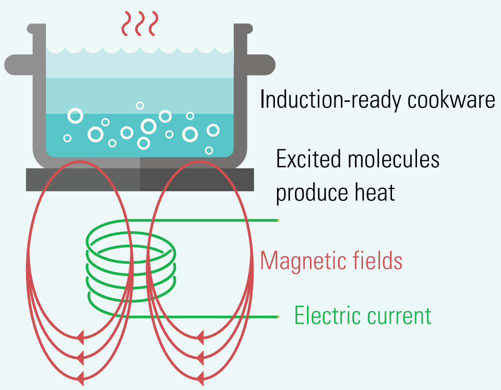
> "Once you get the hang of them, they're far easier than cooking on gas or electric."
>
> **— Celebrity Chef James Ramsden**

3 https://www.consumerreports.org/electric-cooktops/the-best-induction-cooktops/

HOW DO I KNOW IF MY EXISTING POTS WILL WORK ON AN INDUCTION COOKTOP?

To tell if a pot or pan is compatible with your induction stove, hold a magnet to the bottom. If the magnet clings to the underside, the cookware will work on an induction cooktop. If the magnet grabs the pan softly, you may not have good success with it on your cooktop.

FIGURE 5.3: HOW ELECTRIC INDUCTION COOKING WORKS



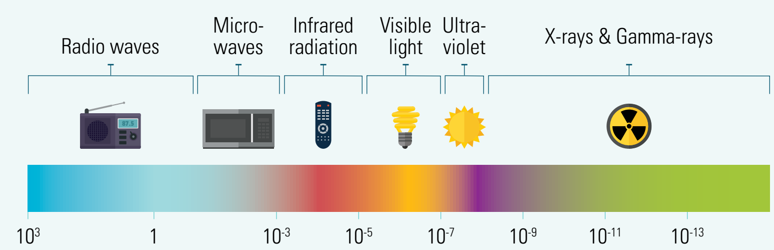
- » An electrically charged copper coil underneath the hot top surface creates a electromagnetic field.
- » When ferrous metal cookware (magnetic) is placed in this field an electric current is induced, causing the cookware to heat.
- » The cookware becomes the heat generator, making the appliance very energy efficient.
- » Without cookware in the electrmagnetic field, no energy is consumed and no heat produced.

Source: Image from Richard Young, Mark Duesler, Hot New Induction Technologies for Cooler Kitchens

5.2.2_INDUCTION COOKING AND ELECTROMAGNETIC FIELDS

All electronic equipment (such as cell phones, electric wiring in buildings, baby monitors and WiFi systems) create electromagnetic fields (See Figure 5.4). Like with the arrival of microwave ovens, each new technology has faced consumer concerns about whether electromagnetic fields (EMFs) can cause bodily harm. The same is true now for induction cooktops.

FIGURE 5.4: THE ELECTROMAGNETIC SPECTRUM



There are many reasons that these concerns are overstated in relation to induction cooking. Induction cooktops work by creating a fairly powerful but low frequency (24 kHz) magnetic field. While high frequency electromagnetic radiation (such as ultraviolet or gamma rays) is known to cause cellular damage, potentially resulting in cancer, lower frequency radiation such as radio signals and the earth's magnetic field are pervasive and not harmful. The magnetic field that emanates from an induction hob is equally harmless, and the strength of the field falls within inches of the hob, which is why pots need to be touching the cooktop surface to heat up.[4]

4 https://academic.oup.com/europace/article/8/5/377/460579

Granted, a small measure of uncertainty still exists about the low frequency non-ionizing radiation generated by many common devices, like computers, WiFi hotspots, and LED lights. The EMF from an induction stove is classified as a class 2b carcinogen, alongside coffee and pickles: "it is possibly carcinogenic to humans — but no conclusive evidence has yet been found."[5] The National Cancer Institute notes that "No mechanism by which ELF-EMFs[6] or radiofrequency radiation could cause cancer has been identified."[7]

One final area where some caution is warranted concerns people with implanted pacemakers and defibrillators, which can be sensitive to EMFs. Like any other equipment, induction cooking carries an inherent — albeit minimal — risk to human health and safety, and misuse can exacerbate such risk. While the odds are extremely low that the pacemaker may malfunction if placed within a couple of inches of an operating induction hob, the risk is greater than if that same pacemaker was inches away from an open flame on a gas cooktop. As we will see in the next section, the benefits of induction technology far outweigh these concerns.

> "I have had elderly staff members and pregnant staff members, and after working with and learning about electric kitchen appliances I am more concerned about the harmful effects of the carcinogenic byproducts of burning natural gas than I am with any potential ELF and ELM that could come off of an induction unit."
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

5 https://therationalkitchen.com/induction-cooking-safe/

6 Extremely Low Frequency Electro-Magnetic Frequencies (ELF-EMFs).

7 https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet

5.2.3_HEALTH AND SAFETY BENEFITS OF AN ALL-ELECTRIC KITCHEN

Non-combustible: All-electric kitchens with no open flames and no gas lines minimize ignition sources and mitigate the risk of gas leaks and gas-induced fires. The lack of open flames also eliminates the risk of grease fires and the burning of cloth and other combustible and flammable materials.

More thermally comfortable: Since there is almost no waste heat transferred into the kitchen, an all-electric kitchen is much cooler than its gas-powered equivalent. Commercial kitchens in particular — which are characterized by high occupancy and a great deal of moving about in tight spaces as well as long hours of use — stand to benefit most from a more comfortable ambient temperature. Cutting out gas powered equipment also reduces the demand on ventilation hoods and cooling equipment (saving cost and energy use). Most modern commercial kitchen hoods are specifically controlled by heat and smoke sensors that directly save energy in an all electric kitchen

Fewer accidents: Specific to induction cooktops, it is almost impossible to lean against a control knob and inadvertently turn on the hob since it requires both the selected hob to be turned on and a vessel placed on the unit before a connection can be made. Induction appliances have additional cooking and safety features such as cooking timers, alarms, and automatic shut off if a pot boils over or boils dry. Furthermore, fewer burns and other injuries occur with induction cooking. Unlike all other types of cooktops, the handles on pots and pans do not heat up considerably — only the surfaces contacting the induction hob are heated. The heated portions of induction equipment are more confined and efficient than other electric equipment, and there are no open flames as with gas cooking appliances; consequently, the risks of injuries occurring are minimal.

Healthier indoor air quality: all-electric kitchens using induction can offer better air quality due to the lack of combustion. Natural gas cooking appliances, which are currently used by a third of U.S. households, can contribute to poor indoor air quality, especially when used without an exhaust hood.

5.2.3.1_Combustion and Air Quality

Cooking with gas emits nitrogen dioxide (NO_2), carbon monoxide (CO), formaldehyde, carbon dioxide (CO_2), particulate matter (PM), and volatile organic compounds (VOCs), each of which can cause or exacerbate various respiratory and other ailments.[8] For people experiencing diminished lung capacity (including some survivors of COVID-19), it's now more important than ever to improve indoor air quality to ensure a better quality of life while at work and at home. Figure 5.5 describes the potential health impacts of several indoor air pollutants.

Gas burners are estimated to add 25–33% to the week-averaged indoor NO_2 concentrations during summer and 35–39% in winter. The variability between seasons likely reflects the fact that windows are closed and natural air ventilation is lower in winter.[9] Numerous studies have shown that elevated indoor NO_2 levels have been associated with chest tightness, shortness of breath, increased asthma attack incidences, and daily deaths.[10 11 12] At higher concentrations, NO_2 has been associated with increased sensitivity to allergens in patients with asthma.[13]

Exposure to carbon monoxide is most serious for those who suffer from cardiovascular disease, as it can enter the bloodstream and reduce oxygen delivery to the body's organs and tissues. Elevated indoor CO levels have been associated with increased incidences of chronic obstructive pulmonary disease, asthma symptoms, and lower respiratory system infections.[14]

FIGURE 5.5: OVERVIEW OF HEALTH EFFECTS OF MAIN POLLUTANTS FROM GAS STOVETOPS AND OVENS

Pollutant	Acute Health Effects	Chronic Health Effects
Nitrogen oxides (NOx)	Decreased lung function, asthma exacerbation, respiratory infection, stroke	Premature mortality, lung and breast cancer, cough, shortness of breath, asthma, wheezing, respiratory illness in children
Carbon monoxide (CO)	Death, brain damage, seizures, memory loss, dementia, headaches dizziness, nausea	Brain and heart toxicity, heart failure and cardiovascular disease, low birth weight
Fine particulate matter ($PM_{2.5}$)	Stroke, increased blood pressure	Premature mortality, bronchitis, asthma onset and exacerbation, low birth weight and preterm birth
Ultrafine particles (UFP)	Increased blood pressure	Cardiovascular disease, neurological disorders
Formaldehyde	Respiratory/eye/skin irritation, sneezing, coughing, nasal congestion, drowsiness, chest tightness, shortness of breath, asthma exacerbation, death (higher doses)	Cancer, asthma and bronchitis in children, damage to respiratory system, headaches, sleep disorders, memory loss, birth defects, low birth weight, spontaneous abortion

Source: Dr. Yifang Zhu, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, April, 2020, Table 2-8. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/

8 https://ehp.niehs.nih.gov/doi/10.1289/ehp.122-A27

9 https://ehp.niehs.nih.gov/doi/10.1289/ehp.122-A27

10 Touloumi G, Katsouyanni K, Zmirou D, Schwartz J, Spix C, Ponce de Leon A, et al. Short-term effects of ambient oxidant exposure on mortality: a combined analysis within the APHEA project. Am J Epidemiol. 1997.

11 Jarvis D, Chinn S, Luczynska C, Burney P. The association of respiratory symptoms and lung function with the use of gas for cooking. Eur Respir J. 1998.

12 Hajat S, Haines A, Goubet SA, Atkinson RW, Anderson HR. Association of air pollution with daily GP consultations for asthma and other lower respiratory conditions in London. Thorax. 1999.

13 Tunnicliffe WS, Burge PS, Ayres JG. Effects of domestic concentrations of NO_2 on airway responses to inhaled allergen in asthmatic patients. Lancet. 1994.

14 Zhu, Y., Connolly, R., Lin, Y., Mathews, T., and Wang, Z., Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, Fielding School of Public Health, UCLA, April 2020.

The indoor pollutant that scientists believe may be most harmful to human health is particulate matter (PM), including fine particulates (less than 2.5 micrometers in diameter) and ultrafine particulates (smaller than 1 micrometer). These are produced by both gas and electric burners and by cooking. They are potentially very harmful because they can enter the lungs and even the bloodstream or other tissues.[15] As Figure 5.6 demonstrates, the health benefits of electrictrification and clean air, vis-a-vis particulate matter, also provide economic benefits. Figure 5.7 suggests that while cooking in general emits particles of concern, these and many other pollutants are associated with cooking on gas stoves.

FIGURE 5.6: ESTIMATED ANNUAL MONETIZATION OF HEALTH BENEFITS FROM RESIDENTIAL BUILDING ELECTRIFICATION FOR FIVE CALIFORNIA AIR BASINS

Air Basin	All $PM_{2.5}$ Mortality Valuation (Annual)	Acute Bronchitis Valuation (Annual)	Chronic Bronchitis Valuation (Annual)
San Francisco Bay Area	$1.2 billion	$100,000	$58 million
South Coast	$1.0 billion	$97,000	$46 million
Mojave Desert	$0.6 billion	$57,000	$26 million
Sacramento Valley	$0.2 billion	$16,000	$7 million
San Joaquin Valley	$0.2 billion	$18,000	$6 million

Source: Dr. Yifang Zhu, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, April, 2020, Table 3-2. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/

Much research shows that indoor air pollution is a health concern for residential kitchen occupants in particular, where ventilation is less strictly regulated than commercial kitchens.This is especially true for children and other vulnerable populations; refer to additional research provided in Section 5.3.3. Although commercial kitchens tend to provide good ventilation systems, a chef standing over a gas stove cannot help but regularly inhale the various harmful emissions produced by burning natural gas.

Contribution to Better Outdoor Air Quality: Research has shown that the combustion byproducts of indoor gas appliances generally get transported outside, via windows, doors, and ventilation systems such as the hoods over cooktops. The harm from CO, NOx and PM that can occur to building occupants can, in turn, harm those outside as well, as Figure 5.8 indicates (using California regions as examples).[17]

Finally, a recent study[16] determined that gas cooktops and stoves leak natural gas and other harmful pollutants, even when not in use. In fact, the study indicated that more than three quarters of gas appliances' emissions occur when in "steady-state off." According to the study, "Using a 20-year timeframe for methane, annual methane emissions from all gas stoves in U.S. homes have a climate impact comparable to the annual carbon dioxide emissions of 500,000 cars."

15 https://newscenter.lbl.gov/2013/07/23/kitchens-can-produce-hazardous-levels-of-indoor-pollutants/

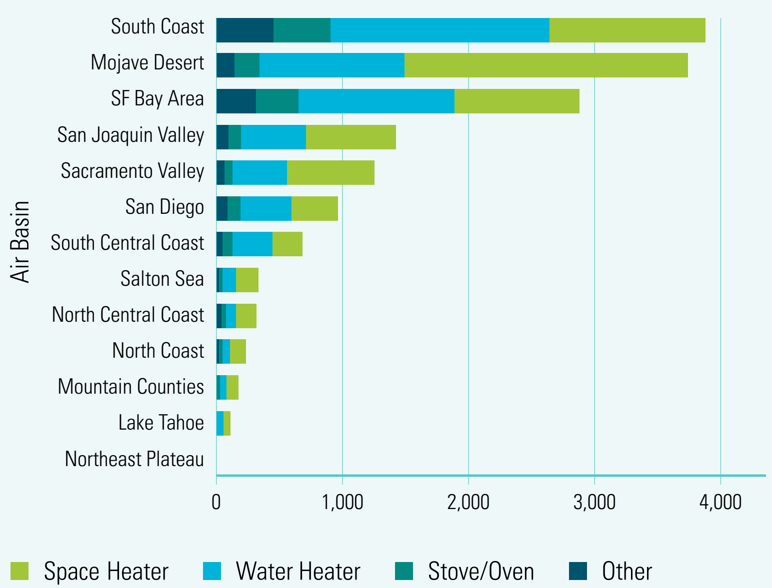
16 Eric D. Lebel, D.; Finnegan, C.; Ouyang, Z.; Jackson, R. Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes. 2022. *Environ. Sci. Technol.*

17 Dr. Yifang Zhu, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, April, 2020, Table 2-8. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/

FIGURE 5.7: DIFFERENTIATING POLLUTANTS FROM COOKING FOOD VS. GAS FUEL

Pollutants Generated from Cooking Food (regardless of stove type)	Pollutants Associated with Gas Stoves
Particulate Matter (PM_{10}) Small particles with a diameter less than 10 micrometers. Commonly measured in cooking activities like frying or broiling with the highest emissions levels.	**Ultrafine Particles (UFP)** These tiny particles are less than 100 nanometers (nm) in diameter and are hazardous to health. Cooking is the main source of UFP in homes, particularly those with gas stoves. Gas stoves and electric coil resistance stoves emit high quantities of UFP, particularly smaller than 10 nm in diameter.
Particulate Matter ($PM_{2.5}$) Small particles with a diameter less than 2.5 micrometers. $PM_{2.5}$ can penetrate deep into the lungs and even enter the bloodstream. Stove tests show emissions are dependent on a number of factors such as the type of food cooked, cooking temperature, type of oil used, and type of fuel/stove used.	**Nitrogen Oxides (NOx)** When nitrogen and oxygen react to each other, especially at high temperatures, they produce several toxic gases. NO_2 and NO are the principal gases associated with combustion sources (collectively known as NOx). * A 2001 laboratory study showed no rise in NOx when using an electric stove. * A study published in 2016 showed that after subtracting outdoor contribution, all-electric homes had NOx levels close to zero.
Other Emissions from cooking also include various volatile organic compounds (VOCs) such as benzene and acrolein as well as polycyclic aromatic hydrocarbons (PAHs).	**Nitrogen Dioxide (NO_2)** Nitric Oxide (NO) is oxidized in the air to form NO_2. More data exists on NO_2 than NO. NO_2 is regulated by the EPA and thus is the component most studied and considered by the EPA in terms of health effects.
	Nitric Oxide (NO) A primary gas associated with combustion; NO is also a precursor to NO_2. * A 2001 major study found NO concentrations on electric stoves were insignificant compared to gas stoves.
	Carbon Monoxide (CO) An odorless, colorless gas. A 2011–2013 study found that gas stoves can substantially increase the risk of elevated CO in the home.
	Formaldehyde (CH_2O or HCHO) A known human carcinogen. Exposures at levels that occur in homes have been associated with human health impacts such as lower respiratory infections. A new test of one gas stove shows that simmering on low heat for multiple hours can produce significant exposure levels if ventilation is not used.
	Other Emissions from cooking also include various volatile organic compounds (VOCs) such as benzene and acrolein as well as polycyclic aromatic hydrocarbons (PAHs).

FIGURE 5.8: NOx EMISSIONS IN TONS/YEAR



Source: Dr. Yifang Zhu, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, April, 2020, Figure 3-2. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/

5.2.3.2_Residential Indoor Air Quality Issues and Health benefits

Natural gas use in residential kitchens poses unique health risks to occupants, especially children.

» Prior to the recent pandemic's shelter-in-place requirements, people spent an average of 90% of their time indoors, exposed to all the various substances permeating the indoor environment, including those that result from cooking. Since the onset of COVID-19, more people have spent even more time inside and are cooking and baking at home more than before. Therefore, residential indoor air quality should be a top public health concern, especially as scientific studies continue to reveal the vulnerability of the population with respiratory conditions to the ill effects of air pollution, both indoor and outdoor.

» Due to the noisy nature of many ventilation hoods, residents often do not use their range hoods while cooking. Some research estimated that, during a typical winter week, 1.7 million Californians could be exposed to carbon monoxide (CO) levels that exceed standards for ambient air quality, and 12 million could be exposed to excessive nitrogen oxide (NO_2) levels, if they do not use venting range hoods during home cooking.[18]

» Research shows that in kitchens without proper ventilation, cooking for one hour with a gas stove and oven, NO_2 levels are so high they exceed both state and national outdoor acute air quality standards in more than 90% of the homes modeled (see Figure 5.9).[19]

» Gas stoves emit many pollutants that are respiratory irritants. Children under age six who live in homes where gas stoves are used for cooking or even heating the room have an increased risk of asthma, wheezing, and reduced lung function. More research is needed to help understand the correlation of good ventilation to decreased respiratory illnesses, but there are enough studies to encourage taking precautions. Figure 5.10 demonstrates how NO_2 can impact children.

18 https://ehp.niehs.nih.gov/doi/10.1289/ehp.122-A27

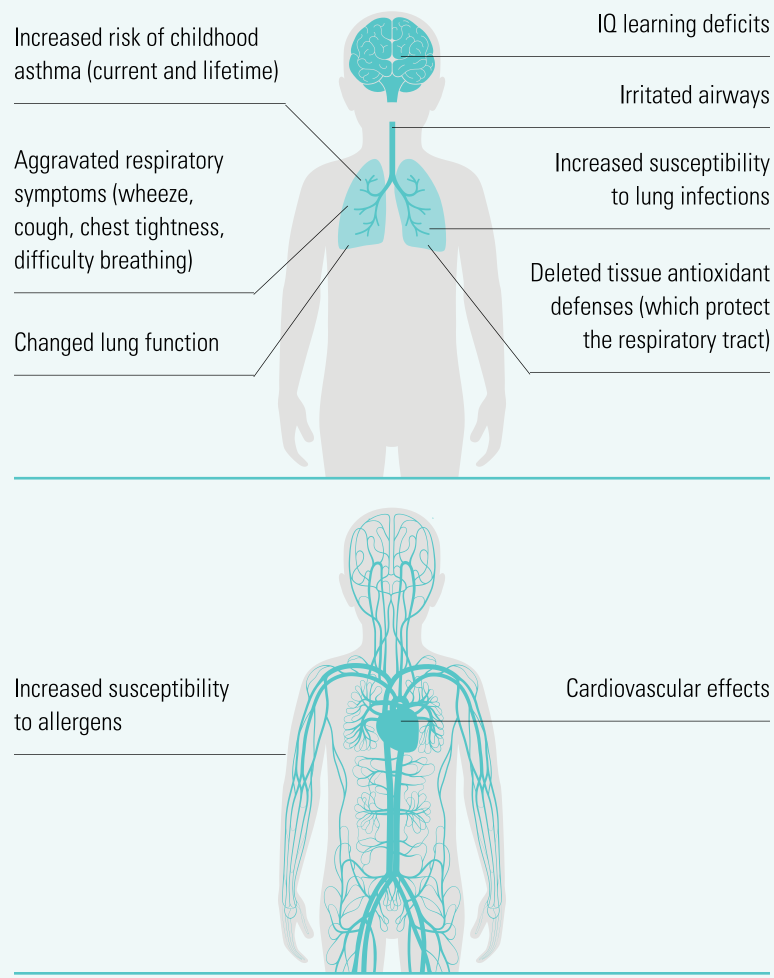
19 https://rmi.org/insight/gas-stoves-pollution-health/

FIGURE 5.9: INDOOR EMISSIONS FROM GAS STOVES OFTEN EXCEED OUTDOOR STANDARDS

Outdoor Standards for NO_2	1-hr average (ppb)
US National Standard (EPA)	100
Canadian National Standard	60
California State Standard	180
Indoor Guidelines for NO_2	**1-hr average (ppb)**
Canada	90
World Health Organization	106
Measured NO_2 Emissions from Gas Stoves	**Peak (ppb)**
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop (no food)	82–300
Gas oven (no food)	130–546

Source: https://rmi.org/insight/gas-stoves-pollution-health/

FIGURE 5.10: HEALTH EFFECTS OF NO_2 IN CHILDREN



Source: https://rmi.org/insight/gas-stoves-pollution-health

- Asthma is the number one chronic disease in children. More than 1 in 7 children in California have an asthma diagnosis. In some California Counties, 1 in 4 kids have asthma. A recent study concluded that replacing all residential gas appliances with clean electric alternatives would cut particulate matter pollution (Figure 5.11 shows the anticipated reductions in PM2.5 concentrations that would be achieved). The study estimates that these reductions would be enough to result in approximately 350 fewer deaths, 900 fewer cases of bronchitis, and $3.5 billion in health savings each year in California.[20]

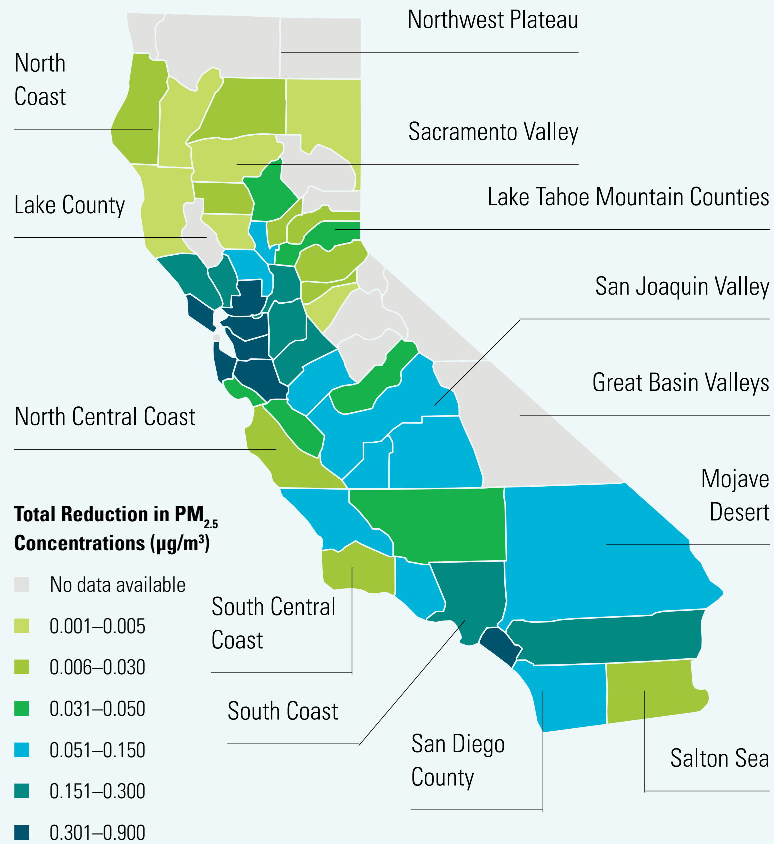
5.2.4_INDUCTION IMPROVES CULINARY PERFORMANCE

Cooking with electric appliances in general, and induction equipment in particular, has the potential to make the experience in the kitchen better for any cook.

Thermal Comfort: Given that gas cooktops are only 30–35% efficient, about 70% of the energy is lost to the ambient environment rather than used to cook the meal. Open gas flames, especially in busy commercial kitchens, tend to unduly and inefficiently warm the room. Reducing the ambient heat in commercial kitchens can improve people's working conditions and make cooking a more enjoyable experience.

Temperature Responsiveness: Induction equipment provides unparalleled precise temperature control. Pan temperatures react to user adjustments much quicker than other types of electric or gas equipment. When the hob is turned down or off, the heat stops immediately so there is no need to remove the pan from the cooking surface. Contrast this with grates and gas burners that can stay hot for a significant amount of time after cooking, which can lead to overcooking and make it harder to clean the pans.

FIGURE 5.11: TOTAL REDUCTION IN AMBIENT $PM_{2.5}$ CONCENTRATIONS IN CALIFORNIA FROM ELIMINATION OF GAS APPLIANCES BY COUNTY IN 2018



Source: Dr. Yifang Zhu, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, April, 2020, Figure 3-3. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california/

20 Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. Dr. Yifang Zhu, April 2020.

Speed/High Food Production Capacity: Induction hobs boil water in half the time of gas burners. The production capacity of induction (for the three manufacturers listed in Figure 5.12) averages 70.9 lb/hour, a substantial improvement over electrical resistance (average of 43.5 lb/hour for the two manufacturers listed) and gas (38.6 lb/hour for the Samsung unit).[21]

FIGURE 5.12: COOKTOP HEAT-UP TIME RESULTS

Cooktop	Induction A (Frigidaire)	Induction B (GE)	Induction C (Samsung)	Resistance Ceramic (Whirlpool)	Resistance Coil (Frigidaire)	Gas Burner (Samsung)
Medium Hob Input Rate	2.8 kW	2.5 kW	2.3 kW	1.2 kW	1.5 kW	9.5 kBTU/hr
Equivalent kBTU/hr	9.6	8.5	7.8	4.1	5.1	9.5
5-lb water heat up time (min)**	5.3	5.8	6.4	18.8	11.5	14.1
Efficiency	86.2%	86.8%	85.3%	70.3%	72.3%	30.6%
Large Hob Input Rate	3.6 kW	3.7 kW	3.3 kW	2.5 kW	2.4 kW	17 kBTU/hr
Equivalent kBTU/hr	12.3	12.6	11.3	8.5	8.2	17.0
12-lb water heat up time (min)**	9.8	9.3	11.6	17.8	15.5	18.6
Efficiency	85.2%	86.1%	83.0%	75.5%	79.3%	31.9%
Production* Capacity (lb/hr)	73.5	77.2	62.2	40.4	46.5	38.6

*calculated based on a single high-input element or burner heating 12 lb of water from 70 to 200°F in an 8 qt pot

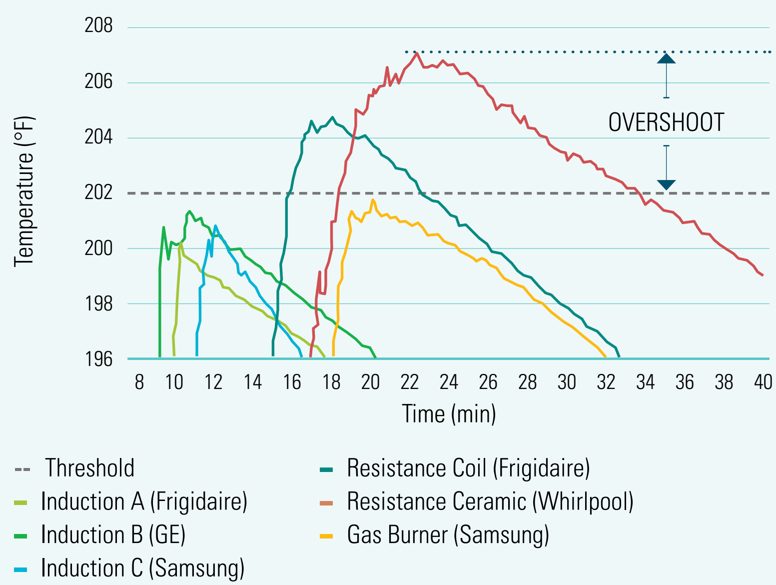
** water heated from 70°F to 200°F.

Source: *Residential Cooktop Performance and Energy Comparison Study*, Frontier Energy, Report # 501318071-R0, July 2019.

21 Denis Livchack, Russel Hedrick, Richard Young, Mark Finck, Todd Bell, Michael Karsz. Frontier Energy. "Residential Cooktop Performance and Energy Comparison Study," July 2019, Report #501318071-R0. Report prepared for SMUD, Sacramento Municipal Utility District. Table 1 and Figure 7 (https://cao-94612.s3.amazonaws.com/documents/Induction-Range-Final-Report-July-2019.pdf)

Precision control: Digital displays often indicate exact cooking temperature on induction appliances, and heat adjustments are so instantaneous that cooks no longer need to rely on visual clues from the fire or the ambiguous range of high/low dial controls for gas or electrical resistant cooktops. Figure 5.13 shows the speed and accuracy of control that is possible with an induction cooktop versus electric resistance and gas.

5.13: TEMPERATURE OVERSHOOT RESULTS FOR 12-LB OF WATER



*calculated based on a single high-input element or burner heating 12 lb of water from 70°F to 200°F in an 8 qt pot, and then turning off the element/hob or burner and leaving the pots of water in place. Water temperature was measured for 40 minutes after turning off the hob or burner to see how much residual heat was transferred to the water above the 200°F end of test (defined as overshoot), and how fast the water cooled down to 190°F.

Source: *Residential Cooktop Performance and Energy Comparison Study*, Frontier Energy, Report # 501318071-R0, July 2019.

Consistency: Instead of continuously turning heat up and down and constantly checking the temperature of the meat, such as when frying chicken, it is easy to find the exact power level that maintains the precise temperature required. In fact, the low temperatures are so precise that a double boiler is not needed for melting or low simmering.

More working surface area: Induction cooktops provide a flat area which is very safe to work on. This results in an increase in available working surface area in a kitchen. It is safe to place a cutting board, recipe or cooking tools on the cooktop as long as they are not magnetic and do not cover the controls.

Easy to clean: The hob itself isn’t directly heated, so there’s little chance of burnt-on food. A simple wipe is all that is generally necessary to clean an induction cooktop, which reduces overall clean up time and cost of cleaning chemicals. Less need of using harsh chemicals also improves indoor air quality.

5.2.5_BARRIERS TO ACCEPTING ELECTRIC INDUCTION KITCHENS

This Volume aims to provide alternatives to traditional, inefficient — and possibly harmful — food preparation equipment. Induction technology is among the most promising of these alternatives. As a relatively new option, it faces some important barriers to widespread use; however, these issues, several of which are listed below, are not insurmountable.

Unfamiliarity: Chefs tend to be very process-oriented and often develop personal relationships with their tools and equipment. Taking them out of their comfort zone (i.e., using gas equipment), especially without providing ample reason and training, can create a strong reaction and pushback to the idea of induction cooking.

Upfront costs: Financiers of culinary endeavors tend to dwell on the upfront costs rather than the long term implications of their investments. Induction equipment may have a higher cost than equivalent gas equipment, but will more than pay for itself over the life of the unit through energy efficiency and increased throughput, which is much faster than their gas counterparts. Furthermore, it is not always true that an all-electric kitchen will cost more to build than a conventional kitchen.

Maintenance availability: Those who are responsible for maintenance often worry about the ability to get induction kitchen equipment serviced due to its relatively recent entry to the American marketplace. Although this is a valid concern when sourcing equipment, reputable appliance vendors always have options for certified service representatives who are able to take care of the equipment during its lifetime. Oftentimes companies won't even begin selling their equipment in a territory until there is a reliable certified maintenance source in the area that can take care of their equipment. It's incumbent on the company to give its equipment the best possible chance to have a long and effective life.

5.3_Residential Kitchens + Case Studies

In order to successfully design a multifamily residential project with all-electric kitchens, planners must clearly communicate the costs, benefits, and functionality of different kitchen options based on client specifications. Moreover, as *Volume 3 (Multifamily Residential, Hotels/Motels, and Similar Buildings)* describes, healthy indoor air quality is a key aspect of meeting social equity responsibilities: Given pervasive respiratory diseases (like COVID-19) and increasing climate disruptions, which keep us indoors more, it is important that we improve our indoor air quality. Electrification is a huge step in that direction, and designing and properly installing energy efficient, cost-effective electric cooking appliances is a key contribution to these goals.

5.3.1_START THE CONVERSATION ON DAY ONE

Unlike other building systems, cooking equipment is something that many decision makers personally and directly use every day. Simply suggesting that people adopt a new cooking technique and technology is like asking them to stop a relationship with an old friend — the cooking equipment they are familiar with can evoke a more emotional response than just about any design decision. Many reach codes in California cities and counties demand all-electric building systems, but have exceptions for cooking appliances for this reason. Accordingly, it's crucial to dedicate time early during a project goal-setting session to consider the health, environmental, and cost benefits of all-electric kitchens.

Consumer Reports is a reliable indicator of current market trends, and a growing number of top-rated ranges are electric and induction. In other words, the market and end users continue to embrace induction technology and products. For stakeholders who aren't familiar with induction technology, however, it is important to use demos or show induction cooking videos to engage in fun conversations and spark people's curiosity and commitment to change. It is important for home chefs to directly experience how electric kitchens — especially induction — work and feel assured that it would be a great choice for how they cook.

When advocating for all-electric kitchens, it is important to bring empathy to the conversation and listen carefully for cues that may indicate sources of a user's resistance. This kind of empathic listening makes it easier to align the end-user's concerns with the technology's benefits, such as energy and overall construction cost savings, induction cooking's selling points, and better indoor air quality. For instance, induction is highly recommended for housing for seniors, for families with young children, and for people with respiratory and immuno-compromising diseases.

Bringing a clear understanding of the benefits of all-electric kitchens to early and ongoing conversations, alongside a deep insight into your clients' and end users' needs, can help to craft a roadmap for success.

5.3.2_SELLING INDUCTION: PROVIDE A HANDS-ON EXPERIENCE

The design phase is an ideal time to reshape the perception of owners and potential residents. In addition to sharing a detailed overview of operational considerations and benefits, it may prove helpful to have potential residents experience the benefits of induction cooking first hand. This could assuage concerns over food quality and safety, and counter a preconceived bias for gas. It can also help dispel other myths about induction cooking.

Many residential appliance showrooms have "try before you buy" sessions, where you can schedule a demonstration or try out appliances with assistance of their staff. Local clean power organizations sometimes have an induction hob loaner program available. While portable induction hobs are an inexpensive introduction to the technology, they often aren't as powerful as a standard induction cooktop; it's also worth noting that some portable products could be louder and less steady than the permanent higher grade induction appliances.

5.3.3_ENVIRONMENTALLY RESPONSIBLE COOKING IS ALSO SOCIALLY AND CULTURALLY RESPONSIBLE

Cooking and sharing food is about bringing family and friends together. It is also an act of sharing cultural traditions and knowledge. Today's electric cooking technology, such as induction cooktops and appliances like Instant Pot™, offer a new conduit to pass along culture while also creating a safe, healthy, and sustainable environment for the next generation. In fact, many home cooks and professional chefs have been sharing their successes and joyful transitions from cooking on gas to cooking with electrical appliances. Using all-electric equipment offers the opportunity for shorter cook times, safer and healthier indoor environments, and an atmosphere more conducive to togetherness and learning.

CHEFS' THOUGHTS...

" As a corporate chef in the appliance industry, I have had the pleasure of cooking side-by-side with people of all walks of life for many years as we explored both induction cooking and other electric cooking options. I have cooked with little kids and aging-in-place couples, Chinese grandmothers, multi-generational families from India, famous chefs, groups of architects, designers, and more. From making naan, to wok cooking to whipping up a perfect caramel in half the time, these rewarding adventures made me into the induction and electric kitchen super-fan that I am today."

— Chef Rachelle Boucher

" I've cut my culinary teeth in the kitchens of some of the nation's top restaurants; across a wide range of cooking cultures — from the American culinary greats to classical European traditions; to my grassroots, Vietnamese origins; and Top Chef. Coincidentally, I've always found that electric kitchen appliances and electrified kitchens seemed to offer an advantage in precision cooking. Thanks to innovative electric cooking technologies (I.e., combi-oven, induction, etc.) the variables around heat can be precisely controlled. And in my book, that's what cooking is all about. I love that I can cook better and be aligned with my ethos to implement green practices. And that's why I support the full electrification of all commercial and residential kitchens. Electric kitchens for a sustainable future."

— Tu David Phu, Celebrity Chef and Top Chef Alumnus

5.3.4_EQUIPMENT IN RESIDENTIAL ALL-ELECTRIC KITCHENS

Residential electric kitchen equipment comes in numerous configurations to meet a variety of culinary needs. Many manufacturers provide residential induction ranges that come with an electric oven, which bake foods more evenly and have many more features than gas ovens (such as convection cooking, microwave-assisted speed cooking, steam cooking, built-in air fry technology, and more). Some new cooktops have fully functional, built-in ventilation systems, which eliminate the need for overhead hoods. For modern and minimalist kitchens, a single surface countertop with the induction elements hidden below the surface is available. With this technology, the kitchen island (Figure 5.14) could truly become multi-functional, offering space not just for cooking and dining but for doing homework, gathering as a family, or playing games.

FIGURE 5.14: A SINGLE SURFACE COUNTERTOP WITH THE INDUCTION ELEMENTS HIDDEN BELOW THE SURFACE

5.3.4.1_The Benefits of Residential Induction Hobs

Induction offers a number of benefits when compared to equivalent gas and electric appliances. These include:

» **Cooking Performance**

- The low settings are so precise that a double boiler is not needed for melting or low simmering.
- Induction appliances can have additional cooking and safety features such as timers, alarms, timed cooking and automatic shut off if a pot boils over or boils dry.

» **Safety**

- Reports show that gas and electric coil ranges and cooktops were involved in 62% of reported home cooking fires, 89% of cooking fire deaths and 79% of cooking fire injuries. Unattended burners were the leading cause of cooking fires and related casualties. While clothing was the item first ignited in less than 1% of these fires, clothing ignitions led to 8% of the home cooking fire deaths, especially during holiday times.[22]
- Modern appliances that enable the reduction of the total cooking time, or have a timer that would automatically shut off would help prevent such accidents.
- Induction hobs are responsible for a substantial reduction in accidental burns. Only the surfaces contacting the induction hob are directly heated.
- The lack of open flame, extremely hot surfaces, and generally better air quality create a safer environment, particularly for children, people with disabilities, and the elderly.

» **Reduced Maintenance**

- Cleaning the induction hob is quick and easy. The hob itself isn't directly heated, so there's little chance of burnt-on food. In fact, it's possible to place a thin medium such as cloth, newspaper or paper towel between the pan and induction surface; heat will still transfer to the vessel and food efficiently, and cleaning will be even easier. Reduced need for cleaning chemicals also prevents more indoor air quality pollutants and saves money.

» **Other Benefits**

- Depending on your location there may be incentives and rebates for investing in induction and other electric residential kitchen equipment. Check with the local government or utility.
- Induction cooktops provide a flat surface, effectively increasing counter space in small residential kitchens.

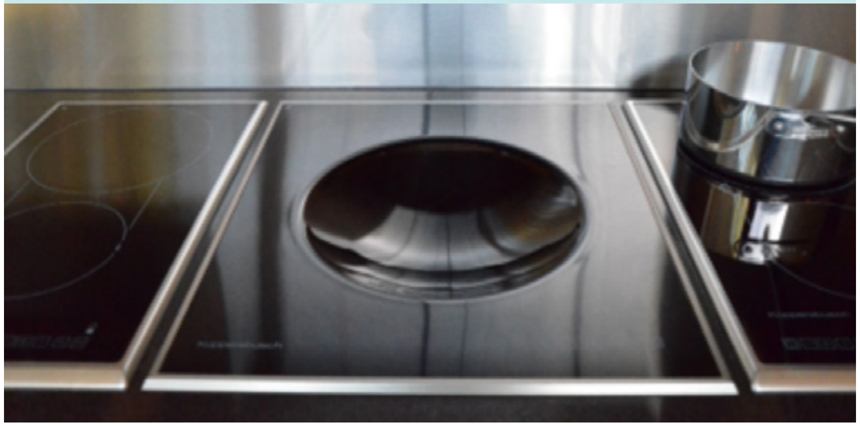
5.3.4.2_Residential Induction Woks

The art of cooking with woks is undergoing significant changes due to induction technology. Concave induction wok hobs, for example, are now available for residential use (see Figures 5.15 and 5.16). The concave sides of the hob heat up the sides of the wok, producing greater responsiveness than heating surfaces found in traditional wok pans, which require high BTU gas burners to achieve the same result.

Alternatively, flat bottom woks generate a larger surface area of heat when placed on standard induction hobs (see Figure 5.17).

22 https://www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Home-Cooking-Fires

FIGURE 5.15: CONCAVE INDUCTION COOKTOP IN A HOME KITCHEN



Source: David Kaneda

FIGURE 5.16: PORTABLE CONCAVE INDUCTION WOK HOB

Source: https://www.nuwavenow.com/shop/mosaic

5.17: FLAT BOTTOM WOK FOR INDUCTION

Source: https://foodsguy.com/best-woks-induction-cooktop/

5.3.4.3_Residential Convection Ovens

Convection electric ovens preheat and cook faster and more evenly than gas ovens and require no rotation of the pans because continuously operating fans move heated air within the oven. When it comes to roasting, convection also results in crisper and more pleasingly browned dishes because the exhaust also pulls moisture out of the oven. Finally, convection is more energy-efficient and allows home chefs to cook multiple dishes at once. Since flavors do not transfer, there's no need to worry about cooking savory and sweet dishes in the same oven at the same time.

5.3.4.4_Residential Combi and Steam Ovens

Combi steam ovens are electric and combine three distinct cooking methods: convection (as defined above), steam, and convection/steam combination. Convection allows for baking, roasting and, in some models, broiling. Steam is used to prepare rice and vegetables, pasta or delicately poached fish to the perfect temperature and texture. Finally, the combination method uses both convection and steam simultaneously, which produces foods that are moist and flavorful. It also reduces the potential of overly dry food. Roasted meats and vegetables, baked breads, pastries, and casseroles all benefit from this technique. Combi steam ovens are exceptional for reheating food; although they take longer to reheat than microwaves, they yield a superior result. Residential Combi Steam ovens do not, however, have a self-clean function.

Speed ovens combine three cooking methods as well: convection, microwave, and a convection/microwave combination. They can be used as a small, efficient oven or to quickly heat and cook foods like a stand-alone microwave oven. It can also combine the technologies to cook food faster than in a standard oven and to a better quality finish than in a microwave alone. Some versions can also broil foods.

5.3.4.5_All-Electric Residential Outdoor Cooking Equipment

All-electrical cooking is not limited to the indoors. Outdoor portable induction carts and electric grills are also worthy of consideration (see Figure 5.18). No gas hook-up is needed; it needs only an outdoor electrical outlet. Many of the products can also be stored easily. Most importantly, there is no charcoal smoke to sting your eyes or harmful CO, methane, or NOx emissions.

5.18: INDUCTION HOB AND TEPPANYAKI TROLLY

Source: https://www.architonic.com/en/product/indu-cooking-plates-400-one-zone/1332480#&gid=1&pid=6

5.3.4.6_Residential Hood Selection

Selecting the appropriately sized hood for all-electric residential kitchens is still important to ensure fumes and grease are captured for better indoor air quality. Fortunately, induction cooktops and other electric appliances do not need ventilation hoods that require as much space or power as with gas appliances. Larger capacity hoods are bulkier and louder and require more make-up air. When hoods are smaller and quieter, they are often used more frequently. In fact, some induction tops are directly connected to ventilation, turning on and off as needed.

Current residential Codes and Standards generally do not recognize any difference between gas, electric resistance, and electric induction appliances. However, good design practices generally end up with a hood that exceeds the minimum exhaust air requirements in Code for residential kitchen hoods. Thus, in situations where a designer is guided by good practice rather than minimum Code compliance, there are opportunities to take advantage of the decreased need for ventilation with induction appliances. Commercial kitchen codes provide guidance on how to size any exhaust hood, and these rules can be used to establish the reduction in hood exhaust capacity based on hood configuration and appliance type. Codes are likely to change in the near future as they continue to encourage all-electric options for buildings and recognize some of the benefits of certain electric technologies such as induction cooktops.

5.3.5_COSTS AND FINANCIAL INCENTIVES FOR RESIDENTIAL KITCHENS

Currently, induction cooktops and ranges cost slightly more than their gas-based counterparts. Fortunately, many local regulatory agencies, utilities, and non-profit organizations offer rebates for purchasing induction — often over $300 — for homeowners who replace a gas range with an induction range. As the technology matures and supplies increase, costs will likely continue to become more competitive.

For new residential construction projects, a cost-benefit analysis of induction versus gas cooking should be performed. It should include expected increases in equipment cost as well as potential offsetting reductions in infrastructure cost. Rental unit developers and owners should also include operating cost reductions from reduced air-conditioning loads in all-electric kitchens.

As noted in the previous section, induction cooktops and ranges can accommodate lower exhaust air rates, even though the required minimum exhaust rate does not differentiate by cooktop type in current Codes. When good design practice governs a kitchen hood design, using induction equipment can result in a reduced cost for meeting desired exhaust and make-up air requirements. Additional space savings can be achieved with all-electric kitchen designs, potentially reducing the size of kitchens and hence the total cost.

Many local municipalities, particularly in California, mandate that all new residential projects be all-electric, and they aim to require the same for future retrofit projects. The decision to build all-electric, multi-family housing infrastructure from the start can offset the potentially expensive retrofit and electric infrastructure upgrades that may be coming in the near future.

Marketing an all-electric project, with an emphasis on how induction and other electric kitchen equipment provides a clean, healthy, and family-friendly indoor environment, can help set the building apart in a crowded marketplace.

5.3.6_GROUND-UP DESIGN CONSIDERATIONS

Design teams should start a dialogue with owners, developers and utility suppliers early to understand utility power infrastructure requirements and availability and outline steps necessary for installation during construction. *Volume 3 (Multifamily Residential, Hotels/Motels, and Similar Buildings)* delves into other electric appliance considerations, including hot water heat pump power requirements.

Conceptually, residential kitchen gas and electric appliances can be swapped one-to-one, except that some appliances are more energy efficient and offer more versatility, such as induction cooktops, combi ovens, or convection ovens with air fry features, etc.

Induction ranges come in 30-inch and 36-inch widths, with a few 48-inch wide luxury options. 30-inch induction ranges come in a variety of brand features, are widely available, and often cost the same as their gas counterpart. However, the price range of 36-inch induction ranges vary significantly and are only made by a few manufacturers.

An alternative option to ranges is to provide a cooktop on the counter and a separate oven or ovens. For example, for micro-units, a 24-inch induction cooktop and a countertop toaster oven or a seperate oven under the counter would be more efficient for space planning, since there is no 24-inch induction range yet. Not all induction range ovens come with the latest features; providing a separate cooktop and oven can allow for the flexibility to modernize the oven or change the oven type in the future.

5.3.7_RETROFIT DESIGN CONSIDERATIONS

Assessing the feasibility of upgrading electrical infrastructure capacity is a crucial step in a retrofit project that includes eliminating gas or changing electric equipment and appliances. If upsizing electric panels and transformers is cost prohibitive or not supported by the utility infrastructure, then the user can opt for induction countertop hobs (single or double units) as well as a countertop electrical convection oven/microwave or multicooker (e.g., Instant Pot™), which simply require 120 volt wall outlets, not dedicated electrical circuits. In small apartments, these portable appliances also provide the flexibility of storing them, freeing up counter space. Unlike other countertop cooking appliances, however, it is important to locate even countertop induction hobs under new or existing exhaust hoods.

Residential units with central domestic hot water systems and central laundry facilities often have an existing small 30 to 50 amp panel for each apartment. There are "smart" panel systems that can manage electrical loads, such as electrical vehicle charging, a hot water heater, or induction cooktop. For example, condominiums can use a load sensing EV charger controller (e.g., the DCC-9 from DCC Electric) that is designed to allow the connection of an EV charger to the main feeder of the unit's electrical panel without affecting the load calculation. Similarly, hard-wired load switching devices (e.g. the simpleSwitch by B&B Technology Solutions) can be connected as a load management device that shares the power between two appliances.

5.3.8_RESIDENTIAL KITCHEN CASE STUDIES

5.3.8.1_Belfield Townhomes

Source: Sam Oberter

Project Location: Philadelphia, PA

Completion Year: 2012

Project Size: 5,760 square feet

Source: Tim Griffith

What:

The project involved the development, design, and construction of three row homes for the Raise of Hope (ROH) organization, a local Community Development Corporation in Philadelphia. The townhomes, designed to provide affordable housing for very low-income residents, contain four bedrooms and three full bathrooms, one of which is accessible on the ground floor. Parking is provided onsite and accessed from the rear. This project is intended to be a model of affordable and sustainable housing for the City of Philadelphia. The homes are designed as high performance buildings utilizing Passive House™ standards, and they approach zero-energy status.

An all-electric eat-in kitchen with induction cooktop and convection oven offers a pleasant and healthy place for families to spend time together. All energy consumption from electric cooking appliances can be directly offset by onsite renewable energy, which is an attractive saving for affordable housing residents.

This project is the recipient of the 2014 International Passive House award presented by the Passive House Institute (PHI) in Darmstadt, Germany and a 2nd Place Award in Affordable Housing by the Passive House Institute US (PHIUS).

How:

HVAC	Ultimate Aire ERV with a GE PTAC
DHW	50 gallon GE heat pump water heater
Cooking	Induction cooktop and convection oven
Building Envelope	Airtight envelope and triple glazed windows
Predicted EUI	22 kBTU/SF/year
Client	Philadelphia Redevelopment Authority, Raise of Hope
Architect / Developer	Onion Flats / Plumbob
General Contractor	JIG Inc.

5.3.8.2 Manzanita Square

Source: Bruce Damonte

Source: Tim Griffith

Project Location: San Francisco State University, San Francisco, CA

Completion Year: 2020

Project Size: 239,000 square feet

What:

Manzanita Square is a student residential and mixed-use complex that creates a new campus gateway, mediating space between the University's southern edge, the Parkmerced residential neighborhood, and the larger community.

The eight-story mixed-use residential complex creates a uniquely urban student living experience. Its 169 apartments with two staff units are organized around a landscaped public courtyard with retail space. At ground level, the building interior is planned as a centralized hub of community space — a vibrant urban retreat encompassing a social lounge directly adjacent to the main building entry, game room, coffee/kombucha bar, the Academic Success Center, and a podium with lease spaces for retail or food services

The design team capitalized on the microclimate of the site to employ a super-insulated building envelope design that dramatically reduced heating loads and eliminated the need for active cooling systems. This created the opportunity for "all-electric" residences, which allowed for individual metering and the opportunity to empower each resident with complete energy consumption information.

How:

HVAC	Common Areas: VRF systems with MERV-8 and MERV-13; Residential Units: ERVs with MERV-13 and electric resistance baseboard radiators
DHW	Central Heat Pump Water Heating System with recirculating loop
Cooking	Electric Resistance, Energy Star for residences; Induction Warmers at individual tables at ground floor restaurant (retail tenant)
Building Envelope	Rain Screen system over 6" mineral-wool blanket insulation outboard of structural framing; R-20+ walls and R-30+ roof; Thermally-broken Aluminum Frame dual-pane, argon-filled low-E glazing
Electrical Load Offset	200 kW roof-mounted PV system designed, not installed
Predicted EUI	22 kBtu/SF/year
Building Code	2016 California Building Code
Developer	American Campus Communities
Architect	Multistudio
General Contractor	Build Group
Mechanical Design-Build Contractor	ICOM Engineers
Electrical Design-Build Contractor	Helix Electrical
Plumbing Design-Build Contractor	J.W. McClenahan Co.
Structural Engineer	Nishkian Menninger / IMEG
Energy Consulting	Point Energy Innovations

Trade-offs and Challenges:

» Electric resistance appliances were installed, due to lower first cost, even though induction is much more energy efficient and would save operational cost. There was also concern, in 2017 when induction was still an unfamiliar technology, that the students might not have induction-ready pots and pans.

Lesson Learned:

» With robust all-electric-ready infrastructure, and the strong support of SFSU (client) and ACC (developer) for implementing an all-electric building, the retail tenant of the ground floor restaurant fitted out an all-electric back of house kitchen and induction warmers at individual dining tables in 2021. This case study shows that an understanding and availability of all-electric kitchen technology has improved over time.

» Reduced infrastructure (no gas line!) and reduced infrastructure coordination (simpler joint trench) allowed the project to be delivered ahead of schedule, even after a rainy construction season that was also impacted by the COVID-19 pandemic.

5.4_Commercial Kitchens + Case Studies

Commercial kitchens can use up to five times the amount of energy than other building programs. It stands to reason that if you want to make a big impact in building decarbonization, the commercial kitchen and its culinary program should be a top priority.

> " Microsoft is committed to being carbon negative by 2030 — which means tackling every aspect of our business and reevaluating practices to drive out carbon emissions. On our headquarters redevelopment project in Redmond, Washington, we are building 17 new buildings with 3 million square feet of office and amenity space.
>
> These buildings will serve over 12,000+ meals a day in involves 77,000 square feet of all electric kitchens and food amenities of kitchen space — all solely powered by electricity. **We will be introducing new radiant + induction cooking styles at a scale that's never been done before.** As we embarked on this journey to deliver all-electric dining facilities at this scale over 3 years ago our teams worked diligently to overcome barriers such as equipment availability, throughput considerations and station design. We have leaned into this as an opportunity to consider different approaches to menus and training. **We have seen a positive response from the industry in these few short years enabling this transition for us,** and hope to see this trend continue."
>
> **— Katie Ross, Global Real Estate & Facilities Sustainability Lead at Microsoft**

Microsoft Redmond Campus Case Study

A comprehensive case study of this groundbreaking achievement can be found in the Commercial Buildings volume.

Replacing gas appliances in existing commercial kitchens or installing all-electric equipment in new projects may be the easy part of the decarbonization process. Convincing owners, chefs, culinary design consultants and foodservice providers to adopt new cooking equipment and techniques may present the biggest challenge.

This is why it is critical for the design team to set the stage for early and continual dialogue regarding expectations, perceived challenges, and positive outcomes with anyone who has a stake in a project's sustained success. A holistic discussion around food offerings, cooking staff retention, and operational savings can ensure a better design. Underlying these conversations: all electric kitchens produce food quality for all cuisines that are at least as good, if not better, than their gas-based counterparts. This winning recipe also includes the benefits of improved air quality, enhanced comfort, better staff morale, long-term cost savings, and reduced greenhouse gas emissions.

5.4.1_TALKING ABOUT THE QUALITY OF FOOD ON DAY ONE

While this guide discusses the many positive attributes of an all-electric kitchen, what people care about most is good, authentic food. Often, when proposing an all-electric kitchen to a commercial project client, it is helpful to start with a conversation about delivering quality food more efficiently, in a more comfortable environment, and reducing overall operational costs. It is also important to acknowledge that producing ideal results may require adapting new techniques and skills.

In reality, the quality of food is based on the quality of the equipment, team, and chef — less so on the actual heat source. Where induction cooking excels is in offering teams far superior pieces of equipment that allow more control over their craft by being able to cook with greater precision, speed, and consistency.

> "I have had the pleasure of cooking for Legislators, University Presidents, a World Certified Master Chef, and everyone in between. When my guests tasted our food and learned that it was prepared in an All-Electric Kitchen they were blown away that we were able to provide such exceptional quality food without the use of gas equipment. It is always a pleasure to see the moment when people realize that there is nothing tethering them to the antiquated shackles of gas cooking."
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

5.4.1.1_Supporting Effective Techniques

There are very few techniques in the pantheon of cooking that are not achievable with induction. At its absolute core, cooking comes down to using heat to take an ingredient from its raw state to a desired state of doneness. As such, it doesn't matter to the food where the heat source comes from — it simply needs to be provided. And, the difference between gas and electric cooking equipment is in the increased power, control, and speed that induction technology provides.

The notion that the techniques developed over the course of culinary history will be fundamentally upended and subverted by induction technology is a manifestation of the unwillingness to let go of a bygone era, one that holds our environment, our health, and our planet hostage.

Chefs have always pushed the boundaries of culinary art through new developments in technology and understanding. It's how Albert Adria was able to develop a sponge cake recipe using a microwave. It's how Alex Stupak was able to develop a Creme Brulee that needed no baking, which led Aki Kamozawa and H. Alexander Talbot to develop a key lime pie custard that could be tied into a knot. With the embrace of induction cooking we can now continue our pursuit of culinary knowledge with clean air, increased control, and a clear conscience.




Source: Troisgros Grande Maison in Roanne, France - cooking with induction in a Michelin 3 star restaurant. (photo: Rick Theis) | http://troisgros.fr/page_3-maisons

5.4.1.2_Commercial Kitchen Equipment

Full kitchen electrification is a reality. In fact, most of the equipment in a typical conventional kitchen is already electric. Deli meat slicers, buffalo choppers, blenders, food processors, steam jacketed kettles, and steamers all run on electricity.

There are just a select few appliances that still rely on gas, but these too can be switched to an electric counterpart (often that is built to be identical in footprint, so there would be no design impacts).

COMMON GAS-FIRED COMMERCIAL COOKING EQUIPMENT

- **Range**
- **Ovens (convection, deck, combination)**
- **Flat top griddle**
- **Fryers**
- **Tilt skillet**
- **Food warmers (drop-in/flat)**
- **Broiler/salamander**
- **Wok Range**

Currently, every piece of commercial gas-fired food preparation equipment has a modern, electric counterpart designed to be more efficient, safer to use, and capable of outperforming its gas version. These pieces of electric equipment have the added benefit of providing more control over cooking and operation, increasing overall throughput, and decreasing overhead costs in the process.

> " No other cooking technology that we've tested is faster than the fastest induction elements — we're talking 2-4 minutes speedier than the competition to bring 6 quarts of water to a near boil."
>
> — ***Consumer Reports***[23]

5.4.1.2.1_OVENS

For commercial kitchens, there are three distinct options: Convection oven, Combination oven, and Deck oven (which are all more insulated than their gas counterparts). Increased insulation improves their energy efficiency and puts less heat into the ambient kitchen space. Figure 5.19 includes many of these items common in an all-electric commercial kitchen.

FIGURE 5.19: A HIGH TECH ALL-ELECTRIC KITCHEN LINEUP WITH COMBI OVEN, INDUCTION COOKTOP, FLEXIBLE BRAISING PAN, BLAST CHILLER, HOT AIR FRYER, AND HEAT RECOVERY DISHMACHINE

Source: Picture courtesy of the Frontier Energy Induction Technology Center | fishnick.com/ITC/

23 "Pros and Cons of Induction Cooktops and Ranges: What to know before buying an induction range or cooktop." *Consumer Reports*. December 3, 2019. | https://www.consumerreports.org/electric-induction-ranges/pros-and-cons-of-induction-cooktops-and-ranges/

Convection Oven

Convection electric ovens preheat and cook faster and more evenly than their gas counterparts, and they require no rotation of the pan because continuously operating fans move heated air within the oven. In a gas oven, temperatures are hotter at the top of the oven, so baking requires rotation and placement farther from the heat source. When it comes to roasting, convection also results in crisper, browner dishes (because the exhaust pulls moisture out of the oven), is more energy efficient, and allows chefs to cook multiple dishes at once as flavors do not transfer (there's no need to worry about mixing savory and sweet dishes in the same oven).

Combination Oven

Combination electric ovens use a mix of three distinct cooking methods: Convection, Steam, and Convection/Steam Combination. Convection Steam allows the chef to prepare rice and vegetables, or even delicately poach fish to the perfect temperature and texture. The final cooking method uses a combination of convection and steam simultaneously. The benefits of these two methods working together produce results that are moist, flavorful and have minimal shrinkage, thus reducing the potential for dry food. Most combination ovens come with a self-clean function, cutting down on labor and chemical use: it quickly cleans itself and flushes away any excess water, leaving the oven ready for the next day, with minimal interaction.

Deck Oven

An electric deck oven offers unparalleled control over the precise temperature of the top and bottom elements. It also offers the ability to manage a "heat barrier," which allows for greater control over baking. This allows greater control over baking. For instance, with pizza there is the ability to set the bottom elements higher, allowing you to set a crispy crust while you delicately melt the cheese on top. The "heat barrier" allows you to work in the oven with the door open without the fear of losing precious heat; therefore, the unit does not have to work as hard to replenish that heat and thus saves money and energy over time. They also have the ability to inject steam into each individual deck or compartment allowing you to easily set crusts on breads such as baguettes and the like.

Source: An electric Tandoori oven by Golden Tandoors

5.4.1.2.2_COMMERCIAL INDUCTION WOK

Cooking food made on high heat with a wok — as typically used for many Asian recipes — has been one of the lingering justifications for commercial kitchens to keep gas cooktops. However, since 2013, there have been significant and recognized advances for induction wok cooking in hotel facilities in China. Full-size induction woks were introduced to the U.S. market at the 2019 National Restaurant Association conference (see Figures 5.20 and 5.21).

FIGURE 5.20: EXAMPLES OF COMMERCIAL INDUCTION WOKS

Source: Picture courtesy of The Frontier Energy Induction Technology Center | fishnick.com/ITC/

FIGURE 5.21: CHEF MARK DUESLER, COOKING ON A COUNTERTOP INDUCTION WOK

Source: Picture courtesy of The Frontier Energy Induction Technology Center | fishnick.com/ITC/

5.4.1.2.3_ELECTRIC WARMING OPTIONS

Flat Induction Warmers

Induction warmers work exactly the same as their induction range counterparts except that they have built-in restrictions. Typically the temperatures are adjustable from 120°F- 210°F, allowing for unparalleled control over the food you are warming.

Note that it may be necessary to use heat lamps above the food since the warmers only heat the bottom of the serving vessel, not the sides or top.

Induction Wells

Induction wells offer customizable capabilities that were previously unheard of in the world of food warming. Most wells work with either 2" or 4" deep hotel pans, and with two induction units in each well, they are further customizable by having one half raised to accommodate a 2" pan and the other lowered to accommodate a 4" pan (see Figure 5.22). This offers great flexibility to the production line and reduces overall deeper pan usage and cleaning time and costs. Since no plumbing hook-up is needed, induction wells also save on first cost and water consumption.

Some induction well units come with a low/medium/high setting. It is recommended to find induction wells that offer the full range of temperature control that are offered with the flat induction warmers.

FIGURE 5.22: INDUCTION WELL

Source: https://www.webstaurantstore.com/vollrath-fc-6ih-02120-two-well-modular-induction-drop-in-hot-food-well-120v-1590w/9226IH02120.html

5.4.1.2.4_COMMERCIAL KITCHEN HOODS

Similar to residential codes, current commercial Codes and Standards generally do not recognize any difference between gas, electric resistance, and electric induction appliances. Thus, all-electric commercial settings will require the same sized hoods as their gas counterparts. However, modern control systems for hood exhaust can provide exceptional savings. Some of the most advanced systems available use optic and temperature sensors to monitor the level of cooking activity, continually adjusting based on the need at the time. The simple payback on these systems is often very attractive (i.e., less than 3 years). Coupled with heat recovery (if your state allows it), the potential exists for considerable operational savings.

With increasing use of induction appliances, codes are likely to change in the near future as they continue on their course to encourage all-electric options for buildings and better recognize the specific performance characteristics of induction technology.

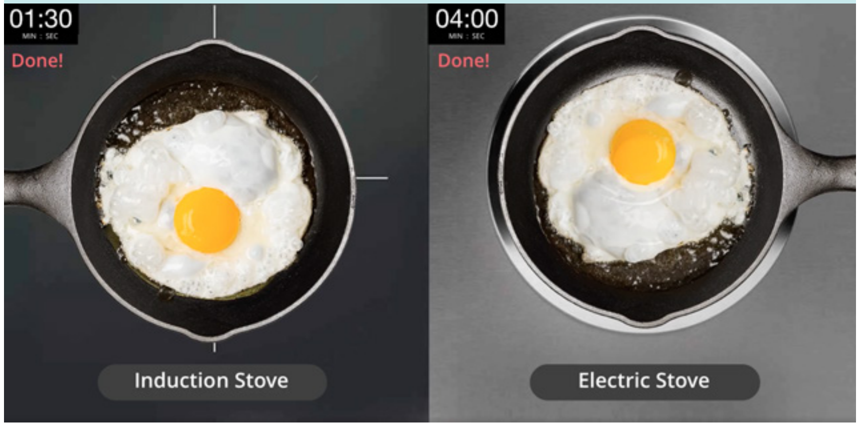
5.4.1.3_Throughput

> "We've noticed an increase in our throughput. Due to the equipment's incredible response time and immediate heating we are able to cook more food in a shorter amount of time. This has created an environment where we are able to put out a high quality product in a shorter time span. We have been virtually limitless in what we can create with our induction equipment and have seen no reduction in quality or variety."
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

Chefs tend to judge the efficiency and success of their kitchens by the concept of throughput: how much high quality food can their kitchen process and serve as quickly as possible.

Induction technology is important in this conversation because by harnessing its speed and efficiency, cooking time can decrease dramatically (see Figure 5.23). Whether it's saute pans getting hotter faster or a pot of water coming to a boil in half the time of the gas counterpart, induction speeds up the process, allowing chefs to get more food cooked and served.

FIGURE 5.23: THE DIFFERENCE IN TIME SPENT TO COOK AN EGG



Source: http://sponsored.bostonglobe.com/frigidaire/induction/. Similar time lapse videos can be viewed on Hot Induction Technology for Cooler Kitchens at https://www.youtube.com/watch?v=yG8hn4vyWf0.

With more true back-of-house induction hobs coming from manufacturers, operators are beginning to see the benefits of induction for production in the kitchen. Power and durability make these commercial units highly compatible with the rigors of production cooking. While typical light-duty countertop induction hobs generate up to about 1,800W of power, hobs designed for the back-of-house can generate 2,500W or more. Most can generate 3,500W, equivalent to a typical 31,000 BTU gas burner. They're also engineered to withstand the heat and grease in a production kitchen that might cause lighter duty hobs to fail.

Precision and Control

Induction technology generates an incredibly precise amount of localized heat. It has the instant on/off characteristic of gas-flame cooking that chefs like, but it is even more precise. Many of today's induction hobs allow the cook to either adjust power from 0%–100% in increments of 1% or to choose a specific set point temperature, from about 70°F to 500°F and accurate to within 1°F. Cooks cannot do this on a gas burner. Built-in programmability is also available on some units, which reduces the training required for cooking to specific recipe specs.

How exact an induction hob should be depends on your application. If you're using induction hobs simply for sauteing you probably don't need much in the way of settings or bells and whistles. However, if you're searing proteins for sous vide, making pastry creme, or tempering chocolate — techniques that require precise temperatures — or if you want employees to strictly follow a multi-stage cooking process, you should carefully consider what tools to equip your chefs with.

Speed and Efficiency

Since most of the energy in an induction hob goes directly into the pan, it heats much faster than on a gas flame, which heats and cooks food faster. Induction hobs are typically about 84%–93% efficient while gas burners, in contrast, are only about 30%–44% efficient. In other words, if a gas burner puts out 35,000 BTU per hour and is 35% efficient, only about a third of the energy or heat is going into the pan.

Meanwhile, 22,750 BTU per hour is dissipated into the air. Thus, the need for powerful hoods to capture and remove the byproducts of combustion, heat and moisture, which in turn means your HVAC has to work harder to keep the kitchen cool. With induction, kitchen employees stay more comfortable.

> "Chefs are all about control. Once you talk about how much control you have, it piques their interest. With induction, you can set the temperature to the degree you want. You can fine tune the settings for the food you are going to poach or sear. It gives unparalleled control. Instant temperatures. Pans get hot immediately."
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

Safety and Human Error

Even with the strictest precautions in place, accidents can still happen in the kitchen, including extinguishing pilot lights by overboiling pots, leaving a towel too close to burners, and getting burned when grabbing a pot without a towel. When these accidents happen, they usually cost the establishment money. Induction ranges have the added benefit of lessening the consequences of common mistakes by a considerable degree. According to the CDC an average burn to an extremity such as hands, arms, or legs can cost an average of $6,226 in terms of medical costs and work loss. That cost, based on 2010 figures, does not take into account the cost of increased insurance premiums experienced by the employer.[24] Reducing the risk of injury, of course, has its own benefits.

Source: At Marlow & Sons in Brooklyn, all the cooking is done on five induction units in the basement.
https://www.nytimes.com/2010/04/07/dining/07induction.html

5.4.1.4 _Training

When planning an all-electric commercial kitchen, simply informing the kitchen staff of all the benefits described in this guide and expecting their complete buy-in is likely overly optimistic. There needs to be a plan in place for educating the staff on how electrification will help them in their day-to-day tasks. We recommend a two-pronged approach to help educate and ease any anxiety:

First exhibit the ease of operating the new equipment and demonstrate its practical applications to the kitchen staff's existing work. Showing them the ease, versatility, and speed of the equipment may be enough to get them onboard.

24 Calculations done on June 22, 2021 via US Centers for Disease Control and Prevention's "Data & Statistics (WISQARS™): Cost of Injury Reports" | https://wisqars.cdc.gov:8443/costT/

Secondly, educate and earn the support of the managing chefs in advance of the transition. A chef is the most influential person in the culinary hierarchy and their excitement about induction technology can be highly influential with the rest of their staff.

The Transition is Easy

The beauty of induction cooking is that a cook does not have to change their understanding of how to cook since the principles are the same as a gas range. You turn the knob, your pan gets hot, you cook — it's as simple as that. Once you understand the basic nature of the unit you start to unpack the benefits of its ease of use as well as its speed, efficiency, thermal comfort and every other benefit that this document has outlined.

How Much Time Will It Take to Train?

Depending on staffing size, training on induction equipment should take a minimum of two days although three days is ideal. This should always be done by a trained chef who has experience using the equipment and experience teaching others on this technology. This is important to be able to troubleshoot and prevent mistakes.

Source: Cooking with induction at Pineapple and Pearls in Washington, DC, a Michelin star restaurant. (photo: Rick Theis)

SAMPLE TRAINING SCHEDULE

Day 1: Chef & Culinary Leadership (Mandatory)

Day 2: Other Staff (Mandatory)

Day 3: (Optional/Recommended)

An optional third day is beneficial for when a kitchen comes online for the first time. Learning something new is always easier during a relaxed setting than when the kitchen is "live." Having an experienced Chef Consultant in the kitchen for the first day of prep and cooking is beneficial to ensure that the information given was properly conveyed. Being able to correct behaviors and mistakes in real time will go a long way to establishing good habits that will keep the equipment safe and in good working order for years to come.

NOTE: It is imperative that a trained chef experienced in operating a high-level electric kitchen educate and train the team on proper usage and maintenance to ensure long-term success.

" I have been training folks in all manner of skill sets, age groups, and experience for many years now. You name it, I've encountered it. I'm always impressed by how quickly everyone takes to the new equipment. To them the concept is simple… turn the dial and start cooking, but of course it's so much more than that."

— Chef Chris Galarza, Forward Dining Solutions LLC

5.4.2_INDOOR ENVIRONMENTAL QUALITY

An all-electric kitchen has a number of health and safety benefits as discussed in section 5.2.3. Figure 5.7 suggests that while cooking in general emits particles of concern, these and many other pollutants are associated with cooking on gas stoves.

An increasing number of investigations support the health benefits to be gained from eliminating indoor cooking using natural gas. In an effort to understand the public health impacts over the past decade, a study was initiated by the Center for Climate, Health, and the Global Environment at the Harvard T.H. Chan School of Public Health in Boston, MA. This study was recently published in *Environmental Research Letters*.[25] The authors used three different public health modeling tools to estimate the health impacts from specific emissions sources, including commercial cooking activities. Results indicated that, in 2008, somewhere between 4,800 and 8,200 mortality cases in the U.S. were due to commercial cooking. This increased to between 7,100 and 13,000 mortality cases in 2017. The study further estimated that cooking with gas had the highest estimated health burden due to $PM_{2.5}$ in 9 states: WA, NV, FL, MA, CT, NY, NJ, MD, and DE.[26]

Good indoor air quality translates to more comfortable and healthier working conditions, and all-electric kitchens are quieter, cooler, and safer. Happier and safer cooking teams yield higher quality output and lower staff turnover.

25 A decade of the U.S. energy mix transitioning away from coal: historical reconstruction of the reductions in the public health burden of energy, by Jonathan J Buonocore, Parichehr Salimifard, Drew R Michanowicz and Joseph G Allen. Table 1. Published May 5, 2021. https://iopscience.iop.org/article/10.1088/1748-9326/abe74c

26 Ibid. See Figure 9.

5.4.2.1_Comfort

> "Since we've adopted induction technology and committed to the overall electrification model of our kitchen systems, we've noticed a significant improvement in my employees' moods and overall comfort at work. In turn we've seen an **overall improvement of guest-facing interactions.** We have seen less conflict and a more relaxed working environment."
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

While comfort is a relative term, there are some parameters that can be applied to commercial kitchen spaces. Ideally, a comfortable working environment is one in which the ambient temperature is never excessively hot, where fresh air circulates regularly, and where staff interactions are more relaxed and amiable. Such conditions are vital for creating an environment in which people can thrive.

"Thermal comfort" is a complicated topic and has been written about endlessly by engineers and scientists. There are six primary factors that directly influence a person's thermal comfort, and these can be grouped in two categories. First, personal factors, which are characteristics of the occupant, are affected by metabolic rate and clothing level. Environmental factors, on the other hand, are conditions of the thermal environment, and these are affected by air temperature, mean radiant temperature, air speed, and humidity.

It is generally hot in a commercial kitchen, a fact that has been largely accepted by designers and kitchen staff. There is growing recognition, however, of the adverse effects of heat stress on workers. In February 2016, the National Institute for Occupational Safety and Health (NIOSH) published the Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments, a technical resource on heat stress and heat-related illness signs and symptoms. In 2017, OSHA updated the chapter in their Technical Manual on heat stress.[27] For an active commercial kitchen, the recommended temperature Threshold Limit Value (the temperature above which a worker will experience heat stress) is around 81.5°F (27.5°C), assuming the worker is exposed to the hot kitchen environment 50% to 75% of the work day. Recent Federal action is likely to result in new regulations that will set maximum indoor temperature standards for commercial kitchens at 80°F.

BIDEN ADMINISTRATION MOBILIZES TO PROTECT WORKERS AND COMMUNITIES FROM EXTREME HEAT

New Initiatives at OSHA and Across Agencies Will Enhance Workplace Safety, Build Local Resilience, and Address Disproportionate Heat Impacts

On September 20th, 2021 President Joe Biden issued an order to create new initiatives at OSHA and other agencies to enhance workplace safety, build local resilience, and address disproportionate heat impacts. This coordinated, interagency effort to respond to extreme heat in the workplace is leading to new regulations that will set indoor temperature standards to 80°F. This will make it more difficult for any commercial kitchen using gas as a primary heating source to comply with these stricter regulations due to the inefficiency of gas equipment and the excessive heat it produces.[28]

ASHRAE has developed a comfort standard — Standard 55 — based on models that evaluate satisfaction with the thermal environment against an "operative" temperature, which is a metric derived from air temperature, mean radiant temperature, and air velocity (see Figure 5.24). In practice, however, these comfort models are rarely applied to commercial kitchens. Given all the hot surfaces in a working kitchen, the air temperature required to offset the radiant energy from all the hot surfaces would be quite cool (often 66°F or less). Further, increasing the air velocity in a kitchen to help achieve an appropriate operative temperature can have detrimental effects on the performance of exhaust hoods and can inadvertently cool plated food before it is served. The best way to achieve "comfort" conditions in a commercial kitchen is by reducing the radiant heat emanating from the equipment (i.e. the temperature and area of hot surfaces).

The reduced cooling loads from induction cooking equipment come, at least partially, from a reduction in radiant energy. Thus, an all-electric kitchen can help make comfortable thermal environments in commercial kitchens an affordable and practical reality. This isn't to say that induction cooking will solve every social problem on a team, but since establishing all-electric kitchens, many workplaces have experienced noticeable improvement in staff demeanor and interactions, which have created a more welcoming environment for guests. Anecdotal evidence from chefs who manage commercial kitchens suggests that when people are not overheated and uncomfortable they tend to be happier and more relaxed at work, which in turn reduces overall tension and gives people more patience with each other.

The switch to electric also solves the problem that most high-end kitchens have with providing an enjoyable experience at the Chef's Table (a table typically in the kitchen in which the guests are witness to the action and receive personalized service from the chef). Many kitchens have problems with guests being uncomfortably hot at the Chef's Table, and thus lose out on consistent bookings at the most expensive table in the house. Eliminating gas equipment can lead to a much more satisfying guest experience, which may help keep Chef's Tables fully booked.

27 https://www.osha.gov/otm/section-3-health-hazards/chapter-4

28 https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/20/fact-sheet-biden-administration-mobilizes-to-protect-workers-and-communities-from-extreme-heat/

FIGURE 5.24: "COMFORT" RANGE FOR THE ACTIVITY LEVEL (METABOLIC RATE) AND CLOTHING ASSUMED TO BE TYPICAL IN A COMMERCIAL KITCHEN

The range highlighted in green shows the "comfort" range for the activity level (metabolic rate) and clothing assumed to be typical in a commercial kitchen, and is based on relatively still air (20 feet per minute). At 60% relative humidity, the operative temperature comfort range is from approximately 59°F to 69°F.

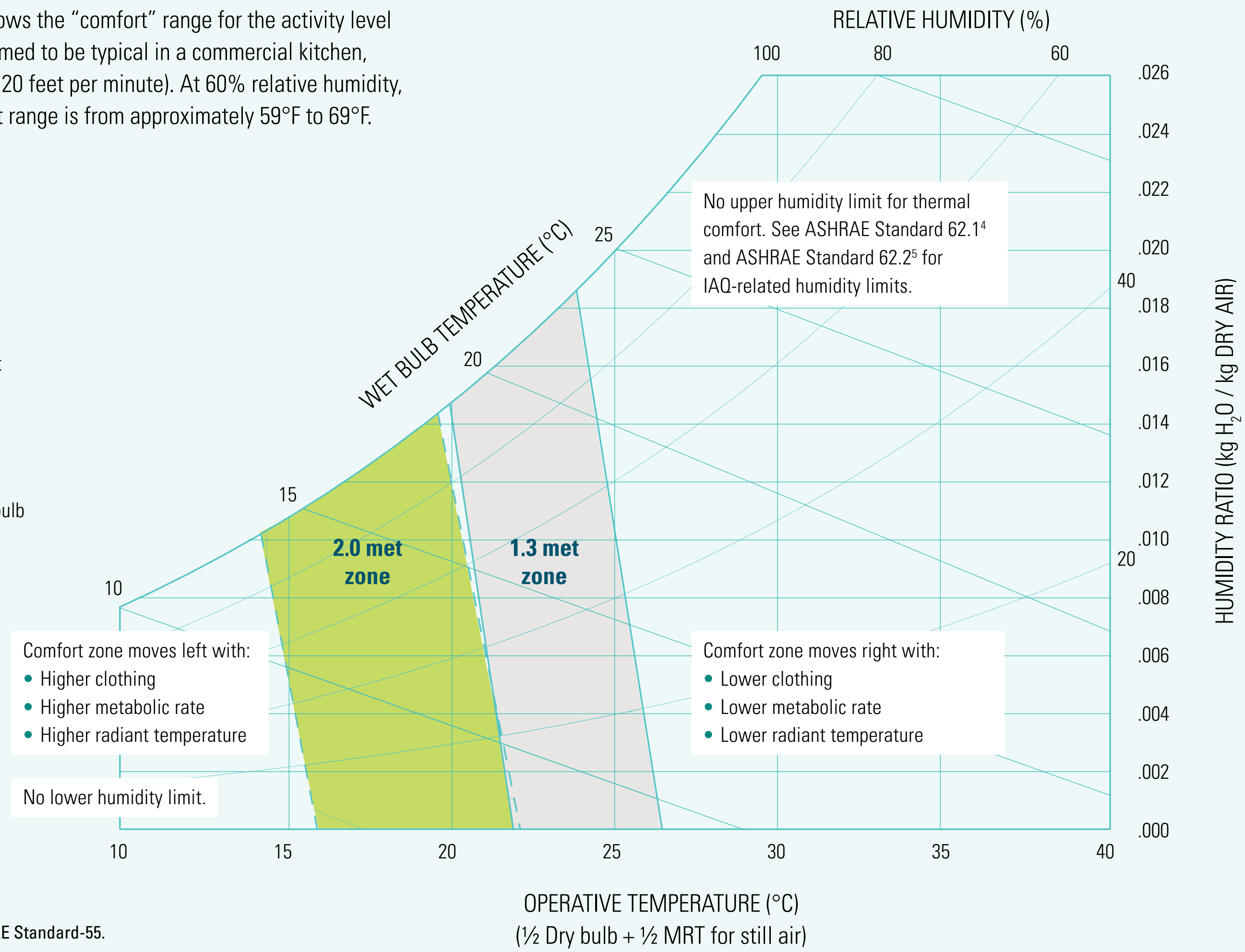
This graph is only applicable for the following conditions:

Metabolic Rate: 1.3 met or 2.0 met as indicated on graph (interpolation of met values not allowed)

Clothing Level: 0.65 clo

Average air speed: 20 fpm

Graph cannot be applied based on dry bulb temperature alone.



5.4.2.2_Safety

A commercial kitchen without open flames and very hot surfaces is a safer place to cook for several reasons:

Reduction in Fires

The lack of open flames greatly reduces the chances of accidental fires (see Figure 5.25). The risk of personal injury or damage stemming from aprons and towels catching on fire from contact with pilot lights and gas hobs is also greatly reduced, as are grease fires and other fire-related incidents.

FIGURE 5.25: AT SONOMA ACADEMY IN SANTA ROSA, CALIFORNIA, TEACHING KITCHENS WITH INDUCTION BURNERS CREATE LESS CHANCE FOR ACCIDENTAL FIRES AND ARE EASIER TO CLEAN FOR NEW STUDENTS AND FACULTY

Source: Celso Rojas

Reduction in Burns

Similarly, induction technology can greatly reduce hot surface areas, thus reducing the chance of employees burning themselves on the cooking surfaces or cookware handles.

Significant Reduction in Air Pollutants

The omission of combustible gas means no more air pollutants such as carbon dioxide, carbon monoxide, and nitrous oxide. This results in a kitchen that is safer for those with breathing difficulties, such as those suffering from asthma or bronchitis or experiencing diminished lung capacity, including those who have survived COVID-19.

Reduced Need for Caustic Cleaning Chemicals

Because there are no heat sources in an induction range, anything that spills onto the surface does not burn on and can thus be cleaned with just soapy water. As discussed in 5.4.3.1 below, this allows for a significantly easier cleaning process. For staff in a commercial kitchen, not only does induction technology make end-of-shift cleaning easier, it reduces their exposure to harsh cleaning chemicals and related burns and noxious vapors.

5.4.3_KEEPING IT WORKING: MAINTENANCE

Responsible commercial kitchen ownership and operation requires regular maintenance and cleaning of the equipment. It's the simplest way to ensure a long lasting and well-functioning kitchen. It’s also among the least popular or desirable kitchen tasks but is arguably the most critical. An all-electric kitchen can drastically reduce the time and effort required for maintenance and cleaning, relative to a traditional gas-powered kitchen. Embracing the electric kitchen means spending more time cooking and less time scrubbing.

> "Our induction equipment has cut down on our overall cleaning budget by largely eliminating the harsh chemicals needed to clean traditional equipment as well as the time needed by the staff to clean said equipment. Now we only use hot soapy water and a clean towel to clean everything from our ranges to our flat tops. This makes for a much **more enjoyable cleanup and saves us money.**"
>
> **— Chef Chris Galarza, Forward Dining Solutions LLC**

5.4.3.1_Easy Cleaning

Traditional gas equipment generally needs to be taken apart and scrubbed daily, often with harsh chemicals. The foil in the drip trays need daily cleaning and relining, their foil liners discarded and replaced, cleaned, and relined. The closing chef also needs to ensure that the pilot lights are re-lit and the burners properly in place. In short, cleaning a traditional gas line is expensive, in terms of both time and money, and is often seen simply as a "cost of doing business."

These costs, however, can be reduced significantly while also increasing overall productivity. Since the induction hobs are housed under the work surface, there are fewer places for food to burn onto. Additionally, induction griddles no longer require degreaser and grill bricks to clean. Simply using hot soapy water and a gentle scrub pad lifts all of the food debris and leaves the surfaces with a mirror finish. This not only cuts down on time but also chemical/cleaning costs as well. Gone are the days for grill bricks, harsh degreasers and other heavy duty cleaners, as well as long end-of-shift cleaning processes.

Due to the simplicity and efficiency of the clean-up, kitchen staff can spend less time cleaning and more time cooking. A switch to induction can lead to far fewer disruptions, such as forgetting to relight the pilot lights, or accidents, such as mistakenly turning on the burners, which can create gas leaks and potential health and safety dangers. Induction significantly reduces the risk of chemical burns and eliminates burns from touching a hot burner. The staff of an all-electric kitchen are now safer and more productive, which in turn saves the operator money and increases revenue in the long run.

5.4.3.2_The Tools: Pots and Pans

As noted above, not all cookware is compatible with induction equipment. The cost of pan replacement depends on whether the pots and pans currently on hand are induction-ready. In reality, though, it is recommended to replace all of your pans when switching from gas to induction. While this may sound exorbitant, expensive, and unnecessary, it's essential to maximize the efficiency and power of a kitchen using induction technology. Regardless of their magnetic qualities, pans that have been used on gas ranges have been damaged to some degree by the flame. The extreme nature of gas cooking degrades and warps the metal which means that, over time, a pot will sag in the middle or not sit flat (see Figure 5.26). When this happens, pans tend to sway and won't sit still on a burner. This is dangerous and can cause major injury if not replaced. Establishments should be replacing their cookware every other year anyway, or whenever they show signs of warping.

On an induction surface it's imperative to have a flat bottomed cooking surface to ensure a good connection with the induction unit. Without this flat bottom you could have hot spots, inconsistent temperatures, and — in extreme cases — an improper connection, which won't heat the pan at all. Poor connections between the induction unit and the cookware risks damaging the unit.

While the new cookware recommendation may sound contrary to the touted cost savings of induction, over time the investment will pay for itself. On average, restaurants replace their cookware every 3 to 5 years, depending on business levels. Fortunately, pans that are used exclusively on an induction unit boast much longer than average life spans. While Chef Chris Galarza was at the helm of Chatham University's Eden Hall Campus, he was using the same pans for over five years with no signs of warping or degradation.[29] The savings in kitchenware replacement should be included in any financial assessment, reducing the life cycle cost of maintenance for all-electric versus conventional kitchens.

FIGURE 5.26: WARPED AND BURNT PANS ARE EXTREMELY COMMON IN CONVENTIONAL COMMERCIAL KITCHENS

5.4.3.3_The Tools: Equipment

See "Maintenance Availability" in section 5.2.5 for a discussion of the equipment maintenance considerations.

5.4.4_FINANCIAL CONSIDERATIONS AND INCENTIVES

When shopping for electrified kitchen equipment, it is imperative that proper due diligence and research be done. The initial cost of the equipment, for example, is only one among many cost considerations that should be assessed. Listed below are a number of cost considerations, and this can help stakeholders determine what equipment is best suited for their operation. Prior to purchasing, it is recommended that an expert be consulted to help choose the right equipment for the right operation. Cutting corners at this stage may compromise the efficacy of the operation down the line, as the old adage goes: "you get what you pay for."
With proper choices and care, an operation can enjoy an all electric-kitchen for many years.

Cost Considerations

1. First cost and construction time savings (one less utility)
2. Availability of tax incentives and credits
3. Overall reduction in utility costs
4. Increased production efficiency and throughput
5. Rebate and other cost offset programs available from local utilities and governmental entities
6. Reduction in pot and pan replacements (increase in lifespan by several years)
7. Reduced life cycle costs and increased ROI potential

29 Interview with Chef Chris Galarza, June 24, 2021.

5.4.4.1_Energy Efficiency

Commercial food service equipment consumes over $10 billion of energy per year in the U.S., with as much as 80% of that energy wasted — transformed into heat and noise by inefficient equipment.[30] According to the most current Commercial Building Energy Consumption Survey from the US DOE (2012),[31] food service is the most energy intensive occupancy type in this database with over 3.5 times more energy use per square foot than office buildings (see Figure 5.27). This is likely due, in large part, to the long work-days (often 14 hours per day or more) as well as the inefficiency of gas cooking: when you cook with gas, as much as 50 to 80 percent of the energy used goes into the atmosphere, heating your kitchen, but not your food (see Figure 5.28).

FIGURE 5.27: ENERGY USE INTENSITY BY PRINCIPAL BUILDING ACTIVITY

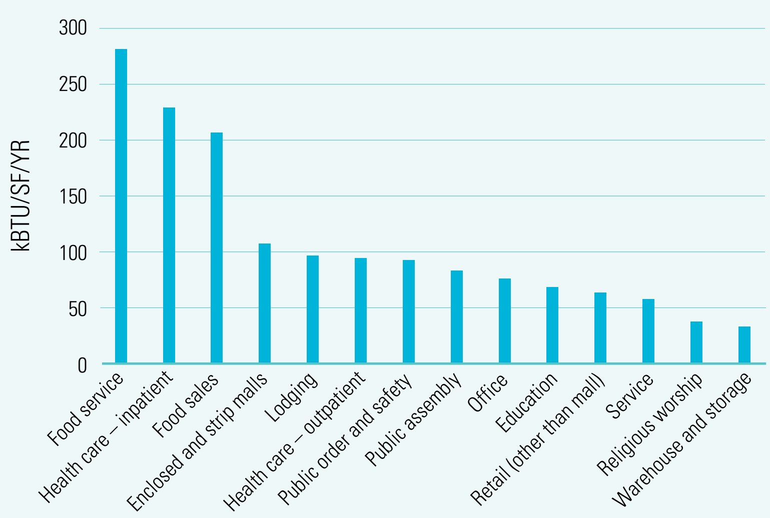
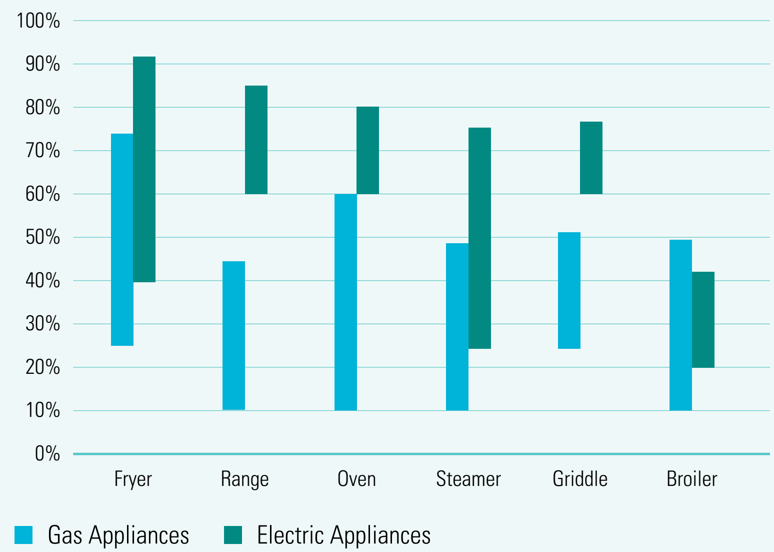


FIGURE 5.28: EFFICIENCY DIFFERENCE — GAS VS. ELECTRIC EQUIPMENT



Source:
https://fishnick.com/handouts/06232016/RYoung-Sustainability_Beyond_the_Plate-06232016.pdf

30 https://www.buildinggreen.com/feature/commercial-kitchens-cooking-green-opportunities

31 https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption

According to research by Brent Ehrlich:[32]

> *The food service industry has lagged behind many others where energy and water efficiency are concerned. Old, inefficient kitchen equipment was made to last for decades and is often kept as a matter of tradition, passed from chef to chef as restaurants change hands. New restaurant owners trying to save on start-up costs — particularly if they are renting the building space — may look for bargains in used kitchen equipment, weighing first costs against restaurant failure rates that approach 60% in the first three years of operation, according to a study by researchers at Ohio State University.*
>
> *Focusing only on lower first costs can be a poor business decision, however, even considering the chances of failure.* ***Large utility bills month after month cut into profits, while new energy-efficient equipment can often pay for itself in as little as a year.*** *Faced with a future likely to include higher utility costs and a challenging business climate, commercial kitchen owners and renters alike are beginning to view energy and water efficiency as both an environmental and business necessity.*

5.4.4.2_First Cost, Operating Cost, and Carbon Emissions Reduction

This practice guide is unapologetic in its advocacy for all-electric equipment in kitchens and elsewhere. The environmental, equity, and public health benefits are too strong to do otherwise.

However, there are currently tradeoffs between first costs and long-term savings, GHG emissions reductions, maintenance costs (where significant reductions can be realized in an all-electric kitchen as discussed in section 5.4.3), and other considerations. Thus, it is always beneficial to evaluate the choice between an all-electric kitchen and other design approaches from the standpoint of life cycle cost.

Until market demand lowers the cost of induction equipment, the first cost of most electric commercial kitchen equipment is still likely to be more than their gas counterparts. In addition, electricity is often more expensive than gas. These two factors often present financial challenges for projects seeking to replace traditional kitchens with all-electrical kitchens. Smart design strategies, rebates and other incentives from utilities and local governments, onsite renewable energy systems, a focus on life cycle cost instead of first cost, and support from policy makers can help alleviate these barriers, real or perceived.

Irrespective of rebates and other incentives, there are several ways to assess the costs and trade-offs inherent in your initial kitchen design and planned operations. To understand these tradeoffs, one can look to a study performed by a leading California-based food services consulting firm, which used PG&E utility rates and average carbon emissions from the California electricity grid. The study was developed in order to evaluate the potential first cost, operating cost, and carbon emissions reductions from three kitchen design scenarios: A) a Base Efficiency Cookline, B) an energy efficient Hybrid Cookline, and C) an All-Electric Cookline (see Figure 5.29).[33]

Commercial food services equipment does not get updated frequently, so the Base Efficiency Cookline is modeled from equipment that has largely gone unchanged since World War II. By replacing this old equipment with more energy efficient equipment, including an induction cooktop and a rapid cook oven, the Hybrid Cookline would save roughly $4,000 in fuel cost and 24.3 tons of carbon emissions annually when compared to the Base Efficiency Cookline. The upfront investment in new equipment can be easily paid back from fuel cost savings.

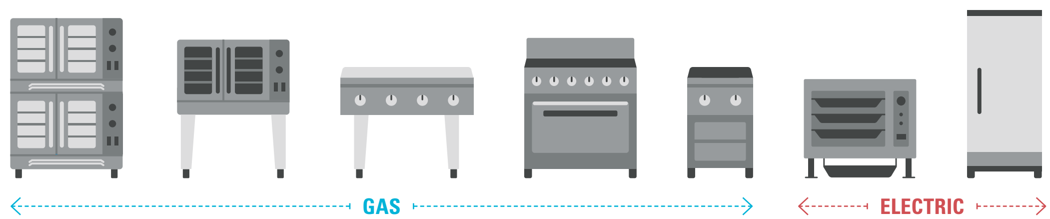
Replacing all kitchen appliances with all-electric models (the All-Electric Cookline) would save $2,456 in annual fuel costs and approximately 32.1 tons of carbon emissions, compared to the Base Efficiency Cookline. The All-Electric Cookline's higher annual fuel costs versus the Hybrid Cookline is due to the higher electricity costs, which can be reduced or eliminated by investments in onsite renewable electricity generation.

32 https://www.buildinggreen.com/author/brent-ehrlich

33 Decarbonizing the Commercial Kitchen with Energy Efficient Equipment, FISHNICK, April 30th, 2020.

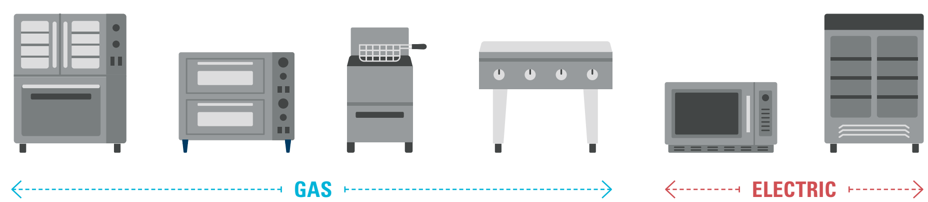
FIGURE 5.29: COMPARISON OF A TRADITIONAL ("BASE EFFICIENCY") COOKLINE, A HYBRID COOKLINE (MIXED FUEL), AND AN ALL-ELECTRIC COOKLINE

BASE EFFICIENCY COOKLINE



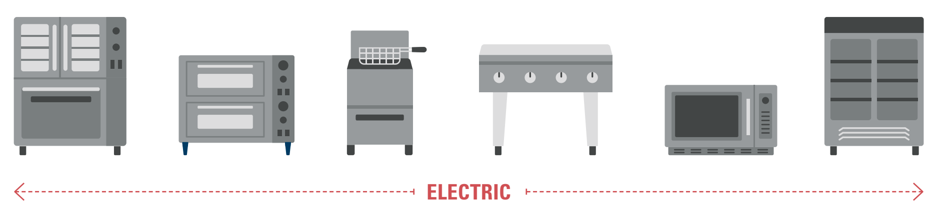
CO_2 = 37.3 metric tons / year
Fuel Cost = $11,812 / year

HYBRID KITCHEN COOKLINE



CO_2 = 13 metric tons / year
Fuel Cost = $4,079 / year
Savings vs Base = 24.3 tons and $7,733

ALL-ELECTRIC KITCHEN COOKLINE



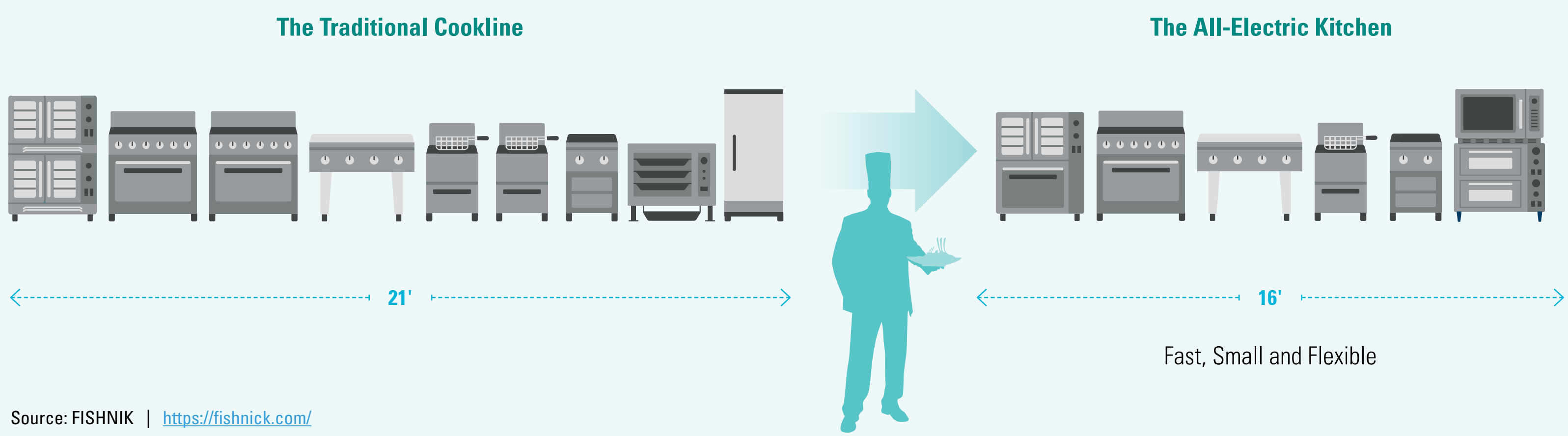
CO_2 = 5.2 metric tons / year
Fuel Cost = $9,356 / year
Savings vs Base = 32.1 tons and $2,456

Source: Decarbonizing the Commercial Kitchen with Energy Efficient Equipment, FISHNICK, April 30th, 2020.

This study points out other savings from the all-electric kitchen that may not be included in the financial modeling and that are also worthwhile for designers and owners to examine:

- **The savings on labor and staff**
  - The newer cooking equipment could produce more food in a shorter amount of time due to the efficiency and precision of the equipment.
- **More flexible use of all-electric equipment**
  - Modern, all-electric equipment can help a kitchen be more versatile provide more consistent quality, elevating the culinary performance in ways that can enhance an operation's revenue.
- **The space savings of an all-electric cookline**
  - The space savings could result in a smaller kitchen area (see Figure 5.30). An all-electric cookline requires a smaller footprint than a traditional cookline for equal or improved throughput. The freed up space could lead to lower rent or provide additional dining area, which can help generate more revenue.
- **The first cost and operational costs savings from kitchen exhaust hood systems**
  - The reduced size of controlled kitchen ventilation systems could cut energy cost by as much as 50 percent.

FIGURE 5.30: AN ALL-ELECTRIC COOKLINE REQUIRES A SMALLER FOOTPRINT THAN A TRADITIONAL COOKLINE FOR EQUAL OR IMPROVED THROUGHPUT



Source: FISHNIK | https://fishnick.com/

5.4.5_THE IMPORTANCE OF COMMUNICATION AND EXPERTISE

Designing, building, and operating an all-electric kitchen usually involves a diverse set of professionals, including architects, engineers, chefs, and various appliance manufacturers and vendors. Communication is key: many chefs don't speak "Climate Change," and many architects don't speak "Food Preparation." As such, translating between professionals is key to the success of any project.

5.4.5.1_Consult with an Experienced Chef

When considering the buildout of an electric kitchen, it can be critical for the success of the project to seek the expertise of a chef who has experience working in an all-electric space and can speak from an authentic point of view. Chefs or other qualified consultants can offer a unique perspective to a project that architects and engineers often can't bridge. When clients defer to their trusted in-house chefs, it's imperative that the chef is on board with the project at its onset. A well-respected chef/consultant can often assuage any concerns and can be instrumental in getting more hesitant chefs on board.

Culinary teams are often put off by the introduction of new technology, and instead argue for the inefficient but well known gas equipment. Having a consultant who can "speak their language" on a peer-to-peer basis can help lessen or eliminate the push back. Even better, it may generate excitement for the change. A chef who can speak to the efficacy of the equipment that will be inhabiting the space can be extremely effective at changing hearts and minds.

The earlier a chef or consultant can be introduced into the conversation the better.

5.4.5.2_Recommended Stakeholder Engagement

The various stakeholders in the design process can bring useful attributes and skills to the conversation:

The Owner

Every owner has a vision that extends past just getting a kitchen or project completed; there are often long-term investment and business concerns as well. Understanding the Owner's perspective is essential to framing the opportunity and approach to all-electric kitchen design. Cost, risk, attractive leasing, market competition, and employee satisfaction are common considerations. Speaking from a point of employee retention and wellness continues to be of much interest. Understanding market forces and code pressures will help them understand and value current investments against future proofing strategies. Framing the opportunity around leadership, employee health, and overall energy savings helps to flesh out the conversation so that it is not just about the decision between gas or electricity.

The Chef/Culinary Consultant

Having a colleague who has gone through the transition and understands the world the culinary team inhabits is a powerful tool to use to help quell any resistance. It is also important to provide kitchen design consultation to assist chefs and small restaurant owners with the task of figuring out long-term financial planning based on an ROI analysis (and one that includes all life cycle costs). Furthermore, the fact that healthy food is often the least energy intensive, while things like deep fried foods are very energy intensive, should be considered in ROI evaluations.

The Operations Staff

Operations staff are at the crux of the whole undertaking. As the primary users, it is important that they make their vision clear and be in constant communication with the rest of the team to ensure that the vision is being met. It is also important that they serve as the point of contact for the design team and act as a liaison to make sure that the needs of the culinary team and the design team are met.

The Architect

The role of the architect is to start the conversation on day one of the design process. They should urge the client to get the food services team involved early, especially the end users, and allow time for open dialogue and hands-on experience selecting the right kitchen equipment for the right menu. This gives time for the culinary team to creatively think how to prepare certain dishes in a new, safe and more precise way with all-electric kitchen equipment. It is also crucial to compare the space savings and more robust and versatile food output of all-electric kitchens compared to traditional gas kitchens. It is worth noting during the early design process that an all-electric kitchen can provide the same throughput as a larger gas-fired kitchen, which can free up space for revenue-generating activities or other programmatic features.

The Engineers

It is useful to have an engineering team that includes members who are experienced in providing complete evaluations of the costs and benefits of all-electric kitchens (including detailed life cycle cost analyses). The engineers should be able to highlight potential energy use reductions available from a design that uses all-electric kitchen equipment. In most cases, engineers will be able to demonstrate that the energy cost savings provide a reasonable payback period for investments in induction equipment and advanced exhaust hood controls. They might also highlight the increased likelihood of delivering good thermal comfort in the kitchen, as well as the benefits of improved indoor air quality. Furthermore, all-electric, single fuel kitchens are generally easier for the engineering team to design since there are fewer utilities to coordinate and many of the safety issues that need to be addressed with the installation of natural gas systems do not exist in an all-electric kitchen.

Hands-on Engagement

Each stakeholder should consider the value of visiting an educational center that provides hands-on experience with all-electric kitchen equipment. For example, for more than 30 years the Food Service Technology Center (FSTC)[34] in Northern California has offered consultation for energy and water efficiency design and provides current rebate program information. Their "Try Before You Buy" program gives chefs and restaurant owners hands-on experience to test recipes and all-electric products before making a financial commitment. The experiential knowledge gained in this kind of a setting can feed back in crucial ways into the design phase.

34 https://fishnick.com/fstc/

5.4.7_COMMERCIAL KITCHEN CASE STUDIES

5.4.7.1_Eden Hall Campus, Chatham University

Source: Sam Oberter

Source: Mithun

Project Location: Pittsburgh, Pennsylvania

Completion Year: 2016

Project Size: 48,250 square feet[35]

35 985 SF Cafe/Kitchen building, 3,535 SF Field Lab, 20,500 SF dormitory building, and 23,500 SF Common building (which includes dining and banquet facilities, and classroom spaces).

What:

The Eden Hall Campus of Chatham University, a private university in Pittsburgh, Pennsylvania was created to be the world's first fully self-sustained and ZNE university campus. It boasts 46 geothermal wells, an on campus water treatment site, and a 40 acre farm. The campus' Commons Building houses an all-electric kitchen that consists of induction ranges, induction flat tops, induction warmers, convection ovens, an electric triple deck oven with two built in proofers, an induction tilt skillet, an electric fryer, and an electric steamer. The kitchen is equipped with hood vents that have a heat recovery system built in and that works in conjunction with the geothermal systems.

Given the energy-intensive nature of a campus dining program, an extensive energy analysis focusing on the commercial kitchen equipment and HVAC systems was conducted during the design phase. Through this process, induction equipment was shown to reduce kitchen energy consumption by over 50%, in comparison to a traditional kitchen using natural gas. Further, the demand-based exhaust hoods with integrated heat recovery, the geo-exchange heat pump, and the radiant heating and cooling systems dramatically reduced HVAC energy for the dining program. The facility is predicted to operate at an EUI of 121 kBtu/ft2-yr, which is almost 60% below a typical full-service restaurant.

The Commons Building was designed with an onsite PV system that was expected to offset approximately 50% of the building's electrical energy use, with the other half almost entirely satisfied by a small cogeneration system that also provides recovered thermal energy for space heating and domestic water heating.

How:

HVAC	VAV hood vents with geothermal compatible heat recovery
DHW	All-electric (details not available)
Cooking	Induction range, Induction tilt skillet, Steamers, Electric convection ovens, Electric deck ovens w/proof boxes, Recessed induction warmers, Electric fryer, Induction flat top griddles, Recessed counter top induction hobs
Owner	Chatham University
Architect	Mithun
General Contractor	SOTA Construction
Mechanical Engineering	Interface Engineering
Electrical Engineering	Interface Engineering
Structural Engineer	KPFF Engineers
Kitchen Consultant	The Marshall Group / Chef Chris Galarza

Source: Chris Galarza

5.4.7.2 _McAteer High School Culinary Center Renovation

Source: Tim Mena

Source: Tim Mena

Project Location: San Francisco, CA

Completion Year: 2019

Project Size: 9,000 square feet

What:

McAteer Culinary Center Renovation was the first all-electric kitchen for the San Francisco Unified School District (SFUSD). This renovation project served as a prototype kitchen for five future "central kitchens" that will deliver fresh meals instead of prepackaged foods to Early Education Development programs across the SFUSD. For the health of staff, students and community members, SFUSD's Sustainability Department strongly advocated for electrification and the removal of natural gas for this project. The electrification of the project included the installation of state-of-the-art, energy-efficient commercial kitchen equipment such as electrical combi ovens, an industrial electrical kettle, and an electrical tilting skillet. The kitchen also connects to a welcoming servery and cafeteria for McAteer high school students and staff to dine in.

How:

HVAC	All Electric High Efficiency Indoor Fan Coils and Outdoor Condensing Units with SEER values up to 14
DHW	Existing natural-gas fired domestic hot water heater
Cooking	Combi Oven, Portable Induction cooktop, Electrical and convection oven
Owner	SFUSD
Architect	Multistudio
General Contractor	Build Group
Mechanical Engineering	Capital Engineering Consultants, Inc.
Electrical Engineering	Helix Electrical
Structural Engineer	Murphy Burr Curry, Inc.
Kitchen Consultant	The Marshall Associates, Inc.

Electrification features:

Energy efficient commercial kitchen equipment such as electrical combi ovens, an industrial electric kettle, and an electric tilting skillet were incorporated for batch cooking of bulk food. A 1 kW portable induction hob is used at a separate workstation dedicated for small numbers of meals to suit special dietary needs, such as gluten-free meals.

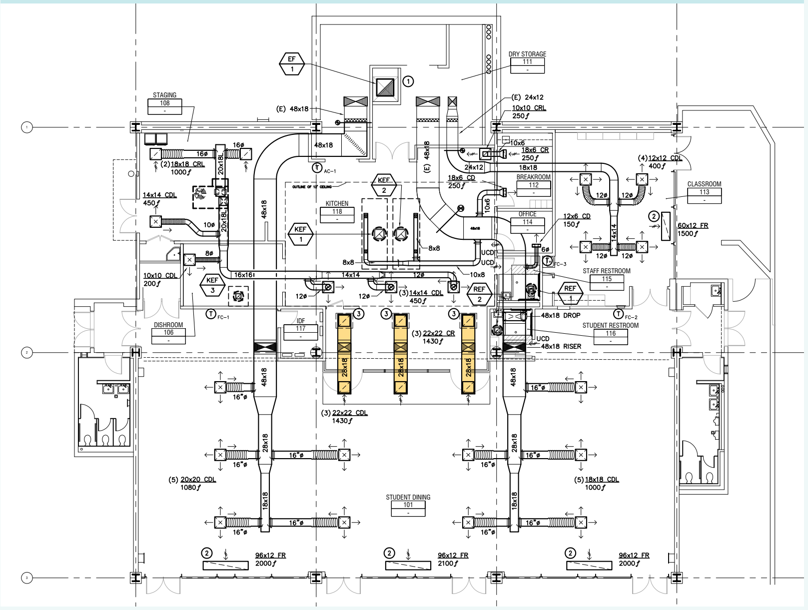
A demand controlled kitchen ventilation strategy saves energy by adjusting the quantity of kitchen hood exhaust and incoming outdoor air to reflect the amount of cooking taking place under the hood. The system maintains full capture and containment of smoke and combustion byproducts in response to appliance operation.

Demand controlled kitchen ventilation systems reduce fan power consumption and produce HVAC savings proportional to the reduction in airflow of approximately 10% to 50%.

Additionally, the McAteer kitchen space is directly adjacent to the dining room. An additional energy saving strategy incorporated transfer air from the dining area (which has large OSA ventilation loads) into the kitchen (highlighted in yellow in Figure 5.31) to serve as make-up air during kitchen hood operation. Transferring this pre-conditioned air allowed for the downsizing of the heat pump that serves the kitchen area proper.

Split heat pumps (indoor fan coil unit and outdoor heat pump unit) provided all heating and cooling. A BMS system was installed to optimize energy use. A new 24-inch ventless heat pump dryer was also installed along with an on-site washer for all kitchen-related laundry.

FIGURE 5.31: TRANSFER DUCTS (HIGHLIGHTED IN YELLOW) ALLOW FOR THE USE OF DINING AREA VENTILATION AS MAKE-UP AIR TO THE KITCHEN HOOD EXHAUST SYSTEMS



Lesson Learned:

A challenge for electrification was getting the operation and maintenance team on board for switching the existing gas domestic hot water heater to electric heat pump water heaters. More outreach and training with the O&M team leading up to future kitchen projects would be beneficial.

Testimony from Joshua Davidson, chef from SFUSD Student Nutrition Services:

Compared to our most recent experience with a gas-powered kitchen, the space here is much more comfortable. Not having to fiddle with matches or crawl on the floor to relight pilots is a welcome change of pace and safety.

All of the electrical appliances perform better than their gas counterparts, but the real stars of the show here are the Combi oven and the new kettles. The gas kettle we used previously was much slower to warm. The Combi oven is leaps and bounds faster than any other oven we've used, with warm-up times sometimes under a minute and never more than 5 minutes. One combi oven can output the same amount of food as four regular ovens.

The new tilt skillet and kettles give us much more even and reliable temperature control. The combi oven gives us capabilities we didn't have before, like low temperature steaming for perfectly textured hard-cooked eggs. As things return to normal after the pandemic, we have growth plans and the new equipment is a big part of that. Catering programs for school districts, the city, or school events are all in progress due to the excellent output of the kitchen.

One of the best things about the new ovens is they can be unplugged and rolled away to thoroughly clean the workspace. Even surface heating means the tilt skillet does not develop burn spots that accumulate carbon over time. Induction burners never cover the pots and pans in carbon, so there is a whole world of cleaning we don't even have to think about anymore.

Significantly, since the new all-electric kitchen provides such a versatile food menu, teachers and staff have started purchasing meals at the cafeteria, which was unprecedented in the past.

5.4.7.3_Janet Durgin Guild and Commons, Sonoma Academy

Source: Michael David Rose

Source: Celso Rojas

Project Location: Santa Rosa, CA

Completion Year: 2018

Project Size: 22,494 square feet

What:

Sonoma Academy, a private high school in Santa Rosa, California, has an all-electric kitchen with induction equipment that serves the students, staff and faculty. Located at the base of Taylor Mountain, the project includes 29 geoexchange wells, and enough photovoltaics to ensure the project is net positive. Early work with the school included an energy balance matrix that helped outline options for storing, preparing and cooking the desired diversity of food options the school wanted to provide its community. Equipment selection was vetted through the priorities of sustainability, quality, variety, and education, resulting in induction ranges, induction flat tops, convection ovens, and induction warmers.

The very tight kitchen and back-of-house area generated discussions on how to maximize the space for efficiency and use. Benchmark systems like LEED, WELL and the Living Building Challenge (LBC) provided the lenses through which marketplace offerings were matched with all team members' needs (including the school dining vendors that would eventually operate the facility). All materials and systems, including the cooking and warming components were vetted through the LBC's Materials Petal. The project was awarded the LBC Petal for Material, Health and Happiness and Equity along with Zero Carbon. The project is an AIA Top Ten COTE winner.

How:

HVAC	Ground Source Heat Pump (GSHP), FCUs and energy recovery
DHW	Electric water heater, preheated through GSHP
Cooking	Ovens, Combi ovens, Induction ranges, Tilt kettle
Owner	Sonoma Academy
Architect	WRNS Studio
General Contractor	XL Construction
Mechanical Engineering	Interface Engineering
Electrical Engineering	Integral
Structural Engineer	Mar Structural Engineering
Foodservice / Kitchen	Consultant Flik/Vision Builders

Good indoor air quality is critical to learning environments. Connection to nature, daylight and natural ventilation dictated the building's design — 80% of the project is naturally lit. South-facing exterior blinds tune for exposure and wind- managing sunlight and heat for the teaching kitchen, the main kitchen and the dining room.

Active and passive mechanical design strategies are incorporated, taking advantage of the mild Bay Area's climate. Natural ventilation and ceiling fans are used throughout the shoulder season, providing user control, passive cooling, and a high degree of user adjustability.

Radiant heat and cooling is used during the more extreme months, which is provided by geo-exchange ground source heat pumps. The geo-exchange system provides groundwater directly to the radiant manifolds when the groundwater is at an appropriate temperature — expected to provide 10-15% of the annual cooling demand. The mechanical system captures waste heat from the ventilation air and refrigeration system in the commercial kitchen — used for space heating and domestic hot water production. The central heat pump is also used for domestic hot water heating — one of the largest demands due to food service.

As food service facilities often have an EUI above 400, a significant challenge included working with the food service provider and the school to tune choices and detail use schedules, resulting in aggressive load reductions in the maker and food service equipment in order to get to ZNE. The food service EUI is 98 while the classrooms and office total an EUI of 17. In total the project has tracked an EUI of 38.

The kitchen facility is 100% electric, including electric warmers and induction cooktops, which reduce or eliminate energy consumption by eliminating idling. The reduced byproducts and particulates contribute to a healthier work environment for the kitchen staff, and due to the open kitchen plan, a healthier dining experience for the students and community.

5.5_The Induction Misconception Library

As a relatively new but proven and promising technology, induction is subject to many misconceptions about its impact and effectiveness. Figure 5.32 (Parts 1 and 2) outlines the misconceptions and realities of induction equipment.

FIGURE 5.32:_THE INDUCTION MISCONCEPTION LIBRARY, PART 1

Misconception	Reality
Cooking with induction is difficult	While there is a learning curve, getting used to the power and control of induction is quite easy and very rewarding. The additional features (that are not even available in gas appliances) may take more time to master.
Induction cooking is overrated and benefits are overstated. Gas cooking is the gold standard for a reason.	Induction is in fact considerably underrated and its benefits understated: • Induction cooking provides precise temperature adjustments that gas cannot. • There is no idling of equipment with induction, unlike the gas counterpart. • There is no combustion and therefore no carbon monoxide and other harmful combustion byproducts. • There is much cleaner air quality in the work environment. • Induction heats up significantly quicker than gas.
Cooking with gas gives you more control.	Induction cooking offers more control over gas. Most units come with built-in temperature displays that help fine tune your cooking by individual degrees. It responds far quicker to the temperature changes because it works with the molecular structure of the pan to more effectively control temperature and speed response time. The result is faster and more precise control.
Induction cooktops and ranges don't cook as well as gas, and because of this quality suffers.	Food served on cruise lines is fully prepared on all-electric kitchen equipment since no gas is allowed on these vessels. The popularity of meals on cruises suggests food quality is on a par with land-based kitchens.
The radiation waves from induction are harmful.	There are many reasons that these concerns are overstated in relation to induction cooking. The EMF from an induction stove is classified as a class 2b carcinogen, alongside coffee and pickles. The National Cancer Institute notes that "No mechanism by which Extremely Low Frequency Electro-Magnetic Frequencies (ELF-EMFs) or radiofrequency radiation could cause cancer has been identified." For further discussion of these considerations, see section 5.2.2.
Chefs or home cooks can't preheat their pans and therefore can't sauté properly.	With induction there is no longer a need to warm your pans prior to sauteing. Chefs developed that technique to assist in the heating of their pans due to the woefully inefficient method of gas cooking. Also removing the pan from the induction unit doesn't render the pan or the heat in the pan useless. It's no different than removing a pan from the fire. The pan still retains its heat for a period of time.

FIGURE 5.32:_THE INDUCTION MISCONCEPTION LIBRARY, PART 2

Misconception	Reality
The glass surface of the induction equipment will crack/warp because it's not able to withstand a professional kitchen setting.	Induction units do not use tempered glass and are instead installed with tempered ceramic glass. This is an important distinction. While tempered glass withstands constant temperatures up to 470°F, tempered ceramic glass can withstand temperatures surpassing 1,200°F. This means the surface of induction equipment will not crack and warp.
The glass surface of induction isn't conducive to home cooking practices.	Tempered ceramic glass on induction units can handle intense activity with ease and there is no reason why it shouldn't be conducive to home cooking practices. The same glass is used in commercial kitchen induction equipment.
Induction costs too much and isn't worth the price in the long run.	The induction unit itself does currently cost more than a traditional gas range. However, numerous federal/state/local authorities offer rebates that offset the higher cost. It's also important to account for the fact that induction cooking is 80%–90% efficient compared to its gas counterpart, at 30%–40%. Induction technology saves money in the long term.
Induction cooking technology does not accommodate wok cooking.	Induction cooking has evolved to accommodate induction wok cooking. This new equipment is created for the wok to sit comfortably in the unit. This also has the added benefit of creating contact with all surfaces of the wok, making wok hei achievable using induction. Induction wok cooking also has the added benefit of saving the average Asian food restaurant hundreds of thousands of gallons of water per year. (https://p2infohouse.org/ref/50/49033.pdf) Also see 5.3.4.2 "Residential Induction Woks."
The nature of induction requires you to replace all of your pots and pans because most stainless steel isn't magnetic. For this reason alone induction is too expensive and not worth it.	While much commercial cookware may need to be replaced, most residential cookware works perfectly. Exceptions are old style anodized aluminum, copper, and glass cookware. Most of today's cookware works, such as triple ply cookware, cast iron, enameled cast iron and many others. Remember this: if a magnet sticks, it works. And, don't forget that pans that are used exclusively on an induction unit boast much longer than average life spans (especially in commercial settings).
There isn't enough electric equipment to justify the change.	Nearly every piece of cooking/warming equipment in any home or commercial kitchen is already electric. There are only a few that still use gas. Below is a list of equipment that can be replaced with all-electric equipment: Gas cooktops, ovens, and ranges; convection, combination, rapid cook, rack, and deck ovens; flat top griddles; fryers; woks, tilt skillets, soup wells; well warmers, delivery bags.

5.6_Other Resources

Residential Kitchen Data Hub

(https://www.buildingdecarb.org/kitchen-electrification-group-resource-directory.html)

Rebate Programs

- Sacramento Municipal Utility District (SMUD) induction rebates
  - SMUD Multifamily Retrofit (https://www.smud.org/en/Business-Solutions-and-Rebates/Business-Rebates/Multi-Family-go-electric-incentives)
  - SMUD All-Electric Smart Homes (New) (https://www.smud.org/en/Going-Green/Smart-Homes)
  - SMUD Appliance Rebates (https://www.smud.org/en/Rebates-and-Savings-Tips/Rebates-for-My-Home/Home-Appliances-and-Electronics-Rebates)
- BayRen induction rebates (https://bayrenresidential.org/get-rebates)
- Silicon Valley Clean Energy Rebates (https://content.govdelivery.com/accounts/CAORGSVCE/bulletins/2fd0aeb#induction)

Residential Kitchen Hands-on Experiences

Culinary and maker spaces dedicated to sharing the excitement of electric kitchens with online events, chef experiences, videos and content:

- The Electric Kitchen Workshop, Monark Premium Appliance, San Francisco, CA (https://monarkhome.com/).
  - Other Monark Premium Appliance locations:
    - Santa Clara, San Rafael, Concord, and Rancho Cordova, CA
    - Reno, NV
    - Miami, Bonita Springs, Palm Beach, and Pompano, FL
- Yale Appliance Dorchester, Framingham and Hanover MA (www.yaleappliance.com)
- Miele USA Experience Centers
  - San Francisco and Beverly Hills, CA
  - Boca Raton and Coral Gables, FL
  - Chicago, IL
  - Manhattan, NY
  - Princeton, NJ
  - Scottsdale, AZ
  - Seattle, WA
  - Tyson's Corner, VA
- Pirch Appliances (www.pirch.com)
  - Costa Mesa, Glendale, Palm Springs, La Jolla, and Solana Beach, CA

- BSH Appliances Experience and Design Center (https://www.bosch-home.com/us/kitchen-planning-resources/showrooms)
  - Irvine, CA
  - Chicago, IL
  - New York, NY
- Monogram Design Centers (www.monogram.com)
  - Chicago, IL
  - Denver, CO
  - Philadelphia, PA
  - Norwalk, CT
- Fisher & Paykel Experience Center (https://www.fisherpaykel.com/ca/inspiration/experience-centres)
  - Costa Mesa, CA and New York, NY
- Hestan Cue Smart Cooking (www.hestancue.com)
  - Vallejo, CA
- Purcell-Murray (www.purcellmurray.com)
  - San Francisco, CA
- Riggs Distributing, Burlingame, CA (https://www.riggsdistributing.com/events/)
- Portable Induction Loaner Programs (https://www.acterra.org/induction)
- Advanced Energy Center, Sonoma Clean Power, Santa Rosa, CA (https://scpadvancedenergycenter.org/education-hub)

Residential Kitchen Videos for Conversation Starter

- *Nourishing Our Net-zero Future:* Induction vs Gas Cook-off, by Multistudio (https://vimeo.com/363936356)
- Spotlight on Electric Induction Cooking! (https://www.youtube.com/watch?v=eOeauIma3xM)

Commercial Kitchens

- Food Service Technology Center offers consultation for energy and water efficiency design and provides current rebate program information; "Try Before You Buy" program offers hands-on experience with food services equipment before financial commitment. (https://fishnick.com/fstc/)
  - The Induction Technology Center (ITC) is a technical and educational resource dedicated to sharing accurate and unbiased energy and performance information about induction cooktops, woks, and hot food holding. Based at the Food Service Technology Center (FSTC), the ITC was created to help demystify induction cooking and holding and assist in the promotion and adoption of this efficient technology. (www.fishnick.com/itc)
- SMUD Rebates for Commercial Kitchens (https://www.smud.org/en/Rebates-and-Savings-Tips/Go-Electric/Business-Go-Electric)
- Induction for Commercial Kitchens, on-demand webinar from Sonoma Clean Power's Advanced Energy Center (https://scpadvancedenergycenter.org/news/induction-for-commercial-kitchens-webinar-recording-1)

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CONNECTING POLICY AND PRACTICE WITH DESIGN URBAN FABRICK

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Contributors

Building Decarbonization Practice Guide Content Leadership

- **Panama Bartholomy,** Building Decarbonization Coalition
- **Rachelle Boucher,** Kitchens to Life
- **Glenn Friedman,** PE, FASHRAE, Taylor Engineers
- **Christopher Galarza,** Forward Dining Solutions
- **Miranda Gardiner,** AIA, iMasons Climate Accord
- **Steven Guttmann,** PE, BCxP, LEED Fellow, Guttmann & Blaevoet
- **Teresa Jan,** AIA, LEED AP, WELL AP, Multistudio
- **Heidi Lubin,** eSix Development
- **Kyle Pickett,** William J. Worthen Foundation
- **Katie Ross,** Microsoft
- **Pauline Souza,** FAIA, LEED Fellow, WELL AP, LEED AP BD+C, LFA, WRNS Studio
- **Alice Sung,** AIA, LEED AP BD+C, SEA, Greenbank Associates
- **Ted Tiffany,** LEED AP BD+C, Building Decarbonization Coalition

Project Manager

- **Brett Rosenberg**, LEED AP, Cushman & Wakefield

WJWF Intern

- **Laura Barbosa,** Construction Industry Workforce Initiative

Graphic Design

- **Stoller Design Group**

Copy Editor

- **Geoff Martin,** Wheelhouse Writing Services

Working Group Members and Content Contributors

- **Katie Ackerly,** AIA, David Baker Architects
- **Sean Armstrong,** Redwood Energy
- **Heather Burpee,** University of Washington Integrated Design Lab
- **Don Davies,** PE, SE, Magnusson Klemenic Associates
- **Pierre Delforge,** Natural Resources Defense Council
- **Patrick Doss-Smith,** HGA
- **Susan Freed,** County of San Diego
- **Andreas Gyr,** Google
- **Ryan Hamilton,** Consortium for Energy Efficiency
- **Barry Hooper,** SF Environment
- **Josh Jacobs,** LEED AP+ BD&C, UL
- **Dirk Kestner,** PE, LEED AP BD+C, ENV SP, Walter P Moore
- **Bruce King,** Ecological Building Network
- **Candice Kollar,** Kollar EcoCreative and William J. Worthen Foundation
- **Meghan Lewis,** Carbon Leadership Forum
- **Lisa Fay Matthiesen,** FAIA, LEED Fellow, Amazon
- **Maurya McClintock,** McClintock Facades Consulting, LLC
- **Hilary Noll,** AIA, LEED AP BD+C, Mithun
- **Kelsey Rose Price,** PE, Hines
- **Cole Roberts,** PE, LEED AP, WELL AP, Arup
- **Henry Siegel,** FAIA, LEED AP, Siegel + Strain Architects
- **Stacy Smedley,** Skanska
- **Larry Strain,** Siegel + Strain
- **Mark Webster,** PE, LEED AP BD+C, Simpson Gumpertz & Heger
- **Wolfgang Werner,** AIA, LEED AP BD+C, CPHD, Urban Fabrick, Inc.
- **Breana Wheeler,** BRE (BREEAM USA)
- **Tamim Younos,** Green Water-Infrastructure Academy

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