Health Impact Review of ESHB 1589
Supporting Washington's clean energy economy and transitioning to a clean, affordable, and reliable energy future
(2023 Legislative Session)

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WASHINGTON STATE BOARD OF HEALTH

HEALTH EQUITY
Governor's Interagency Council on Health Disparities

Full review
The full Health Impact Review report is available at:
https://sboh.wa.gov/sites/default/files/2024-01/HIR-2024-04-ESHB%201589.pdf

Acknowledgements
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ESHB 1589, Supporting Washington's clean energy economy and transitioning to a clean, affordable, and reliable energy future.
(2023 Legislative Session)

Evidence indicates that ESHB 1589 would likely result in a large gas company not providing gas service to any new residential or commercial locations and may result in the company limiting service for some existing customers in the future, which may decrease the use of natural gas and increase the use of electricity among some residential and commercial buildings, which would likely result in improved health outcomes. There is unclear evidence how provisions may impact equity.

BILL INFORMATION

Sponsors: House Environment & Energy (originally sponsored by Representatives Doglio, Fitzgibbon, Berry, Alvarado, Bateman, Ramel, Peterson, Lekanoff, Hackney, Macri, and Kloba)

Summary of Bill:

Full details about the provisions of this bill can be found in the bill text linked above. Given the provisions analyzed, the summary below only highlights bill sections relevant to this Health Impact Review.

- Prohibits a large gas company[a] from furnishing or supplying gas service, instrumentalities, and facilities to any commercial or residential location that did not receive gas service or did not file applications for gas service as of June 30, 2023.
- Exempts certain manufacturing facilities from the prohibition on the extension of gas service.
- Exempts other types of facilities that are required to have redundant emergency backup power generation systems, including medical, correctional, and military, until January 1, 2040.
- Removes a large gas company's[a] obligation to serve natural gas by excluding it from requirements in RCW 80.28.110.

HEALTH IMPACT REVIEW

Summary of Findings:
This Health Impact Review found the following evidence for relevant provisions in ESHB 1589:

- **Informed assumption** that prohibiting a large gas company from extending natural gas service to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023, (with specific exemptions) would likely result in a large gas company not providing gas service to any new commercial or residential location.

[a] Specified as serving more than 500,000 retail natural gas customers in Washington State on June 30, 2023.

This assumption is based on proposed changes to current law and information from key informants.

- **Informed assumption** that removing a large gas company's obligation to serve may result in a large gas company limiting service for some existing gas customers. This assumption is based on proposed changes to current law and information from key informants.
- **Informed assumption** that a large gas company not providing natural gas service to new commercial or residential locations and limiting service for some existing gas customers may decrease use of natural gas and increase use of electricity among some residential and commercial buildings. This assumption is based on Washington State energy policies and information from key informants.
- **Strong evidence** that decreasing use of natural gas among residential and commercial buildings would likely result in improved health outcomes.
- **Unclear evidence** how improving health outcomes related to decreased exposure to natural gas emissions may impact equity.

Introduction and Methods

A Health Impact Review is an analysis of how a proposed legislative or budgetary change will likely impact health and health disparities in Washington State (RCW 43.20.285). For the purpose of this review "health disparities" have been defined as differences in disease, death, and other adverse health conditions that exist between populations (RCW 43.20.025). Differences in health conditions are not intrinsic to a population; rather, inequities are related to social determinants (access to healthcare, economic stability, racism, etc.). This document provides summaries of the evidence analyzed by State Board of Health staff during the Health Impact Review of Engrossed Substitute House Bill 1589 (ESHB 1589).

Staff analyzed the content of ESHB 1589 and created a logic model visually depicting the pathway between bill provisions, social determinants, and health outcomes and equity. The logic model reflects the pathway with the greatest amount and strongest quality of evidence. The logic model is presented both in text and through a flowchart (Figure 1).

We conducted an objective review of published literature for each step in the logic model pathway using databases including PubMed, Google Scholar, and University of Washington Libraries. The annotated references are only a representation of the evidence and provide examples of current research. In some cases, only a few review articles or meta-analyses are referenced. One article may cite or provide analysis of dozens of other articles. Therefore, the number of references included in the bibliography does not necessarily reflect the strength-of-evidence. In addition, some articles provide evidence for more than one research question and are referenced multiple times.

We consulted with people who have content and context expertise about the provisions and potential impacts of the bill. The primary intent of key informant interviews is to ensure staff interpret the bill correctly, accurately portray the pathway to health and equity, and understand different viewpoints, challenges, and impacts of the bill. We spoke with 23 key informant interviewees, including: 9 state agency staff working on air quality and/or energy policy; 4 people representing 3 organizations focused on climate-related policy; 3 people working on state building and energy codes; 3 people representing 2 organizations of commercial energy customers; 2 people involved in commercial real estate development; and 2 people representing a utility in Washington State.

We evaluated evidence using set criteria and determined a strength-of-evidence for each step in the pathway. The logic model includes information on the strength-of-evidence. The strength-of-evidence is summarized as:

- **Very strong evidence:** There is a very large body of robust, published evidence and some qualitative primary research with all or almost all evidence supporting the association. There is consensus between all data sources and types, indicating that the premise is well accepted by the scientific community.
- **Strong evidence:** There is a large body of published evidence and some qualitative primary research with the majority of evidence supporting the association, though some sources may

have less robust study design or execution. There is consensus between data sources and types.

- **A fair amount of evidence:** There is some published evidence and some qualitative primary research with the majority of evidence supporting the association. The body of evidence may include sources with less robust design and execution and there may be some level of disagreement between data sources and types.
- **Expert opinion:** There is limited or no published evidence; however, rigorous qualitative primary research is available supporting the association, with an attempt to include viewpoints from multiple types of informants. There is consensus among the majority of informants.
- **Informed assumption:** There is limited or no published evidence; however, some qualitative primary research is available. Rigorous qualitative primary research was not possible due to time or other constraints. There is consensus among the majority of informants.
- **No association:** There is some published evidence and some qualitative primary research with the majority of evidence supporting no association or no relationship. The body of evidence may include sources with less robust design and execution and there may be some level of disagreement between data sources and types.
- **Not well researched:** There is limited or no published evidence and limited or no qualitative primary research and the body of evidence was primarily descriptive in nature and unable to assess association or has inconsistent or mixed findings, with some supporting the association, some disagreeing, and some finding no connection. There is a lack of consensus between data sources and types.
- **Unclear:** There is a lack of consensus between data sources and types, and the directionality of the association is ambiguous due to potential unintended consequences or other variables.

This review was completed during the interim and was not subject to the 10-day turnaround required by law. More information and detailed methods for this review are available upon request.

Analysis of ESHB 1589 and the Scientific Evidence

Summary of relevant background information

Natural gas

- Natural gas is a fossil fuel energy source containing many different compounds,[1] including a high percentage of methane (often more than 85%) and varying amounts of ethane, propane, butane, and inerts (e.g., nitrogen, carbon dioxide, and helium).[2] Natural gas distribution systems are the largest source of urban methane.[3]
- Natural gas is one of the major fuels used in the U.S. for residential and commercial space heating and for electric power generation[2] (i.e., burning natural gas to generate electricity). It can also be used for cooking, water heating, heating pools, outdoor fireplaces, fireplace inserts, dryers, etc. (personal communications, November 2023).
    - Among all U.S. households that used natural gas in 2020, space heating was the most common end use followed by water heating, cooking (using ovens, cooktops, and ranges), and outdoor grilling.[4]
- Approximately 2.49 million tons of volatile organic compounds (VOCs) are emitted each year from oil and natural gas production in the U.S.[3] Compounds such as benzene, toluene, ethylbenzene, and ortho-, meta- and para-xylenes (collectively BTEX) are present in natural gas and are toxic, carcinogenic, and/or atmospherically reactive.[3]

Natural gas in Washington State

- In 2020, natural gas consumption in Washington State totaled 255 billion cubic feet (1% of total U.S. consumption).[5]
    - The state does not have any natural gas reserves or production.[6] Canada supplies most of the natural gas Washington uses either directly or via Idaho.[6]
    - Washington has 1 underground natural gas storage field, the Jackson Prairie Gas Storage Facility, located in Western Washington, which has capacity to store about 47 billion cubic feet of natural gas.[6]
- According to the U.S. Energy Information Administration (EIA), the heating value of natural gas consumed by Washington State in 2023 (9-month year to date) was 1,093 British thermal units (Btu) per cubic foot.[7] One Btu is the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit (F) at the temperature the water has its greatest density (approximately 39 degrees F).[8]
- In 2019, the electric power sector accounted for the largest share of Washington State's natural gas consumption for the first time, and it has remained the largest natural gas consumer in the state since.[6] In 2022, 30% of natural gas delivered to consumers was used to generate electricity.[6]
- In 2022, the residential sector was the second-largest natural gas consuming sector accounting for more than 25% of the state total.[6]
    - In 2020, state level data indicate that 41% of primary occupied housing units (i.e., excluding vacant units, seasonal units, second homes, military houses, and group quarters) in Washington State used natural gas.[9]

    - In 2022, 33% of households in Washington State use natural gas for space heating.[6]
- In 2022, the commercial sector consumed nearly 20% of the state's natural gas.[6]
    - National surveys indicate that in 2018 approximately 50% of commercial buildings and 70% of building floorspace in Washington State used natural gas.[5]

State energy system

- Washington State has a relatively low energy demand, with per capita consumption among the bottom third of U.S. states.[5]
- Washington State is a net exporter of electricity and produced about 3% of total electricity in the U.S. in 2020.[5]
    - The state is the leading producer of hydroelectricity in the U.S., with nearly two-thirds of the state's electricity provided by hydropower (mainly from the Federal Columbia River power system).[5]
    - Among other electricity generating resources, Washington has 21 natural gas-fired power plants.[5] In 2020, nearly 30% of natural gas consumed in the state was used for electricity production, fueling approximately 12% of electricity generated, the second highest fuel source after hydropower.[5]
- Washington State is a net importer of other forms of energy, consuming roughly 2.5 times the amount of energy it produces (including natural gas, oil, and other fossil fuel sources).[5]
- Various utility[b] types serve natural gas and electricity customers, and often serve both. Municipally-owned utilities, consumer-owned utilities (electricity cooperatives), and public utility districts (PUDs) serve Washingtonians in addition to 5 investor-owned utilities (1 provides electricity only, 2 provide natural gas only, and 2 provide both).[5]
    - Puget Sound Energy (PSE) is the largest investor-owned natural gas company in the state, serving more than 900,000 natural gas customers.[10]

Washington State law

- The Washington State Legislature has passed multiple laws in recent legislative sessions to move Washington's energy sector toward decarbonization.[11] Decarbonization of an energy system involves providing energy while reducing greenhouse gases emitted into the atmosphere.[12] This requires both energy efficiency and transitioning to energy sources that release no or minimal greenhouse gases into the air.[12]
- In 2019, the Legislature passed Washington's Clean Energy Transformation Act (CETA) (Chapter 288, Laws of 2019), which requires 80% of electricity used in the state to come from renewable or non-emitting sources by 2030 and allows the remaining 20% to be carbon-neutral via off-sets or other compliance mechanisms.[11] By 2045, CETA requires all electricity in Washington to come from clean energy sources (i.e., an electricity supply free of greenhouse gas emissions).[13]

[b] This Health Impact Review uses the terms "utility" or "utilities" to refer to the utility provider rather than the consumable product delivered to customers.

- In 2020, the Legislature passed Engrossed Second Substitute House Bill 2311 (Chapter 79, Laws of 2020), which set a target to reduce the state's greenhouse gas emissions 45% below 1990 levels by 2030, 70% below 1990 levels by 2040, and 95% below 1990 levels (and achieve net zero emissions) by 2050.[11] Because emissions in 2022 were higher than in 1990, Washington State must reduce emissions by 48% by 2030 to achieve its interim goal.[11]
- In 2021, the Legislature passed the Climate Commitment Act (CCA) (Chapter 316, Laws of 2021 partial veto) and directed the Washington State Department of Ecology (Ecology) to implement a cap and invest program to reduce greenhouse gas emissions consistent with statewide statutory emission limits.[14]
- To meet Washington State's overall greenhouse gas reduction targets, emissions associated with natural gas use in buildings must decrease by 14% (from 2022 levels) by 2030.[11]
- Washington State law (RCW 19.27A.160) requires that "residential and nonresidential construction permitted under the 2031 state energy code must achieve a [70%] reduction in annual net energy consumption, using the adopted 2006 Washington State Energy Code as a baseline."[15] The statute directs the Washington State Building Code Council (SBCC) to adopt state energy codes beginning in 2013 through 2031 that incrementally move towards that goal.[15]
    - SBCC "establishes the minimum building, mechanical, fire, plumbing and energy code requirements necessary to promote the health, safety and welfare of the people of the state of Washington, by reviewing, developing and adopting the state building code."[16]
    - SBCC initially adopted the 2021 Washington State Energy Code in 2022 (personal communication, SBCC, December 2023). However, SBCC decided to reopen rulemaking to incorporate a new understanding of federal policy into the State's energy codes.[17,18]
    - On November 28, 2023, SBCC reviewed and adopted changes for the Washington State Energy Code – Commercial Provisions (WAC 51-11C) and Washington State Energy Code – Residential Provisions (WAC 51-11R).[19]

U.S. context

- In 1975, U.S. Congress passed the Energy Policy and Conservation Act (EPCA) which regulates the energy efficiency of several consumer products (e.g., water heaters, furnaces, stoves, heating products) and "preempts state and local regulations concerning the energy efficiency [and] energy use […] of any covered product that has a federal energy conservation standard."[20]
- In 2022, U.S. Congress passed the Inflation Reduction Act (IRA), which "included new charges on certain natural gas facilities for their methane emissions, eventually rising to $1,500 per ton of methane."[21]
- In 2023, the National Academies of Sciences, Engineering, and Medicine released a Consensus Study Report from its Committee on Accelerating Decarbonization in the United States. The Consensus Study Report identified gaps and barriers to

implementation that would prevent the U.S. from meeting its climate, economic, and societal goals. In total, the Committee's analysis resulted in approximately 80 recommendations across 10 broad themes.[22]

- The Committee recommended states and communities "consider adopting moratoria on extension of new gas lines into areas previously unserved by natural gas unless or until there is a showing that such extensions will reduce greenhouse gas emissions."[22]

Other jurisdictions and litigation

- As of November 2023, 121 state and local jurisdictions around the country had passed provisions since 2019 requiring or incentivizing all-electric or zero-emissions new buildings and new construction in existing buildings, including jurisdictions in Washington State (e.g., Seattle and Shoreline).[23] In contrast, as of February 2020, 20 states had passed laws prohibiting cities from prohibiting natural gas.[24]
- In July 2019, Berkeley, California, became the first jurisdiction in the U.S. to prohibit natural gas infrastructure in new buildings.[20]
  - In November 2019, the California Restaurant Association sued Berkeley in the U.S. District Court for the Northern District of California (District Court).[20] The District Court dismissed the challenge. However, the decision was appealed to the U.S. Court of Appeals for the Ninth Circuit (Ninth Circuit).[20]
  - On April 17, 2023, the Ninth Circuit struck down Berkeley's ordinance in *California Restaurant Association v. City of Berkeley.*[20]
    - The Ninth Circuit concluded that the federal EPCA "preempted Berkeley's ban because [the ordinance] prohibited the onsite installation of natural gas infrastructure necessary to support covered natural gas appliances."[20] The Ninth Circuit's Opinion stated:

      > We only hold that EPCA prevents Berkeley from banning new-building owners from 'extending' fuel gas piping within their buildings 'from the point of delivery [to the customer] at the gas meter.' […] Our holding doesn't touch on whether the City has any obligation to maintain or expand the availability of a utility's delivery of gas to meters.[25]

    - The decision could apply to similar regulations in states and municipalities in the Ninth Circuit, which includes Washington State.[20]
  - The City of Berkeley filed a petition asking the Ninth Circuit to review the decision of the 3 judge panel and rehear the case "en banc", in which a group of 11 judges would review the case and issue a new opinion, replacing the panel's ruling.[26]
    - The U.S. Department of Energy submitted an amicus brief in support of the City of Berkeley's petition for rehearing.[27]
    - On January 2, 2024, the Ninth Circuit denied the city's petition for rehearing.[28]

- In 2022, Massachusetts passed Chapter 179 of the Acts of 2022, which included a pilot program (Section 84) that allowed 10 communities to enact laws to prohibit new fossil fuel hookups.[29] In 2023, a bill (H.3227) was introduced to expand access to the fossil fuel free demonstration project.[30,31]
- In May 2023, New York became the first state in the country to prohibit natural gas and other fossil fuels in some new construction.[32,33] Provisions included in the state's budget will require new buildings be constructed with only electric hookups for appliances and utilities.[33] New York law goes into effect for buildings with fewer than 7 stories in 2026 and for taller buildings by 2029.[33] It provides exceptions for large commercial and industrial buildings.[32] For example, hospitals, critical infrastructure, and commercial food establishments will be exempt from requirements as will buildings where the local electric grid is not immediately capable of handling the additional electric load.[33]
    - In October 2023, gas and construction trade groups filed a lawsuit in federal court to block New York state's law from going into effect.[33-35] Like the California Restaurant Association, the organizations argue the law violates the federal government's rules around how gas appliances are regulated under the EPCA.[33]

Summary of ESHB 1589

Full details about the provisions of this bill can be found in the bill text. Given the provisions analyzed, the summary below only highlights bill sections relevant to this Health Impact Review.

- Prohibits a large gas company[c] from furnishing or supplying gas service, instrumentalities, and facilities to any commercial or residential location that did not receive gas service or did not file applications for gas service as of June 30, 2023.
- Exempts certain manufacturing facilities from the prohibition on the extension of gas service.
- Exempts other types of facilities that are required to have redundant emergency backup power generation systems, including medical, correctional, and military, until January 1, 2040.
- Removes a large gas company's[c] obligation to serve natural gas by excluding it from requirements in RCW 80.28.110.

Health impact of ESHB 1589

Evidence indicates that ESHB 1589 would likely result in a large gas company not providing gas service to any new residential or commercial locations and may result in the company limiting service for some existing customers in the future, which may decrease the use of natural gas and increase the use of electricity among some residential and commercial buildings, which would likely result in improved health outcomes. There is unclear evidence how provisions may impact equity.

Pathway to health impacts

The potential pathway leading from the provisions in Sections 2 and 3 of ESHB 1589 to health and equity are depicted in Figure 1.

[c] Specified as serving more than 500,000 retail natural gas customers in Washington State on June 30, 2023.

We made the informed assumptions that prohibiting a large gas company from extending natural gas service to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023, (with specific exemptions) and removing the company's obligation to serve would likely result in a large gas company not providing gas service to any new commercial or residential location and may result in the company limiting service for come existing gas customers. These assumptions are based on proposed changes to current law and information from key informants. Additionally, we made the informed assumption that a large gas company not providing natural gas service to new commercial or residential locations and limiting service for some existing gas customers may decrease use of natural gas and increase use of electricity among some residential and commercial buildings. This assumption is based on Washington State energy policies and information from key informants.

There is strong evidence that decreasing use of natural gas among residential and commercial buildings would likely result in improved health outcomes.[3,36-43] There is unclear evidence how improving health outcomes related to decreased exposure to natural gas emissions may impact equity in Washington State as it is unknown 1) who in PSE's service area currently has natural gas service; 2) who may occupy new residential and commercial construction prohibited from using natural gas; 3) who may have their natural gas service discontinued in the future; and 4) whether programs, assistance, or other incentives are or will be available to customers to support electrification and who may be eligible for these programs.

Scope

Due to time limitations, we only researched the most linear connections between specified provisions of the bill and health and equity and did not explore the evidence for all possible pathways. For example, we did not evaluate potential impacts related to:

- Utility planning requirements. The bill would require the Washington Utilities and Transportation Commission (UTC) to initiate a process to consolidate utility planning requirements and to waive rules to facilitate an integrated system plan; establish by rule a cost-effectiveness test for certain emissions reduction measures; determine appropriate recovery mechanisms for a combination utility to meet its integrated system plan; and adopt depreciation schedules for any gas service plant. Additionally, it would authorize UTC to approve a merger of the electric and gas rate bases of a combination utility if it will result in a net benefit to customers. The bill would also require a combination utility to file an integrated system plan by January 1, 2026, and every four years, that achieves specific objectives. It would also establish labor requirements for any project in a gas decarbonization plan or electrification plan with a cost of more than $10 million. As these provisions are subject to rulemaking and multiple decision points that may affect implementation, this Health Impact Review did not assess potential impacts related to utility planning requirements.

- Local electric utilities. Electric utilities, including PSE in its service areas, may need to update their systems to meet increased demand for electricity from new construction and existing natural gas customers whose service may be discontinued (personal communications, December 2023). This may require additional infrastructure (e.g., right

of ways, substations, transformers) to ensure the capacity and reliability of the local grid (personal communications, December 2023). Key informants noted that this type of infrastructure planning would require significant lead time to allow utilities to build capacity for the additional workload and energy load to serve additional fully electric buildings (personal communications, December 2023). As this analysis does not address provisions in ESHB 1589 focused on utility planning for electrification, this Health Impact Review did not analyze the impact on long-term planning for the electrification of residential and commercial buildings in PSE's natural gas service area or how provisions may impact additional local electric utilities.

- Economic effects for businesses and consumers. Key informants noted the significant cost of designing/retrofitting structures to be all-electric (e.g., transformer upgrades). Without incentives or subsidies, the initial cost may be prohibitive for some. However, this Health Impact Review did not evaluate health outcomes related to the economic impacts of electrification for businesses, consumers, and localities.

- Potential impacts to Tribes or Tribal development. PSE may serve natural gas to some Tribes. Tribes may experience unique impacts and outcomes in addition to those outlined for other groups in this analysis. This Health Impact Review did not specifically evaluate potential impacts to Tribes or Tribal development.

- Health impacts on communities impacted by increased electricity generation. The fuel source used to generate electricity (e.g., coal, natural gas, wind, solar, hydropower) may generate greenhouse gas emissions or may be emissions free. The Washington State Legislature has passed multiple laws (e.g., CETA, CCA) in recent legislative sessions to move toward decarbonizing the energy sector.[11] Washington State has reduced electric grid emissions by 17% since 2010.[44] According to the Washington State Department of Commerce (Commerce), 2020 data indicate the average emissions rate (metric tons of carbon dioxide equivalent [MMTCDE] per megawatt-hour [MWh]) for electricity generated by PSE was 0.428 mt/MWh.[5] PSE and 2 other investor-owned utilities ranked among the highest emissions rates for all electric utilities (investor-owned and otherwise) operating in Washington State in 2020.[5] Researchers have estimated the effects of emissions from electricity production. One study estimated that $PM_{2.5}$ from electricity production "cause 21,000 premature deaths per year in the [U.S.]".[22] Another study stated that air pollution from electricity production "may be easier to control than $PM_{2.5}$ emissions from road dust or residential wood burning,"[22] As it is unknown what fuel mix may be available to PSE and other utilities to meet increased electrical demand resulting from implementation of ESHB 1589 Sections 2 and 3, this Health Impact Review did not analyze the health impacts of increased electricity production.

- Household transition from solid fuels (coal, wood, straw, crop waste, etc.) to natural gas. There is a large body of international research demonstrating how use of solid fuels for cooking and heating negatively impact health.[36] More specifically, household air pollution from solid fuels has caused 2.3 million deaths worldwide.[36] Among them, 1.06 million deaths are attributed to cardiovascular diseases; 420,000 deaths are caused by

respiratory infections and tuberculosis; and 398,000 deaths are associated with chronic respiratory diseases.[36] Research also shows that solid fuel use is more common among low- and middle-income countries, compared to higher income countries.[45] Evidence shows that transitioning from solid fuel to natural gas likely improves health.[36,45] Further, key informants stated that some Washington State residents use solid fuels to heat or cook (personal communication, Ecology, November 2023). The Residential Energy Consumption Survey (RECS) shows that 11% of primary occupied housing units in Washington State used wood as fuel.[9] Some key informants shared that prohibiting natural gas may result in greater use of propane or wood burning by some customers (personal communications, December 2023). New construction will need to meet standards established in the State Energy Codes (residential). Therefore, this Health Impact Review did not analyze the health impacts of household transition from solid fuel to natural gas.

- Health outcomes related to being in proximity of oil and natural gas drilling sites. Washington State does not have any natural gas reserves or production.[6] There is a large body of evidence showing that hydraulic fracturing, or natural gas and oil extraction, contributes to a wide range of negative health outcomes.[46] Drilling sites introduce pollutants into nearby water and air which can lead to a host of health issues including cancer.[46] Natural gas extraction also contributes to racial inequities. Evidence indicates that sites for energy production and petrochemical facilities are disproportionately placed near historically disadvantaged groups of people. For example, "communities of color are 75[%] more likely to live near pollution from the fossil fuel industry."[22] Since Washington State does not produce natural gas and Health Impact Reviews focus on how proposed legislation may impact health and equity in Washington State (RCW 43.20.285), this analysis did not evaluate health outcomes related to being in close proximity to oil and natural gas drilling sites.

Magnitude of impact

ESHB 1589 has the potential to affect any energy customer (person or business) who moves into or currently occupies a residential or commercial building (or unit) within a large natural gas company's service area. The bill identifies a large gas company as a company that serves more than 500,000 retail natural gas customers in Washington State on June 30, 2023.

In Washington State, various utility types serve natural gas and electricity customers, and often serve both. Municipally-owned utilities, consumer-owned utilities (electricity cooperatives), and public utility districts (PUDs) serve Washingtonians in addition to 5 investor-owned utilities (1 provides electricity only, 2 provide natural gas only, and 2 provide both).[5] Among companies that provide natural gas in Washington State, only Puget Sound Energy (PSE) meets EHSB 1589's definition of a large gas company (personal communications, November 2023). If passed, the provisions would affect those service areas in which PSE provides natural gas. PSE provides natural gas and electric services in some areas, natural gas only in some areas, and electric service only in some areas.[47]

Under Section 2 of the bill, those locations that did not have or had not applied for natural gas service as of June 30, 2023, would not be eligible for a service extension. The bill includes specific exemptions to the gas extension prohibition (e.g., manufacturing facilities). Key informants noted that this prohibition would likely primarily affect newly constructed residential and commercial buildings (personal communications, November-December 2023). New buildings for institutions not expressly exempt (e.g., schools, universities, government buildings) located in PSE's service area would also be prohibited from having a new natural gas line (personal communications, December 2023).

Section 3 of the bill would remove a large gas company's obligation to serve natural gas to customers who request service. Removing the obligation to serve could affect both new residential and commercial construction as well as existing residential and commercial customers within a large natural gas company's service area (personal communications, December 2023). This would allow the company to limit service for existing customers in the future (e.g., as lines are decommissioned).

Puget Sound Energy (PSE)

PSE's service area (6,000 square miles) consists primarily of the Puget Sound region of Western Washington, where approximately 4 million people live.[10] The utility serves over 900,000 natural gas customers and approximately 1.2 million electric customers.[10] About half of PSE's natural gas customers also receive electricity from PSE (personal communication, PSE, December 2023).

PSE provides natural gas service to parts of King (not Enumclaw), Kittitas (not Ellensburg), Lewis, Pierce, Snohomish, and Thurston counties.[47] According to the 2018-2022 American Community Survey 5-year estimates, 33.9% of occupied housing units in Washington State use utility gas for heating.[48] Estimates show use of utility gas for heating varied among the 6 counties served by PSE (41.8% of occupied housing units in King County [inclusive of Enumclaw], 40.0% in Snohomish, 34.4% in Pierce, 31.9% in Thurston, 20.1% in Kittitas [inclusive of Ellensburg], and 8.9% in Lewis Counties use utility gas for heating).[48] PSE purchases 100% of the natural gas supplies needed to serve its customers.[49] About 50% is purchased from producers and marketers in British Columbia and Alberta, Canada, and the rest comes from U.S. Rocky Mountain states.[49]

PSE provides electric service to all of Kitsap, Skagit, Thurston, and Whatcom counties and parts of Island, King (not Seattle), Kittitas, and Pierce (not Tacoma) counties.[47] The electricity that PSE supplies to its customers comes from various sources, including natural gas.[50] About 46% of the electricity supplied comes from PSE power plants (i.e., hydroelectric, thermal power plants, and wind farms), and the rest is purchased from other utilities, independent power producers, and energy marketers across the western U.S. and Canada.[50] In 2020, the fuel mix for electricity delivered to PSE customers included natural gas (27%), hydroelectric (24%), coal (23%), unspecified (14%), wind (9%), solar (1%), other (i.e., biomass, non-biogenic and petroleum) (1%), and nuclear (<1%).[50]

New construction and existing buildings
No specific data document how many new residential or commercial buildings are built in Washington State. Housing unit estimates from the U.S. Census Bureau may provide limited information about residential construction. However, similar data are not available for commercial buildings (personal communication, Washington State Office of Financial Management [OFM], December 2023).

The Population Estimates Program, within the U.S. Census Bureau, updates the population and housing unit estimates annually for all states and counties.[51] The U.S. Census Bureau defines a housing unit as "a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as a separate living quarters […] in which the occupants live and eat separately […] and which have direct access from the outside of the building or through a common hall."[51] OFM uses this information, housing completion data reported by cities and counties, and annexation census data to produce housing estimates for cities and counties in Washington State.[52] Estimates show the net change (i.e., additions and removals/loss) and cannot show how many new residential buildings were constructed in a given year (personal communication, OFM, December 2023). Based on estimates of housing units between April 1, 2022, and April 1, 2023, an estimated 29,878 housing units were added across the 6 counties in which PSE provides natural gas.[52]

Natural gas consumers
In 2022, EIA data indicated there were 1,271,260 residential consumers of natural gas in Washington State.[53] This is nearly 100,000 more residential consumers compared to 2017.[53] Residential consumption is defined as "gas used in private dwellings, including apartments, for heating, air-conditioning, cooking, water heating, and other household uses."[53]

In 2022, data from the EIA indicate that there were 108,368 commercial consumers of natural gas in Washington State, a growth of nearly 4,000 since 2017.[53] Commercial consumption is defined as "gas used by nonmanufacturing establishments or agencies primarily engaged in the sale of goods or services."[53] This includes "hotels, restaurants, wholesale and retail stores and other service enterprises; gas used by local, State, and Federal agencies engaged in nonmanufacturing activities."[53] In 2022, commercial consumers in Washington State used an average of 582,000 cubic feet of natural gas annually.[53]

PSE staff estimate that about 10,000 new natural gas connections were added to its system in 2022 and about 9,000 in 2023 (personal communication, PSE, January 2024). Most of these new connections were residential; however, the utility does not have a specific breakdown of how many were residential versus commercial (personal communication, PSE, January 2024). Overall, the utility has generally seen fewer natural gas hookups each year (personal communication, PSE, January 2024).

Exemptions
The bill outlines specific exemptions to the natural gas extension prohibition. First, facilities engaged in one or more manufacturing processes described by North American Industry Classification System (NAICS) codes beginning with 31, 32, or 33 would be exempt from bill provisions and eligible for natural gas service extension. Based on data from the Washington

State Department of Revenue (DOR), from April through June 2023 (Quarter 2), there were 11,243 businesses with NAICS codes 31-33 in Washington State.[54] There were 3,232 businesses with NAICS code 31,[54] indicating businesses involved in manufacturing food products; beverage and tobacco products; textiles and textile products; apparel; and leather and allied products.[55] There were 2,561 businesses with NAICS code 32,[54] indicating businesses involved in manufacturing wood products; paper; printing and related support activities; petroleum and coal; chemicals; plastics and rubber; and nonmetallic minerals.[55] There were 5,450 businesses with NAICS code 33,[54] indicating businesses involved in manufacturing primary metals; fabricated metals; machinery; computers and electronics; electrical equipment; appliances and components; transportation equipment; furniture and related products; and miscellaneous products (e.g., medical equipment and supplies).[55]

Second, buildings that are required by federal or state regulation to have redundant emergency backup power generation systems (e.g., correctional facilities and hospitals) are exempt from the prohibition until January 1, 2040, at which point any new facilities would no longer have the option of having a new natural gas connection. Finally, facilities operated by the U.S. Department of Defense that use reciprocating internal combustion engine generators that support energy resilience, energy security, and energy efficiency initiatives are also exempt until January 1, 2040.

Overall, ESHB 1589 has the potential to affect any energy customer (person or business) who moves into or currently occupies a residential or commercial building (or unit) within PSE's natural gas service area.

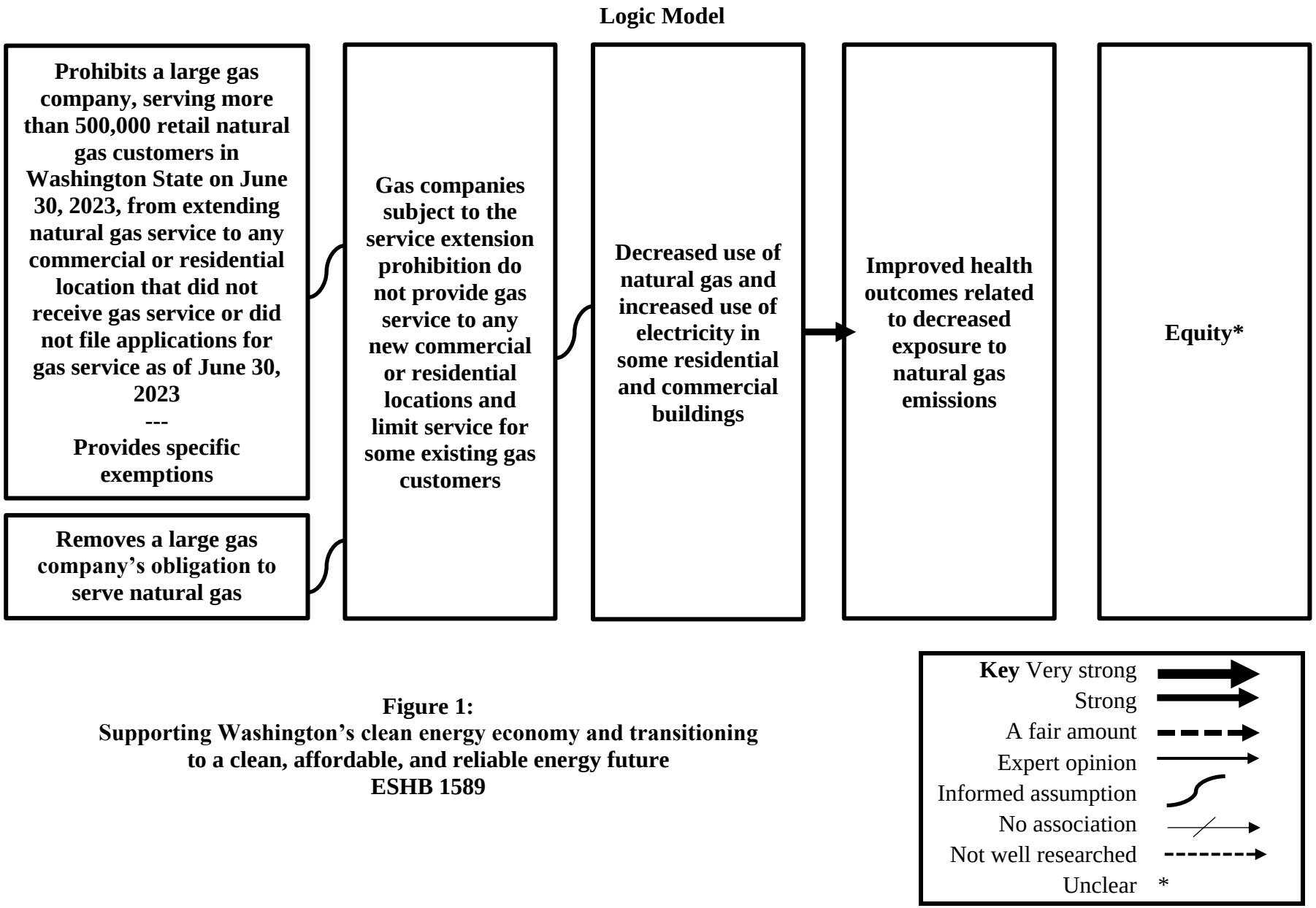

Figure 1:
Supporting Washington's clean energy economy and transitioning to a clean, affordable, and reliable energy future
ESHB 1589

Summaries of Findings

Would prohibiting a large gas company from extending natural gas service to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023, (with specific exemptions) result in a large gas company not providing gas service to any new commercial or residential location?
We have made the informed assumption that prohibiting a large gas company from extending natural gas service to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023, (with specific exemptions) would likely result in a large gas company not providing gas service to any new commercial or residential location. This informed assumption is based on proposed changes to current law and information from key informants representing Puget Sound Energy (PSE), the Washington State Building Code Council (SBCC), and the Washington State Utilities and Transportation Commission (UTC).

Under current law (RCW 80.28.110), all utilities, including those providing natural gas have, upon reasonable notice, an obligation to serve all persons and corporations who may apply and be reasonably entitled to such service.[56] This obligation is grounded in a basic agreement between utilities and states: "[i]n exchange for the grant of a monopoly over utility service in a given territory […] utilities agree to provide service to every customer who wants it at regulated rates."[57] This obligation was also intended to reduce the potential for discrimination of customers by income, race/ethnicity, profitability, or additional characteristics (personal communications, December 2023). In practice, this obligation means that utilities must provide gas service to all customers at the same price and under the same conditions (personal communications, December 2023).

If passed, ESHB 1589 Section 2 would apply to a large gas company. The bill identifies a large gas company as a company that serves more than 500,000 retail natural gas customers in Washington State on June 30, 2023. Only PSE, which serves over 900,000 natural gas customers, meets the bill's description of a large gas company (personal communications, November-December 2023). If passed, the provisions would affect those service areas in which PSE provides natural gas. PSE provides natural gas and electric services in some areas, natural gas only in some areas, and electric service only in some areas.[47] About half of PSE's gas customers also receive electricity from PSE (personal communication, PSE, December 2023).

Section 2 of ESHB 1589 would prohibit PSE from furnishing or supplying gas service, instrumentalities, and facilities to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023. The bill outlines specific exemptions to the prohibition. First, facilities engaged in one or more manufacturing process described by North American Industry Classification System (NAICS) codes beginning with 31, 32, or 33 would be eligible for natural gas service extension. Second, buildings that are required by federal or state regulation to have redundant emergency backup power generation systems (e.g., correctional facilities and hospitals) are exempt from the prohibition until January 1, 2040, at which point any new facilities would no longer have the option of having a new natural gas connection. Finally, facilities operated by the U.S. Department of Defense that use reciprocating internal combustion engine generators that support energy resilience, energy security, and energy efficiency initiatives would also be exempt until January 1, 2040. All other buildings not

expressly exempt, including institutions such as school, universities, and government buildings, would be prohibited from receiving new natural gas services (personal communications, December 2023).

Section 2 would limit expansion of the natural gas system by prohibiting PSE from providing gas service to new commercial and residential locations. In areas where PSE provides both natural gas and electric service, new locations would have access to PSE's electricity services only. In areas where PSE provides natural gas services only and another utility provides electricity, new residential and commercial locations would only be able to receive services from the electric utility that services their area. PSE staff noted that there would need to be a process to ensure that electric utilities (e.g., Tacoma Public Utilities; Seattle City Light; public utility districts; and smaller providers) in areas where PSE currently provides natural gas service were able to prepare for potential changes to meet the energy demand for new residential and commercial buildings (personal communication, PSE, December 2023). There is not currently a process for utilities to communicate and plan for such a transition (personal communication, PSE, December 2023).

Additional Washington State regulations

Key informants noted two recently adopted regulatory mechanisms that are expected to limit future expansion of natural gas service in Washington State (personal communications, November-December 2023). First, UTC changed the methodology used to calculate natural gas line extension allowances.[58] The previous Perpetual Net Present Value (PNPV) methodology, authorized for use by natural gas companies between 2016 and 2017, significantly increased the credit provided to customers through natural gas extension allowances.[58] For example, the PNPV methodology increased PSE's natural gas line extension allowance from $1,932 to $4,179 for residential customers.[58] The upfront cost of extending a line was then distributed evenly among all the utility's customers (ratepayers) over time (personal communications, November-December 2023). In 2019, UTC "received testimony from the Northwest Energy Coalition (NWEC) noting that the PNPV calculation [could] result in subsidies from current natural gas customers to new customers".[58] Following further comments to revisit the issue, UTC discontinued use of the PNPV methodology in 2021, ordering natural gas utilities regulated by the commission to file tariff revisions by November 17, 2021.[58] The new Net Present Value (NPV) methodology imposes a 7-year calculation timeline, reducing the line extension allowance for new residential customers of each natural gas company to approximately $2,000.[58] Multiple key informants shared the cost of running a new line would be significant and would likely discourage new connections to the natural gas system (personal communications, November-December 2023). However, some people may choose to pay the additional costs for a new natural gas connection (personal communications, December 2023).

Second, SBCC adopted new residential and commercial energy codes on November 28, 2023. Residential codes apply to all single family homes, town homes, and multi-unit buildings with exterior entrances (personal communication, SBCC, December 2023). The commercial energy codes apply to all other buildings. The current 2018 state energy codes went into effect February 1, 2021 (personal communication, SBCC, December 2023). The newly adopted codes will go into effect March 15, 2024.[59]

The new 2021 state energy codes are designed to increase efficiency in residential and commercial buildings to meet requirements in Washington State law (RCW 19.27A.160) (personal communication, SBCC, December 2023). Updated state energy codes beginning in 2013 have moved incrementally towards the goal.[15] Specifically, "residential and nonresidential construction permitted under the 2031 state energy code must achieve a [70%] reduction in annual net energy consumption, using the adopted 2006 Washington State Energy Code as a baseline."[15]

Under the current 2018 and newly adopted 2021 energy codes, both new residential and commercial construction may incorporate fossil fuel appliances for space heating and water heating (personal communication, SBCC, December 2023). The energy code does not set efficiency standards for cooking appliances (personal communication, SBCC, December 2023). While the federal Energy Policy and Conservation Act of 1975 (EPCA) requires that the lowest efficiency gas appliance is allowed to be installed, burning fossil fuels to provide space heating and water heating is less than 100% efficient (personal communication, SBCC, December 2023). Meanwhile, electric heat pumps are generally 200-300% efficient (personal communication, SBCC, December 2023). Therefore, if a new building uses less efficient fossil fuel appliances to provide space heating and/or water heating, then it must make up that efficiency from other systems (e.g., more efficient windows, fans, insulation) each of which may cost more money (personal communication, SBCC, December 2023). As efficiency requirements in the state energy code have increased, fewer fossil fuel appliances are installed because they are not as energy-efficient and require additional efficiency measures elsewhere to meet the overall efficiency goals set by the state (personal communication, SBCC, December 2023). However, ultimately it is up to the market and the designer whether fossil fuel appliances are installed in new residential and commercial construction (personal communication, SBCC, December 2023).

Some key informants expect eliminating subsidies for natural gas pipe extensions coupled with implementing the new residential and commercial energy codes will make it unlikely that newly developed buildings would use natural gas for space heating and water heating regardless of ESHB 1589 Section 2 (personal communications, November-December 2023). Together, the policies make installing a natural gas line at a new location cost prohibitive (personal communications, November-December 2023). However, some key informants noted that limiting PSE's expansion of gas service to the meter at new buildings may further limit natural gas for additional end-uses, including cooking, stoves, and outdoor fireplaces (personal communications, December 2023).

While the UTC's natural gas service line extension allowance change and the SBCC's newly adopted residential and commercial energy codes are expected to limit the number of new potential natural gas customers in Washington State (personal communications, November-December 2023), there is still the potential that people may choose to pay the full cost of having a natural gas line extended to their location. Therefore, based on information from key informants, we have made the informed assumption that prohibiting PSE from extending natural gas service to any commercial or residential location that did not receive gas service or did not apply for gas service as of June 30, 2023, (with specific exemptions) would likely result in PSE not providing natural gas service to any new residential or commercial location, including new

locations where people may have otherwise paid to receive natural gas service for space heating, water heating, cooking, etc.

Would removing a large gas company's obligation to serve natural gas result in a large gas company limiting natural gas service for some existing gas customers?
We have made the informed assumption that removing a large gas company's obligation to serve may result in PSE limiting service for some existing gas customers. This informed assumption is based on proposed changes to current law and information from key informants.

Under current law (RCW 80.28.110), the obligation to serve requires that, upon reasonable notice, PSE provide a natural gas connection and furnish all available gas as demanded to all persons and corporations who may apply and be reasonably entitled to such service.[56] This means, to discontinue service to a branch of the gas system, a utility would need every customer within a designated area (street, neighborhood, etc.) to voluntarily agree to discontinue their gas service (personal communications, December 2023). PSE staff noted that in 2023 very few residential or commercial customers voluntarily discontinued service (personal communication, PSE, January 2024). Additionally, there are various factors that could lead to a property to discontinue service (beyond electrification), so it is difficult to understand how many customers have discontinued natural gas service to electrify (personal communication, PSE, January 2024).

If passed, ESHB 1589 Section 3 would remove the obligation to serve for a large gas company. This would allow PSE to refuse to serve customers requesting service at new residential or commercial locations not previously served by natural gas (aligned with Section 2), and it would allow the utility to limit natural gas service to locations (residential and commercial) with existing connections (personal communications, November-December 2023). Key informants noted that Section 3 would enable PSE to begin scaling back natural gas service within its service area for existing customers (personal communications, November-December 2023). For example, if policies supporting electrification do not prompt customers to voluntarily electrify, the removal of the obligation to serve would permit PSE to discontinue natural gas service without an existing customer's voluntary agreement (personal communications, November-December 2023).

PSE staff stated that, if ESHB 1589 were to pass, they would anticipate reaching out to UTC for guidance and would look to UTC to write rules or issue a policy statement to describe the conditions and process by which the utility could discontinue natural gas service for existing customers (personal communication, PSE, December 2023). UTC staff shared that rulemaking would be needed to guide implementation (personal communication, UTC, January 2024).

In areas where PSE provides both gas and electric service, removing the obligation to serve would allow the company to plan for potential changes to electricity demand. However, in areas where PSE provides natural gas but not electric service, this would require coordination with electric utilities (e.g., Tacoma Public Utilities; Seattle City Light; public utility districts; and smaller providers) to ensure utilities were able to prepare for potential changes to meet the energy demand as customers transitioned from natural gas to electricity only (personal communications, PSE, December 2023). Representatives from PSE stated that this would be a new process and require developing new communication channels among utilities to coordinate

and ensure any increased demand on the electrical grid could be met (personal communications, PSE, December 2023).

Overall, key informants agreed that if PSE's obligation to serve was removed, the new law would provide PSE the option to limit service for some existing natural gas customers in the future (personal communications, November-December 2023). Therefore, we have made the informed assumption that removing the obligation to serve may result in PSE limiting service for some existing natural gas customers.

Would a large gas company not providing natural gas service to new commercial or residential locations and limiting service for some existing gas customers result in decreased use of natural gas and increased use of electricity in some residential and commercial buildings?

We have made the informed assumption that a large gas company not providing natural gas service to new commercial or residential locations and limiting service for some existing gas customers may decrease use of natural gas and increase use of electricity in some residential and commercial buildings. This informed assumption is based on Washington State energy policies and information from key informants representing commercial energy customers, commercial real estate development, and SBCC.

Generally, key informants agreed that if these provisions were enacted, use of natural gas would decrease and use of electricity would increase in PSE's natural gas service area (personal communications, November-December 2023). Although, UTC staff noted that there is already an obligation to comply with CETA and CCA, which utilities are planning to meet, and those laws dictate the use of natural gas in buildings (personal communication, UTC, January 2024). Key informants provided different perspectives on the considerations and challenges of meeting electrical requirements for new construction, retrofitting existing buildings to be all-electric, and potential impacts on development.

New construction

PSE not providing natural gas service for new residential locations and commercial locations in its natural gas service areas would involve new construction in these areas to incorporate all-electric systems for space heating, water heating, cooking, etc. (personal communications, November-December 2023). Key informants representing commercial real estate developers and various professionals involved in development noted the policy would impact building types and buildings differently (personal communication, NAIOPWA, December 2023). For example, the type of equipment required and associated construction costs would vary based on the type of construction (e.g., residential, commercial, industrial), building size, required uses (e.g., commercial kitchen, warehouse), etc. (personal communications, December 2023).

Buildings would need to be designed and constructed to include appropriately sized electrical equipment and capacity to meet the additional electricity demanded (personal communications, December 2023). New residential and commercial locations would need to work closely with their local electric utility to buy transformers and size equipment appropriately to serve the full load of the development (personal communications, December 2023). Key informants indicated that in the past few years supply chain issues have presented major constraints for accurately

sizing electrical equipment, particularly for large projects and those with uniquely high energy demands and could continue to delay development (personal communications, December 2023).

Key informants representing developers anticipate the prohibition of new natural gas connections may decrease development within PSE's natural gas service area (personal communication, NAIOPWA, December 2023). Ultimately, developers need to meet investors' return on cost expectations to secure the capital investment required to build a project (personal communication, NAIOPWA, December 2023). If it is more expensive to build in a specific area and a project still needs to meet the investor return to secure financing (both equity and debt), then a developer may wait until market rents increase, costs decrease (e.g., land prices or construction costs decrease), or something else happens to make the project financially viable (personal communication, NAIOPWA, December 2023). Alternatively, developers may pursue projects in areas outside PSE's service area where capital costs are lower and new natural gas connections are available (personal communication, NAIOPWA, December 2023).

Residential

Key informants representing developers and architects shared that functionally the technology exists to build all-electric residential spaces (personal communications, December 2023). For example, in market-rate residential 3-story walk-ups (garden multi-family), residential units are often already almost fully electric (personal communication, NAIOPWA, December 2023). Evidence indicates that building some types of electric-ready infrastructure is less expensive than building infrastructure with natural gas.[44] For example, "gas piping increases the cost to construct a typical single-family home in Washington [State] by $2,940."[44] However, key informants shared that some all-electric development currently costs more than if a project was served by both natural gas and electricity (personal communications, December 2023). For example, depending on the building type (midrise or high rise) it may be $10,000 to $30,000 more expensive per unit (personal communication, NAIOPWA, December 2023). The provisions would likely have a significant impact on larger urban, high-density infill development projects (e.g., large multi-family developments) which generally use natural gas for space heating (personal communication, NAIOPWA, December 2023).

Commercial

Key informants shared that energy requirements and challenges related to developing all-electric commercial buildings will vary significantly based on building type and use. Key informants representing developers noted designing and constructing all-electric industrial buildings (e.g., large warehouses) and life sciences (e.g., biotechnology) would be particularly expensive and challenging from an equipment perspective (personal communication, NAIOPWA, December 2023).

Additionally, key informants representing various types of commercial spaces shared member concerns about costs to build and run locations required to be all-electric. Key informants representing independent grocers, convenience stores, and suppliers shared that some of their members have explored what it would cost to establish new all-electric locations and that some members have built new locations that meet similar requirements (personal communication, Washington Food Industry Association [WFIA], December 2023). Specifically, in 2021, the City of Seattle adopted new energy codes,[60,61] which eliminated use of fossil fuels like natural gas for

most water heating and space heating in new construction (non-residential and multifamily buildings 4+ stories) and during substantial alterations or when space or water heating systems are replaced.[60] The codes do allow natural gas for cooking.[61] One member who built a new location reported it cost $1 million more to build an all-electric system than it would have to build a location served by natural gas (personal communication, WFIA, December 2023).

Similarly, key informants stated that PSE not providing natural gas service to new commercial locations would affect businesses with commercial kitchens (e.g., restaurants, municipal buildings) (personal communications, December 2023). Currently, most industrial kitchens and many cultural cuisines rely on natural gas to cook with flame. Limiting the number of available restaurant spaces with natural gas connections may increase competition for these spaces and contribute to rising prices of commercial leases (personal communications, December 2023). Additionally, new small businesses often purchase used appliances to limit the start-up costs of opening a restaurant (personal communications, Washington Hospitality Association [WHA], December 2023). Some members expressed concern that higher priced commercial glass cooktops and induction appliances may pose a barrier to entry for new small businesses, and these appliances may not be appropriate for some cultural cuisines (personal communication, WHA, December 2023).

Existing natural gas customers

Limiting natural gas for some existing customers would affect residential customers and commercial customers in areas where PSE may discontinue service. Affected customers would likely need to purchase new appliances (e.g., electric, induction) and update their electrical systems (e.g., panels, transformers, wiring), as needed, to meet the increased demand for electricity (personal communications, December 2023). This may require reconfiguring or retrofitting building spaces to incorporate equipment to support an all-electric system (personal communications, December 2023). Alternatively, some customers may choose to move to a new space that has natural gas service or that would not require reconfiguring or retrofitting (personal communications, December 2023).

Key informants representing commercial real estate developers shared that the opportunity to disconnect natural gas service would introduce significant uncertainty into the market (commercial, multifamily, and mixed-use developments) (personal communication, NAIOPWA, December 2023). Key informants noted that if developers know early in a project's timeline, they can design an all-electric building that meets facility requirements, but retrofitting an existing building to incorporate the physical space required to house appropriately sized electrical equipment for an all-electric facility may require significant and costly reconfiguration decisions (personal communication, NAIOPWA, December 2023).

<u>Residential</u>

Limiting natural gas for some existing residential customers would require affected customers (i.e., owners) to replace their natural gas appliances (e.g., stove, water heater, furnace, natural gas fireplace, dryer) with all-electric appliances. In addition to purchasing electric appliances to replace existing gas appliances, this would involve a customer checking that each new appliance had the appropriate electrical hookup (e.g., correct wiring, voltage, electrical panel) for any new electric appliances. A customer may need to pay an electrician to install the necessary electrical

outlet to transition from their gas appliance(s) (e.g., gas stove) to new electric versions. For example, national data suggests switching from gas heat to electric heat costs between $2,600 and $4,200.[62] This cost includes disconnecting and capping off the gas line, removing and disposing of the gas furnace, and installing any new wiring.[62] However, it does not include the potential cost of upgrading an electrical panel, which can cost between $500 and $2,000.[62] Additionally, some areas require a permit to "ensure a furnace and any required electrical or ductwork installations are completed in a safe manner and in accordance with federal, state, and local codes."[62] Total costs for customers to electrify would depend on the number of natural gas appliances to be replaced and whether programs, assistance, or other incentives are available or would be in the future to support residential electrification.

Commercial

Limiting natural gas for some existing commercial customers would require affected customers to consider how to meet their individual energy demands. Commercial customers may currently use natural gas for space heating, water heating, cooking, and/or back-up generators (e.g., to run systems that require electricity during a power outage) (personal communications, December 2023). If PSE notified a commercial customer that their natural gas service was going to be discontinued, the business would need to consider which appliances would need to be replaced with electric alternatives, what electrical system upgrades would need to be made to supply any new systems, and how to provide power to redundant systems (e.g., refrigeration, lighting, elevator) in case of a power outage (personal communications, December 2023). For example, grocers generally use natural gas to heat stores which have unique heating needs as they must maintain a comfortably heated environment for customers and employees in spaces that include constantly opening customer doors, large open back doors for deliveries, and significant sections with refrigeration (personal communication, WFIA, December 2023). Key informants who represent or work with commercial customers expressed concern that replacing entire systems would present a financial burden for businesses and the costs would need to be made up through rent or price increases (personal communications, December 2023).

Key informants presented differing views on how prohibiting natural gas would affect buildings during a power outage. For example, some key informants questioned how residential and commercial customers would meet their energy needs during a power outage, noting that natural gas is often used to run backup generators, fuel commercial refrigeration systems, and heat homes (e.g., fireplace inserts) when electricity fails (personal communications, November-December 2023). Additional key informants noted that many gas appliances require electricity and may not operate during a power outage (personal communications, November 2023). Finally, some key informants noted that an earthquake would be the most likely cause of an extended power outage in Western Washington and may damage natural gas infrastructure (personal communications, December 2023).

Overall, key informants generally agreed that if Sections 2 and 3 of ESHB 1589 were enacted, use of natural gas would likely decrease and use of electricity would likely increase in PSE's natural gas service area (personal communications, November-December 2023). Additionally, key informants stated that these bill provisions may increase costs associated with development, reconfiguring, and retrofitting; introduce uncertainty in the market; and result in some customers relocating outside of PSE's natural gas service area to areas of the state with natural gas service

and lower development costs (personal communications, December 2023). Therefore, we have made the informed assumption that a large gas company not providing natural gas service to new commercial or residential locations and limiting service for some existing gas customers may decrease use of natural gas and increase use of electricity in some residential and commercial buildings.

Would decreasing use of natural gas and increasing use of electricity in residential and commercial buildings improve health outcomes?

There is strong evidence that decreasing use of natural gas among residential and commercial buildings would likely result in improved health outcomes.[3,36-43] The majority of evidence evaluating indoor air quality related to natural gas focuses on residential buildings and cooking rather than other end-uses (e.g., space heating). There is a large body of evidence showing that indoor air pollution and poor air quality overall contribute to negative health outcomes.[3,36-39,45] Evidence indicates that natural gas distribution and use contribute to poor air quality.[3,37,39,40,45] Evidence is available on the impacts of natural gas on both indoor and outdoor air quality.

Indoor air quality

Indoor air pollution and health are connected, and "as air pollution intensifies, there is a commensurate rise in the global burden of disease."[36] People living in the U.S. spend approximately 87% of their time indoors, and there can be greater variation in indoor air quality compared to outdoor air quality.[22] Indoor air pollution and indoor smoke lead to respiratory system diseases and asthma, reduce life expectancy, and elevate disease prevalence and hospitalization rates.[36] Air pollution exposure in the home is also "associated with chronic obstructive pulmonary disease [COPD], lung cancer, acute respiratory infections, cerebrovascular disease, ischemic heart disease, and adverse birth outcomes [… and] has also been associated with epigenetic adverse effects, which change DNA expression and [increase] the inflammatory effects of pollutants."[38] Indoor air pollution may also lead to decreased cognitive function, mental disorders, and lowered quality of life.[36] These negative health impacts are due to cooking, heating, and other energy use activities in the home.[36]

Natural gas is a fossil fuel energy source, and its use affects indoor air quality.[3] Natural gas contains many different compounds,[1] including a high percentage of methane (often more than 85%) and varying amounts of ethane, propane, butane, and inerts (e.g., nitrogen, carbon dioxide, and helium).[2] Both unprocessed and processed natural gas give off various emissions which can be harmful to health.[3] Key informants stated that the majority of buildings in Washington State are connected to a gas line (personal communication, Washington State Office of the Governor, November 2023). The Residential Energy Consumption Survey and the Commercial Buildings Energy Consumption Survey have found that 59% of Washington State homes and 68% of commercial buildings in the Pacific region burn fuels on-site for cooking, heat, or hot water.[44] Survey data show that in 2020, 41% of Washington State homes used natural gas.[9] Research has found that indoor natural gas stoves are used for cooking in about one-third of U.S. households.[37,63] Natural gas use contributes to emission factors and indoor concentrations of ultrafine particles.[39] While there are various ultrafine particles found in natural gas and that are released upon its combustion, the majority of particles studied in scientific literature are methane (CH_4), nitrogen oxides (NO_x), carbon dioxide (CO_2), and fine particulate matter ($PM_{2.5}$).

Methane (CH_4)

Natural gas recovered from ground sources is approximately 70% CH_4, but processed natural gas is over 95% CH_4.[21] Natural gas emits CH_4 through leakages in homes through stoves, heating boilers, and water heaters.[21,37,64,65] One study collected samples from natural gas stoves in homes in California, where measurements were taken during a steady-state-off, turning on and off, and during combustion.[37] Study results showed that "natural gas stoves emit [approximately] .08-1.3% of the gas they use as unburned CH_4 and that total U.S. stove emissions are 28.1 [gigagrams] Gg CH_4 [per year]."[37] CH_4 emissions from stoves in a steady-state-off were responsible for 76% of total stove emissions.[37] The researchers did not find differences in emissions based on age or purchase price of the stove or based on average income levels where the stoves were located.[37]

A separate study that examined gas water heaters from 64 homes in California found that, on average, individual tankless water heaters emitted 2,390 g CH_4 per year and storage water heaters emitted 1,400 g CH_4 per year, 0.93% and 0.39% of their total natural gas consumption, respectively.[65] The researchers scaled the measurements to estimate emissions of storage and tankless water heaters in the U.S., and found that "water heaters overall emitted an estimated 82.3 Gg CH_4 [per year], 0.40% of all natural gas consumed by these appliances […]"[65] Research also shows that natural gas heating boilers also emit CH_4. One international study found that gas boilers leak CH_4 at an average rate of 0.22% (i.e. the ratio of CH_4 leakage to natural gas consumption).[64]

CH_4 leakage in homes leads to adverse health outcomes.[3,21,37,40] High concentrations of CH_4 can displace oxygen in the air, which can lead to "rapid breathing, rapid heart rate, clumsiness, emotional upsets and fatigue."[66]

Nitrogen oxides (NO_x)

Nitrogen oxides (NO_x) are irritant gases that "can cause bronchoconstriction, airway hyperresponsiveness, and airway inflammation with increased risk of asthma exacerbations, bronchitis, and wheezing."[40] Research shows that NO_x is emitted by natural gas stoves.[37] In a study that collected samples from natural gas stoves in homes in California, the researchers found that NO_x emissions were linearly related to the amount of natural gas burned.[37] Research has shown that NO_x exposures can irritate the respiratory tract, aggravate asthma, and lead to respiratory diseases.[22,37]

Nitrogen dioxide (NO_2) is one component of NO_x and is emitted when cooking with gas but not electric stoves.[40] Overall, "many studies have reported elevated concentrations of […] NO_2 in homes with natural gas cooking burners, compared to homes with electric cooking."[39] A "modeling study of multifamily housing in Boston found that cooking with gas burners is a major source of NO_2 in homes."[39] While the U.S. does not have indoor exposure guidelines for NO_2, "Canada has a maximum residential exposure limit of 90 parts per billion (ppb) over a 1 [hour (h)] exposure and 11 ppb over the long term (>24 h)."[37] Indoor gas cooking can lead to levels of NO_2 that are beyond the recommended levels described in outdoor air quality recommendations set by the U.S. Environmental Protection Agency (EPA) (National Ambient Air Quality Standard [NAAQS] of 100 ppb).[40] One study of air samples collected from homes

with gas stoves found that 4 out of 9 homes studied had kitchen levels of NO_2 above the NAAQS after boiling and simmering activities on the stovetop and in the oven.[39]

Researchers have stated that NO_2 can exacerbate asthma, even with levels lower than the recommended levels.[40] The EPA has reported that even short term exposure to NO_2 can cause respiratory illness, and a 2013 meta-analysis found that as NO_2 increases so does the severity of asthma symptoms in children.[67] However, one systematic review and meta-analysis found that literature conducted on gas cooking and respiratory outcomes in children are mostly cross-sectional studies, include various definitions of key terms, and have potential sources of bias and inaccuracies.[41] The researchers of this particular review and meta-analysis concluded that the literature has a high degree of heterogeneity, is generally of low study quality, and "does not provide sufficient evidence regarding causal relationships between gas cooking or indoor NO_2 and asthma or wheeze." [41] Overall, reducing use of natural gas may decrease levels of NO_2. For example, one randomized controlled trial found that electrification of cooking can decrease NO_2 in the kitchen and bedroom.[40]

Carbon Dioxide (CO_2) and Carbon Monoxide (CO)

It is well-established that natural gas produces CO_2 when burned.[21,68] One study examined the operation of natural gas cooking burners among homes in California and found that concentrations of CO_2 "increased quickly as burners fired at maximum settings […and] remained elevated throughout the simulated cooking events[…]."[39] In a separate, similar study, results show that all combined gas stoves across the U.S. emit approximately the same amount of annual carbon dioxide as 500,000 cars.[37] Low concentrations of CO_2 lead to headache and difficulty breathing and high concentrations of CO_2 lead to increased blood pressure, unconsciousness, convulsions, and death.[69]

Further, CO, a deadly, poisonous gas, is produced when natural gas is improperly or incompletely burned.[68] Indoor combustion, such as with unvented gas fireplaces, can release CO, even when appliances are functioning correctly.[22] Researchers have stated, "many studies have reported elevated concentrations of CO […] in homes with natural gas cooking burners, compared to homes with electric cooking."[39] In high doses, "CO can cause fatigue, headaches, confusion, and death."[22]

Particulate Matter ($PM_{2.5}$)

Particulate matter (PM) is a combination of particles from several sources, "including fossil fuel combustion, wildfires, windblown dust, agriculture, and chemical reactions of other pollutants […]"[22] Cooking generally releases some fine particulate matter, defined as particles that are 2.5 micrometers or less in diameter ($PM_{2.5}$) (personal communication, Washington State Department of Health [DOH], November 2023). Some particulate matter is released during cooking, regardless of the type of fuel used.[40] Evidence indicates that cooking with natural gas releases twice the amount of $PM_{2.5}$ as compared to cooking with electricity.[42] $PM_{2.5}$ "can infiltrate the lungs [… and lead to] ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, and lower respiratory infections.[22] Overall, exposure to $PM_{2.5}$ can damage the respiratory system and may result in premature death.[42]

Additional substances

While most of the research on natural gas emissions, indoor air quality, and health focuses on CH_4, NO_x, CO_2, and $PM_{2.5}$, there are additional toxic compounds present. One study collected samples from indoor natural gas stovetops and outdoor gas appliance lines and found that there were 296 nonmethane volatile organic compounds (NMVOCs) in end-use natural gas.[3] The substances detected included benzene, hexane, toluene, heptane, and cyclohexane, and emissions were heightened during winter months.[3] Evidence indicates that 7% of these compounds are hazardous air pollutants.[3]

Mitigators

Research has found that certain factors may mitigate negative health impacts of natural gas for household users. For example, filtration devices, use of stove range hoods, and awareness may mitigate affects.[36,39,40]

Researchers have found that filtration devices decrease NO_2 and use of stove range hoods can reduce both NO_2 and $PM_{2.5}$.[40] However, "according to National Health and Nutrition Examination Survey [NHANES] data, among children living in households that use gas stoves, only 21.1% live in households where the stove's exhaust vent is always used."[63] Further, one study found that range hood functionality varies, with the largest reduction of nanometer-sized particles (PN), particles with diameters of 6 nanometers or larger, reduced by 80-95%.[39] Data show that a lack of hood use or poor ventilation can lead to levels of NO_2 that surpass the 1-h national standard.[37] Awareness of the need to ventilate when cooking and building standards may decrease exposures to NO_2.[39]

Research also shows that people's awareness of household energy use and their attitudes about energy can significantly impact household energy consumption.[36] Researchers have described a cycle among household energy users, where use of clean energy improves health, and improved health can allow consumers to be aware of the impact of energy consumption on their own wellbeing.[36] As cleaner energy leads to less health burden, consumers may make different choices about their home fuel use type.[36]

In sum, evidence indicates that reductions in natural gas may improve health outcomes related to indoor air quality. For example, a 2013 systematic review found an association between asthma and gas cooking. One study found that "13% of childhood asthma could be prevented by eliminating gas cooking."[40] Finally, researchers have stated that households with residents who have asthma, chronic pulmonary disease, or other respiratory diseases should consider transitioning from gas to electric cooking.[40]

Outdoor air quality

Outdoor air quality and health are connected and outdoor air pollution is "associated with a number of human health effects including heart attacks, asthma attacks, bronchitis, hospital and emergency room visits, work and school days lost, restricted activity days, respiratory symptoms, and premature mortality."[70]

Natural gas distribution and use impacts outdoor air quality.[40] U.S. oil and natural gas production make up over 69% of the total U.S. energy consumption, where natural gas is the dominant

energy source for the industrial, commercial, residential, and electrical power generation sectors.[3] There are over 45,000 miles of pipelines in Washington State, and 25 of the 36 pipeline operators carry natural gas.[71] Nationally, the residential sector accounts for about one-third of all energy consumption, after industrial and transportation sectors.[36] Across the U.S., there are approximately 630,000 total leaks in natural gas distribution systems, or 0.51 leaks per pipeline main mile (one leak for approximately every two miles of a main).[72] These leaks contribute to methane emissions of 0.69 [teragrams] Tg/year.[72] In addition, approximately 2.49 million tons of volatile organic compounds (VOCs) are emitted each year from oil and natural gas production in the U.S.[3]

A study of indoor natural gas stovetops and outdoor gas appliance lines in the Greater Boston area found that there were 296 NMVOCs in end-use natural gas samples collected.[3] The researchers estimated that overall emissions inventories did not account for approximately 120-356 kilograms per year of benzene emissions from natural gas in the area.[3] The researchers also estimate that leakage from natural gas may create underreported CH_4 and additional VOCs.[3] Natural gas leakage negatively impacts air quality directly through toxicants "and indirectly as ozone precursors and precursors to [secondary organic aerosol (SOA)] that make up a fraction of $PM_{2.5}$."[3] In addition, compounds such as benzene, toluene, ethylbenzene, and ortho-, meta- and para-xylenes (collectively BTEX) are present in unprocessed natural gas and are toxic, carcinogenic, and/or atmospherically reactive.[3]

In addition, natural gas distribution systems are the largest source of urban CH_4.[3] According to the U.S. EPA, "about 6.5 million metric tons of CH_4 leak from the oil and gas supply chain each year – around 1% of totally natural gas production."[21] Other researchers have calculated higher leakage rates (9%).[21] Researchers have estimated that CH_4 leaks account for 10% of natural gas's contributions to climate change, while the remaining 90% are due to CO_2 emissions after the natural gas is burned.[21] CH_4 is "86 times more potent than CO_2"[40] and approximately 28 times more warming than CO_2.[21] CH_4 also contributes to ground level ozone, which harms ecosystems.[73] Researchers have stated that reduced CH_4 concentrations could increase global crop yields by 26 million [tons] per year."[73] In addition, CH_4 is considered a hazardous air pollutant that causes 1 million premature deaths worldwide every year.[43] Exposure to ozone "damages airways, aggravates lung diseases, causes asthma attacks, increases rates of preterm birth, cardiovascular morbidity and mortality, and heightens stroke risk."[74] Researchers have also stated that reductions in greenhouse gas emissions "could have significant positive health outcomes from reduction in co-emitted air pollutants."[22] Overall, evidence indicates that reductions in natural gas may improve health outcomes related to outdoor air quality.

In sum, natural gas distribution and use contribute to poor indoor and outdoor air quality and contribute to a myriad of negative health outcomes. There is strong evidence that decreasing use of natural gas among residential and commercial buildings would likely result in improved health outcomes.

Would improving health outcomes related to decreased exposure to natural gas emissions impact equity?

There is unclear evidence how improving health outcomes related to decreased exposure to natural gas emissions may impact equity in Washington State. It is unknown 1) who in PSE's

service area currently has natural gas service; 2) who may occupy new residential and commercial construction prohibited from using natural gas; 3) who may have their natural gas service discontinued in the future; and 4) whether programs, assistance, or other incentives are or will be available to customers to support electrification and who may be eligible for these programs. However, it is well-documented that people of color, people with low socioeconomic status, children, older adults, people with heart and lung diseases, women, and pregnant people are most likely to be affected by air particle pollution exposure.[22,36,40,41,44,67,75-89] Without further information about who may experience decreased exposure to natural gas emissions, there is unclear evidence how improving health outcomes may affect equity.

Available residential energy consumption data provide limited insight into who currently has natural gas service. The U.S. Energy Information Administration (EIA) reports data on fuels used in U.S. homes.[4] Overall, 61% of all primary occupied housing units across the U.S. in 2020 used natural gas for one or more end uses (i.e., space heating, water heating, cooking, or outdoor grilling).[4] State level EIA data indicate that 41% of primary occupied housing units in Washington State used natural gas in 2020.[9] Nationally, these data are available by household income or by owner or renter status, but data are not reported at the state level. Generally, the percentage of U.S. households with natural gas service increases as household income increases, with those households earning less than $60,000 per year being less likely than average to have natural gas service and those earning $100,000 or more being more likely than average to have natural gas service.[4] National data from 2020 also indicate that those housing units (i.e., single family, mobile home, and apartments) occupied by an owner are slightly more likely to have natural gas service than those occupied by a renter.[4]

While estimates of the percentage of occupied housing units that use gas utility for heating are available by county for Washington State, we do not have data on who is more likely to currently have natural gas service (for space heating, water heating, cooking, etc.) in PSE's service area. Moreover, Washington State specific data are not available to indicate whether the groups who are most likely to be affected by particle exposure generally are disproportionately exposed to natural gas emissions in residential or commercial settings. Information is available indicating areas in Washington State that are generally overburdened and highly impacted by criteria air pollution (i.e., particulate matter [$PM_{2.5}$ and PM_{10}], ozone [O_3], nitrogen dioxide [NO_2], carbon monoxide [CO], sulfur dioxide [SO_2], and lead [Pb]).[90] In December 2023, the Washington State Department of Ecology published a report which identified 16 overburdened communities highly impacted by criteria air pollution, and 6 were located within PSE's service area—Everett, North Seattle and Shoreline, South Seattle, South King County, Northeast Puyallup, and South and East Tacoma.[90]

It is also unknown who (individuals and businesses) may occupy new residential and commercial construction prohibited from using natural gas. This would likely depend on the types of development (e.g., single family, multifamily residential, commercial, industrial) built within PSE's service area as well as rents charged. A decrease in new construction would likely create more competition in older less expensive housing and commercial stock, which could drive up rental and lease costs (personal communications, December 2023). Residential and commercial tenants who can pay more may choose to stay in PSE service areas, while tenants who cannot may look at new development outside the service boundary or older existing developments

within the service boundary (personal communication, NAIOPWA, December 2023). Increased rental or lease costs would have a greater effect on people and businesses with lower incomes (personal communications, December 2023).

Additionally, it is unknown which existing PSE natural gas customers (residential and commercial) may have their service disconnected in the future. Key informants shared that retrofitting existing buildings to be all-electric would likely be more challenging for owners of smaller buildings (personal communication, NAIOPWA, December 2023). If additional space is required to house electrical equipment, it may reduce the net rentable area, which would likely be a larger portion of the building's net rentable square footage (personal communication, NAIOPWA, December 2023).

While it is unknown who would be affected by the natural gas extension prohibition or discontinued service within PSE's service area, evidence indicates that without a managed transition from natural gas to electricity groups who are least financially able to make the transition would be disproportionately burdened by electrification efforts. In 2023, the National Academies of Sciences, Engineering, and Medicine released a Consensus Study Report from its Committee on Accelerating Decarbonization in the United States.[22] The report stated, "[w]ith electrification of buildings, power systems, and industrial uses, sales of traditional forms of natural gas service will decrease, but customers who remain in need of natural gas service will require access to supply delivered over safely operating local and higher-pressure gas pipelines."[22] Lower sales volumes will decrease revenue for local natural gas utilities, which will still need to spend money to maintain and operate the system infrastructure.[22] Authors explained, "[f]ewer sales over an existing asset base with such on-going costs will have adverse consumer price impacts, all else equal, potentially further reducing demand."[22] Therefore, "consumers [who are] slower to transition to electrification—which, based on previous examples of shrinking utility customer bases, are likely to be disproportionately lower-income households and people of color—would bear the burden of these higher [natural gas utility] costs."[22] This aligns with concerns shared by key informants in Washington State (personal communications, November-December 2023). Key informants also expressed concern that independently owned, new, and minority-owned businesses may be the least able to absorb the financial shock of electrifying (personal communications, December 2023).

There are some programs, assistance, or incentives available to customers to support electrification. For example, the federal Inflation Reduction Act created rebates for customers purchasing a new electric or induction stove (up to $840) as well as an additional incentive ($500) for those switching from gas or propane.[91] However, it is unknown what programs, assistance, or incentives are or would be available to customers to support electrification if ESHB 1589 were to pass, or who may be eligible for these programs.

Inequities due to racism

Evidence indicates that certain groups of people are more likely to experience poor air quality due to structural and environmental racism.[75] Environmental racism can be defined as "any policy, practice or directive that differentially affects or disadvantages (where intended or unintended) individuals, groups or communities based on race".[76] In contrast, environmental justice can be defined as "the right to a clean environment and workplace."[75] The impacts of

environmental racism on exposure to outdoor air pollution have been examined. One study found that areas of the U.S. with higher-than-average Black, Asian, and Hispanic or Latino populations have been consistently exposed to higher $PM_{2.5}$ levels, as compared to areas with higher-than-average white populations.[77] In a separate multilevel analysis of over 65,000 U.S. census tracts, the researcher used a state racism index to gauge Black-white inequities to measure differences in exposure to outdoor pollution.[75] Results of the study show that states with higher levels of Black-white gaps had higher levels of exposure to air pollution and more environmental health risk.[75] The author stated that, "the disproportional exposure across communities is tied to systematic inequalities in environmental regulation and other structural elements such as housing and incarceration."[75]

Data show that Black families with low-incomes are more likely to be below the federal poverty level than other families (53% of Black families, compared to 39% of non-Hispanic white, 44% of Hispanic, and 42% of families of another race).[92] Further, households face a high energy burden when they spend more than 6% of their income on energy and experience a severe energy burden when spending more than 10% of their income on energy.[78] Research shows that energy burdens tend to be higher among Black, Hispanic, and Native American households.[78] One analysis found that in Seattle, "14% of Black households and 15% of Hispanic households in the area experience a high energy burden (above 6%), compared to a citywide median energy burden of 1.8%."[78] The same study found that "the median energy burden of Black households in Seattle is 28% higher than that of non-Hispanic white households."[78] Further, households of color with lower incomes are more likely to live in "older, less energy efficient homes, where energy efficiency upgrades would improve both the health and financial stability of the household."[22]

Evidence indicates that air pollution is higher in areas of the U.S. with more people of color and more people with low socioeconomic status.[79] Communities of color also experience higher rates of health conditions related to poor air quality.[22,67,79,80] For example, communities of color and people with lower household incomes experience higher concentrations of and exposures to NO_x and $PM_{2.5}$ emissions, as well as additional air pollutants, which contribute to measurable differences in health and life expectancy.[22,79] A large cohort study found that men; Black, Asian, and Hispanic people; and people eligible for Medicaid (interpreted as an indication of low socioeconomic status) were found to have greater risk of death with exposure to $PM_{2.5}$ than the general population.[80] In addition, "15.7[%] of [Black] non-Hispanic children have asthma, compared to about 7.1[%] of white non-Hispanic children."[67] Research shows that people of color are more likely to have higher rates of emergency department visits for asthma and other diseases and are "more likely to be living with at least one chronic condition that enhances their susceptibility to air pollution, including asthma, diabetes, and heart disease."[22] One researcher stated, "racial-ethnic exposure [inequities] to air pollution from emissions sources are found to be consistent across incomes and within urban and rural areas."[22] Overall, communities of color are more likely to experience poor air quality and worse health outcomes related to poor air quality. Reductions in exposure to natural gas may lead to some decreases in exposure to harmful pollutants and decreases in some negative health outcomes. However, reductions in exposure to natural gas are unlikely to comprehensively decrease systemic inequities in air quality due to racism.

Inequities by socioeconomic status

Evidence indicates that certain groups of people are more likely to experience poor air quality due to inequities in socioeconomic status. Data indicate that "in 2018, 11% of low-income households across Washington faced a high or severe energy burden…"[78] However, energy burdens vary across Washington State. For example, 37% of low-income households in Ferry County experience a high energy burden, compared to 6% in Snohomish County.[78]

Households with lower socioeconomic status are "more likely to suffer health effects from […] air pollution."[67] For example, people living in smaller housing units, housing units with more people living in the home, and less adequate ventilation has been shown to contribute to increased levels of NO_2 in the home.[67] Further, research indicates that use of gas stoves or space heaters as a source of heat is somewhat common, is associated with lower income, and can negatively impact indoor air quality.[67] For example, a "study of 150 asthmatic pre-school age children in Baltimore found that 14[%] of households use the stove/oven as a source of heat, which consistently produced higher levels of NO_2 than using stoves only for cooking."[67] In addition, approximately 90% of rental homes do not have adequate ventilation for gas cooking.[81] Renters do not usually have the ability to choose which fuel is used in their home.[81] People with low income are also less likely to have access to healthcare or be able to afford interventions to reduce air pollution exposure, which can exacerbate negative health outcomes.[82]

In addition, certain costs are associated with transitioning from natural gas to electricity. Evidence indicates that building some types of electric-ready infrastructure (e.g., single family homes) is less expensive than building infrastructure with natural gas.[44] For example, "gas piping increases the cost to construct a typical single-family home in Washington [State] by $2,940."[44] However, key informants shared that some all-electric development (e.g., midrise or high rise) currently costs more to develop than if a project was served by both natural gas and electricity (personal communications, December 2023). Meanwhile, all-electric homes save approximately $40 on utilities each year and avoid common price fluctuations of gas market prices.[44] Key informants also stated that continued use of natural gas across Washington State could increase costs to customers (personal communications, November-December 2023). For example, as natural gas customers decrease over time, costs to continue to provide natural gas services increases (personal communications, November-December 2023). However, there are additional costs to people who currently have and use natural gas but may experience discontinued service under passage of ESHB 1589. Households may need to purchase new electric appliances and/or upgrade or modify their home electricity system if gas service is limited. Costs for new electric appliances and system updates vary widely. Lastly, research also shows that as income increases, homes tend to shift to cleaner and more convenient high-quality energy.[36] Research has also found that education level, household awareness, household size, and health influence energy transition behaviors.[36]

Overall, communities with low incomes are more likely to experience poor air quality. Reductions in exposure to natural gas may lead to some decreases in exposure to harmful pollutants and decreases in some negative health outcomes for people with low incomes. However, transitioning to electricity may increase initial costs to some people, and reductions in exposure to natural gas are unlikely to comprehensively decrease systemic inequities in air quality by socioeconomic status.

Inequities by age

Evidence shows that children and older adults are particularly sensitive to poor air quality. Children's immature respiratory systems and incomplete development of the immune and nervous systems contribute to experiencing worse health outcomes related to poor air quality.[36] Children are generally more susceptible to air pollutants, including PM and NO_x, as their respiratory systems are still developing and they have a faster breathing rate.[83-85] For example, a prospective cohort study of 1,759 children (average age, 10 years) found associations between air pollution and 3 measures of lung function—forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and maximum mid-expiratory flow rate.[84] Results of the study showed the effects of ambient air "pollutants on FEV1 were similar [regardless of gender], and remained significant among children with no history of asthma and among those with no history of smoking, suggesting that most children are susceptible to the chronic respiratory effects of breathing polluted air."[84] Specifically, "cumulative deficits in the growth of lung function during the [8]-year study period resulted in a strong association between exposure to air pollution and a clinically low FEV1 at the age of 18 years."[84] Authors noted such lung function deficits may increase the risk of respiratory conditions in young adulthood.[84] Furthermore, "reduced lung function is a strong risk factor for complications and death during adulthood."[84]

Exposure to pollution from natural gas stoves impacts children's respiratory health. A meta-analysis that examined the association between gas stoves and childhood asthma found that "children in homes with gas stoves have a 42[%] increased risk of experiencing asthma symptoms (current asthma), a 24[%] increased risk of ever being diagnosed with asthma by a doctor (lifetime asthma), and an overall 32[%] increased risk of both current and lifetime asthma."[67] A separate study that examined population-level impacts of gas cooking and childhood asthma found that 12.7% of current childhood asthma in the U.S. is attributable to gas stove use.[63] Health impacts are worsened among children with intersecting marginalized identities. For example, "children living in areas with high levels of outdoor air pollution and lower-income, African-American and Hispanic children with asthma are likely the most disproportionately burdened by indoor air pollution from gas stoves."[67] However, one systematic review and meta-analysis found that literature conducted on gas cooking and respiratory outcomes in children are mostly cross-sectional studies, include various definitions of key terms, and have potential sources of bias and inaccuracies.[41] The researchers of this particular review and meta-analysis concluded that the literature has a high degree of heterogeneity, is generally of low study quality, and "does not provide sufficient evidence regarding causal relationships between gas cooking or indoor NO_2 and asthma or wheeze."[41]

Older adults are also more susceptible to air pollutants than the general population.[86] Older adults have lowered immune response and physiological functions which contribute to experiencing worse health outcomes related to poor air quality.[36] Older adults are also more likely to have unrecognized heart or lung diseases which can impact health outcomes related to poor air quality.[82] Evidence shows that exposure to air pollution from fossil fuel appliances can also increase risk of dementia and Alzheimer's Disease.[44] In addition, research shows that energy burdens tend to be higher among elderly households.[78] While there are currently no studies of the health effects of cooking with gas stoves among older adults, older adults are more sensitive to NO_2 and at higher risk of negative health outcomes related to NO_2 exposure.[81] Overall, evidence

indicates that decreased exposure to natural gas may decrease inequities among children and older adults.

Inequities by existing health conditions
People with existing health conditions (i.e., respiratory infections, respiratory diseases, heart or circulatory disease, diabetes, history of stroke) are especially sensitive to air pollution.[83,86,87] People with heart or lung diseases are at increased risk because PM can aggravate these health conditions.[83] People with a prior history of heart attack or stroke and people with diabetes are also at heightened risk of experiencing severe health impacts due to poor air quality.[82] In addition, inequities for children may be compounded by intersecting inequities due to health conditions. According to the 2021 Washington Healthy Youth Survey, 16.0% of Washington 10th graders reported that a doctor or nurse told them they had ever had asthma.[88] Researchers have stated that households with asthma, chronic pulmonary disease, or other respiratory diseases should consider transitioning from gas to electric cooking stoves.[40] Overall, evidence indicates that decreased exposure to natural gas may decrease inequities among people with certain existing health conditions.

Inequities among women and pregnant people
Women and pregnant people experience inequities related to air quality. Evidence indicates that women's heightened sensitivity of respiratory and cardiovascular systems leads to worse health outcomes after exposure to poor air quality.[36] In addition, people who are pregnant are at heightened risk of poor air quality because both the pregnant person and the fetus may be exposed to pollutants.[36,82] For example, research on a prospective birth cohort of pregnant people in Spain found that the presence of a gas cooker in the home was associated with decreased mental development among children at age 14 months.[89] Evidence indicates that decreased exposure to natural gas may decrease inequities among women and pregnant people.

Overall, there is unclear evidence how improving health outcomes related to decreased exposure to natural gas emissions may impact equity in Washington State. While it is well-documented that people of color, people with low socioeconomic status, children, older adults, people with heart and lung diseases, women, and pregnant people are most likely to be affected by air particle pollution exposure, it is unknown who may be directly affected by decreased exposure to natural gas emissions under ESHB 1589. Specifically, it is unknown 1) who in PSE's service area currently has natural gas service; 2) who may occupy new residential and commercial construction prohibited from using natural gas; 3) who may have their natural gas service discontinued in the future; and 4) whether programs, assistance, or other incentives are or will be available to customers to support electrification and who may be eligible for these programs.

Annotated References

1. **U.S. Energy Information Administration. Natural gas explained. 2022; Available at: https://www.eia.gov/energyexplained/natural-gas/. Accessed 11/15/23.**
The U.S. Energy Information Administration (EIA) "collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment." This webpage provides an overview of natural gas (e.g., where it comes from, how it forms, its use).

2. **Agency U.S. Environmental Protection. 1.4 Natural Gas Combustion. 6th ed1996.**
This subsection of a U.S. Environmental Protection Agency document discusses natural gas combustion including firing practices, emissions, controls, and updates since the 5th edition.

3. **Michanowicz D. R., Dayalu A., Nordgaard C. L., et al. Home is Where the Pipeline Ends: Characterization of Volatile Organic Compounds Present in Natural Gas at the Point of the Residential End User. *Environ Sci Technol.* 2022;56(14):10258-10268.**
Michanowicz et al collected samples of natural gas in the Greater Boston metropolitan area to study the amount of volatile organic compounds (VOCs) present. The researchers cite prior research to explain that U.S. oil and natural gas production makes up over 69% of the total U.S. energy consumption, where natural gas is the dominant energy source for the industrial, commercial, residential, and electrical power generation sectors. Approximately 2.49 million tons of VOCs are emitted each year from oil and natural gas production in the U.S. Compounds such as benzene, toluene, ethylbenzene, and ortho-, meta- and para-xylenes (collectively BTEX) are present in unprocessed natural gas and are toxic, carcinogenic, and/or atmospherically reactive. Further, natural gas distribution systems are the largest source of urban methane. This study sought to understand whether these compounds are also present in processed natural gas. Samples (N= 234) were collected at 69 different locations and were tested for methane, ethane, and nonmethane volatile organic compounds (NMVOC). The researchers collected samples from indoor natural gas stovetops and outdoor gas appliance lines and used U.S. Environmental Protection Agency (US EPA) Methods to guide their sample collections and conducted a spatially stratified sample design. Sample collection quality control and assurance measures were conducted. Study results showed that there were 296 NMVOC in end-use natural gas, and 7% of these compounds are hazardous air pollutants. Substances detected included benzene, hexane, toluene, heptane, and cyclohexane. Emissions were heightened during winter months. The researchers estimated that 120-356 kg/yr of annual benzene emissions from natural gas in the Greater Boston area are not accounted for in emissions inventories and that there are additional indoor emissions unaccounted for. The researchers also estimate that leakage from natural gas may create underreported methane and additional VOCs. The authors connect the research findings to health, and state that natural gas leakage negatively impacts air quality through direct toxicants “and indirectly as ozone precursors and precursors to [secondary organic aerosol (SOA)] that make up a fraction of PM2.5.” The researchers stated, “addressing [natural gas]-methane leakage for climate reasons may produce additional health co-benefits through this inhalation risk pathway.”

4. **U.S. Energy Information Administration. 2020 Residential Energy Consumption Survey (RECS) Data. 2023; Available at: https://www.eia.gov/consumption/residential/data/2020/index.php?view=characteristics. Accessed 12/19/2023.**
This U.S. EIA webpage provides data from the Residential Energy Consumption Survey (RECS) collected in late 2020 and early 2021. Final data were released in March 2023. Data include highlights for fuels used in U.S. homes by state. For example, 2020 data indicate that 41% Washington homes were all-electric (i.e., do not use natural gas, propane, wood, fuel oil, or kerosene for any end use; homes may use other fuels for outdoor grilling only). Natural gas was used in 45% of homes for any number of end uses. Table HC1.5 presents fuels used and end uses in U.S. homes by household income in 2020. Evidence indicates that natural gas was used in 61% of U.S. homes for some end use in 2020. Households with lower incomes were less likely than average to have natural gas service (i.e., 56% of households with <$5,000 income; 53% of households with $5,000-$9,999; 54% of households with $10,000-$19,999; 56% of households with $20,000-$39,999; and 58% of households with $40,000-$59,999). While households with higher incomes were more likely than average to have natural gas service (67% of households with $100,000-$149,999 income and 73% of households with income >$150,000). This trend holds true for all end uses (i.e., space heating, water heating, cooking, and outdoor grilling). Table HC1.2 presents fuels used and end uses in U.S. homes, by owner or renter. Evidence indicates that housing units (single family, mobile homes, and apartments) occupied by an owner were somewhat more likely to have natural gas service than those occupied by a renter. Among U.S. housing units with natural gas service, the most common end use was space heating (86%) followed by water heating (81%), cooking (64%), and outdoor grilling (6%).

5. **Issue Brief 4: Washington State's Energy System. In: Commission WUaT, ed. Lacey, WA2022.**
This Issue Brief from the Washington Utilities and Transportation Commission describes Washington's energy system, including natural gas consumption and transmission as well as electricity generation (e.g., using natural gas), consumption, and transmission.

6. **Washington State Energy Profile. Available at: https://www.eia.gov/state/print.php?sid=WA. Accessed 11/28/2023.**
This U.S. Energy Information Administration (EIA) webpage provides an overview of the Washington State Energy Profile, including information about energy consumption. It also provides specific information about natural gas and other fuel sources.

7. **Table 25. Heating value of natural gas consumed, by state, 2021-2023. In: Administration USEI, ed. November 2023 ed2023.**
This table summarizes data sourced from the U.S. Energy Information Administration: Form EIA-857, *Monthly Report of Natural Gas Purchases an Operations Report.*

8. **Units and calculators explained: British thermal units (Btu). Available at: https://www.eia.gov/naturalgas/monthly/pdf/table_25.pdf. Accessed 12/7/2023.**
This U.S. Energy Information Administration webpage provides and overview of British thermal units (Btu).

9. **Administration U.S. Energy Information. Annual household site fuel consumption in United States homes by state—totals and averages, 2020. 2023.**
The Residential Energy Consumption Survey includes information about what types of fuel is used by states in the U.S. Data indicate that in 2020, 41% of Washington State homes used natural gas.

10. **Puget Sound Energy. About us. Available at: https://www.pse.com/en/about-us. Accessed 11/15/2023.**
This Puget Sound Energy (PSE) webpage provides an overview of the company, its customers, and its service area.

11. **Issue Brief 2: Climate Legislation in Washington State. In: Commission WUaT, ed. Lacey, WA2022.**
This issue brief from the Washington Utilities and Transportation Commission describes state legislation that addresses climate change by prioritizing decarbonization.

12. **FAQ: Energy Decarbonization Pathways Examination. Lacey, WA: Washington Utilities and Transportation Commission; 2022.**
This FAQ provides an overview of decarbonization pathways and answers general questions about decarbonization.

13. **Washington State Department of Commerce. Clean Energy Transformation Act. 2023; Available at: https://www.commerce.wa.gov/growing-the-economy/energy/ceta/. Accessed 12/1/2023.**
This Washington State Department of Commerce webpage provides an overview of the Clean Energy Transformation Act (CETA).

14. **Concerning the Washington Climate Commitment Act, Chapter 316, Laws of 2021 (partial veto), Revised Code of Washington(2021).**
This statute is known as the Washington Climate Commitment Act. Among other provisions, the statute created a cap and invest program for greenhouse gas emissions to be implemented by the Department of Ecology.

15. **RCW 19.27A.160 Residential and nonresidential construction—Energy consumption reduction—Council report, Revised Code of Washington(2009).**
This state statute establishes the State Building Codes Council responsibility to adopt state energy codes that incrementally move towards achieving a 70% reduction in annual net energy consumption, using the adopted 2006 Washington state energy code as a baseline.

16. **About the Council. Available at: https://sbcc.wa.gov/. Accessed November 22, 2023.**
The Washington State Building Code Council "establishes the minimum building, mechanical, fire, plumbing and energy code requirements necessary to promote the health, safety and welfare of the people of the state of Washington, by reviewing, developing and adopting the state building code." As of November 2023, amended codes are being reviewed by the Council, and included changes related to natural gas regulation.

17. **Council Washington State Building Code. Proposed Rule Making CR 102 In: Reviser OotC, ed. Vol WSR 23-21-105. Olympia, WA2023.**
This CR-102 filing announced the State Building Council's rulemaking to modify sections of the commercial and residential energy codes.

18. **Council Washington State Building Code. Proposed Rule Making CR 102 In: Reviser OotC, ed. Vol WSR 23-21-106. Olympia, WA2023.**
This CR-102 filing announced the State Building Council's rulemaking to modify sections of the commercial and residential energy codes.

19. **Adopted Changes to the Energy Code for EPCA Concerns. 2023; Available at: https://www.sbcc.wa.gov/news/adopted-changes-energy-code-epca-concerns. Accessed 1/3/2024.**
This Washington State Building Code Council website announced the newly adopted energy codes for both commercial and residential buildings.

20. **Wochner D.L., Mayer B.A., Endemann B.B. , et al. Ninth Circuit cans Berkeley Gas Ban under Federal Law. *The National Law Review.* 2023;XIII(332).**
This article in The National Law Review outlines the history of the *California Restaurant Association v. City of Berkeley* case as well as the Ninth Circuit Court of Appeals' decision. The Court struck down Berkeley's Ordinance No. 7,672-N.S., titled "Prohibition of Natural Gas Infrastructure in New Buildings." The analysis discusses implications of the decision specifically the emphasis on the "use" of covered products, federal Energy Policy and Conservation Act (EPCA) preemption of local building codes. Seven requirements (outlined in the article) must be met for a state or local building code to survive EPCA preemption.

21. **How much does natural gas contribute to climate change through CO2 emissions when the fuel is burned, and how much through methane leaks? 2023; Available at: https://climate.mit.edu/ask-mit/how-much-does-natural-gas-contribute-climate-change-through-co2-emissions-when-fuel-burned. Accessed, 2023.**
The Massachusetts Institute of Technology Climate Portal published this article about emissions due to natural gas. The article features evidence from the U.S. Energy Information Administration, U.S. Environmental Protection Agency, and peer-reviewed literature. The authors describe ways that CO2 emissions due to burning natural gas and methane leaks are both contributors to climate change.

22. **National Academies of Sciences Engineering, and Medicine. Press TNA.Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions.2023.**
This prepublication version of a Consensus Study Report, by the National Academies of Sciences, Engineering, and Medicine, documented the evidence-based consensus of the Committee on Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions. It was the second report from the committee that was constituted in 2020 to address “societal, institutional, behavioral, and equity drivers and implications of deep decarbonization.” The report was subjected to a rigorous and independent peer-review process, and it represents the position of the National Academies on the statement of task. The committee’s analysis “resulted in approximately 80 recommendations directed toward a variety

of government, non-profit, and private-sector actors. These recommendations can be grouped into […] 10 broad categories, which represent main themes of the report" including Ensuring Equity, Justice, Health, and Fairness of Impacts.

23. **Zero Emission Building Ordinances. 2023; Available at: https://buildingdecarb.org/zeb-ordinances. Accessed 11/28/2023.**
This webpage from the Building Decarbonization Coalition tracks state and local government decarbonization efforts.

24. **Nilsen E. . Cities tried to cut natural gas from new homes. The GOP and gas lobby preemptively quashed their effort. *CNN.* 2/17/2022, 2022.**
This news article details those states that have passed "preemption laws" that prohibit municipalities from banning natural gas as well as bills being considered by state legislatures as of February 2022. The reporter cites evidence from the U.S. Environmental Protection Agency that U.S. residential and commercial emissions comprised 13% of the country's total emissions in 2019. "Roughly 80% of emissions came from the combustion of natural gas, the fuel that heats homes or powers a restaurant's cooking stoves, and emits planet-warming gases like methane and carbon dioxide in the process."

25. **Bumatay Judge. Opinion in California Restaurant Association v. City of Berkeley. In: Circuit USCoAftN, ed. *D.C. No. 4:19-cv-07668-YGR.* Vol No. 21-162782023.**
This Decision of the Court establishes the ruling of the U.S. Court of Appeals for the Ninth Circuit in the California Restaurant Association v. City of Berkeley case. The Court held that the Association established that Berkeley's ordinance would "imminently harm its members because it alleged that its members would open or relocate a restaurant in Berkeley but for the city's ban on natural gas piping. The Opinion was written by Judge Bumatay and Concurrences were written by Judge O'Scannlain and Judge Baker.

26. **Legal Planet. What's Next in the Fight over Berkeley's Natural Gas Ordinance. 2023; Available at: https://legal-planet.org/2023/06/01/whats-next-in-the-fight-over-berkeleys-natural-gas-ordinance/. Accessed 12/8/2023.**
This article from Legal Planet provides an overview of the status of the *California Restaurant Association v City of Berkeley* case as the Ninth Circuit considers Berkeley's petition to rehear the case. Legal Plant is an independent, academic law and policy blog and a collaboration between faculty at UC Berkeley School of Law and UCLA School of Law.

27. **Walsh S.T., Allen B., Klass A., et al. No. 21-16278 Brief for the United States as Amicus Curiae In Support of Petition for Rehearing. In: Energy USDo, ed. 6/12/2023 ed. Washington, DC2023.**
This U.S. Department of Energy Amicus Curiae was submitted in support of the City of Berkeley's petition to the U.S. Court of Appeals for the Ninth Circuit to rehear the *California Restaurant Association v. City of Berkeley* case. It stated, "This Court should grant rehearing to correct a panel opinion that destabilizes the long-settled understanding shared by the [U.S. Department of Energy], the States, municipalities, and the courts over the allocation of regulatory authority in this area." Authors reasoned, the ruling "threatens to preempt broad

swaths of State and local health and safety law; and throws a wrench into the federal government's administration of the [Energy Policy and Conservation Act]."

28. **CRA v. City of Berkeley, Order and Amended Opinion. In: Circuit USCoAftN, ed. *D.C. No. 4:19-cv-07668-YGR.* Vol No. 21-16278 2024.**
The Ninth Circuit Court of Appeals panel issued an order and amended opinion on January 2, 2024. It denied the City of Berkeley's petition for rehearing en banc and ordered that no future petitions be entertained. Eight justices dissented from the denial of rehearing en banc.

29. **An Act Driving Clean Energy and Offshore Wind, General Laws of the Commonwealth of Massachusetts, §84 (2022).**
This Massachusetts State law provided for a pilot project in which 10 local communities can "adopt and amend general or zoning ordinances or by-laws that require new building construction or major renovation projects to be fossil fuel-free, and enforce restrictions and prohibitions on new building construction and major renovation projects that are not fossil fuel-free".

30. **An act expanding access to the fossil fuel free demonstration project. Sabadosa, trans. *Commonwealth of Massachusetts.* Vol Chapter 179 of the Acts of 2022. 193rd ed2023.**
This bill before the General Court of the Commonwealth of Massachusetts would expand the demonstration project to accept any city or town that has local approval provided that the town or city meets the criteria included in the bill (e.g., housing affordability threshold, specified zoning ordinance).

31. **More Massachusetts cities seek to ban gas, citing lack of diversity in pilot and urgency of climate crisis. 2023; Available at: https://energynews.us/2023/08/03/more-massachusetts-cities-seek-to-ban-gas-citing-lack-of-diversity-in-pilot-and-urgency-of-climate-crisis/. Accessed 11/29/2023.**
This article published by the Energy News Network describes efforts in Massachusetts to expand the state's pilot project passed in 2021 which will allow 10 communities to enact policies to ban new fossil fuel hookups. A new bill, H.3227, was proposed during the 2023 Session. The article noted that the Department of Energy Resources' final regulations for the pilot program were to be enacted August 4, 2023.

32. **Ramirez R. , Nilsen E. . New York becomes the first state to ban natural gas stoves and furnaces in most new buildings. *CNN*2023.**
This news article announced New York State's ban on natural gas and other fossil fuels in most new buildings. The ban does not apply to all new buildings. Specifically, large commercial and industrial buildings (e.g., stores, hospitals, laundromats, and restaurants) are excluded from the policy.

33. **O'Brien B. New York State bans natural gas in some new construction. *Reuters.* 5/3/2023, 2023.**
This news article reported on New York State's ban on natural gas in some new construction.

34. **Press Associated. Lawsuit to Block New York's Ban on Gas Stoves Is Filed by Gas and Construction Groups. *U.S. News & World Report.* 10/13/2023, 2023.**
This news article reports on the New York State policy prohibiting gas stoves and furnaces in new buildings and the court cased filed by the National Association of Home Builders and the National Propane Gas Association, and others, which alleges the rules are preempted by the federal Energy Policy and Conservation Act.

35. **Simões M. . Efforts to Block Gas Bans Across the Nation Are Growing. Will it Work in New York? *City Limits.* 11/29/2023, 2023.**
This news article discusses the New York State law to prohibit the use of fossil fuel equipment in new construction. On October 12, 2023, a lawsuit was filed by 13 plaintiffs in the Court for the Norther District of New York arguing that the new law "violates a federal law that gives the U.S. government authority to set energy-efficiency standards for appliances." The suit follows a similar case in California, in which the Ninth Circuit federal appeals court overturned the City of Berkeley's ban on natural gas.

36. **Li Hui, Li Yue, Zheng Guoliang, Zhou You. Interaction between household energy consumption and health: A systematic review. *Renewable and Sustainable Energy Reviews.* 2024;189.**
Li et al. conducted this systematic literature review and bibliometric analysis to examine household energy use. The research studies were gathered from the Web of Science core database between 1985 and 2021. The researchers included 583 documents for review. The bibliometric analysis included several steps to delete records without certain information and then analyzed the relationship between keywords to generate a graph and visual. The researchers studied the following 4 hotspots: household energy consumption and indoor air pollution, indoor air pollution and health, household energy consumption and health, and rural household energy consumption and energy transition. Each of these research hotspots were systematically reviewed and analyzed separately. Research object, scope, and method are also explored. Information is provided on which keywords are closely linked to the topics in this paper. Households use energy for cooking, heating, cooling, lighting, transportation, and more. Households may use coal, straw, liquefied petroleum gas, natural gas, and/or electricity for these functions. The residential sector accounts for about one-third of all energy consumption, after industrial and transportation sectors. Prior research found that individual awareness and energy attitude can significantly impact household energy consumption. The authors describe a cycle among household users and state that use of clean energy improves health and improved health can allow consumers to be aware of the impact of energy consumption on their own wellbeing. Overall, the results of this study show that “household energy consumption and health are mutually affected through channels of indoor air quality and health awareness.” Household energy consumption and indoor air pollution research is categorized into economic and behavior-oriented paradigms, where consumers make choices about energy fuels based on costs/benefits and a myriad of additional motivating internal and external factors. A separate review and meta-analysis found that most low and middle income countries are impacted by indoor air pollution due to solid fuel combustion. Indoor air pollution and health are linked, and “as air pollution intensifies, there is a commensurate rise in the global burden of disease.” More specifically, household air pollution from solid fuels caused 2.3 million deaths worldwide. Among them, 1.06 million deaths are attributed to cardiovascular diseases, 420,000 deaths are caused by respiratory

infections and tuberculosis, while 398,000 deaths are associated with chronic respiratory diseases." Most research focused on solid fuels as sources of CO, SO2, PM, and soot, and health impacts varied depending on exposure. The research showed that women, children, and elderly were most affected by exposure. These differences were due to the following: children's immature respiratory systems and incomplete development of the immune nervous system, the elderly's lowered immune response and physiological functions, women's heightened sensitivity of respiratory and cardiovascular systems, and pregnant people's increased vulnerability to air quality. Indoor air pollution and indoor smoke lead to asthma, respiratory system diseases, and additional disease burdens. Research showed that education, disposable income, and health awareness partially mitigate some of these impacts. Indoor air pollution reduced life expectancy and elevated disease prevalence and hospitalization rates. It could also potentially lead to decreased cognitive function, mental disorders, and lowered quality of life. The negative health impacts were due to cooking, heating, and other energy use activities. Further, as cleaner energy leads to less health burden, consumers may make different choices about their home fuel type. Research showed that awareness and attitude change whether homes purchase energy efficient products. Research on energy transition among rural areas found that transition is influenced by many factors, including resource endowment and energy availability. Policies, policy enforcement, and income subsidies can speed up the transition processes. As income increases, homes tend to shift to cleaner and more convenient high-quality energy. Research has also found that education level, household awareness, household size, and health also influence transition behaviors. Cultural traditions may also influence consumers. Health factors are often neglected in rural household energy selection. "Heating fuels such as natural gas and solar energy, are preferred due to lower pollutant emissions compared to coal and oil. They have a minimal impact on air quality and mitigate risks associated with respiratory and cardiovascular health." Discussion on the research methods used in the studies reviewed is included. The authors reiterate the importance of health awareness, especially in rural areas.

37. **Lebel E. D., Finnegan C. J., Ouyang Z., Jackson R. B. Methane and NO(x) Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes.** ***Environ Sci Technol.*** **2022;56(4):2529-2539.**

Lebel et al. calculated methane and NOx emissions generated from stoves powered by natural gas. The researchers calculated the amount of methane released from 53 homes through several stages of stove use (steady-state-off, turning on and off, and during combustion) and quantified NOx emissions during combustion. The article explains that natural gas leaks that occur inside homes are called "post-meter" emissions. The researchers cited prior research, stating that appliances in Boston and Indianapolis (excluding pilot light emissions) emitted 0.038% of the gas they consumed, while whole home post meter emissions in California totaled 0.5% of the residential consumption of all natural gas statewide. Across the U.S., about one-third of homes use natural gas for home cooking, which is greater than 40 million homes. While the U.S. does not have indoor exposure guidelines for NO2, "Canada has a maximum residential exposure limit of 90 parts per billion (ppb) over a 1 h exposure and 11 ppb over the long term (>24 h)." In this study, homes across 7 California counties were studied. Stove burners were measured using a room chamber method, and the researchers injected the space with ethane to determine the room volume by dilution and ethane decay. These measurements, along with the steady-state off, combustion, steady-state on measurements of methane were collected several times per site. From there, methane emission measurements were scaled to estimate national levels. The study

results showed that "natural gas stoves emit [approximately] .08-1.3% of the gas they use as unburned methane and that total U.S. stove emissions are 28.1 Gg CH4 year−1." Emissions from stoves in a steady-state-off were responsible for 76% of total emissions. The results also showed that all combined gas stoves across the U.S. emit approximately the same amount of carbon dioxide as 500,000 cars. The researchers also explained that gas stoves also emit NOx, where the NOx emitted was linearly related to the amount of natural gas burned. NOx exposure can lead to respiratory diseases. Exposure of NO2 can be reduced when using a range hood, but data show that lack of hood use or poor ventilation can lead to levels of NO2 that surpass the 1-h national standard. The researchers include a summary of findings from previous methane studies. The researchers did not find differences in emissions based on age, purchase price, and average income levels where the stoves were located. The research concluded with study limitations and recommendations.

38. **Luo M., Liu T., Ma C., et al. Household polluting cooking fuels and adverse birth outcomes: An updated systematic review and meta-analysis. *Front Public Health.* 2023;11:978556.**

Luo et al. conducted a systematic review and meta-analysis to examine the association between household polluting cooking fuels and adverse birth outcomes. The authors cited prior research to state that household air pollution exposure is "associated with chronic obstructive pulmonary disease, lung cancer, acute respiratory infections, cerebrovascular disease, ischemic heart disease, and adverse birth outcomes [… and] has also been associated with epigenetic adverse effects, which change DNA expression and potentiate the inflammatory effects of pollutants." In this research, studies were considered for inclusion "if they were (1) original studies, (2) conducted in the human population, and (3) quantified the association between [household air pollution] exposure during pregnancy and adverse birth outcomes ([low birth weight, small for gestational age, stillbirth, and preterm birth])." One of the reasons for article exclusion was if the control group was not exposed to clean fuels, which included natural gas. The research included articles published up until January 16, 2023, and included 16 cross-sectional, 5 case–control, and 11 cohort studies. The majority of the studies were conducted in Asia. The research examined the strength of the associations in the studies and included subgroup and meta-regression analyses to explore sources of heterogeneity. The authors followed the PRISMA guidelines. Details on data extraction, quality assessment, and statistical analysis were included. The results of the analysis found that polluting cooking fuels were associated with low birth weight, stillbirth, small for gestational age, and preterm birth. However, the authors stated that limited literature, observational study design, exposure and outcome assessment, and residual confounding within the studies analyzed signal there is a need for additional research. Study design and sample size were associated with heterogeneity and cooking fuel types were potentially heterogeneous. The researchers stated that the use of cooking fuels can emit PM and NO2. Further, "biomass fuels had a larger pooled [odds ratio] for the association with [low birth weight] than fossil fuels." The researchers discussed study limitations and ideas for future research. The results of this analysis should be interpreted with caution, since many studies included are cross-sectional and case-control, there is possibility for misclassification of outcome and exposure, and since the analysis included heterogeneity even after the subgroup, meta-regression, and sensitivity analyses were conducted.

39. **Singer B. C., Pass, R.Z., Delp, W.W., Lorenzetti, D. M., Maddalena, R. L. . Pollutant concentrations and emission rates from natural gas cooking burners without and with range hood exhaust in nine California homes.** ***Building and Environment.*** **2017;122:215-229.**

Singer et al. examined the operation of natural gas cooking burners in 9 homes in California to measure time-resolved concentrations of carbon dioxide (CO2), nitric oxide (NO), nitrogen oxides (NOx), nitrogen dioxide (NO2), particles with diameters of 6 nm or larger (PN), carbon monoxide (CO), and fine particulate matter (PM2.5). The authors cited prior research to describe that natural gas cooking burners contribute to emission factors and/or indoor concentrations of ultrafine particles. Further, "many studies have reported elevated concentrations of CO and NO2 in homes with natural gas cooking burners, compared to homes with electric cooking." A separate study of 350 California homes found that NO2 and NO concentrations increased with increased use of natural gas cooking burners. Lastly, a "modeling study of multifamily housing in Boston found that cooking with gas burners is a major source of NO2 in homes." The measurements in this study were conducted in the kitchen and bedroom and took place after boiling and simmering activities on the stovetop and in the oven, and with and without a range hood in use. The cooking appliance details varied across the 9 homes, and not all appliances included a venting hood range. The results showed 4 out of 9 of the homes had kitchen levels of NO2 above the national ambient air quality standard. The researchers found that range hood functionality varied, with the largest reduction in PN reduced by 80-95%. The researchers stated that increased awareness of the need to ventilate when cooking and building standards may decrease exposures to NO2.

40. **Balmes J. R., Holm S. M., McCormack M. C., et al. Cooking with Natural Gas: Just the Facts, Please.** ***Am J Respir Crit Care Med.*** **2023;207(8):996-997.**

Balmes et. al. wrote this research brief regarding natural gas stoves and the impact of natural gas on health and climate change. Methane is the main ingredient in natural gas, which is "86 times more potent than CO2." The authors stated, "[n]atural gas is the primary residential fuel type for heating and cooking in the [U.S.], with 15% of all natural gas use attributed to residential consumers." The researchers stated, "[u]sing a 20-year time frame for methane's climate forcing, 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." Some particulate matter is released during cooking, regardless of the type of fuel used. Nitrogen dioxide is emitted by gas cooking but not by electric cooking. Nitrogen oxides are irritant gases that "can cause bronchoconstriction, airway hyperresponsiveness, and airway inflammation with increased risk of asthma exacerbations, bronchitis, and wheezing." Indoor gas cooking can lead to levels of NO2 that are beyond the recommended levels described in outdoor air quality recommendations set by the EPA (National Ambient Air Quality Standard [NAAQS] of 100 ppb). The researchers stated that even lower levels of NO2 may impact asthma. A 2013 systematic review found a pooled odds ratio of 1.34 when examining the relationship between asthma and gas cooking. One study found that "13% of childhood asthma could be prevented by eliminating gas cooking." At the time of this publication, there were likely no randomized controlled trials examining the transition from gas to electric cooking and the impacts on children's health. One randomized controlled trial found that electrification of cooking can decrease NO2 in the kitchen and bedroom, and that filtration devices decrease NO2, and use of stove range hoods can reduce both NO2 and PM2.5. The authors stated that households with asthma, chronic pulmonary disease, or

other respiratory diseases should consider transitioning from gas to electric cooking. The authors concluded with policy recommendations and state that "eliminating natural gas hookups for new residential construction is justified."

41. **Li W., Long C., Fan T., et al. Gas cooking and respiratory outcomes in children: A systematic review. *Glob Epidemiol.* 2023;5:100107.**
Li et al. conducted a systematic review to examine gas cooking and respiratory outcomes in children. The researchers included 66 studies published through June 1, 2022, in this analysis. The study outcomes included were asthma and wheeze. The research study selection, data collection, quality evaluation, and evidence synthesis methods are described. The research uses the PRISMA checklist to report findings in this review. The review included 29 studies that examined the association between gas cooking and asthma, 37 studies that examined the association between gas cooking and wheeze, 20 studies that examined the association between indoor NO2 and asthma, and 16 studies that examined the association between indoor NO2 and wheeze. The majority of studies included were cross-sectional, include various definitions of key terms, and potential sources of bias and inaccuracies. For example, several studies reported differences in cooking methods, and many studies did not control for confounders such as dampness, mold, pets, and tobacco smoke. The paper included a critique of a previous meta-analysis conducted in 2013 by Lin et al. The researchers conclude that the literature is not homogeneous, is generally of low study quality, and "does not provide sufficient evidence regarding causal relationships between gas cooking or indoor NO2 and asthma or wheeze." Study limitations and directions for future research are provided.

42. **Hu T., Singer, B., Logue, J. Compilation of Published PM2.5 Emission Rates for Cooking, Candles and Incense for Use in Modeling of Exposures in Residences. U.S. Department of Energy Building Technologies Program, Office of Energy Efficiency and Renewable Energy;2012.**
Hu et al. conducted a study to examine the health impacts of PM2.5. The main goal of the research was to "produce a database of pollutant emission rates associated with cooking and the burning of candles and incense." The report included an overview of emissions terminology, a literature review, and a calculation of emissions rates. Evidence included indicated that cooking with natural gas released twice the amount of PM2.5, compared to cooking with electricity.

43. **Methane emissions are driving climate change. Here's how to reduce them. 2021; Available at: https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them#:~:text=Methane%20is%20the%20primary%20contributor,at%20warming%20than%20carbon%20dioxide. Accessed November 22, 2023.**
The United Nations (UN) environment programme published this story on methane and climate action in 2021. The article includes an overview of methane, where it comes from, how it harms health, and ways to decrease methane.

44. **Institute Rocky Mountain. All-Electric Buildings: Key to Achieving Washington's Climate Goals.State-Level Building Electrification Factsheets. 2023.**

The Rocky Mountain Institute published a report on state-level building electrification and compiled statewide factsheets with state-specific information. Washington State factsheets include information on climate impacts, health impacts, infrastructure, and more.

45. **Nix Emily, Fleeman Nigel, Lorenzetti Federico, et al. Health effects of liquid and gaseous fuels for household energy use: systematic evidence mapping. *Environmental Research Letters.* 2022;17(12).**
Nix et al conducted a systematic review on the health effects of liquid and gas fuels used for household energy consumption. The review was conducted across 12 international databases and examined impacts across high- middle- and low- income countries. The research examined was compiled into the World Health Organization Health Effects of Household Liquid & Gaseous Fuels Database, then mapped to understand the breadth and potential gaps of the research. The authors pointed out that WHO guidelines for indoor air quality (GIAQ): household fuel combustion includes recommended levels for PM2.5 and CO for household energy devices. A meta-analysis was also conducted on the health impacts of fuels but information on this study is not included in this paper. The research focused on both emissions from fuels as well as accidents and injuries from use of fuels. Peer-reviewed studies from India, China, the U.S., the United Kingdom, Nigeria, Nepal, and Australia were included (N= 587) and were conducted between 1980 2021. The researchers followed PRISMA guidelines for their analysis. A large body of evidence exists on the impacts of LPG for cooking in low- and middle-income countries, and use of natural gas in high-income countries for cooking and heating. “Particulate matter and nitrogen oxides were the most monitored pollutants.” Research in this review generally focused on impacts to women and found that self-reported health outcomes and symptoms were the most common assessment methods. Several health outcomes were reported, and the majority were respiratory health issues. The most studied health issue was asthma, followed by COPD/lung health, burns and scalds, bronchitis/lung infections, and acute lower respiratory infections/pneumonia. Some studies examined lung infection indicators, adverse pregnancy outcomes, CO poisoning, hypertension, cancer, cardiovascular disease, tuberculosis, accidental poisonings, cognitive development, stroke, cataracts, congenital defects, and diabetes. The research that examined disease and injury generally focused on liquified petroleum gas, natural gas, or kerosene. This review did not examine the directionality of the research, regarding whether the fuels had a positive or negative impact on health. Much research has been done supporting the change to low or no emissions fuels, which includes natural gas. However, inefficient burning of these fuels can lead to emissions and decreased health. The majority (88.2%) of studies focused on cooking, and 63.5% of these studies were conducted in lower- and middle-income countries. The researchers concluded with recommendations for additional research.

46. **National Institute of Environmental Health Sciences. Hydraulic Fracturing & Health. 2022; Available at: https://www.niehs.nih.gov/health/topics/agents/fracking/index.cfm. Accessed 12/22/2032.**
This National Institute of Environmental Health Sciences provides an overview of health risks posed by hydraulic fracturing, also known as fracking, a method used to extract natural gas and oil from shale rock formations.

47. **Energy Puget Sound. PSE Service Area. Bellevue, WA.**

This document provides Puget Sound Energy's Service Area, including where it serves natural gas customers, electric customers, and both electric and natural gas customers.

48. **U.S. Census Bureau. Why We Ask Questions About...Home Heating Fuel. American Community Survey 2023; Available at: https://www.census.gov/acs/www/about/why-we-ask-each-question/heating/. Accessed.**
This U.S. Census webpage allows users to search American Community Survey (ACS) results for the home heating fuel question included on the survey. The data are sourced from the latest ACS 5-Year Estimates Data Profiles/Housing Characteristics (2018-2022). Nationally, an estimated 47.1% of occupied housing units use utility gas for heating compared to 40.2% that use electricity for heating. In Washington State, an estimated 33.9% of occupied housing units use utility gas for heating and 57% use electricity.

49. **Natural gas supply. Available at: https://www.pse.com/en/pages/energy-supply/natural-gas-supply. Accessed 11/15/2023.**
This PSE webpage discusses its natural gas supply.

50. **Electricity supply. Available at: https://www.pse.com/en/pages/energy-supply/electric-supply. Accessed 11/15/23.**
This PSE webpage describes the company's electricity supply including source of the electricity.

51. **U.S. Census Bureau, Population Estimates Program (PEP). Housing Units. Available at: https://www.census.gov/quickfacts/fact/note/US/HSG010221. Accessed 12/17/2023.**
Defines how the U.S. Census Bureau describes housing units.

52. **Postcensal Estimates of April 1 Housing Units, 1980, 1990 to Present. In: Office of Financial Management FaRD, ed. Olympia, WA2023.**
The table presents the Washington State Office of Financial Management's (OFM) postcensal estimates of April 1 housing by structure type. These "postcensal estimates are estimates that reference the prior census point." HIR analysts used estimates for counties served by PSE natural gas to consider change over time in residential housing units. Based on postcensal estimates of housing units, between April 1, 2022, and April 1, 2023, an estimated 29,878 housing units were added across the 6 counties in which PSE provides natural gas: King County (excluding Enumclaw) 18,705 additional housing units; Kittitas County (excluding Ellensburg) 70 housing units; Lewis County 451 housing units; Pierce County 3,689; Snohomish County 5,499 housing units; and Thurston County 1,464 housing units. One unit housing units represented the majority of growth in Kittitas (an estimated 65 units), Lewis (254), and Pierce (1,930) Counties. While 2 or more housing units represented the majority of additional units in King (16,931 units), Snohomish (3,999), and Thurston (1,002) Counties.

53. **U.S. Energy Information Administration. Natural Gas | Data. 2023; Available at: https://www.eia.gov/dnav/ng/ng_cons_num_a_EPG0_VN3_Count_a.htm. Accessed 12/22/2023.**
This U.S. EIA webpage presents data on the number of residential consumers, number of commercial consumers, and number of industrial consumers of natural gas by state from 1987

through 2022. It also provides the average annual consumption per commercial consumer as well as for industrial consumers.

54. **Revenue Washington State Department of. Gross Business Income by industry, identified by SIC and NAICS codes. 2023.**
Washington State Department of Revenue (DOR) assigns NAICS codes to businesses in Washington State based on primary business activity, determined as the highest taxable activity. Based on data from April through June 2023 (Quarter 2) (the most recent data available), there were 11,243 businesses with NAICS codes beginning with 31, 32, or 33 in Washington State, including 3,232 businesses with NAICS codes beginning with 31; 2,561 businesses with NAICS codes beginning with 32; and 5,450 businesses with NAICS codes beginning with 33.

55. **North American Industry Classification System: Introduction to NAICS. 2023; Available at: https://www.census.gov/naics/#q1?99967. Accessed 11/21/2023.**
This U.S. Census Bureau webpage includes information about the North American Industry Classification System (NAICS). NAICS is classification of businesses in the U.S. developed under the direction and guidance of the Office of Management and Budget (OMB). The intent of the classification system is to allow for the collection, analysis, and publication of statistical data describing the U.S. business economy. There is no central governmental agency that assigns NAICS codes. Rather, various agencies assign NAICS codes using multiple methods. NAICS codes offer 5 levels of detail, with a 2- through 6-digit hierarchical classification system. NAICS codes beginning with 31-33 refer to manufacturing businesses. NAICS codes beginning with 31 relates to business involved in manufacturing food products; beverage and tobacco products; textiles and textile products; apparel; and leather and allied products. NAICS codes beginning with 32 relates to businesses involved in manufacturing wood products; paper products; printing and related support activities; petroleum and coal; chemicals; plastics and rubber; and nonmetallic minerals. NAICS codes beginning with 33 relates to businesses involved in manufacturing primary metals; fabricated metals; machinery; computers and electronics; electrical equipment; appliances and components; transportation equipment; furniture and related products; and miscellaneous products (e.g., medical equipment and supplies).

56. **RCW 80.28.110 Service to be furnished on reasonable notice, Revised Code of Washington(2021).**
This Washington State statute establishes utilities obligation to serve all customers who request service.

57. **Wallace N. , Zerbe A. , Wara M. , Sivas D.A. Removing Legal Barriers to Building Electrification. Palo Alto, CA: Stanford Law School Environmental Law Clinic; 2020.**
This paper out of the Stanford Law School Environmental Law Clinic evaluates the legal issues of transitioning "from mixed fuel (natural gas and electric) to all-electric service." It explores electrification and the obligation to serve in California and makes policy recommendations the California Legislature could take to address legal uncertainties raised by termination of service.

58. **Commission Washington Utilities and Transportation. Order 1 Authorizing and Requiring Tariff Revisions. In: Commission WUaT, ed. Lacey, WA2021.**

This Order from the Washington Utilities and Transportation Commission details the processes by which the Commission considered whether natural gas utilities should continue to use the Perpetual Net Present Value Methodology to calculate natural gas line extension allowances. It provides history and background and details public comments, discussion, and the Commission's decision from its October 28, 2021, open meeting.

59. **Energy Code. 2023; Available at: https://www.sbcc.wa.gov/state-codes-regulations-guidelines/state-building-code/energy-code. Accessed 1/3/2024.**
This SBCC webpage provides information about the state energy code.

60. **City of Seattle. Seattle Energy Code. Available at: https://www.seattle.gov/environment/climate-change/buildings-and-energy/seattle-energy-code. Accessed 12/14/2023.**
This City of Seattle webpage from the Office of Sustainability & Environment provides an overview of the Seattle Energy Code, "a construction code that ensures new buildings are energy efficient from the start." The energy codes are updated every 3 years. In 2021, updates and amendments to the commercial energy code were signed into law. Key updates included: 1) eliminating fossil fuels from most water heating and space heating systems in new construction and substantial alterations, and in most equipment replacements (space heating: applies to commercial and multifamily construction effective March 2021; water heating: applies to hotel and multifamily effective January 2022 and new construction and substantial alteration non-residential commercial buildings effective April 1, 2022).

61. **Ryan J. Seattle bans natural gas in new buildings. *KUOW*. 2/2/2021, 2021.**
This news article provides a brief overview of the City of Seattle's 2021 ban on most fossil fuels in new buildings. The City's revised energy code applies to commercial buildings and to multifamily housing at least 4 stories tall.

62. **Bob Vila. How Much Does an Electric Furnace Cost? 2023; Available at: https://www.bobvila.com/articles/electric-furnace-cost/#:~:text=The%20cost%20to%20switch%20from%20gas%20heat%20to,furnace.%20It%20also%20includes%20installing%20any%20new%20wiring. Accessed 12/13/2023.**
This webpage discusses the costs associated with installing an electric furnace either new, as a replacement for an existing electric furnace, or when converting from a natural gas or oil furnace.

63. **Gruenwald T., Seals B. A., Knibbs L. D., Hosgood H. D., 3rd. Population Attributable Fraction of Gas Stoves and Childhood Asthma in the United States. *Int J Environ Res Public Health.* 2022;20(1).**
Gruenwald et al examined the population-level implications of gas cooking and examined how childhood asthma and household use of gas stoves are linked. The researchers cite prior research and state the indoor gas stove use for cooking is present in 35% of U.S. households, with certain states' use as high as 68%. In this study, the researchers calculated the population attributable fraction (PAF) for gas stove use and current asthma among children in the US. The researchers sought to update the effect-size estimates for childhood asthma by searching studies as old as 2013. No new associations were reported, so this study used previously calculated effect sizes for

current asthma in North America and Europe combined. The proportion of children exposed to gas stoves was calculated from the American Housing Survey for the U.S. PAFs were calculated using a previously published approach that quantified uncertainties about PAF point estimates. Certain states are oversampled, in this survey, allowing for more in-depth analysis among these states. Washington State was not specifically studied. Study results show that 12.7% of current childhood asthma in the U.S. is attributable to gas stove use. States across the U.S. appear to have different proportions of how much childhood asthma could be prevented if gas stove use was not present. Differences are due to varying exposure to gas stoves among children. Study limitations are included. Prior research found, "according to National Health and Nutrition Examination Survey data, among children living in households that use gas stoves, only 21.1% live in households where the stove's exhaust vent is always used." The researchers include recommendations to reduce childhood asthma attributable to gas stoves, which include replacing gas cooking with cleaner alternatives such as electric and reducing exposure through ventilation.

64. **Zhang Mengjie, Gao Lan, Wang Quanda, et al. Methane Leakage Measurement of Natural Gas Heating Boilers and Greenhouse Gas Emissions Accounting of "Coal-to-Gas" Transition for Residential Heating in Rural Beijing. *Environmental Science & Technology Letters.* 2022;10(1):93-97.**
Zhang et al. studied 30 gas boilers in Beijing, China to estimate the leakage rates of methane, and assess the greenhouse gas emissions, compared to coal heating methods. The research found that the leakage rate was, on average, 0.22%. The study found that the "coal-to-gas" transition for residential heating in this area reduced overall greenhouse gas emissions by 44.8%. The authors included supporting information in the publication, including the working principle of gas boilers, pictures of on-site measurement, calculations, and inventories, etc.

65. **Lebel E. D., Lu H. S., Speizer S. A., et al. Quantifying Methane Emissions from Natural Gas Water Heaters. *Environ Sci Technol.* 2020;54(9):5737-5745.**
Lebel et al. studied 64 water heaters from homes in California. The purpose of the research was to "(1) quantify methane emissions from natural gas leaks and incomplete combustion while off, turning on or off, and in steady-state operation from 35 homes; and (2) characterize daily usage patterns over 1−2 months per water heater to estimate activity factors from 46 homes." The researchers found that, on average, individual tankless water heaters emitted 2390 g CH4 yr-1 and storage water heaters emitted 1400 CH4 yr-1, 0.93% and 0.39% of their natural gas consumption, respectively. The authors scaled the measurements to estimate emissions of storage and tankless water heaters in the U.S., and found that "water heaters overall emitted an estimated 82.3 CH4 yr-1, 0.40% of all natural gas consumed by these appliances […]"

66. **Chemical Profiles: Methane. 2023; Available at: https://www.ccohs.ca/oshanswers/chemicals/chem_profiles/methane.html#:~:text=A%20high%20concentration%20can%20displace,coma%20and%20death%20can%20occur. Accessed, 2023.**
The Canadian Centre for Occupational Health and Safety publishes chemical profiles for a wide range of substances. This profile provides basic information about methane, including health impacts of inhalation.

67. **Seals B. A., Krasner, A. Health Effects from Gas Stove Pollution. Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club;2020.**
Seals and Krasner published this report, documenting the health impacts of gas stoves. The report includes key findings on which particles from gas stoves affect indoor air quality, information on indoor air quality inequities, and recommendations. The authors reviewed literature and included all citations used in the report.

68. **What is Natural Gas? 2022; Available at: https://portal.ct.gov/PURA/Gas-Pipeline-Safety/What-is-Natural-Gas. Accessed.**
Connecticut's Department of Energy and Environmental Protection published this webpage explaining what natural gas is and how it can produce carbon dioxide and carbon monoxide.

69. **Agency U.S. Environmental Protection. Appendix B – Overview of Acute Health Effects. 2015.**
The U.S. Environmental Protection Agency published this overview of acute health effects associated with carbon dioxide. The document includes the dangerous, lethal effects of carbon dioxide at high exposure concentrations, as well as beneficial use of carbon dioxide during oxygen deficiency.

70. **Outdoor Air Quality: What are the trends in outdoor air quality and their effects on human health and the environment? 2023; Available at: https://www.epa.gov/report-environment/outdoor-air-quality#:~:text=For%20example%2C%20outdoor%20air%20pollution,respiratory%20symptoms%2C%20and%20premature%20mortality. Accessed, 2023.**
The U.S. Environmental Protection Agency published this webpage on outdoor air quality. The page includes categories of indicators, health outcomes, and more. References are included for information stated on the webpage.

71. **Pipeline Safety. 2022; Available at: https://www.utc.wa.gov/public-safety/pipeline-safety. Accessed, 2023.**
The Washington Utilities and Transportation Commission publishes information about natural gas pipelines on their website. This webpage contains information about the Pipeline Safety Program.

72. **Weller Z. D., Hamburg S. P., von Fischer J. C. A National Estimate of Methane Leakage from Pipeline Mains in Natural Gas Local Distribution Systems. *Environ Sci Technol.* 2020;54(14):8958-8967.**
Weller et al. estimated methane emissions from U.S. local distribution natural gas pipes. The researchers used "data collected from an advanced mobile leak detection (AMLD) platform." The study results show that there are approximately 630,000 leaks in U.S. distribution systems, which results in methane emissions of 0.69 Tg/year. The authors included calculations for quantifying uncertainty. The evidence indicates that the likelihood of leaks changes depending on the pipe age and material. The authors state that their "national methane emissions estimate is approximately 5x greater (95% cr int: 1.7x, 8.7x) than the U.S. Environmental Protection Agency's current greenhouse gas inventory estimate for pipeline mains in local distribution

systems due to both a larger estimated number of leaks and better characterization of the upper tail of the skewed distribution of emission rates."

73. **Programme United Nations Environmental Health. Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.Nairobi2021.**
The United Nations Environmental Health Programme and the Climate & Clean Air Coalition (CCAC) published this 2021 report on global methane and ways to reduce methane. The assessment discusses ways that slowing the fossil fuel industry may slow the rate of global warming. Researchers stated that reduced methane concentrations "could increase global crop yields by 26 million [tons] per year."

74. **How Methane Impacts Health. Global Clean Air Available at: https://globalcleanair.org/methane-and-health/#:~:text=Methane's%20health%20impacts&text=Exposure%20to%20ozone%20and%20particulate,mortality%2C%20and%20heightens%20stroke%20risk. Accessed.**
The Environmental Defense Fund Published this webpage on how methane impacts health. The page states that methane contributes to ground level ozone which "damages airways, aggravates lung diseases, causes asthma attacks, increases rates of preterm birth, cardiovascular morbidity and mortality, and heightens stroke risk."

75. **Alvarez C. H. Structural Racism as an Environmental Justice Issue: A Multilevel Analysis of the State Racism Index and Environmental Health Risk from Air Toxics. *J Racial Ethn Health Disparities.* 2023;10(1):244-258.**
Alvarez conducted a cross-sectional multilevel analysis of over 65,000 U.S. census tracts to evaluate the following research question: "Do neighborhoods located in states with higher state racism index report greater environmental health risk from outdoor air toxics?" The researcher used a state racism index (an aggregate of Black-white gaps, from the social determinants of health literature) to gauge Black-white inequities to measure differences in exposure to outdoor pollution. The index is the average of five scales: residential segregation and Black-white ratios in incarceration, educational attainment, economic status, and employment. Higher scores in the index indicated greater systemic Black-white gaps. The dependent variable examined was estimated cancer risk and noncancer respiratory system risk from outdoor air toxics. This data was pulled from the National Air Toxics Assessment (NATA). The researcher controlled for race, levels of female-headed households, renter status, geographical factors, and EPA regions. The researcher conducted multilevel modeling to calculate differences across groups. Results of the study showed that states with higher levels of Black–white gaps had higher levels of exposure to air pollution and more environmental health risk. The author stated, "[t]he findings demonstrate the importance of identifying neighborhood-level environmental conditions (i.e., outdoor air pollution exposure) for understanding systematic racism." Alvarez found that "the greater systematic racism of a state is linked to greater levels of outdoor air pollution in all neighborhoods." The author stated that, "the disproportional exposure across communities is tied to systematic inequalities in environmental regulation and other structural elements such as housing and incarceration."

76. **The complicated history of environmental racism. 2020; Available at: http://news.unm.edu/news/the-complicated-history-of-environmental-racism. Accessed February 2023.**
The University of New Mexico newsroom publishes a news article about environmental racism. The article focuses discussion with Honors College Assistant Professor Myrriah Gómez, who studies environmental racism. Gomez quotes a definition of environmental racism from Robert Bullard's book Dumping in Dixie. Bullard defines environmental racism as "any policy, practice or directive that differentially affects or disadvantages (where intended or unintended) individuals, groups or communities based on race."

77. **Jbaily A., Zhou X., Liu J., et al. Air pollution exposure disparities across US population and income groups. *Nature.* 2022;601(7892):228-233.**
Jbailey et al. connected demographic data from the US Census Bureau and American Community Survey and PM2.5 data across the USA. The researchers used 2000-2016 data across approximately 32,000 zip codes. The researchers created a dataset with median household income, race/ethnicity, and population density, then used publicly available data to track PM2.5 levels. Then, the researchers developed methods to quantify disparities by "defin[ing] a state of equality (or lack of relative disparities) among various populations as a state in which equal proportions of the various populations are exposed to pollution levels higher than a threshold of interest, chosen in relation to the EPA standard and WHO guidelines for PM2.5." The data were mapped and visualized to demonstrate connection between race/ethnicity and income with PM2.5 levels across the U.S. The data and code used in this study are publicly available. Sensitivity analyses were conducted to test the methods used. The study found that areas of the U.S. with higher-than-average Black, Asian and Hispanic or Latino populations have been consistently exposed to higher PM2.5 levels, as compared to areas with higher-than-average white and Native American populations, and areas with low-income populations have been consistently exposed to higher PM2.5 levels, as compared to areas with high-income groups. The authors also examined disparities relative to policy standards. The research showed that exposure relative to safety standards set by the EPA and WHO have had increasing disparities over time. The authors stated that the research is descriptive and cannot be used to investigate causal relationships. The researchers noted the "importance of strong, targeted air-pollution-reduction strategies, not only to reduce overall air-pollution levels but also to move closer towards the EPA's aim to provide all people with the same degree of protection from environmental hazards."

78. **Issue Brief 3: Energy and Equity. In: Commission WUaT, ed. Lacey, WA.**
This Issue Brief from the Washington Utilities and Transportation Commission describes costs of energy and compares costs to poverty levels in Washington State. The brief also discusses recent legislative efforts.

79. **Demetillo Mary Angelique G., Harkins Colin, McDonald Brian C., et al. Space-Based Observational Constraints on NO2 Air Pollution Inequality From Diesel Traffic in Major US Cities. *Geophysical Research Letters.* 2021;48(17).**
It is well documented that air pollution is higher in areas of the U.S. that house more people of color and more people with low socioeconomic status. Research shows that communities of color and people with lower household incomes experience higher concentrations of and exposures to

NOx and diesel emissions, which contribute to measurable differences in health and life expectancy. Heavy-duty diesel vehicles (HDDVs) contribute 3-6% of the US fleet in terms of distance traveled but contribute disproportionate amounts of NOx emissions (7x more than gasoline). The authors noted "stationary sources [of diesel emissions] may be more important across more suburban metropolitan areas." This study utilized data collected by the TROPospheric Ozone Monitoring Instrument (TROPOMI) which uses a satellite to measure NO2 emissions and additional atmospheric gases from space. This research explored NO2 in 52 major cities representing 130 million people between June 2018 to February 2020. Neighborhood-level data on race, ethnicity, and income levels were examined and reported both alone and as combined measures of race/ethnicity and income categories (lowest median income quintile [LIN] tracts and highest median income quintile [HIN] tracts). The researchers computed three metrics to quantify and report on racial segregation within the cities included in the analysis, and point out that "without segregation, air pollution disparities would not be possible". Weekday versus weekend differences in emissions were included to determine an estimated impact of diesel emissions, as prior research found diesel emissions are substantially higher on weekdays. The researchers also accounted for differences in NO2 lifetime by season, and they found that "LIN HIW disparities decrease by 37 ± 3% on weekends in the summer and 32 ± 2% in the winter". The researchers found that a 62% reduction in on-road diesel traffic leads to a 37% decrease in LIN-HIW inequalities. Population-weighted NO2 tropospheric vertical column densities (TVCDs) were found to be 17 ± 2% higher for Black and African Americans, 19 ± 2% higher for Hispanics/Latinos, 12 ± 2% higher for Asians, and 15 ± 2% higher for Native Americans compared to whites. Further, rates were higher for people living in poverty (17 ± 2% higher for people living below, and 10 ± 2% higher for people living near the poverty line, compared to people above). Once the researchers accounted for weekday and weekend emissions, they found that HDDVs contribute significantly to emissions inequalities for Black and African Americans (63 ± 13%), Hispanics/Latinos (52 ± 10%), Asians (36 ± 7%), and Native Americans (62 ± 12%) and for people living below and near the poverty line (56 ± 11%). The researchers found that controlling for HDDV's would not eliminate these disparities. Higher inequalities were found when race-ethnicity and income measures were combined, with 28 ± 2% greater population-weighted NO2 for LINs than HIWs. In conclusion, the researchers found that a "62% reduction in diesel emissions would decrease race-ethnicity and income inequalities by 37%".

80. **Cowlitz County Washington State Department of Health. Millennium Bulk Terminals - Longview Health Impact Assessment, September 2018. September 2018 2018**
Cowlitz County and the Washington State Department of Health conducted a health impact assessment ("a process that helps support the required review and analysis of potential health effects of a plan, project, or policy before it is built or implemented") for the Millennium Built Terminals. The assessment focused on neighborhoods near the proposed terminal, as well as community facilities along the BNSF rail line in Cowlitz County. The full assessment includes an introduction, health evaluation, impacts of coal export, population characteristics, recommendations, and references. Research included in the assessment found that air quality generally returns to background levels at about 500 feet up to nearly 2,000 feet downwind of major roadways or areas with high traffic, trucking, or rail activity. Further, it is well established that "elevated exposures to PM2.5 and PM10 lead to declines in lung function and worsening of heart and lung diseases (like triggering asthma attacks) that may result in hospitalizations or

death". Finally, exposure to PM2.5 and PM10 lead to stroke, type 2 diabetes, neurological and cognitive impairment, and pre-term and low-birth weight babies, and other negative health impacts. A large cohort study found that men; black, Asian, and Hispanic persons; and people eligible for Medicaid (interpreted as an indication of low economic status) were found to have greater risk of death with exposure to PM2.5 than the general population. The full report is available online.

81. **Gas Stove Emissions Are a Public Health Concern: Exposure to Indoor Nitrogen Dioxide Increases Risk of Illness in Children, Older Adults, and People with Underlying Health Conditions.Policy Statements. American Public Health Association;2022.**
The American Public Health Association published this policy statement declaring that gas stove emissions are a public health concern. The equity impacts among children, older adults, and people with underlying health conditions are discussed.

82. **Smoke From Fires. Available at: https://doh.wa.gov/community-and-environment/air-quality/smoke-fires. Accessed, 2023.**
The Washington State Department of Health publishes information about smoke from fires on their website. The "Frequently Asked Questions" section includes information about who is most impacted by poor air quality.

83. **Radiation U.S. EPA Office of Air and. Particle Pollution and Your Health. In: Agency USEP, ed. Vol EPA-452/F-03-001. Washington, DC: U.S. Environmental Protection Agency; 2003.**
This pamphlet from the U.S. Environmental Protection Agency discusses particle pollution, associated risks, and ways to protect health. Risk appears to vary throughout an individual's lifetime: higher in early childhood, lower in healthy adolescents and younger adults, and increasing in middle age through old age (as the incidence of heart and lung disease and diabetes increases). Authors note, children's "lungs are still developing; they spend more time at high activity levels; and they are more likely to have asthma or acute respiratory diseases, which can be aggravated when particle levels are high."

84. **Gauderman W. James , Avol Edward , Gilliland Frank , et al. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. *The New England Journal of Medicine.* 2004;351(11):1057-1067.**
Gauderman et al. conducted a prospective cohort study to assess whether exposure to air pollution adversely affects the growth of lung function during the period of rapid lung development that occurs between the ages of 10 and 18 years. The Children's Health Study recruited 1,759 children "(average age, 10 years) from schools in 12 southern California communities and measured lung function annually for eight years [1993 to 2001]. The rate of attrition was approximately 10 percent per year." The study included communities representing "a wide range of ambient exposures to ozone, acid vapor, nitrogen dioxide, and particulate matter." The relationship of air pollution to the forced expiratory volume in one second (FEV 1) and other spirometric measures was assessed using linear regression. Results showed that "over the eight-year period, deficits in the growth of FEV1 were associated with exposure to nitrogen dioxide (P=0.005), acid vapor (P=0.004), particulate matter with an aerodynamic diameter of less than 2.5 μm (PM2.5) (P=0.04), and elemental carbon (P=0.007), even after adjustment for

several potential confounders and effect modifiers." Moreover, associations were also observed for other spirometric measures. Authors stated, "[e]xposure to pollutants was associated with clinically and statistically significant deficits in the FEV1 attained at the age of 18 years. For example, the estimated proportion of 18-year-old subjects with a low FEV1 (defined as a ratio of observed to expected FEV1 of less than 80 percent [a criterion often used in clinical settings to identify those who are at increased risk for adverse respiratory conditions]) was 4.9 times as great at the highest level of exposure to PM2.5 as at the lowest level of exposure (7.9 percent vs. 1.6 percent, P=0.002)." Furthermore, results showed similar associations between these pollutants and a low FEV1 in the subgroup of children with no history of asthma and the subgroup with no history of smoking. Authors concluded, "[t]he results of this study indicate that current levels of air pollution have chronic, adverse effects on lung development in children from the age of 10 to 18 years, leading to clinically significant deficits in attained FEV1 as children reach adulthood."

85. **Kinsey JS, Williams DC, Dong Y, Logan R. Characterization of Fine Particle and Gaseous Emissions during School Bus Idling. *Environmental Science Technology.* 2007;2007(41):4972-4979.**
Kinsey et al. examine whether restarting school buses will result in higher emissions of diesel pollutants than those attributable to periods of continuous idle. In 2005 (before the implementation of the EPA's 2010 Clean Diesel Standards), researchers measured the idle emissions from 6 diesel school buses (model years ranging from 1997 to 2004) under wintertime conditions to test the hypothesis that "the benefit of anti-idling, including restart, results in less net emissions than continuous idling." Specifically, particulate matter (PM) and gaseous emissions were determined over a simulated waiting period typical of schools in the northeastern U.S. Researchers tested "for both continuous idle and hot restart conditions using a suite of on-line particle and gas analyzers installed in the [EPA's] Diesel Emissions Aerosol Laboratory." Researchers measured PM2.5 as well as carbon monoxide (CO), carbon dioxide, nitrogen oxides (NOx), total hydrocarbons (THC), oxygen, formaldehyde, and the tracer gas in the raw exhaust. Overall, results showed "little difference in the measured emissions between a 10 min post-restart idle and a 10 min continuous idle with the exception of THC and formaldehyde." Meanwhile, engine restart resulted in an emissions pulse. Researchers developed a predictive equation from the experimental data, allowing a comparison between "continuous idle and hot restart for NOx, CO, PM2.5, and PAHs and which considers factors such as the restart emissions pulse and periods when the engine is not running." This equation indicates that restart is the preferred operating scenario as long as there is no extended idling after the engine is restarted. Authors note that the emissions data provided are limited and only applicable to the specific engines, emission controls, diesel fuel, ambient conditions and operating procedures evaluated in the study.

86. **U.S. Environmental Protection Agency. Health and Environmental Effects of Particulate Matter (PM) Available at: https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm. Accessed January 2020, 2020.**
This U.S. Environmental Protection Agency webpage provides an overview of the health and environmental effects of particulate matter. It states, "Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: premature death in people with heart or lung disease nonfatal heart attacks irregular heartbeat aggravated asthma decreased lung

function increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing." Particularly sensitive populations to particle air pollution include people with heart or lung diseases, children, and older adults.

87. **Wargo John, Brown David, University of Connecticut Environmental Research Institute. Environment and Human Health I.Children's Exposure to Diesel Exhaust on School Buses.North Haven, Connecticut: Environment & Human Health Inc.; February 2002 2002.**

This study was designed and results were analyzed by J. Wargo, D. Brown, and the University of Connecticut's Environmental Research Institute. The study consisted of: experimental monitoring, experimental controls, and school day personal monitoring. Experimental monitoring measured black carbon and PM2.5 on buses while idling and en route to test the effects of a) windows being opened and b) the location of monitoring equipment on the bus. Experimental control tests were run to determine how experimental buses (i.e., diesel engine next to driver; diesel engine at rear of bus; and natural gas powered) contributed to carbon and particle levels. Finally, school day personal monitoring of children's (n=15) indoor and outdoor exposure to PM10 and PM2.5 averaged 7 hours. Each child was "accompanied by a research assistant and monitored [i.e., logging behavior, movement, and environmental conditions] from the time each left their home in the morning to the time they each returned home in the afternoon." Each study participant carried a particulate meter, personal sampling pump, and VOC canister throughout the day. Researchers noted that "children's exposure to diesel exhaust from school buses constitutes an additional exposure beyond background levels of particulates reported from current monitoring efforts." Authors found, "Fine particulate concentrations (PM2.5) measured on buses in this study were often 5-10 times higher than average levels measured at the 13 fixed-site PM2.5 monitoring stations in Connecticut." Results showed, "Levels of fine particles were often higher under certain circumstances: when buses were idling with windows opened, when buses ran through their routes with windows closed, when buses moved through intense traffic, and especially when buses were queued to load or unload students while idling." Researchers found queued idling buses had the highest levels of particles and black carbon measured. Moreover, "idling buses tend to accumulate diesel exhaust which may be retained during the ride, depending upon bus ventilation rates," and "particulate and carbon concentrations rise rapidly once idling begins." Such increased exposure is of concern due to associated health outcomes (e.g., exacerbated of respiratory symptoms, decreased lung function, delayed lung development, increased mortality among those with cardiopulmonary diseases) and correlated healthcare needs (i.e., hospital admissions and emergency department visits for respiratory illnesses). Children are more susceptible due to their developing lungs and higher rates of respiration. Based on results, authors made multiple suggestions of how to reduce children's exposure to diesel emissions including, prohibiting bus idling, especially while loading and unloading students. While, the Connecticut Department of Environmental Protection (DEP) did have a regulation (DEP 22a-174-18 [a][5]) to limit idling time to 3 minutes, authors noted "it is neither monitored nor enforced." This finding indicates that compliance monitoring and enforcement is an important component of successful implementation to reduce exposure. Finally, authors report that "bus drivers' exposure to motor vehicle and diesel exhaust is significantly higher than children's, due to longer periods of time spent on buses."

88. **Washington Healthy Youth Survey Report of Results 2021.**

The Washington State Healthy Youth Survey measures health risk behaviors that contribute to morbidity, mortality, and social problems among youth in Washington State. Over 200,000 students participated in the 2021 survey administration.

89. **Vrijheid M., Martinez, D., Bustamante, M. Forns, J., Guxens, M., Sunyer, J. Prenatal Exposure to Gas Cooking and Neurodevelopment at 14 Months. *Epidemiology*. 2009;20(6):37-38.**
Martine et al. studied a prospective population-based birth cohort of pregnant people to examine the affects of natural gas on fetal development. The researchers found that the presence of a gas cooker in the home was associated with decreased mental development among children at age 14 months.

90. **Ecology Washington State Department of. Improving Air Quality in Overburdened Communities Highly Impacted by Air Pollution.Olympia, WA2023.**
This report from the Washington State Department of Ecology (Ecology) was required by the Climate Commitment Act (CCA). As the first required report, "it outlines and provides a baseline for what [the agency] already know[s] about criteria air pollution, certain health impacts, and greenhouse gas emissions in overburdened communities highly impacted by air pollution in Washington." Ecology states that Tribal communities which are highly impacted by air pollution were not included in this report, and the agency is "consulting with Tribal governments and looking forward to adding Tribal communities in future reports." Ecology's Air Quality Program identified 16 areas across Washington State as overburdened and highly impacted by air pollution as of March 1, 2023. Areas include Ellensburg, Everett, George and West Grant County, South King County, Mattawa, Moxee Valley, Northeast Puyallup, North Seattle and Shoreline, South Seattle, Spokane and Spokane Valley, South and East Tacoma, Tri-Cities to Wallula, Vancouver, Wenatchee and East Wenatchee, East Yakima, and Lower Yakima Valley.

91. **Breda I. . What we know about natural gas cooktops in WA. *The Seattle Times.* 1/22/23, 2023.**
This news article outlined the current state of natural gas stoves in Washington State as well as health considerations and policy options being discussed at the national, state, and local levels.

92. **Institute The Urban. Racial and Ethnic Disparities Among Low-Income Families.2009.**
The Urban Institute compiled information on race/ethnicity disparities among low income families and found that low-income Black families are more likely to be below the federal poverty level than other families (53% of Black families, compared to 39% of non-Hispanic white, 44% of Hispanic, and 42 percent of other-race families).