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Review

An Overview of Household Energy Consumption and Carbon Dioxide Emissions in Iran

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Abstract: This review tends to obtain a deeper understanding of the methods used in household energy consumption and carbon dioxide (CO_2) emissions in Iran. Issues relating to energy consumption and CO_2 emissions are very complex. This complexity arises from the fact that energy demand and energy consumption in Iran are influenced by many factors, such as income, household size, age, and gender. In Iran, the relevant energy sources mostly include liquefied petroleum gas (LPG) and electricity, which are used for different sectors, such as transportation, industry, and residential. This overview looks at both the theories and empirical studies of household energy consumption and CO_2 emissions in Iran. Since energy consumption typically results in air pollution, it is often used as an indicator of environmental degradation. Although Iran is recently faced to energy efficiency improvement from all sectors, household energy requirements have been significantly increased. In Iran, a prime motivator had been improving living standards. As Iran gradually turns into a consumer society, households have an enormous influence on the direct use of energy and related CO_2 emissions as well as through indirect use, as embodied in goods and services. The findings of this study can help policymakers to focus on renewable energy projects in order to reduce energy consumption and mitigate CO_2 emissions.

Keywords: household; energy consumption; CO_2 emissions; Iran

1. Introduction

Energy consumption and related carbon dioxide (CO_2) emissions are complex issues at different countries because various factors influence energy supply, energy demand, and energy consumption on a global or local scale [1]. It has been demonstrated that high demand for energy consumption is associated with an increased need for the use of fossil fuels [2]. In developing countries, the most important challenges in the sector of energy are environmental degradation with regard to the use of fossil fuels, CO_2 emissions, and hard access to modern energies such as liquefied petroleum gas (LPG) and renewable, eco-friendly energy sources [3]. In this regard, the public tendency towards using these resources in different counties has been increased [4,5]. Besides, the rate of urbanization and consequently the number of households have been increased in developing countries, which caused more challenges in supplying necessary energy in different sectors [6,7].

It is now well established from a variety of studies that households impact greenhouse gas (GHG) emissions. Druckman and Jackson [8] declared that the amount of GHG emission depends on the amount of energy consumed in households. Therefore, the households' behavior should be changed to lessen the issues related to energy consumption and climate footprint. In this regard, waste management is one of the key priorities of environmental policy in reducing GHG emissions [9]. In terms of the consumed energy, the GHGs intensity differs from different sources. For instance, the amount of emitted GHGs from burning natural gas is estimated to achieve less toxic air pollution rather than the pollution from the coal source in power plants [10]. According to Oladokun and Odesola [11], there are two important strategies, which need to be made for reducing GHGs emission, namely energy conservation and change in households' behavior.

Findings from different lifestyles indicate that households' behavior impact on energy consumption. For instance, households in the UK and Sweden have, respectively, consumed 21% and 51% of the energy in using dishwashers in 1998 [12]. A comparison of the two results from China and the EU reveals that Chinese households traditionally use cold-water for washing the clothes, whereas hot-water is used in the EU' households. According to an investigation by Streimikiene and Volochovic [9], substantial differences have been found among nations to be related to lighting, household size, room temperature, and operating hours of commercial building.

From the 1970s, the lifestyle of Iranian households has been pursued to a higher living standard. A report by the Statistical Center of Iran [13] shows that Iranian's per capita disposal income has been increased from USD 10 to USD 25 from 1990 to 2016, respectively. As far as the disposal income increased, the direct energy consumption in Iran also moved upward 51% [13] from 1.658 8 GJ to 2.505 8 GJ. In contrast to other sectors like industries, the report by Statistical Center of Iran (SCI) shows a decreased rate of direct energy consumption from 16.4% to 10.7% by Iranian households. It seems possible that this discrepancy is due to the low share of household direct energy consumption in GDP [14].

Exceptionally, for the last six decades, Iran has been viewed as a nation with a rapid rate of urbanization, increasing from 31% in 1956 to 75% in 2018 [15]. Although Iran is considered one of the main members in the Organization of the Petroleum Exporting Countries (OPEC), the international sanctions prohibit the export of produced oil and natural gas. Due to easy access to the energy sources in Iran, a considerable amount of these resources are consumed by different sectors of Iranian society [16]. In this regard, the rate of energy consumption and CO_2 emission in Iran has been increased by 6.2 and 6.1 times, respectively, in the last six decades [17]. Iran is placed among the top 10 countries concerning CO_2 emission (Figure 1). It is encountering a fast urbanization rate owing to social-political transformation and industrialization [18,19]. Taking into account the urban settlement within 1960–2017, the urbanization rate increased 2.2 times in Iran [20]. Hence, it caused a significant increment in energy consumption mainly extracted from natural resources [21].

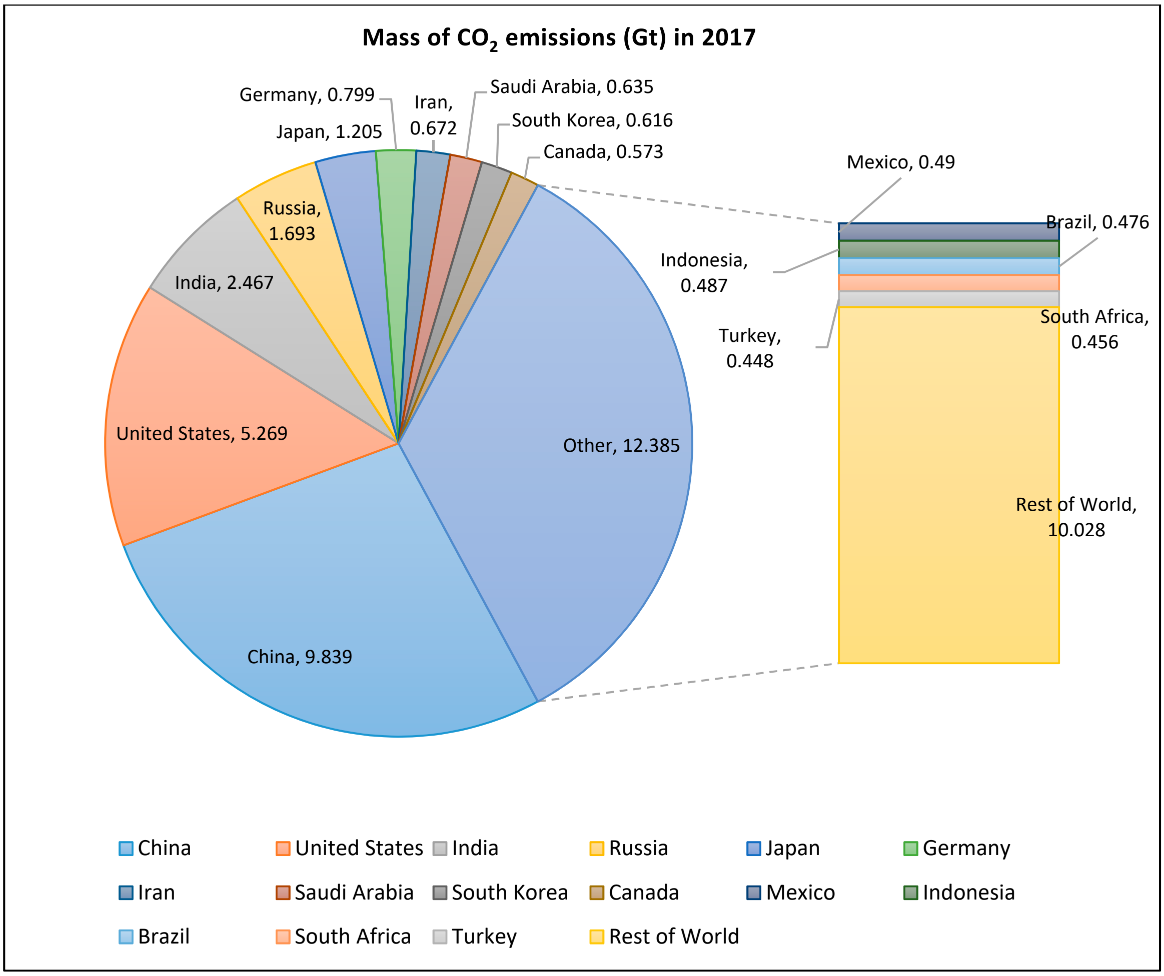

Figure 1. Main countries responsible for global CO_2 emissions, modified from [22].

As a result, Iran's energy policy is mostly focused on the sector of industries rather than the residential sector. The existing studies on energy consumption are extensive and focus particularly on the economic development and the industrial sector in Iran [4,18,23–26]. In a study investigating energy intensity in Iran, Farajzadeh and Nematollahi [27] reported that the residential sector is responsible for about 20% and 33% of total energy consumption and CO_2 emission in Iran, respectively. Therefore, this overview seeks to obtain data that will help to address household energy consumption and related CO_2 emission in Iran. The results from this overview make a major contribution to research in terms of reducing CO_2 emission by households.

The complexity of issues arising from energy consumption, environment, and sustainable development, and related CO_2 emissions has resulted in the need for a comprehensive study into energy consumption by households in Iran. A study on households' energy consumption and CO_2 emissions in cities is important to a country like Iran with a population of more than 80 million and an urbanization rate of 3.5% [13]. The share of households in the total energy demand in Iran in 2010 has been about 25% and increased to 50% in 2019 [19,28], which makes it the highest compared to other sectors. Against this backdrop, a study on household energy consumption patterns is necessary considering the important role energy plays in human development. The energy demand of other sectors (e.g., industrial, agriculture and transportation) in any economy is better captured than the household sector due to centralized ownership, self-interest and increased level of regulation and documentation compared to the residential sector, which is not well defined [29] However, the adoption of disaggregated data on various energy sources used by households in this study gives room for an inquiry into variations that may occur in the energy consumption pattern between the different socio-economic segments in cities.

In addition, the reasons for the preference of any particular energy source(s) are examined by the study. Another possible area of the study would be to investigate households' energy conservation. For a developing country such as Iran, much attention has been paid on the supply side whenever the issue of household energy is mentioned. In the context of climate change and the attendant global warming resulting from the unsustainable consumption pattern of humans especially city dwellers, attention is now focused on lifestyles and attitude of people with regard to energy consumption and CO_2 emissions. In this regard, this overview examines households' energy consumption and CO_2 emissions in Iran towards energy conservation pattern from households for meeting their energy needs. It is hoped that knowledge about the existing consumption across the household sector will help policymakers in formulating policies that will enhance sustainable energy supply and consumption in the country.

2. The Role of Energy in Economic Growth

The role of energy in economic growth has been a controversial topic in previous studies [30,31]. Traditional growth models treat energy as a common factor that has little effect on economic growth. Some more recent entries to neoclassical growth theory include energy as an essential input besides labor and capital for production [32]. With technological improvement, cheaper and more convenient energy has encouraged the substitution of energy derived mechanical power for work done by animals and humans. Since energy is so pervasive, the importance of energy is neglected by humans.

As a critical driver of economic growth, the availability of energy has always been a hot subject on political agendas around the world. Unfortunately, as a modern necessity, energy is also the key contributor to global climate change as well as local air pollution [33]. To respond to energy security and environmental pollution pressures, energy policies have focused on supply-side issues such as economic structural change, technological improvement, and regulatory management [34]. Subsequently, demand-side policies have been gaining more attention from researchers and policymakers. Sustainable consumption is also gaining momentum within the public debate [35].

Electricity consumption by households in Iran increased by 1.53% per year over the past ten years despite significant energy efficiency gains in household appliances and lighting [13]. According to SCI [13], per capita, household energy requirements in Iran show an average increase of 2.36% per year from 2000 to 2015. During the same period, overall energy intensity per household had increased at just 0.25% per year [36]. In Iran, energy price is again reformed in 2019, which affect all aspects of the economy. One of the most common issues in Iran is environmental change, which is considered an effective parameter in reducing CO_2 emissions [37].

2.1. Energy Challenges in an Urbanizing World

Recent trends in energy-related challenges have been grown at all levels of development in the world. Energy challenges also negatively impact on health conditions of residential in cities, crop yields, and forest integrity across the world [38]. Data collected from different levels of regional and national levels of developing countries show that human health has been affected by changes in the human environment, particularly with reference to air and water pollutions in the last two decades [39]. The condition is further compounded by the energy crisis presently affecting Iran, as shown by the international energy sanctions.

In Iran, urbanization plays an essential role in energy policy and planning, and transition from traditional to modern fuels [19]. Nowadays, more than 73% of the population in Iran has been living in cities [40]. Urbanization and industrialization accompanied by the economic development in Iran led to a continuous demographic and extensive growth of cities [41]. Besides, the increasing urban population, competitive pressure due to economic development and scarcity of available resources has led to the introduction of modern energy sources [19]. Increasing energy consumption is related to a growing population and also per capita consumption and changing consumer needs, behavior and lifestyles [42]. Increasing income accompanied by urbanization has led to a rise in household energy consumption. To address this rising trend in energy consumption, policymakers in Iran have tried to enforce energy efficiency improvements for LPG appliances [28].

2.2. Sustainable Consumption

Sustainable consumption is "the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life-cycle, so as not to jeopardize the needs of future generations" [43]. Since then, this definition has been widely used in the research and practices of sustainable consumption. Sustainable consumption is a site- and problem-specific concept [44,45]. Moreover, Sustainable consumption is considered a dynamic concept that shows only the path of desired or required changes [46]. In general, sustainable consumption is a long-term process involving negotiation and consensus building.

Understanding the decision-making process of consumers is the key to the study of what might constitute sustainable consumption [47]. Different criteria impact consumer decision making, as a complex process, including self-interest motives (e.g., price, income, quality, personal taste, and lifestyle) and social and economic incentives (e.g., culture, self-identity, and environmental and social concerns) [48]. The economic conceptual framework is rooted in consumer preference formation and studies in terms of showing the interaction between consumed goods and services within aggregate consumption [49]. On the other hand, the systems of the provision model of consumption view consumption as an active social process rather than just the sum of individual behaviors [50]. Consumption processes are closed to the systems of production and distribution that facilitate individual lifestyles.

The needs opportunities ability (NOA) model (Figure 2) is the basic model used to identify certain forces underlying consumer behavior at both the macro- and micro-level [51]. Based on the motivations–opportunities–abilities model, consumer behavior is determined by the needs, opportunities, and abilities of people to meet their own requirements [52,53]. *Needs* refer to a series of intentions that people follow to preserve or adjust their "quality of life". Energy is required to provide a range of services such as running the appliances in households. Households' energy needs grow along with increasing demand for higher comfort levels such as more substantial houses, more comfortable indoor temperatures, and higher hygiene needs. *Opportunities* are a set of external facilitating conditions, such as availability and accessibility of products, services, and relevant information. *Abilities* are the set of households' internal capacities to pursue products and services. They include financial (e.g., income), temporal (e.g., leisure time), spatial (e.g., home vacant space and location of the house), cognitive and physical (e.g., health, fitness), and skill (e.g., possess of licenses and permits) abilities [54]. Opportunities and strengths determine a consumer's level of behavioral control. Besides, Wu et al. [55] demonstrated that observed behavior can positively affect the behavior of sustainable consumer using the model of "*sustainable consumer behavior influence factors*". Moreover, findings from Zhu and Guo [56] show that the main influence factors of sustainable consumption are technology, regulations, and attitudes of consumers.

The NOA model is embedded in five social contexts: technology, economy, demography, institutions, and culture. Technology improvement and economic development increase consumers' purchase *opportunities* and *abilities* through mass production and lower prices. Demographic changes yield a multiplier effect on consumption as the population increases. Institutions, especially the government, might constrain consumers' *opportunities* and *abilities* by prices or regulations. Cultural norms and values might also penetrate the consumption process by influencing consumers' *needs* and *opportunities*. For example, consumers' sense of "quality of life" and their household energy consumption behavior depend highly on their cultural habits and routines [57,58]. The NOA model offers a beneficial structure for analyzing the driving forces of household energy consumption change at both the macro- and micro-level. Moreover, it provides a dynamic framework of consumers' behavior through consumer's ability and willingness to change [55].

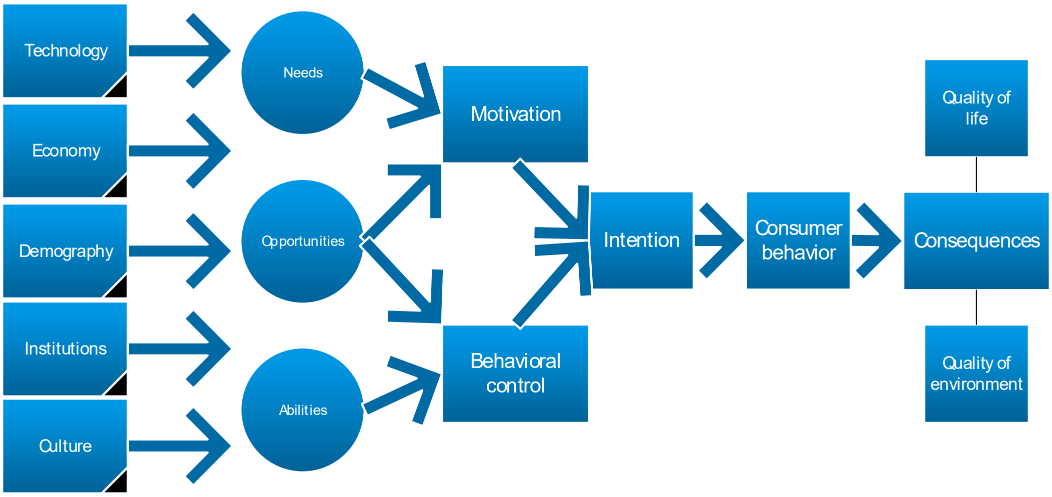

Figure 2. The needs opportunities ability (NOA) model of consumer behavior, modified from [54].

3. Energy Demand and Consumption in Iran

It is essential to incorporate the energy sources to show better comprehension of the outline of energy consumption by households [19]. More recently, an increasing interest has existed in the matter of energy consumption in Iran, primarily from two sectors of industry and transportation. In the past ten years, Iran has faced a rapid development of industrialization and urbanization leading to a fast acceleration in the energy case. This was mainly caused by the fact that the effect of households' energy consumption on the environment is not equivalent to those of industry and transportation sectors. Kenny and Gray [59] similarly indicate that the industry and transport sectors have a key role in CO_2 emissions in Ireland. Sepehr et al. [60] reported that the household sector in Iran allocates about 40% of total energy demand. Therefore, it will undoubtedly have a higher CO_2 emission level and a more considerable impact on the environment [28]. Hence, a tendency exists among people to act in a way to reduce the effect of energy consumption on the environment. The peoples' decisions and choices of energy consumption are the key factors with a positive or negative impact on people's environment and welfare [28]. Thus, the thoughts and performances of the people are the main focus of the debate on energy conservation. If the patterns of energy conservation are changed in a society, it is essential to consider the factors enforcing and motivating the individuals in this manner.

In Iran, the government controls the energy pricing mechanism, which has attempted to improve it by founding a market-based mechanism [61]. Because the subsidies are provided by the Iranian government for energy consumption in different sectors such as residential, the energy price is lower compared to global prices. There is less information regarding the lower price of energy caused by the association between energy consumption and CO_2 emission by households. There is presently no established system that computes and reports directly and indirectly the total household CO_2 emissions. Nevertheless, over the past twenty years, energy consumption has been increased constantly in Iran residential sector [13]. From the residential sector, the total energy consumption in Iran has marginal incremented per capita from 8.1 to 1.3 kJ in 2011. This is due to the use of a central air-conditioner, dishwashing machine, washing machine, and numerous buildings remarkably occupied [13].

From Figure 3, CO_2 emissions in Iran show an increase of nearly 5 times since 1971. Also, the residential sector is responsible for the same trend of direct carbon dioxide emissions increased by the rate of 2.45 times from 1990 to 2011. This considerable increase in household energy consumption has caused a renewed policy by the Iranian government to decline this trend in the last decade. One prompt measure that has been taken is a gradual decrease in energy subside and an increase in energy price. This renewed policy led to a decline in energy demand, and subsequently, the growth rate of oil and electricity consumption fell to −15% and −8%, respectively [62].

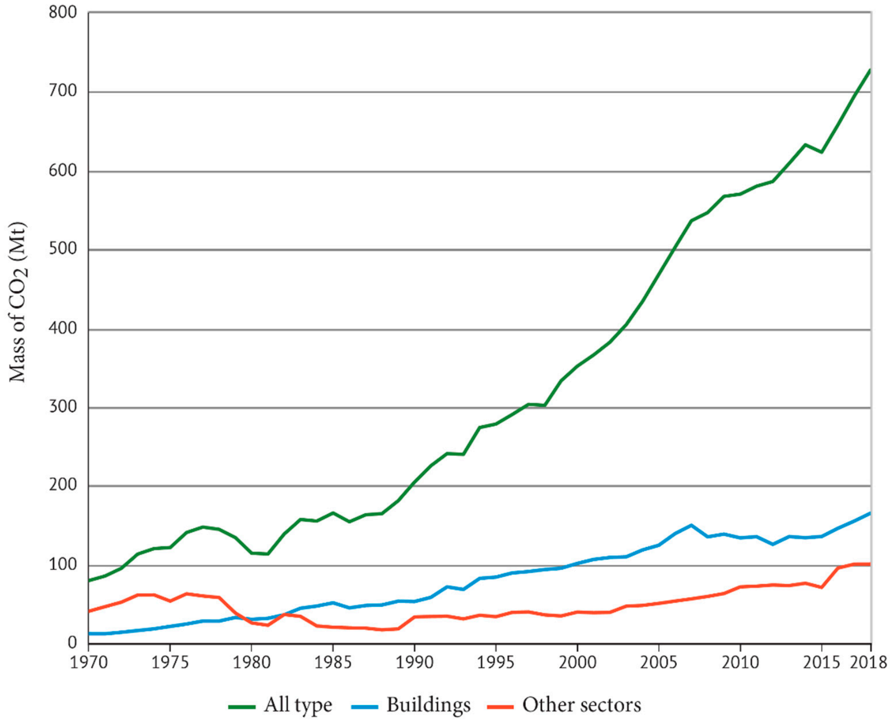

Figure 3. Sectorial CO_2 emissions in Iran from 1971 to 2018, modified from [63].

Iran, as one of the top 10 countries in CO_2 emissions (see Figure 1), is the main owner of oil and natural gas resources and tries to resolve most of its national energy demand by preparing and using fossil fuels. In recent years, there has been an obvious turn from oil products to natural gas [64] and now around $\frac{3}{4}$ of overall energy consumption is covered by the residential sector [13,27]. Iran is a vast country with different environment-friendly natural energy sources such as solar energy or wind power [36]. Current programs lead to an increasing rate of CO_2 emissions, and still, there is no clear and significant plan for applying clean energy sources [37].

4. Household Energy Consumption and CO_2 Emission

A considerable portion of energy demand and consumption in the world is used in cities. An estimation analyzed by the International Energy Agency [65] shows that the world has experienced about two times the growth of energy consumption from 2010 to 2018. In this regard, about 80% of energy consumption has been attributed to cities. From Figure 4, energy consumption and related CO_2 emission show a considerable increase in CO_2 per capita from 7.64 metric tons in 2010 to 8.87 metric tons in 2018 [63]. The urbanization caused to significantly increase the CO_2 emissions in cities by shifting energy sources [65]. More recently, there has been worldwide recognition of the problems associated with greenhouse gas (GHG) emissions within and outside of city boundaries [66–68]. Along with the growth of energy consumption and GHG emissions, however, there is not a direct relationship to recognize energy consumption as an indicator of GHG emissions [69]. According to Mondani et al. [70], energy indicators are categorized as energy use efficiency, energy productivity, specific energy and net energy. Energy consumed in cities can be produced from different sources, including electricity and fossil fuels, each with a different climate footprint [65]. Although the efficacy of produced energy influences the amount of GHG emissions, the energy consumption impacts on GHG emissions through the amount of energy consumed, GHG intensity, and GHG emissions factor [71]. It is therefore likely that a significant preeminence should be made between energy consumption and energy supply [72].

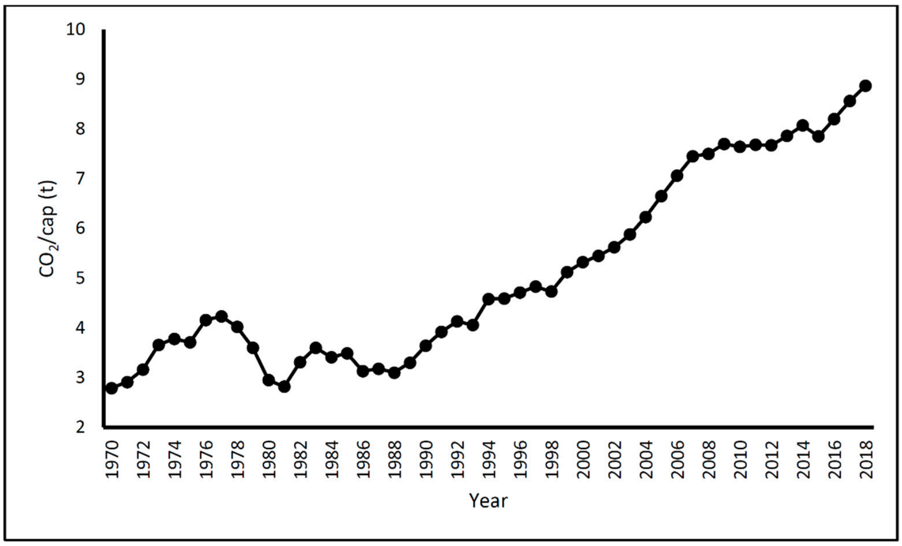

Figure 4. Per capita CO_2 emissions in Iran, modified from [63].

There are five primary sources for CO_2 emissions in Iran (Figure 5), in which industry and household sectors are responsible for 24.1% and 23.4% CO_2 emission, respectively. The results are in accordant to the globally main source of industry sector, which produces more than one quarter (26%) of total carbon emissions [73]. As shown in Figure 5, the second primary source is households with 23.4% of CO_2 emissions. The transportation sector is emitting 21.2% of total CO_2 emissions, and other sectors is considered as the sources of 31.3% of total CO_2 emissions in Iran. So, households are directly the producer of about one-fourth of Iran CO_2 emissions. With a combination of transportation and household sectors, 44.6% of CO_2 emissions have resulted from urban and rural communities. In another way, the residential sector represents an essential role in the effort for emissions reduction, and households are thus a talented group when addressing energy conservation [74]. A consensus exists among scholars and planners at a neighborhood level indicating that household CO_2 emission is related to the density, accessibility to employment, land-use combination, and vicinity to the public transit [75]. Iran's carbon emission will increase to 15.1 metric tons and 9.5 metric tons CO_2 per year without and with countermeasures, respectively, by 2030 [15]. Iran's CO_2 emissions have been increased by 5% annually between 1990 and 2016, whereas the global average for the same period is 2.3% [65].

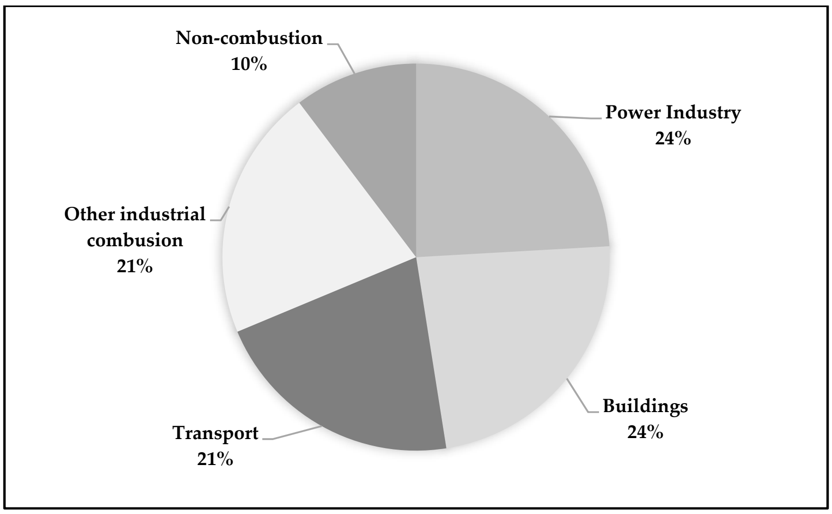

Figure 5. Fossil CO_2 emissions by different sectors in Iran, modified from [76].

Information, motivation, and responsibility are the basis for the household's quantity of CO_2 emission [8]. Some factors affect several instruments including incentives for energy savings, information given by campaigns, energy consultancy, workshops, feedback projects, and publications [77]. Considering the essential role of general public opinion in triggering the consumer's performance, the mentioned factors can significantly contribute to the individual energy savings and increasing the interest and knowledge regarding energy consumption [78]. Learning about the costs and performance of energy-efficient technologies is particularly challenging since their benefits are usually not directly observable. For instance, an energy bill is typically given for the households in Iran providing no individual end-uses breakdown as well as no information on GHG emissions. Proving sufficient feedback to consumers regarding their energy use and on the potential effect of their efficiency investments is essential [79].

Rebound Effects

Rebound effects partly explain why total household energy consumption rises when the energy efficiency of the production sector improves [80,81]. With the existence of a rebound effect, energy efficiency policies may serve the goals of promoting economic growth. However, energy efficiency improvement may lead to more resource use in absolute terms. Rebound effects are composed of four levels. The first level is the price effect. For producers, increased productivity reduces production costs and theoretically enables an increase in supply. The second level is the income effect. When costs per unit of output fall, consumers can afford more energy-intensive products and services. Wilhite [82] points out that the introduction of new technologies may at the same time create new energy-intensive practices. The third is a replacement effect. As the share of energy use in total expenditures reduces, the demand for other goods and services rises, including goods and services that have a significant share of energy embodied in their production. The increased demand for new products and services requires more energy. The last level is a transformation effect. Fuel efficiency and other technological improvements alter human activity through changes in the allocation of time [83].

Household energy consumption increases in both developed and developing countries, even with significant energy efficiency improvements and strict energy price regulation [78,84]. However, this theory only concerns technological change and neglects the impact of changing consumer demand towards higher living standards [57]. Sustainable consumption indicates a research framework as well as directions of desired changes in household consumption behavior [58]. Empirical studies examine household energy consumption patterns of specific countries or regions and explore critical factors that affect household energy consumption [19,85].

5. Influential Perspectives on Household Energy Consumption

The following subsections discuss the current research that explores critical drivers of household energy consumption from three perspectives: (1) factors from the production-side view, (2) factors from the household-side view, and (3) methods used to examine these factors.

5.1. Production-Side View

To comprehend the changing trends of energy consumption, decomposition analysis is normally utilized owing to a set of crucial comparable economic forces. There are changes in energy consumption normally categorized into structural changes and efficiency improvements [35]. Efficiency improvements reduce energy use to produce a product within a particular sector, while structural change is an alternative in the share of economic activities among industries (e.g., shifting from energy-intensive activities to less energy-intensive activities). Mulder and de Groot. [86] found that the structural change causes nearly all the decline in energy intensity in Norway and about half of the decline in Japan from 1970 to 2005.

Most of the decline to structural changes are attributed to early discussions of post-1978 changes in Iran's energy intensity. Fundamental decomposition analysis was utilized by Sabetghadam [87] to test the energy use of Iran within 1981–1987 and indicated that all of the energy intensity reduction was nearly related to the technical change, however, the structural change accounted for a slight increment in energy intensity. The research boundary was further extended by Sabetghadam [87] for 1987–1992 and similar results were obtained. The study indicated that most of the drop in industrial energy intensity in Iran is related to energy efficiency enhancements. Sabetghadam [87] supported that efficiency improvements are the main contributor to aggregate energy intensity reductions but found further that structural change contributed little to energy intensity change. Studying structural change at different levels of aggregation may also yield different results.

5.2. Household-Side Analysis

Energy consumption behaviors that contribute to increasing energy demand are different in developing versus developed countries. In Mexico, cooking, water heating, lighting, and electrical appliances are the fast-growing end uses [88–90]. In Iran, water heating and space heating dominate the set of fast-growing energy end uses among households [28,36,91]. A typical individual's consumption choice in modern society no longer has much to do with basic biological needs such as food or shelter [92–94]. Individuals' choices concerning the amount and quantity of recreation, amusement, housing, food, and other consumables are linked to past or familiar experiences, cultural norms, peer influences, and other social influences, such as those from the media [95]. In this regard, De Almeida et al. [96] stated that entertainment loads and information technologies are crucial contributors to electricity demand. Compared to other countries with similar climates, the households' demand shares for energy via space heating and cooling are rather low in Iran.

On the other hand, energy efficiency improvements can be locked-in to economies through changes in technology and infrastructure—the capital investments identified in the preceding paragraph. Infrastructures such as housing stock and public transportation parts of the hardware have an effect on the pattern of energy consumption. Household energy consumption is strongly influenced by dwelling type and age, surrounding structures, and other housing characteristics, such as insulation and building regulation [78]. Using double-glazed windows and more energy-efficient home appliances contribute to household energy conservation [85]. For instance, through such technological innovations, the energy consumption of dwellings built in the Netherlands is lowering after 1996 [97]. Interestingly the technological innovations are not always costly. A study conducted by Ürge-Vorsatz et al. [98] indicated that 32–33% of global building energy consumption for space heating can be conserved at a relatively low cost in the existing housing stock.

In Iran, urbanization is associated with both higher income and higher household energy consumption [19]. Moreover, increasing urbanization levels will lead to increased adoption of electronic home appliances, lighting, and other amenities [99]. Urban residents' lifestyle changes further causes a growth trend of energy consumption. In developed countries, households in high-density areas are less energy-intensive [100]. Norman et al. [101] conducted a lifecycle analysis on two residential settlements with different density levels in Toronto and found that residents in high-density areas consume less than half of operational energy and produced half the greenhouse gas emission compared to their counterparts who live in low-density areas [101]. According to Ewing and Rong [102], households in sprawling regions are more likely to live in large, detached single-family houses, which consume more operational energy than do single-family houses in compact areas.

Furthermore, cultural and traditional attitudes toward certain goods and behaviors can influence energy consumption preferences by households for a country such as Iran. Culture and traditions are typically passed from generation to generation and are primarily bestowed upon an individual over his or her lifetime. Abrahamse and Steg [30,103] suggest that socio-demographic factors such as income and household size shape households' opportunities and basic needs for energy, while reductions in energy use require a conscious effort—a change in households' behaviors [104]. Wilhite et al. [105] compared energy use behaviors in Japan and Norway and found very different space heating, lighting, and hot water use between the two countries. Not surprisingly, higher hot water usage in Japan was caused by the bathing habit in Japan (both publicly and privately), which had deep cultural roots [106]. Moreover, Norwegians tended to be more energy insensitive during lighting and heating, as they have less annual sunlight and a colder yearly average temperature [107]. Perhaps more surprisingly, however, is that Norwegians heated much of their living areas most of the time, while the Japanese tended to heat only rooms they were immediately using. Low energy prices in Norway may explain some of this discrepancy in behavior. But Sovacool and Griffiths [107] suggested that Norwegians also may have a cultural, physical, and psychological affinity for having all rooms heated.

5.3. Used Methods to Analyze Household Energy Consumption

Input–output (I–O) analysis is frequently used to calculate the total energy requirements of households [108–113]. Kok et al. [114] summarized three types of I–O analysis used by researchers. First is fundamental I–O energy analysis. This method is based on data for the production side of the economy and is useful for describing the environmental impacts of a specific country or comparing differences among countries. The second method combines I–O energy analysis with household survey data. In this method, the consumption data is from household expenditure surveys rather than I–O tables. It combines the energy intensities of different economic sectors or commodities with household expenditure survey data. This method can generate more information on the household level and compare the energy requirement of different household types. The third method combines life-cycle analysis with I–O analysis. It leads to more detailed information on both the production and consumption side. It is good at describing and explaining environmental impacts at the household level.

Based on the primary I–O method, Hajilary et al. [115] calculated CO_2 emission from Iran's household consumption and resulted that the household sector accounted for about 36% of total CO_2 emissions generated through primary energy consumption (Figure 6). The results from Hajilary et al. [115] indicate that rising total population, urbanization, and household consumption per capita contributes to the growth of indirect CO_2 emissions while reduced carbon intensity mitigates the increase in CO_2 emissions.

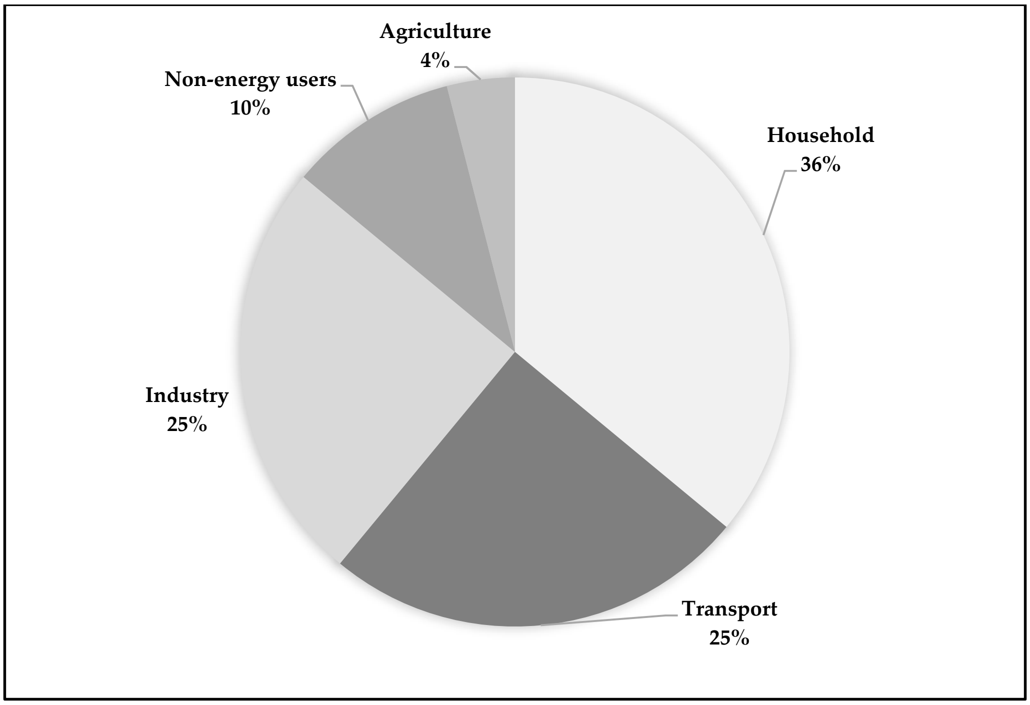

Figure 6. Distribution of energy consumption in different sections in Iran [115]. Reproduced with copyright, Elsevier.

Bin and Dowlatabadi [92] proposed a consumer lifestyle approach (CLA) as an alternative paradigm to show the relationship between household consumption behaviors and their environmental impact. Their findings revealed that about 80% of the energy consumption and related CO_2 emissions are in accordance with energy demand in the USA. In CLA, the consumer's decision making is affected by five interacting groups: (1) external environmental factors (e.g., traditions and technology levels); (2) individual determinants (e.g., attitudes and personal preferences); (3) household characteristics (e.g., housing size, household types and size, and household income); (4) consumer choices (e.g., information and availability of goods and services); and (5) consequences (e.g., consumption related material, energy use, and environmental impacts).

Based on CLA, Soltani et al. [28] compute the direct and indirect energy consumption and related CO_2 emissions of Iranian households in 2016. Household energy consumption was responsible for about 26% of total primary energy use and about 30% of total CO_2 emission in Iran. They also compared household energy use and CO_2 emission for different income levels. Soltani et al. [28] found that income has a considerable effect on the amount and structure of household indirect energy use in Iran. High-income households have a tendency to consume more energy indirectly through goods and services and have a more diversified indirect energy consumption structure.

Micro-level survey data are also widely used in determining household energy requirements [36,116,117]. Combining India's national household expenditure survey data with the estimated energy intensities of production sectors, Pachauri [116] quantifies household direct and indirect energy requirements at the household level in 1993. Pachauri [116] also explores the critical influential factors of household energy requirements through multi-variable regression. Based on the same dataset for the year 1999, Narasimha Rao and Reddy [118] use a multinomial logit model to analyze critical factors that affect households' energy choices for cooking and lighting in India. Moreover, Gould et al. [119] discussed the role of education and attitudes in cooking fuel choice in India and concluded that education is a strong predictor of LPG adoption. O'Neill and Chen [120] employed the residential energy consumption data to test the variables that affect the household energy use in the USA. O'Neill and Chen's study reveals that some demographical factors, particularly household size, have a substantial influence on household energy use.

Recent micro-level studies of household energy consumption in Iran are at the city level [19,121]. Since Iran does not have national surveys that collect energy-related data for households, studies conducted by Soltani et al. [19] and Sadati and Edwards [121] on household energy consumption are at the micro-level. Thus, there appears to be room for micro-level studies that could contribute to a complete understanding of critical factors behind various household energy consumption patterns. Moshiri [36] indicated that micro survey data at the household estimate demands for energy consumption. An advantage of micro-level over the macro-level analysis is that the micro-level can control for the characteristics of households, and makes use of detailed information on capital and its utilization [36].

Knowing the essential elements that influence energy consumption has become very considerable [122]. In the supply-side view, a change in energy consumption is often decomposed into changes in energy efficiency, production input structure, consumption structure, and consumption level. Household-level analysis studies the effect of climate, socio-economic, social demographic, social-cultural, and behavioral factors. Environmental and socio-economic factors significantly affect households' energy consumption. The impact of demographical change, cultural difference, and behavioral models are also examined in some empirical analyses and conceptual frameworks. The theoretical and modeling origin for the explanation of household energy consumption is "the energy ladder" theory. Moreover, "energy services" and "energy mix model" theories are considered.

5.3.1. Energy Ladder

The relationship between the increase in household incomes and the fuel choice for energy consumption is modeled within the energy ladder [123]. In the hypothesis determining the energy ladder theory (Figure 7), it is indicated that the energy source choices of the households can be classified between the most and the least technologically advanced energy sources either in descending or ascending mode. Such a hypothesis controls the households' energy source choice in Iran. As such choices become more financial, they will choose more sophisticated energy sources [19].

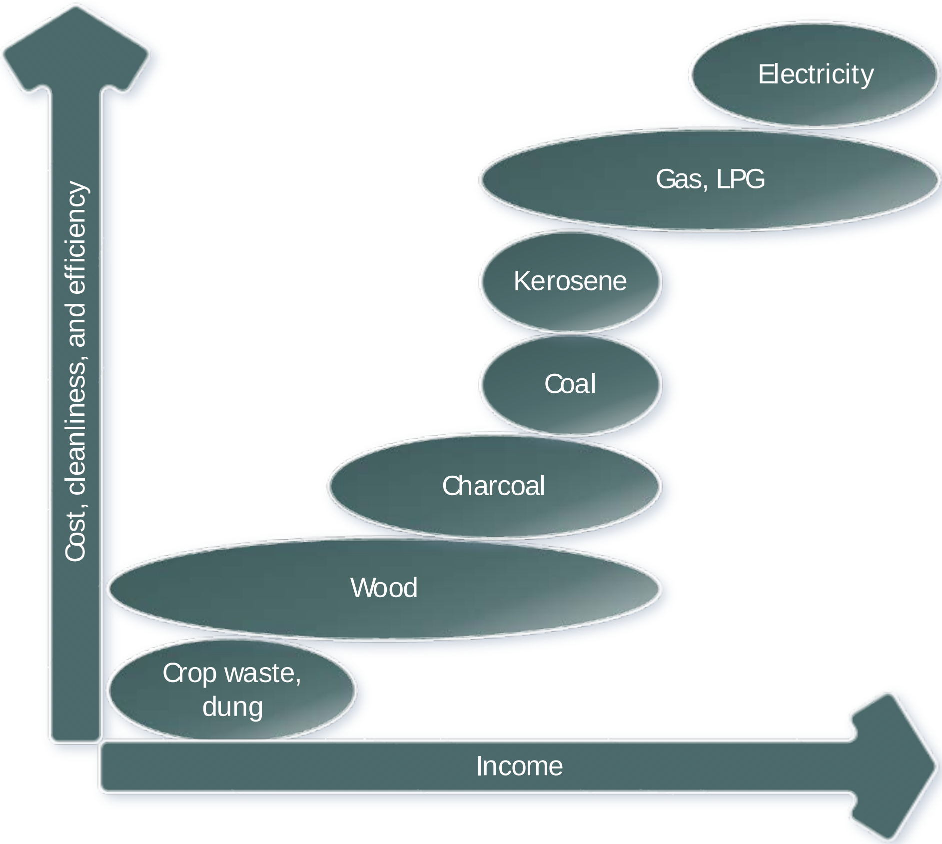

Figure 7. Energy ladder model, modified from the WHO [124].

The energy ladder model consists of three stages. The first stage, known as the traditional stage, refers to the period where the level of reliance on traditional fuels such as dung, wood, and agricultural is high. The second stage, known as the transitional stage, is the stage when households start using kerosene and coal. In the third stage, known as the clean stage, households use clean and efficient energy sources such as electricity and LPG [125]. The lowest rung of the energy ladder comprises traditional energy sources such as dung, crop residue, fuelwood, and charcoal. The middle and high rungs of the ladder include transitional energy sources such as kerosene, LPG, and electricity, respectively [126]. Betterment of households' financial circumstances and their ability to spend more on energy constitute the main drive of upward movement from the lowest to highest rungs of the energy ladder model [125]. When it comes to the relationship between technology and energy ladder model, one can find the connection between the model and technological advancements, efficiently devised energy-consuming appliances, utilization of clean energy sources and reduction of CO_2 and other GHG emissions.

Heltberg [127] believes that identifying the direct and significant impact of households' income on their energy sources is the key accomplishment of energy ladder model. This model acts in both macro- and micro- levels, in which the model implies the relationship between a country's developmental level and energy consumption at the macro-level and it signifies the correlation between households' incomes and their energy source selections at the micro-level [19]. The micro-level of energy ladder model also demonstrates the fact that households tend to move to higher rungs of the model and a result adopt more technologically sophisticated and clean energy sources not because they heed to environmental concerns but because they want to display their socio-economic superiority and betterment to each other. This is notwithstanding the households' income, the price of energy sources and energy-consuming equipment, and the availability of energy sources' impact on households' tendency to change their preference towards energy sources [19].

5.3.2. Energy Services

Energy services implying the advantages of using a particular energy source are quantifiable in temperature, work, or heat units. Modi et al. [128] argue that energy services indicate the advantages of a particular energy source facilitating human beings' welfare. Energy services have multi-variegated nature; thus, one service and benefit can lead to realizing other services and benefits [129]. For instance, a warm bath can have hygienic, clinical, and therapeutic benefits for a person on various occasions. In the rural areas within developing countries, people use biomass energy sources to produce requirement energy, which will be spent on cooking, lighting, and heating. Haas et al. [130] indicate that energy services should be oriented by the inputs, users, domains energy sources, and outputs. It should be stated that this model can be sectorally classified, indicating considerable differences between energy services of household, commercial, transportation, and industrial sectors.

Energy services in cities are classified into low, medium, and high categories. Regardless of a sufficient number of services, low-income households consume a further amount of energy [131]. For households that are categorized in medium and high categories, a sufficient number of services are available. Cooking, lighting, heating, and appliance are identified by Floor and Barnes [132] as the respective domains with aggregated energy services. Dutschke et al. [133] regarded radio, television, lighting, heating, and cooking as the domains of energy services of low-income households. In Africa, water heating, lighting, cooking, radio, television, and refrigeration are the domains with the highest number of materialized energy services [134].

Electricity, natural gas, coal, LPG, and kerosene are the energy source choices of the middle class. These choices have a higher number of energy services. These energy sources are used for cooking, heating, lighting, and entertainment. Sovacool [129] believes that cost economization of energy sources and their transformation into efficient forms encourage the middle class to spend more on energy. In another study, Fouquet [135] mentions that lighting, heating, power, and transportation are the four key areas in which energy services are aggregated. Furthermore, Fouquet [135] believes that the cost reduction of energy sources results in consumption increase.

Sovacool [129] shows that both the middle and upper classes of society have access to technologically advanced energy sources; however, the latter uses more energy. The reason for using a higher amount of energy is that they have more luxuriant and affluent appliances, such as a heated swimming pool, multiple kitchens, and air conditioners [129]. This is not the case for the low-income category since households save their energy consumption as they cannot afford to spend more. They cannot spend energy extravagantly unlike the upper class. Loveday et al. [136] embodied the distinction between these two opposing attitudes regarding energy consumption by households as a low-income category tends to wear more clothes in winter rather than the upper-income category. On the other hand, low-income households do not have the privilege of selecting any desirable energy source for the purpose of heating the house.

Social signaling and conspicuous consumption are two newly coined terminologies through which social scholars describe the relationship between energy consumption and social class. These terms also show the correlation between capital, technological advancements and households' level of comfort and convenience [137]. Unlike the energy ladder model, the energy services model does not consider a linear developmental path for selecting energy sources by households. This model sees households' reaching to one single preferential energy source impossible and emphasizes the simultaneous utilization of multiple energy sources [129].

5.3.3. Energy Mix Model

Energy Mix Model, also known as Fuel Stacking, believes in households' combinatory usage of energy sources. Despite the energy ladder model, the energy mix model does not rely on households' linear advancement towards any particular energy source. Using many energy sources has turned into a prevalent energy consumption strategy for households in developing countries [138]. The energy mix model believes that variables such as socio-demographic variables affect the household's adoption or dropping of an energy source. Furthermore, the model emphasizes that in their daily usage, households have the tendency to complement their energy sources with each other. When these sources complement each other, the energy mix model considers various socio-economic and cultural factors that result in the realization of such complementary energy fusion.

Heltberg [127] observes that the energy mix model does not believe in an ascending movement from one kind of energy source towards another kind. Heltberg [127] maintains that adopting a new energy source (e.g., commercial fuels) by a household does not necessarily result in abandonment of previously used sources (e.g., dung, fuelwood, charcoal). In developing countries, one of the areas where energy sources are used in a comminatory fashion is cooking [139]. Barnes et al. [140] believe that energy consumption patterns have been transforming in time and the best way to comprehend such changing patterns is to see them in developing patterns than seeing them in exclusive shifting stages.

Energy mix models believe that all the social classes of society use energy sources in combination. This observation is not in accordance with the energy ladder model that only believes in direct correlation between households' economic circumstances and the type of energy choice they will have for their routine usages. The energy mix model sees households choose their energy sources through a portfolio or menu. The options of this portfolio or menu can be arranged either based on economic, cultural, and personal criteria [141]. Heltberg [127] emphasizes that the options of such portfolios or menus can be categorized because of their size, composition and diversification.

In their studies on Thai urban communities, Nansaior et al. [142] reach to the conclusion that although urbanization causes the prevalence of clean energy sources and decline of biomass fuels in the options of household energy portfolios, urbanized Thai households still use traditional fuels and energy sources such as biomass fuels. Such a combination of traditional and modern energy sources proves the combinatory premise of the energy mix model. Both the energy mix model and energy service ladder challenge the validity of all the claims of the energy ladder model [142].

5.4. Critique of the Energy Ladder Model

As mentioned earlier, the energy ladder model has been challenged by various models and the works of scholars and researchers. It is found that owing to the betterment of households' income in most developing countries, they do not essentially move towards the ideal sources. In other words, the energy choices of the households cannot be placed in a linear continuum with the lowest end including dung, fuelwood and crop residue, and the highest-end including electricity and LPG. In the energy ladder model as an exclusivist model, the emphasis is only on determining the role of households' income within their energy source selections. Although the key role of households' income in their energy source choices should be acknowledged, the impacts of other factors on households' energy source choices should be considered as well.

Chambwera [143] observes that while energy price and households' income impact the amount and the type of energy that will be consumed by them, there are other cultural factors that can undermine the choices households should have based on the economic circumstances. In other studies, it is proven that even in cases where households can afford clean and technologically advanced energy choices, they may choose more traditional sources because of their cultural affinities. This shows that, in some cases, the brunt of cultural and personal preferences in choosing household energy sources is higher than the influence households' economic circumstances are going to have.

In the study in India, Joon et al. [138] report that the reason that India has not experienced a complete movement towards clean fuels and more advanced energy sources are not economic and it is needed to be sought in the socio-economic traits of the Indian society. When it comes to cooking, Indians do have taste preferences that can be accomplished through the usage of more traditional energy choices. That is why, while they use LPG stoves for preparing tea and vegetable, more traditional stoves, which are called Chulah (s), are used for baking bread. They think that such stoves will make the prepared bread crunchier and more delicious.

In the study by Mekonnen and Kohlin [144], it is observed that the urbanized Ethiopian households use multiple energy sources. This multiplicity has very little to do with either an increase or decrease in their income and, as a result, undermines the linear expectation of the energy ladder model. In addition to the lack of correlation between the Ethiopian households' incomes and energy source choices, it is observed that each society regards a kind of energy luxurious and does not see a single technologically advanced fuel or energy source as being the ultimate luxurious choice. In Ethiopia, wood and charcoal are conventionally considered as traditional and inferior energy choices because households can spend most of their income on such energy sources. In another study in Ethiopia, Gebreegziabher et al. [145] believe that all energy sources are interchangeable with each other. The multiplicity in households' energy source choices attests to the versatility of their lifestyles and food habits.

A study shows that, in Mexico, people do not yearn linearly to accomplish a single type of fuel or energy source and use various fuels and energy sources combinatorially. Most Mexican households use fuelwood and LPG simultaneously for maintaining their daily energy requirements. Some households even start using more traditional energy sources and cooking appliances not because of deterioration of their financial circumstances but because of the impact of cultural and personal factors [141]. All the aforementioned factors attest to the fact that the emergence of a new technologically advanced energy source, e.g., LPG, does not necessarily put an end to the usage of more conventional sources in households. In most cases, households tend to diversify their energy source choices and fuels rather than relying on one particular fuel or energy source [142].

6. Influential Factors on Household Energy Consumption and CO_2 Emissions

Research on household energy consumption not only focuses on energy directly consumed by households but also energy embodied in the goods and services consumed by households. Both aspects of household energy consumption in direct and indirect CO_2 emissions were studied in several studies. For example, in the study of Brizga et al. [146], the connection between CO_2 emissions and households' energy consumption in the Baltic States was evaluated. A model of households' energy consumption was introduced by Dai et al. [147] that affects the CO_2 emissions in China. Zhang et al. [148] in another study in China observed that altering lifestyle, from traditional to modern, increased the CO_2 emissions in Chinese households. Barr et al. [149] assessed the factors relevant to the habitual and purchase-oriented actions that influence the rate of energy conservation in the UK. Correspondingly, Trotta [150] took into account the role of demographic, environmental, and residential circumstances in the UK's household energy consumption. Soltani et al. [19] reported that numerous variables affect the pattern of household energy consumption such as household size and age, educational and income level, and gender. In this concern, household energy consumption is increased by increasing energy demand as a result of population growth in Iran. Soltani et al. [28] evaluated the factors affecting Iranian household energy consumption and related CO_2 emissions (Figure 8). The share of energy conservation depends on five main factors of income, educational level, household size, household age, and gender [28]. Variations mainly depend on differences in income levels of households.

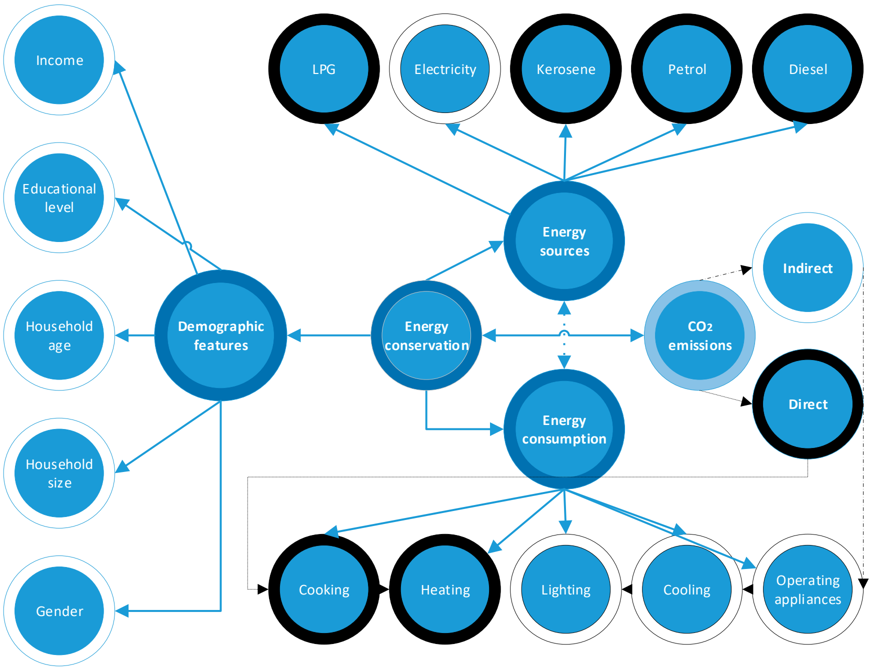

Figure 8. Influential factors on the CO_2 emissions from Iranian households energy consumption [28]. Reproduced with copyright, Elsevier.

The pattern of households' energy consumption is mostly based on income level, human behavior, and geographical area [151]. Weather and wealth partly determine the change across countries in the quantity of energy utilized per capita, which is large both at the household and economy levels. This is also properly credited to various lifestyles. Income and household size are the main determinants behind the changes in the energy requirement. While more direct energy (for example electricity, motor fuel, and natural gas) is relatively required by the lowest income classes, higher, more indirect energy (for example the energy needed for the production of food) is required by income classes in absolute and relative terms. For instance, for holidays the energy requirement is very sensitive to the rises in income. On a household level, a large spread exists in the energy requirement, even within a class with the same household size and income.

Income is well-known to have a significant and positive effect on household energy consumption. Income affects household energy use behavior in several ways. On the one hand, it influences the level of consumption via income elasticity, which measures the responsiveness of the quantity needed for the energy source to a change in income [28]. That is, rising income leads to increasing demand for more electronic appliances and more substantial houses [152]. In the case of appliances, demand for time-saving devices rises with increases in opportunity costs for time, which requires households to use and purchase more energy [153,154]. For example, from 2000 to 2017, the average household energy requirement rose by 53% in Brazil [155]. Moll et al. [156] compared the average household energy requirements for different income groups of households in the Netherlands, the United Kingdom, Norway, and Sweden and found that different levels of income yield different energy consumption behaviors. As a result of these investigations, households with a low income tend to spend a higher portion of their costs in the use of electricity and heating the house; however, they do not prefer to spend a further portion of their cost for transportation and recreation.

On the other hand, income also affects the diffusion of energy-efficient equipment. Higher-income gives consumers the ability to invest in energy-efficient appliances and other rather expensive energy conservation techniques such as better insulation and double-glazed windows. Wealthier households tend to replace older and less efficient appliances more frequently [157]. Moreover, higher income is often linked to higher levels of education and thus to greater environmental information access as well as greater environmental awareness. All of these factors are important in energy conservation. However, Cayla et al. [158] indicate that rich households may lack interest in energy-efficient equipment when the budget share dedicated to such an item is small.

Homeownership also plays a vital role in household energy consumption, especially in rented dwellings. Households in rented dwellings tend to consume more energy if heating costs are included in the rental rate [159]. Homeownership is often related to specific durable products and services as well, which can also influence household demand for energy services. In Iran, renters use less electricity than homeowners simply because they own fewer electric appliances, such as refrigerators, washing machines, and air conditioners [36]. Moreover, the mobility of a household, which is associated with homeownership, can influence households' ability and willingness to invest in energy-efficient appliances and sustainable building design [160].

Other factors, such as climate, technology, infrastructure, energy price, and existing policies, also play an essential role in influencing household energy consumption. Of these, household energy consumption probably varies most with local climate conditions. Places with moderate temperatures such as coastal California have much lower energy consumption levels than sites with temperature extremes like Texas. A typical household's carbon emission is 78% higher in Memphis than in San Diego [161]. Cheng and Li [162] found that household energy consumption is strongly related to heating degree days (HDDs). This relation between household energy consumption and HDDs is also reported in China, Japan, the USA, and Canada [163], Turkey [164], and France [165].

Energy prices also influence household energy consumption in Iran [19]. They are positively correlated with sustainable energy use: higher energy prices result in reductions in energy use [154]. Moshiri [36] suggests that the effects of the energy price reform on household consumption in Iran cause households to be more responsive in terms of their energy use. However, generally, household energy demand is perceived to be relatively price inelastic since it has become a modern-day necessity. Moreover, the price elasticity of energy demand is asymmetric. Consumers seem to be more sensitive to energy price rises than to energy price declines. The asymmetry is probably due to medium- to long-run adjustments to the higher energy prices by making capital investments that induce more-efficient energy use as well as to expectations of future costs rise.

Demographic factors also substantially affect household energy consumption through ownership and choice of appliances and household behavior. Several studies explore the influence of key demographic factors, such as population size, age structure, household size, gender, and urbanization [27,28,123,166]. Farajzadeh and Nematollahi [27] found that some demographic factors, particularly household size, had a substantial influence on residential energy use in Iran. Households with fewer members tend to use more energy per capita than do larger households. Shifting from a one-person to a two-or-more-person household yields reductions on the order of 20% in household direct energy use per capita in Iran [27]. Aging also influences residential energy consumption since energy consumption tends to change over one's lifespan. Elderly households tend to be more energy-intensive than are other households. Farajzadeh and Nematollahi [27] also suggest that decisions made by an aging population could disable the ability of the Iranian government to meet its energy-saving targets. Soltani et al. [19] found that income is the leading variable for households in Iran to consume LPG and electricity while other variables remain constant.

Besides, as argued by Soltani et al. [28], there is no any statistically significant relationship between gender and energy conservation. In this regard, Martinsson et al. [167] found that there is no difference between men and women for their pro-environmental behaviors. Trotta [150] explored the way in which the gender does not determine who is more pro-environmental but the person who is expected to watch out the household activities.

7. Household Energy Consumption Pattern in Iran

It is essential to know about the leading factors that affect households' energy consumption. Wiesmann et al. [168] reported that it is required to incorporate energy sources and the energy demands and needs of households. It can be useful to attain a clear trend in terms of energy choice and energy consumption in an area. As discussed in Section 5.3, several techniques have been introduced to develop a suitable basis for clarification of household energy consumption. In this regard, the energy ladder model was considered as the origin model to elucidate household energy consumption [123]. However, the energy ladder model has been forcefully argued in recent years by scholars [169–171]. In Iran, such a hypothesis (i.e., energy ladder) rules the source of energy for households since the further they go financially, the more modern the energy sources they choose [19]. However, there are certain disadvantages related to the use of the energy ladder model in Iran. In this regard, an increase in income of households does not lead to consuming a modern energy source. Otherwise, there is not a direct relation to consuming traditional energy such as fuelwood and crop residue by the low-income category and modern energy such as LPG, renewable, eco-friendly energy sources by upper-income category.

Besides, empirical work testing the rebound effect theory fails to recognize from the following point in Iran. Most of the studies only focus on the technical change that affects energy efficiency [36]. The effect of shifting consumer demand to higher living quality is missing. Understanding such shifts in consumer demand is very important, especially for developing countries like Iran. As stated by Fuerst et al. [151], the energy consumption pattern of households is based on the income level, human behavior, and geographical area. The weather and wealth can clarify the changes within the countries in the quantity of energy utilized per capita, which is large both at the household and economy levels.

Household energy consumption has been increasing in both rural and urban Iran [18]. Figure 9 shows a trend of specific energy consumption (SEC) in Iran, based on electricity from 1999 to 2017 [172]. Household energy consumption barely met basic human needs, such as cooking. Starting in the 2000s, the cooking fuel shortage is gradually solved via this period's rapid development of agriculture, which enables the availability of more straw and other grain stalks. At the same time, rural households started to use more commercial energy, meaning that electricity became increasingly available in the rural marketplace [173]. Urban households went through a similar transition, from an energy shortage to enough energy to meet basic needs and then further to demand over basic requirements. Compared to their rural counterparts, urban households devote much larger shares of their consumption baskets to commercial energy.

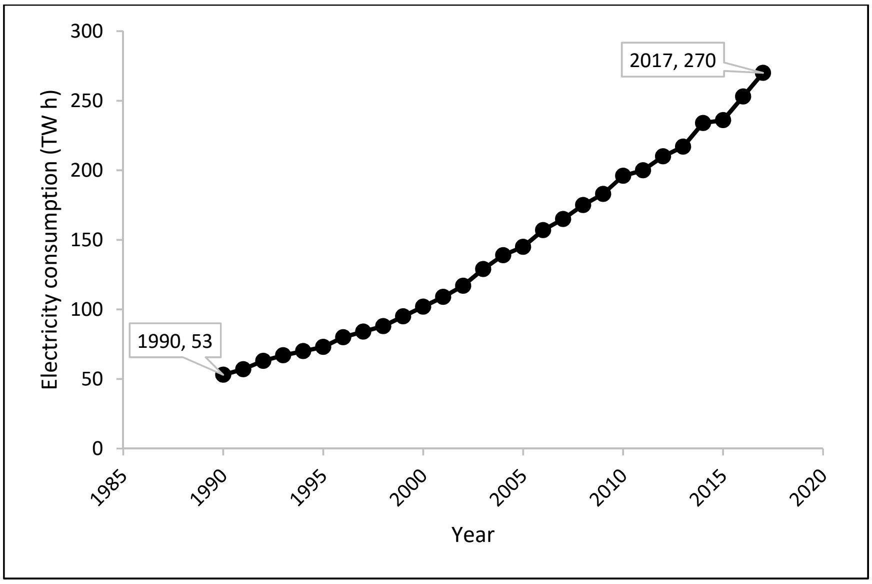

Figure 9. Specific energy consumption in terms of electricity based in Iran from 1999 to 2017, modified from [172]. Terawatt-hour (TW h), a measure of electrical energy, equals to 10^{12} watt-hours.

During the process of energy commercialization, energy consumption in households changed dramatically. In Iran, the share of electricity increased significantly from 53 to 270 TW h between

1999 and 2017, respectively (Figure 9). In this period, annual per capita energy consumption based on electricity increased to 0.95 terawatt-hours (TW h). The transition of fuel composition could be partly explained by households' intensifying share of direct energy use among all household purchases. In urban Iran, the share of delivered energy used for cooking and heating decreased 12%, while the share of energy used for lighting, cooling, and electric appliances increased 12% [173]. After the revolution in Iran in 1979, the primary fuel for cooking and hot water has gradually switched from coal to LPG in urban Iran.

Many studies indicate that household direct energy consumption also varies tremendously across Iran [18,36,173]. Per household CO_2 emissions in central Iran are 69% higher than the national average level. However, in the cities of Western Iran, per capita, household CO_2 emission is 17% lower than the national average. Rural households in the northeast, south, and southwest Iran tend to be more likely to use biomass than are other regions.

Although Iran had already developed a legal foundation in support of energy efficiency for residential buildings and home appliances [60], its efficiency standards were relatively low compared to those applied in western developed countries. Perhaps more critically, Iran's monitoring and enforcement of energy efficiency standards and labels were relatively weak. Few policies directly targeted consumers' energy consumption behaviors. Still, in the summer of 2007, Iran's state council required all government agencies to set their thermostats no lower than 26 degrees Celsius in public buildings. Nonetheless, this environmental edict was largely ignored by provinces and cities outside of Tehran and even some local officials within Tehran [60]. Household-targeted policies about rational energy consumption remain a missing component in Iran. Thus, a study of households' energy consumption behavior is undoubtedly significant to inform energy policy.

8. Conclusions

An attempt has been made in this study to review relevant literatures on household energy consumption and related CO_2 emissions in Iran with the view to establishing the gap that exists. The nexus between household fuel choice and consumption has been a subject of academic scrutiny by researchers over the years. Most studies of household energy consumption in Iran focus on direct energy consumption factors such as the transition of the fuel mix and changes in end-use structures. The reason for varied opinions on which factor influences on household fuel choice and consumption is borne out of the fact that issues relating to household energy are complex and mostly context specified. Available empirical evidence on the relation and causality has failed to provide a conclusive answer among researchers from various disciplines.

Studies of total energy consumption (both direct and indirect) are mainly macro-level analyses based on I–O models. The indirect energy consumption patterns of urban and rural households are calculated and compared on both national and regional levels for specific years. However, a long-term and spatial analysis of household energy consumption in Iran is missing. These studies cannot display a clear picture of how lifestyle changes from poverty to a relatively well-off society have impacted household energy consumption in Iran. Some studies use household survey data to explore household energy requirements. Most of them are descriptive analysis of one or several cities or counties. Few studies examine the driving factors that impact household energy requirements at the micro-level. Thus, there appears to be room for improvement that could contribute to temporal and spatial analysis in the macro-level as well as micro-level analysis to form a complete understanding of household energy consumption in Iran.

Most of the studies that have been conducted on household energy focused only on a single fuel source, even when multiple fuel sources were taken into consideration; some were excluded. Household energy should be considered as a menu or portfolio in which households make use of various fuels for different purposes in meeting their energy service demand. Income is seen as the major driver in household fuel choice and consumption in most of the studies while other factors have been given little or no attention. Although income plays a major role in determining household fuel choice and consumption, taking into consideration the influence of other factors in response to energy consumption and preference will allow for comparison. However, all the likely factors that influence household fuel choice and energy consumption are examined with the view to establishing the role played by each factor in a developing country such as Iran.

Moreover, none of the existing studies in Iran has tried to assess or evaluate the CO_2 emissions arising from household fuel use at homes, much attention with regard to energy use and the environment has been given to deforestation and other environmental problems resulting from the unsustainable consumption of fossil fuels. Besides, the environmental aspect of household energy use should be considered by focusing on CO_2 emissions from commercial fuels (e.g., kerosene, LPG, diesel, petrol) used by urban households in meeting their energy needs.

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Conflicts of Interest: The authors declare no conflict of interest.

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