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Oil Theft, Energy Security and Energy Transition in Mexico

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Abstract: Oil theft refers to the exploitation of crude oil or refined petroleum products for criminal purposes. In Mexico, oil theft—referred to as huachicolero—is endemic and widespread. By framing it within the energy security and transition context, this paper offers a new perspective on the problem of oil theft in Mexico. Focusing on crude oil and refined petroleum, the paper demonstrates that Mexico's energy security—as framed around the 4As (availability, accessibility, affordability, and acceptance)—has deteriorated over the past decade. Application of the 4As framework in the Mexican context shows that the increasing frequency of oil theft has contributed to this deterioration. The proposed solution to the energy security and oil theft problems is centred on Mexico moving from gasoline and diesel to electrification in the transportation sector. The paper demonstrates that, while transport electrification in Mexico has been lagging behind other countries, recent developments in the country point to growing momentum among the country's political and business elites, in tandem with US partners, in support for the energy transition. Areas where further emphasis should be placed to accelerate Mexico's energy transition in the transportation sector are identified. Finally, the feasibility of and potential limitations associated with implementing the transition are evaluated.

Keywords: Mexico; oil theft; energy security; energy transition; electrification

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1. Introduction

Oil theft refers to the criminal exploitation of crude oil or refined petroleum products [1,2]. The transnational nature of oil supply chains gives criminal groups that commit oil theft a global reach [2]. Oil theft is commonplace across many developing—as well as developed—countries. Oil theft in Mexico, locally referred to as huachicolero, is endemic and widespread [3]. The number of illegal taps in Mexico increased from around 200 per year before 2007 to 3000 in 2013, peaking at 15,000 in 2018 [4,5]. Illicit pipeline tapping accounts for most of Mexico's oil theft. Historically carried out in a rudimentary way by huachicoleros, illegal tapping has been transformed into a sophisticated criminal activity controlled by Mexican criminal cartels, who use their money and military power to acquire information on the potential locations of pipeline valves [6]. Cartels also have access to sophisticated technology and expertise that allow large-scale pipeline tapping. They can further store large amounts of gasoline and sell it on the black market [7].

The existing literature, briefly reviewed in Section 2.1, does not consider how oil theft affects Mexico's energy security. In order to address this research gap, this paper utilises an established energy security framework to evaluate the impact of oil theft on Mexico's energy security. The main contribution to the literature is the assessment of Mexico's energy security in the transportation sector over the past two decades. Findings indicate that Mexico's energy security has deteriorated during this period. The analysis presented in the paper demonstrates that oil theft and the associated phenomena have contributed significantly to this deterioration. Policy recommendations for the Mexican government may assist in improving the country's energy security and reducing the prevalence of oil theft. Transport electrification is identified as a potential solution to Mexico's energy security and oil theft problems.

Against this background, the paper proceeds as follows. Section 2 provides a brief review of the relevant literature and outlines recent trends regarding oil theft in Mexico to identify the research gap and set up the context for the study. Specifically, this section demonstrates how and why critical political decisions over the past two decades have rapidly increased oil theft. In this section, two key concepts that are relevant in the context of this paper are described: energy security and energy transition. Specifically, the section outlines the 4As (availability, accessibility, affordability, and acceptance) framework used to assess Mexico's energy security performance in the transportation sector. Section 3 discusses four problems that contribute to Mexico's deteriorating energy security situation. Discussion points include Mexico's declining oil production reserves and refining capacity; growing imports and cost of petroleum; the direct impact of oil theft on Petróleos Mexicanos (PEMEX) and the country's national and energy security; and the slow transition from petroleum. Summarising critical points from the preceding section, Section 4 applies the 4As energy security framework. This section explains how oil theft exacerbates Mexico's energy security challenges in addition to being a threat to national security. An accelerated transition from gasoline and diesel vehicles to electrification in the transportation sector may help Mexico reduce the prevalence of oil theft and enhance energy security. This section also outlines policy recommendations for the Mexican government and the feasibility of and limitations associated with their implementation. The final section offers concluding remarks.

2. Materials and Methods

2.1. Oil Theft in Mexico: Literature Review and Recent Trends

Inquiries into oil theft require more publicly available data and information and more dedicated studies. With the exception of research on Mexico and Nigeria, there are only a few studies focused on the topic [2,8]. In the global context, a report by Ralby (2017) was the first comprehensive global study on oil theft. This study provides insight into the trends in and modalities of oil theft, the criminals responsible and the stakeholders affected by illicit activities, and policy recommendations to reduce its scope and prevalence [7]. Ralby (2017) argues that oil theft provides significant financial resources to those engaged in this criminal activity. Oil theft also creates instability and deprives governments and oil companies of billions of dollars in tax revenues and profit [7]. Romsom (2022) discusses the global prevalence, methods, and consequences of oil theft, an activity that he estimates to be valued at USD 133 billion, equivalent to 5–7% of the global crude oil and refined petroleum market [2]. Eaton (2021) examines the smuggling of refined and unrefined hydrocarbon products across the supply chain, arguing that the challenges increase as profiteers penetrate higher up the supply chain [9]. Soud (2020) proposes countermeasures that can serve as the basis for comprehensive strategies for oil theft mitigation [1].

In the Mexican context, Jones and Sullivan (2019) study the rise of huachicoleros and criminal cartels participating in oil theft, who use violence and corruption to expand the illicit market. They also provide an overview of oil theft in the context of the criminal political economy in Mexico, along with a Cártel Santa Rosa de Lima (CSRL) case study [5]. Correa-Cabrera (2017) describes how one of the foremost criminal organisations, Los Zetas, employed paramilitaries and developed corporate structures when diversifying into oil theft [10]. Flores Pérez (2014) argues that authoritarianism and corruption in post-revolutionary (post-2000) Mexico enabled the diversification of cartels into oil theft [11]. According to Berbotto and Chainey (2021), oil theft gives cartels significant financial resources, which is detrimental to socioeconomic stability and the environment [12]. Their analysis reveals details about the roles performed by cartel members, how they recruit people to provide sensitive information about the pipelines and perform technically challenging illegal taps, and the supporting role of local communities and businesses. Their analysis also reveals the necessary decision making for the continuous success of oil theft operations through illicit pipeline taps [12].

According to Romson (2022) and Battiston et al. (2022), when, in 2007, the Mexican government under President Felipe Calderón started the "War on Drugs", the cartels shifted their focus to oil theft as an alternative source of income [2,6]. Battiston et al. (2022) point to a causal relationship between the War on Drugs, which significantly reduced drug-related profit margins, and oil theft [6]. Figure 1 demonstrates that this criminal activity emerged in full swing after the War on Drugs started and increased exponentially in parallel with Mexico's homicide rate. Indeed, Figure 1 demonstrates a significant correlation between illicit oil taps and the homicide rate, which the effect of the War on Drugs may have caused.

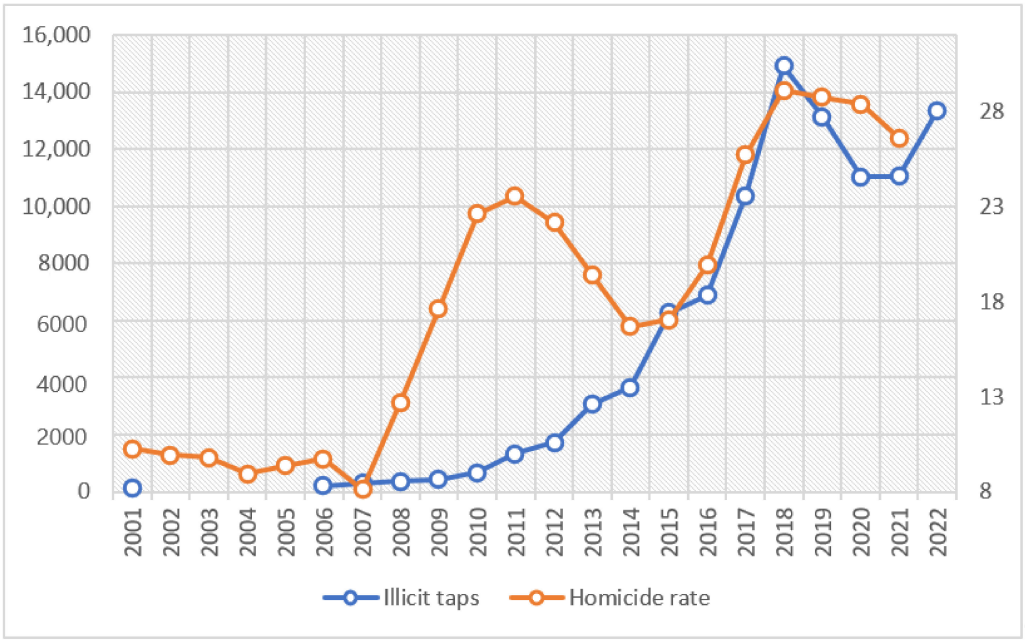

Figure 1. Illicit pipeline taps (left) and homicide rate (right; per 100,000 people) in Mexico (2001–2022). Data from [4,6,13–22].

The energy-sector reforms launched by the government of President Enrique Peña Nieto in 2014 reduced fuel subsidies and ended the monopoly held by state-owned PEMEX. Due to the subsidy reduction, gasoline prices in Mexico increased significantly over the next several years, even during the global oil price crash. The so-called gasolinazo crisis was caused by the most significant increase in gasoline prices in two decades. The crisis contributed to a rapid increase in illegal pipeline tapping and oil theft, particularly since 2014 (see Figure 2) [23]. Mexico's average national gasoline price increased from 13.01 MXN/litre in 2013 to 20.62 MXN/litre in 2016, a 58.5% increase in only three years [24]. While the subsidy reform attracted foreign investment into Mexico's oil sector, it also enabled criminal exploitation of the pressure placed on consumers. According to Soud (2020), the rise in gasoline prices and distrust of the government have enabled criminal organisations to become de facto public service providers, as communities are exploited for the benefit of cartels [1]. Mexican cartels have become firmly embedded in communities across the country by offering heavily discounted or free gasoline, employment, gifts, and community services, such as healthcare [2].

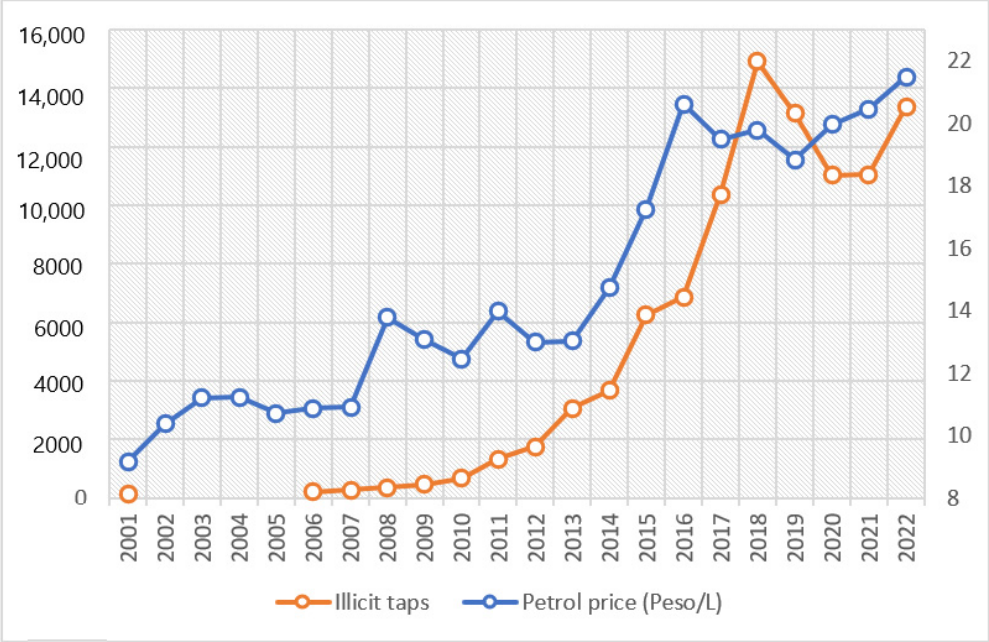

Figure 2. Illicit pipeline taps (left) and average national petrol price (right) in Mexico (2001–2022). Data from [4,6,13–20,24].

President López Obrador's administration, in power since December 2018, has argued that more than 90% of oil theft has been eliminated [5]. Figure 2 demonstrates that oil theft prevalence remained high during the first three years (2019–2021) of his presidency, notwithstanding his claims that oil theft has been "practically eliminated" [25]. A recent study by the International Crisis Group warns about the potential for the Ukraine war to lead to an increase in oil theft in Mexico, with sanctions against Russia probably making it increasingly profitable [18]. Indeed, an increase in crude oil and gasoline prices in 2022 incentivised the black market for gasoline, with Mexico seeing a nationwide increase in oil theft. From January to August 2022, PEMEX reported 8910 illicit taps, a 27% increase compared to the same period in 2021 [20]. These increases are highly focused on northern Mexico, where gasoline shortages have been reported. These were exacerbated due to a growing number of Americans crossing the border looking for cheaper gasoline [26,27].

2.2. Methods and Concepts

2.2.1. Energy Security: The 4As Framework

Energy sits at the nexus of national security, economic prosperity, and environmental considerations. The United National Development Programme (UNDP) defines energy security as "the uninterrupted availability of energy, in various forms, in sufficient quantities and at affordable prices, without unacceptable or irreversible impacts on the economy and the environment" [28]. This paper applies the 4As framework to assess Mexico's energy security performance in the transportation sector. As evident from the discussion in Section 2.1, the existing literature on oil theft has yet to consider the phenomenon from the energy security perspective.

While noting its contested nature, it is practical to conceptualise energy security around the four main dimensions or 4As [29,30]. In the energy security literature, this framework has been applied in the contexts of the Association of Southeast Asian Nations (ASEAN), Australia, Bangladesh, China, and Pakistan, as well as for the implications related to transportation electrification in ASEAN [31–36]. The 4As framework is centred on four key dimensions of energy security present in the supply chain; namely, supply security (availability and accessibility), the economy (affordability), and environmental and social sustainability (acceptance). Supply security includes two dimensions. The first supply security dimension is the availability of energy resources; specifically, the geological exis-

tence of energy resources and production potential. The second supply security dimension, accessibility, refers to the capacity for energy production and the quality of supply chain infrastructure, including refining, processing, and transmission, and includes geographic and geopolitical challenges related to energy access. The economy dimension refers to energy affordability or the cost across the supply chain. The environmental and social sustainability dimension refers to the acceptance of energy production, transportation, and usage [32].

2.2.2. Energy Transition

Energy transition refers to a significant structural change in an energy system. It is a continuously unfolding process that gradually changes the composition of sources used to generate heat, motion, and light [37]. The ongoing energy transition is frequently associated with decarbonisation and refers to a structural shift from hydrocarbon-based energy systems to renewable energy sources and lithium-ion batteries. Key drivers of the energy transition include a growing share of renewable energy in the energy supply mix, electrification, and improved energy storage. Globally, the pace of energy transition, along with regulation and commitment to decarbonisation, has varied significantly. The current energy transition is associated with an increase in the importance of environmental, social, and governance (ESG) factors, specifically the United Nations Sustainable Development Goal (UN SDG) 7: "Ensure access to affordable, reliable, sustainable and modern energy for all" [38]. It is also commonly framed as a just transition from an extractive economy to a regenerative and inclusive (circular) economy, where no one is left behind [39].

3. Results

3.1. Problem One: Mexico's Declining Oil Production and Reserves

In 2004, with crude oil production of 3.83 million barrels per day (mbpd), Mexico ranked as the world's fifth largest oil producer, behind Saudi Arabia, Russia, the United States (US), and Iran. A decade later, the country's oil production declined to 2.79 mbpd, as most prolific fields dried up and new ones to replace them have yet to be discovered [40,41]. In line with the decline in production, Mexico's official proven oil reserves declined from their peak of 55.0 billion barrels, or 7.5% of the world total, in 1983 to 6.1 billion barrels, or only 0.4% of the world total, in 2020. At current production rates, Mexico has only 8.7 years of proven oil reserves left in the ground [40].

In late 2013, aiming to reverse the oil production decline, centre-left president Enrique Peña Nieto put Mexico on an economic reform program [42]. Constitutional and other reforms represented a significant milestone, breaking with the country's long-established dominance of the state, and state-owned PEMEX, in oil and gas. In 1938, Mexico was one of the first countries to nationalise its oil industry. Until 2014, Mexico was the only country in the Organization for Economic Co-operation and Development (OECD) that was closed to international investment in its upstream oil and gas sector [43].

The government under Peña Nieto hoped for the reforms to enable Mexico to produce more hydrocarbons at lower cost, allowing private companies to complement PEMEX's investment through contracts for oil and gas exploration and extraction, and to achieve better results through competition in refining, transportation, and storage. Before 2018, Mexico awarded 107 oil and gas exploration and production contracts [43]. However, in Mexico and Latin America, resource nationalism in the oil sector has deep roots [44,45]. The election of President López Obrador in 2018 signalled Mexico's return to resource nationalism, reversing the opening of the hydrocarbons sector. Perhaps unsurprisingly, by 2021, the country's oil production declined further to 1.93 mbpd, half of its 2004 peak (see Figure 3), with Mexico dropping from 5th to 12th in the ranking of the world's largest oil producers [40].

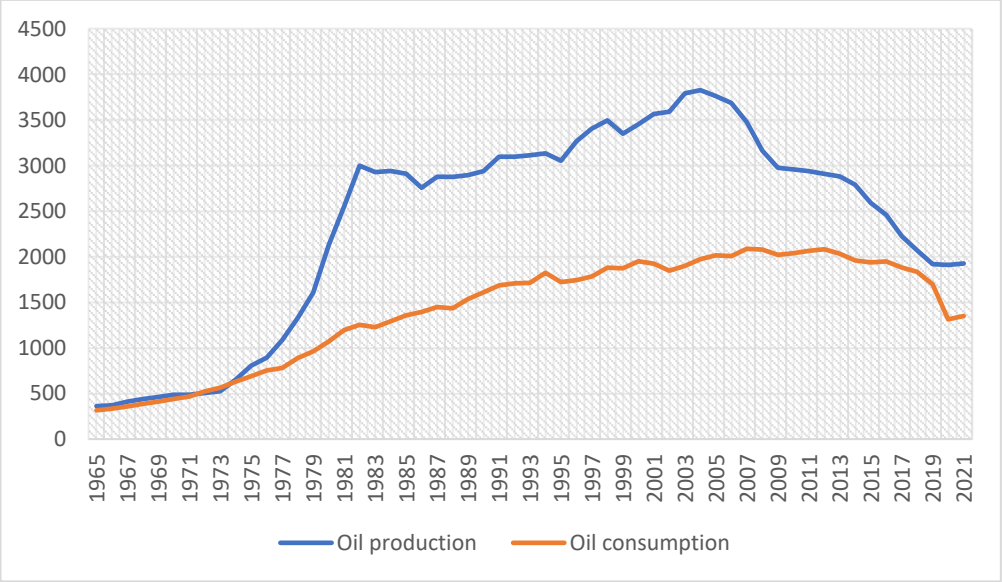

Figure 3. Mexico's oil production and consumption (1965–2021; thousand barrels per day). Data from [40].

3.2. Problem Two: Mexico's Declining Refining Capacity and Growing Imports and Cost of Petroleum

In 2021, Mexico exported 0.58 mbpd of crude oil to the US and 0.48 mbpd to other destinations [40]. While the country is a significant crude oil exporter, it is also heavily reliant on imports of refined petroleum, such as gasoline and diesel. For example, in the same year, Mexico imported 1.12 mbpd of refined petroleum from the US [40]. Mexico needs greater refining capacity to meet domestic demand and has yet to invest in processing its heavy Maya crude. In contrast, most US Gulf Coast refineries are designed to process heavy crude oil, which requires highly sophisticated and expensive technologies that Mexican refineries still lack. Consequently, Mexico exports heavy crude oil to refineries in Texas, which then re-exports refined petroleum to Mexico [46].

Mexico's refineries need significant repairs and upgrades, as in many Latin American countries. As such, they operate well below their nameplate capacity [46]. Mexico has six refineries with a total capacity of 1.56 mbpd. In recent years, these have operated below capacity, with refinery throughput at 0.6–0.7 mbpd since 2018 [35]. In 2013, Mexico's refineries had a throughput of 1.223 mbpd [40]. Mexico's growing reliance on imported refined petroleum and ongoing domestic fuel subsidies are putting significant pressure on government revenues. According to Bloomberg Economics, in May 2022, gasoline and diesel subsidies cost the Mexican government more than double the extra profit from higher crude prices, demonstrating the growing difficulty of keeping domestic prices artificially low. Gasoline and diesel subsidies amounted to an estimated USD 2.39 billion amid a global price rally, while the windfall from PEMEX's crude oil exports was estimated at only USD 1.04 billion [47].

3.3. Problem Three: Impact of Oil Theft on PEMEX and Mexico's National and Energy Security

Mexico's national oil monopoly, PEMEX, accounts for more than 15% of the country's export revenues and nearly 20% of budget revenues [5]. According to Jones and Sullivan (2019), "state control of Mexico's hydrocarbon reserves is an element of national power. Attacking that infrastructure constitutes confrontation with the state in a way that challenges economic and political dimensions of state legitimacy and stability" [5]. During the 2013–2018 period, the value of stolen gasoline ranged between USD 1 and 3 billion per year [4,48]. Oil theft deprives PEMEX and the Mexican government of revenues and erodes business confidence, investment, and national development. It also improves the financial and other capacities of criminal cartels. Partly because of the impact of oil theft on

its operations and declining crude production, PEMEX has the highest debt burden of any major oil company. The company closed 2021 with a financial debt of USD 109 billion and net losses of USD 10.9 billion [49]. Damage inflicted on pipelines and processing facilities, illegal sales of gasoline, and violence against PEMEX and its employees inhibit legitimate operations and negatively affect the company's bottom line [5]. More generally, oil theft is a form of breaking the rule of law, as violence and corruption challenge the Mexican state [50]. From 2006 to 2015, at least 123 PEMEX workers and 12 former employees were arrested for being complicit in oil theft [51]. In 2017, because of wholesale corruption related to oil theft, Salamanca local law enforcement had to be replaced with state police [52].

Escalation of oil theft in recent years has also been associated with numerous explosions of tapped pipelines, deaths of innocent civilians, and gasoline shortages, making oil theft a major national and energy security concern. Local communities often fall victim to accidents stemming from oil theft. The most prominent example occurred on 18 January 2019: following an illegal tap into an oil pipeline in Tlahuelilpan, an explosion killed at least 137 people in the crowd that gathered to collect free fuel [53]. More generally, spills from pipeline taps are frequently not cleaned up, negatively affecting the local population's health and the environment, along with flora and fauna [2]. PEMEX employees have been threatened, kidnapped, and tortured by criminal cartels to provide intelligence on pipelines. PEMEX workers who have refused to collaborate or reported to the police have been killed. The government's militarised response resulted in street executions of oil thieves and an escalation of violence, as evident from Mexico's growing homicide rate (see Figure 1) [52].

3.4. Problem Four: Mexico's Slow Transition Away from Petroleum

Mexico is a member of the International Energy Agency (IEA). The country endorses the EV30@30 campaign launched in 2017 with ten other countries. The campaign objective is to make 30% of vehicles on the road electric by 2030 [54]. Electric and hybrid vehicle sales in Mexico have grown steadily in recent years, increasing from 2.6% of total car sales in the country in 2020 to 4.6% in 2021 [55,56]. In 2021, 47,079 electric and hybrid vehicles were sold in Mexico according to the Mexican Association of the Automotive Industry (AMIA). These shares were primarily made up of hybrid vehicles. Electric vehicles (EVs) accounted for only 0.1% (1140 cars in total) of new car sales in 2021 and 0.4% (2519 in total) in the first eight months of 2022 [55], significantly less than the 10% global average for several reasons [57]. In Mexico, financial incentives for EV purchases are limited. The federal government offers very few fiscal incentives and tax benefits for EVs, in contrast with other countries where EVs are exempt from import taxes [58]. The high price of EVs is another reason for the low adoption of this new technology in Mexico, since most are imported from high-income economies. Another issue is the embryonic development of the charging infrastructure in homes and public spaces [59].

4. Discussion

4.1. The 4As Assessment

Section 2 conceptualises energy security around the four principal dimensions or the 4As. This section positions Mexico's energy security problems, discussed above, within the 4As framework. A key finding from the analysis is that Mexico's energy security has declined across the 4As.

The first dimension is the availability of oil resources, proven oil reserves, and production potential. Mexico's proven oil reserves have declined significantly since their 1983 peak, with less than nine years' worth of reserves left in the ground at current production rates, demonstrating deterioration in the first dimension.

The second dimension is accessibility, or the capacity for oil production and the quality of supply chain infrastructure, including refining and pipelines. This dimension also includes geographic and geopolitical challenges related to accessing crude oil and refined products. In 2021, Mexico's oil production stood at about half of its 2004 peak. Similarly, in 2021, the country's oil refineries processed about half the volume of crude oil

compared to 2013. Significant declines in oil production and refining capacity, along with increased reliance on imported refined petroleum from the US, are clear indications of the deterioration of Mexico's second energy security dimension.

The third dimension, affordability, refers to the cost of refined petroleum products. Data reveal a significant deterioration in this dimension over the past decade, as the average national price of gasoline increased from around 13 MXN/litre in 2013 to more than 21 MXN/litre in 2021 following an increase in import dependence and a reduction in fuel subsidies. While remaining subsidies are keeping gasoline prices artificially low, this is becoming increasingly unsustainable due to the growing cost of refined petroleum imports.

The final dimension, acceptance, refers to social and environmental sustainability related to energy production, transportation, and usage. With calls for the phasing out of fossil fuels intensifying, as demonstrated above, Mexico lags significantly behind its Latin American neighbours in transport electrification.

4.2. Contribution of Oil Theft

Oil theft contributes to Mexico's energy security deterioration in the following ways. The capacity of PEMEX to develop new reserves and increase production is affected by the impact of oil theft on its financial bottom line. As mentioned above, PEMEX has the highest debt burden of any major oil company, and oil theft from PEMEX pushes the company further into debt. Personal security threats for PEMEX employees and corruption negatively affect the company's ability to attract and retain skilled workers and, ultimately, increase oil production. Under pressure from the Mexican government to increase oil production and cut debt, PEMEX illegally flared more than USD 342 million of gas and condensate at two of its most significant oil fields in the three years leading up to August 2022, leading to extensive environmental damage [60].

Security in Mexico's oil sector is also partially responsible for low levels of foreign investment, thus negatively affecting the discovery of new oil reserves and potential production. Domestic instability, the lack of security, and frequent damage to pipelines deter investment in oil exploration and production, pipelines, and refineries. This makes refined petroleum less accessible and affordable to consumers and adds a financial burden to the Mexican state as the country becomes increasingly dependent on imported refined petroleum.

Growing reliance on imports of refined petroleum from the US contributes to the price pressure, as do high (and rising) global crude oil prices. Paradoxically, increases in oil theft in 2022 have been highly focused on northern Mexico, where gasoline shortages were reported due to the cross-border influx of Americans searching for cheaper fuel. Most of this gasoline would have been exported from Mexico to the US as crude oil, refined in Texas, and re-exported to Mexico at a premium price, only to be subsidised and sold at Mexican service stations or tapped and sold by criminal groups at prices well below those in California or other southern US states.

In terms of environmental and social acceptance, damage to pipelines and oil spills are frequently not attended to, negatively affecting the health of the local population and environment, as well as flora and fauna. Unregulated sales of illicitly procured gasoline also contribute to the negative effects on the health of people involved in illegal trade and the surrounding environment.

Finally, in addition to energy security, oil theft also presents a significant threat to Mexican national security. These threats are well-documented. In addition to killings of PEMEX workers and instances of high-level corruption, they include explosions, such as that which occurred in the town of Tlahuelilpan in 2019.

4.3. A Potential Solution and Policy Recommendations

The above analysis demonstrates that Mexico's energy security for oil and refined petroleum has declined significantly over the past decade. In addition, it is argued that oil theft has negatively affected Mexico's energy security across the 4As. This section

proposes that Mexico can reverse its deteriorating energy security situation and reduce the prevalence of oil theft by transitioning from petroleum-based fuels to electric vehicles in the transportation sector. Specific ways by which such a transition could be accelerated are identified. Section 4.4 points to and discusses potential roadblocks.

Both globally and in Mexico, calls for phasing out fossil fuels are intensifying. In 2012, under President Felipe Calderón, Mexico adopted the General Law on Climate Change (Ley General de Cambio Climático). Mexico was the first sizeable oil-producing country to enact climate legislation. This law formalised political commitment and set the direction for climate policy. A decree enacted in 2018 brought Mexico's targets to reduce emissions in line with the Paris Agreement [61]. Mexico's targets included a 30% reduction in greenhouse gas (GHG) emissions compared to business as usual by 2020 and a 50% reduction in GHG emissions below the 2000 level by 2050. Mexico also committed to generating 35% of its energy from renewable sources by 2024 [62].

While the electrification of transport is underway globally, it is advancing in various ways across countries. As demonstrated in Section 3.4, Mexico is a laggard in transport electrification. In 2021, EVs accounted for only 0.1% of new car sales. In the first eight months of 2022, this figure rose significantly to 0.4%, showing signs of awakening to the challenge. A rapid transition from gasoline and diesel vehicles to electrification in the transportation sector would help Mexico address its deteriorating energy insecurity and potentially eliminate the problem of oil theft. Mexico is the fourth largest vehicle exporter in the world, producing approximately three million vehicles annually, behind Germany, Japan, and the US. In 2021, more than 90% of vehicles were exported, mainly to the North American market [63–65]. A global shift to EVs may allow Mexico to expand its car manufacturing industry.

Recent developments in Mexico are promising. In 2022, the government started actively supporting EVs following years of lax fuel economy regulations for light-duty vehicles (LDVs). In April 2022, lithium was identified as a strategic mineral. The government announced that a newly formed public entity would exclusively manage the increasingly strategic lithium value chain. In this context, it is noteworthy that the Latin American region contributes a significant share of the metals needed to produce EVs, such as lithium and copper. The northern Mexican state of Sonora hosts one of the world's largest copper mines and lithium deposits. In June 2022, President López Obrador announced that 50% of vehicles produced in Mexico in 2030 would be zero-emission. More broadly, it has been suggested that the transition to EVs may be able to "pull Mexico's automotive industry out of industrial 'long COVID'" [66]. Recent developments reported in January 2023 indicate that General Motors, Tesla, and Ford have agreed with the Mexican government to either begin or expand EV production in Mexico [67]. Moreover, working groups led by the Ministry of Foreign Affairs and the Ministry of Economy are now examining the roadmap to electrification. Finally, discussions in multiple international fora between Mexico and the US aim to coordinate the two countries' climate change policies and promote EV supply chains [63].

These are essential steps for Mexico. As the next step, the country's strategy requires firm, longer-term targets and a regulatory framework that enables transport electrification. According to Hall et al. (2021), countries leading the transition to EVs can use policies related to five areas to accelerate their adoption: (1) phase-out targets, (2) EV regulations and CO_2 standards, (3) fiscal incentives, (4) charging and refuelling infrastructure, and (5) consumer awareness and fleet purchase requirements [68]. Mexico's opportunities for accelerating the transition to EVs become evident through the lens of these policies. According to Pineda (2022) [63], these are the areas for improvement:

1. Phase-out targets. Mexico still needs to adopt internal combustion engine phase-out targets. While Mexico is a signatory to the COP26 declaration on accelerating the transition to 100% zero-emission car and van sales by 2040, the declaration is non-binding [69]. Moreover, the National Electromobility Strategy developed by the Ministry of Environment (SEMARNAT) adopts a position inconsistent with the

COP26 declaration, setting a goal of only 50% of new sales being electric and plug-in hybrid LDVs and buses by 2040 [70];

2. EV regulations and CO_2 standards. Fuel economy standards for LDVs were implemented between 2014 and 2018, and SEMARNAT expects a second phase of standards. However, its latest proposal does not equate to an EV-forcing standard, as it contains excessive flexibilities and credits for carmakers, allowing them to cut expected reductions in CO_2 by 30%. Without national EV-forcing standards, it will not be easy to increase the national EV LDV sales in the new car market from below 1%. The goal of making 50% of the LDV fleet EVs by 2030 may not correspond with a rapid increase in domestic EV sales. Instead, the status quo, in which the most efficient and clean vehicles are produced in Mexico but sold internationally, may continue. Regarding heavy-duty vehicles (HDVs), despite progress in Latin America (specifically Brazil and Chile), Mexico still needs to catch up and shows no signs of progress [63];
3. Fiscal incentives. A temporary import-tax exemption for EVs is in place until 2024. In addition, EVs are exempt from new vehicle tax. Other local incentives, such as those in Mexico City, include exemption from inspection and maintenance programs and registration taxes. Local governments should adopt comprehensive fiscal incentives to reduce the cost differential between EVs and internal combustion vehicles until cost parity is reached. This would encourage the early adoption of zero-emission EV technologies [63];
4. Charging and refuelling infrastructure. Mexico has around 1146 EV charging stations [50]. Charging infrastructure needs to grow with EV sales to offer potential customers the confidence to purchase EVs. This requires that attention be given to the number and location of chargers; increasing electricity output from the grid; an electricity tariff review; and the standardisation and interoperability of EV charging networks. Increased penetration of electric buses, urban truck fleets, and ride-sharing services indicate the need to grow this infrastructure [63];
5. Consumer awareness and fleet purchase requirements. Local governments are incorporating demand-side policies to support the adoption of EVs. For example, the Mexico City bus rapid transit (BRT) system, Metrobus, is planning to electrify its entire fleet. Despite progress in Mexico City and electric buses on the streets of Guadalajara and Monterrey, mandatory requirements still need to be put in place [63].

With adopted and proposed North American policies and targets to accelerate the uptake of EVs, there is an opportunity for Mexico to explore domestic manufacturing of batteries and other EV components. However, vehicle phase-out targets are still missing, a critical first element of an effective EV strategy. The Mexican government should signal its intention and ambition to transform the country's transportation sector, which is aligned with its climate goals and international commitments. Chile can serve as a positive example. Chile's National Electromobility Strategy, published in October 2021, includes EV sales targets for on- and off-road vehicles, starting with the phase-out of sales of internal combustion engine buses and light- and medium-duty vehicles by 2035 [63,71–73].

4.4. Feasibility and Potential Limitations

Mexico's energy security has deteriorated over the past decade across the 4As when considering the oil and refined petroleum sector. Oil theft has contributed to the deterioration. Mexico can address its energy security challenges and potentially reduce the prevalence of oil theft by transitioning from petroleum-based fuels in the transportation sector. The feasibility and potential limitations associated with implementing transport electrification in Mexico are briefly evaluated below. These are by no means exhaustive, and further research is invited to evaluate the conditions required for and the obstacles to Mexico's sustainable energy transition.

Mexico's transition from crude oil and refined petroleum in the transportation sector will require support from political and business leaders and a general buy-in from the media and the public. It is essential that successive Mexican presidents remain committed

to the transition and keep driving it. The same applies to other key stakeholders whose continued buy-in is essential. These include the Executive Cabinet, the Secretary of Energy, the Secretary of Environment and Natural Resources, the Congress of the Union, and the Energy Regulatory Commission (ERC). Framing the energy transition in Mexico as fair, socially just, inclusive, transparent, and genuinely aiming to leave no one behind will be necessary to win support and regain the general population's trust. There is an opportunity to make the broader national energy transition a centrepiece of Mexico's socioeconomic development towards 2050.

Potential challenges and limitations on Mexico's path towards a clean energy future include policy uncertainty and the lack of political will among key decision makers, the lack of trust in the political system, corruption, and opposition from criminal groups that profit from oil theft. The criminal cartels would likely oppose the shift. However, it is plausible that they would eventually adapt by finding other business opportunities; for example, in the mining supply chain [74–76]. Corruption is the biggest challenge, and it is caused by Mexico's legacy of elite consolidation of power and authoritarian rule [77]. Mexico is ranked 124th out of 180 countries in the 2021 Corruption Perceptions Index, with corruption permeating political and economic segments of society [78]. In the energy sector, Mexico would require a more powerful, democratised, transparent, accountable, and independent ERC to monitor the energy transition and act as a watchdog to ensure accountability in corruption cases.

5. Conclusions

In summary, by framing it within the energy security context, this paper offers a novel perspective on the problem of oil theft in Mexico. Focusing on crude oil and refined petroleum, the application of the 4As energy security framework demonstrates that Mexico's energy security has deteriorated over the past decade. The increasing prevalence of oil theft has contributed to this deterioration. The proposed solution to the energy security and oil theft problems is centred on Mexico's transition from gasoline and diesel to transport electrification. While Mexico's uptake of EVs has been lagging behind other countries, recent developments in the country point to growing momentum among the country's political and business elite, along with US investors, in support for the energy transition. The paper identifies where further emphasis should be placed to accelerate Mexico's energy transition in the transportation sector. Finally, it evaluates the feasibility and potential limitations of implementing the transition. The 4As energy security framework applied in this paper could be extended to assess the energy security implications of oil theft in countries with high prevalence of this criminal activity, such as Nigeria.

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