frontiers in Sustainable Cities

POLICY AND PRACTICE REVIEWS
published: 12 July 2021
doi: 10.3389/frsc.2021.631337

Energy Transition and Sustainable Road Transportation in Turkey: Multiple Policy Challenges for Inclusive Change

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This paper aims to explore energy insecurity in Turkey at the intersection of environmental sustainability, human security and justice vis-à-vis growing energy demand coupled with greenhouse gas emissions coming from the transport sector. High dependence on fossil fuel imports creates bottlenecks for the economy and require urgent shift to renewable energy sources. Prospects for renewable energy transition are analyzed based on focusing on total final energy consumption by energy and transport sector as well as greenhouse gas emissions. In order to propose holistic clarifications to the triangular problem of high fossil fuel dependence, energy demand increase and greenhouse gas mitigation, sustainable energy transition in road transport is put forward. It is justified based on the share of greenhouse gas emissions originating from road transport sector and high taxation levels that create extra burden on private consumers. Energy transition is conceptualized with the theoretical offerings of sustainability transition literature that point out to socio-technical processes, hence the societal, technological as well as external structural contexts of change. Upon this background, this policy and practice review outlines the current policy instruments in order to highlight the mismatch between policy and practices for just energy transition in conjunction with sustainable mobility in Turkey.

Keywords: energy transition, renewable energy, sustainable mobility, electric vehicles, greenhouse gas emission, road transport

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Specialty section:
This article was submitted to Urban Energy End-Use, a section of the journal Frontiers in Sustainable Cities

Received: *19 November 2020*
Accepted: *31 May 2021*
Published: *12 July 2021*

Citation:
Cevheribucak G (2021) Energy Transition and Sustainable Road Transportation in Turkey: Multiple Policy Challenges for Inclusive Change.
Front. Sustain. Cities 3:631337.
doi: 10.3389/frsc.2021.631337

INTRODUCTION

Energy balance of Turkey demonstrates importance of hydrocarbon fuels, particularly coal, natural gas and oil products within the national energy mix (Eurostat, 2020). Fossil fuels have been increasing their share within the total primary energy supply of Turkey. Oil (30%), natural gas (30%), and coal (28%) own the biggest share in total primary energy supply, whereas the share of renewables has been increasing over time but accounted to only about 12% in 2018 (IEA, 2019a).

Turkey has great dependence on fossil imports and its energy demand is set to increase in the future. It is among the world's rapidly developing power markets with its dynamic population, increasing energy demand as a result of continuous economic growth and large-scale urbanization occurred within the last decades (Bilgen et al., 2008). Turkey intends to decrease its energy vulnerability through use of indigenous sources, namely coal as well as nuclear energy development (Richert, 2015). Although, there is great potential for renewable energy deployment there are a number of obstacles that impede their full utilization. Turkey does not have a consistent mitigation strategy and hesitates to ratify Paris Agreement (Alkan et al., 2018). Nevertheless, there are further inconsistencies apparent in Turkey's energy policies. Turkish government aims to improve the renewable energy share within its electricity generation and to meet 10% of its increasing energy demand of the transport sector from renewable sources through a series of policy initiatives. However, there is continuous support for coal use given to producers as well as consumers in need which contradict the political will for renewable energy development and greenhouse gas mitigation (Republic of Turkey, 2012; Republic of Turkey's Voluntary National Review, 2019).

Energy sector is responsible of about 72% of greenhouse gas emissions in Turkey and transport sector alone emits 21% of greenhouse gas emissions as of 2019. GHG emissions of energy sector has raised by 172% over the period of 1990–2017 which signals for alarming need to shift to renewable sources (Republic of Turkey Ministry of Environment Urbanization, 2019). As a result of high dependence on oil in transport sector, the greatest proportion of emissions are derived from the road transport, which more than tripled in 1990–2017 (UNFCCC, 2018, as cited in Climate Action Tracker Report, 2019). On the other hand, energy demand of the transport sector is expected to increase along with the GDP per capita (Saygin et al., 2019). Turkey's UN Climate Change Conference of Parties (COP21) commitments under the current Nationally Determined Contributions and with regards to the 21% reductions of business as usual (BAU) emissions are found to be very optimistic and lacking credible policy outcomes (Işeri and Günay, 2017; Kat et al., 2018). Therefore, it is argued that transformation of the transport sector through integration of domestic renewable sources can decrease energy dependence as well as greenhouse gas emissions of Turkey.

Energy vulnerability has repercussions on a variety of issues including poverty that create inequalities. Energy security means, firstly, securing access to energy by the poorest rural regions and secondly, uninterrupted access to it by different sectors of economy (Kuik et al., 2011; Månsson et al., 2014). The term energy poverty is commonly regarded as access to modern energy services.

Definition of energy access by the IEA encompasses stable and affordable access to electricity and cooking fuels that are environmentally sustainable instead of reliance on traditional sources of biomass, wood or dung (Birol, 2014). It must be stressed that access to modern energy services is not restricted to basic human needs, but also involves productive and modern uses as well as mobility to ensure development, considering their interactive relationship (Sovacool et al., 2012). Mobility as another key energy service implies varied transportation options with adequate infrastructure and fuel sources at cost-effective prices (Woodcock et al., 2007, as cited in Sovacool et al., 2012).

Physical accessibility to electricity does not appear to be a problem in the case of Turkey, where number of people without access to electricity fell from 6 million in 1990s to zero as of 2016 (The World Bank, 2020). Energy poverty in Turkey implies the problems of affordability for basic energy services including electricity, heating and transport. Although there are different ways to calculate energy poverty, one way of looking at it is by measuring the portion of income that is allocated for access to energy services, where 10–15% of a family's monthly or yearly earnings spent on energy services marks the household as energy poor (Dutta, 2011, as cited in Sovacool, 2014). Selçuk et al. (2019) conclude in light of the 2017 data that about 25% of households were computed as energy poor even though that number decreased over time with respect to 2003 levels; and 50% of the lowest income households were regarded as energy poor in Turkey. Despite the fact that energy is an invaluable source that is vital for the conduct of modern daily lives whether it is for cooking, keeping homes warm in winter, cool in summer; working and studying; or producing a variety of goods and services, its affordability seems problematic for low-income Turkish households (Bilgen et al., 2008; Emeç et al., 2015).

According to OECD's Taxing Energy Use Country Note (OECD, 2019a,b) coal and coke for industrial or residential use are not being taxed in Turkey, but neither are renewables. Indeed, coal subsidies granted to poor families for heating greatly hampers transition to cleaner alternatives and has direct effects on air pollution as well as health conditions. Turkish government provides social contribution in the form of coal subsidies for households whose income per person is less than one third of the net average income, and for heating at minimum amount of 500 kg provided once each year in winter. There are further inconsistencies in Turkish energy and climate policies. Transport sector requires an in-depth look for energy sustainability and within the context of energy vulnerability in Turkey, as it holds great share of energy demand and greenhouse gas emissions in the country. Transport poverty is reflected in the share of expenditures for transportation in Turkish households' budget as well as high price components for gasoline and diesel. Transportation expenditures has been increasing its share within the Turkish households' budget over the period of 2009–2018 and reached to 18.3% of the total yearly expenditures in 2018 [Turkish Statistical Institute (TurkStat), 2018]. It is possible to make a correlation between energy/fuel poverty and transport affordability which infers vulnerability to fuel price raises. Difficulty in affording transport costs imply transport poverty, although it is often neglected in the policy discourses as well as in energy poverty literature (Mattioli et al., 2018).

High fuel prices may impede individuals' liberty of mobility and even create further obstacles in terms of socio-economic exclusions; thus, transport poverty may translate into failure of meeting one's personal and diverse transport needs (Berry et al., 2016). Indeed, measurement of transport affordability is rather difficult and complex through mere assessment of the share of household budget as it may be an individual phenomenon rather than the problem of the entire household, even though it is usually accepted that households' transport expenditures exceed that of energy (Mattioli et al., 2018). Mattioli et al. (2018) identifies prices, income and energy efficiency, that includes among all the others, vehicle efficiency as the prominent drivers of fuel poverty with regards to transport affordability.

Turkey has one of the highest levels of gasoline prices in the world which partially stems from the high share of taxes as the government have aimed at increasing its tax revenue since 1999 (Biresselioglu et al., 2014). The high taxation rates imposed on the transport sector could be with the purpose of covering high externalities or higher inelasticity of fuel demands which in return exacerbate revenue increase purposes as energy tax rate levels in Turkey are not optimal due to lack of carbon pricing and fuel efficiency standards for vehicles (Bardazzi and Pazienza, 2014; Bali and Yayli, 2019). Although CO_2 labeling of new vehicles had been introduced in 2009, absence of mandatory CO_2 regulations for manufacturers and tax components hampers the required incentive to change user behavior (Mock, 2016). Inevitably, fuel and vehicle prices in Turkey fail to reflect the environmental costs. On the contrary, high gasoline prices has resulted in a shift to more polluting LPG and diesel used vehicles (Saygin et al., 2019).

Therefore, it is argued that electrification of transport systems in Turkey can provide multiple benefits for energy system changes on different grounds. Firstly, it can reduce greenhouse gas emissions to the benefit of climate change mitigation. Secondly, provided that it will be integrated with electricity supply from local renewable sources it can promote renewable energy deployment and increase energy security (Yergin, 2006; Valentine, 2011). Thirdly, it can help to reduce transport poverty and related inequalities in Turkey. However, large-scale development of electrified vehicles requires cost competitive solutions that can enable equitable diffusion to reduce transport poverty. Indeed, there are various obstacles to be addressed which include choosing the best policy mechanisms that shall offer incentives for suppliers and consumers. A combination of public subsidies in the form of tax incentives; guarantees to reduce financing and other risks; leases as well as R&D spending for sectoral efficiency targets are fundamental in scaling up investments.

Geographically and territorially speaking there is great consensus on the huge opportunities for deployment and full utilization of renewable energy in Turkey (Biresselioglu, 2012; Sekercioglu and Yilmaz, 2012; Mete and Heffron, 2015; Karakosta et al., 2016). However, even if clean energy resources are available, development of incentives through right policy tools for large scale deployment remain as a critical issue to be addressed. So far, the urgent need for meeting increased energy demand and insufficient funding for renewable energy development have led to prioritization of projects with low capital cost over short timeframes in Turkey; but it resulted in more dependence on natural gas imports and environmentally unfriendly options (Sirin and Ege, 2012; Röhrkasten et al., 2016).

Inevitably, Turkey's high energy dependence on fossil fuels and prospective increase in its energy demand create multiple bottlenecks for energy security in geopolitical, environmental and socio-economic terms. Energy as a vital source for conduct of modern daily lives shall be made available and affordable for everyone without compromising the needs of future generations. Having clean alternatives is essential to protect energy vulnerabilities of consumers at the face of price increases or supply disruptions. Review of related policy mixes, namely policy instruments that shall interact to orient attention among public and private actors can help achieving the overarching policy objectives (Kern et al., 2019). Acknowledging the increasing energy demand coming from road transport sector, Turkish government has put various targets under legislative actions and political commitments. This study aims to outline the existing policy framework for energy transition in Turkey and with a particular focus on sustainability transition of the road transport sector. This policy and practice review is organized as follows: analytical grounds of sustainability transition are introduced to underline the pre-requisites of just energy transition and its assessment methods. A qualitative research through in-depth review of public and international reports, policy papers, legislative acts is conducted to assess the most effective policy tools for decarbonising the road sector while drawing parallels with the best practices in the world. The study concludes with a review of key findings and actionable recommendations for just energy transition in order to point out to the existing policy gaps.

ASSESSMENT OF POLICY OPTIONS AND IMPLICATIONS WITHIN THE ANALYTICAL FRAMEWORK OF SUSTAINABILITY TRANSITION

Required environmentally friendly technologies for full utilization of sustainable energy resources are not always cost-efficient, which in return result in trade-offs in government's policy outcomes in the domestic framework. In line with this view, some scholars studied the historical evidences of energy transitions with an attempt to provide future insights. It is concluded that a new energy source with its technologies can become competent over incumbents upon the condition that its services are cheaper than those alternatives (Fouquet and Pearson, 2012). Indeed, the transitions take a very long time and are rather complex processes. Early examples of transition to coal as a result of increase in the price of wood in Great Britain provided a strong incentive in diverting consumers' energy choices at the wake of Industrial Revolution (Allen, 2012).

The role of policy processes upon influencing the extent of sustainability transitions is a widely contested topic in the literature (Meadowcroft, 2011; Lockwood et al., 2016; Roberts et al., 2018; Köhler et al., 2019). The interplay between political factors and economic, technological, and social links are widely conceptualized within the framework of socio-technical systems transitions. Sustainability transitions remain highly political, as regulatory frameworks and distribution of social revenues often require state intervention or governance reform, considering that changes can only be achieved through political processes (Meadowcroft, 2011; Lockwood et al., 2016). According to Meadowcroft (2011), political engagement is taken as a pre-requisite for building coalitions and constructing power centers among different actors.

Socio-technical transitions consist of the socio-technical landscapes and niche innovations that continuously interact with each other (Kuzemko et al., 2016). Moreover, socio-technical transitions of energy regimes infer path dependencies for the adoption of technological innovations, which in return require long-standing commitments to research and development practices. It feeds back to the importance of external structural context of the landscape level, hence the governance with adaptive capacity for the creation of knowledge, supply of necessary resources and formation of markets that will ensure spill-over effects (Smith et al., 2005). In addition to tools used for the social acceptance of renewable energy innovations, Mallett (2007) points out to the role of technology cooperation, whereby adaptation takes place via diffusion and acceptance of new equipment, practices as well as know-how among variety of factors including private sector, civil society and local governments. Overall, it is possible to include different variables consisting of technology, regulation, infrastructure, user practices, cultural meaning as well as maintenance and supply networks for transitions occurring at the intersection of technological niche, socio-technical regime and socio-technical landscape (Geels, 2005).

In the past, security of supply and climate change have been at the center of energy transition narratives. Current discussions are incorporating policy mixes that reshape green deal proposals through social innovation and digital revolution, whereby different social groups play an active role in their reproduction (Bloomfield and Steward, 2020). However, there is relatively limited attention paid to normative impacts of sustainability transitions that incorporate ethical considerations for equity and justice implications (Köhler et al., 2019). Societal transformations will determine the new configuration of wealth distribution, new opportunities and assigned privileges specific to certain social groups (Bennett et al., 2019). Climate mitigation policies may lead to exacerbation of inequalities particularly for the most vulnerable groups including low-income households, migrants, or ethnic minorities (Markkanen and Anger-Kraavi, 2019). Given the intrinsic relation between access to energy services and human development, there is urgent need to treat sustainability transitions with a bottom-up approach that incorporates human values of justice and equity rather than analysis of merely political processes or technological niches.

Considering that transitions hold the potential to exacerbate existing vulnerabilities of people, incorporating a justice dimension to sustainability transitions is imperative (Bennett et al., 2019). Conflictual lines between sustainability and social justice issues are often addressed within the specific domains of energy, and transport inequality. Indeed, ensuring access to affordable, reliable, and modern energy sources enables socio-economic development as energy is the key input for conduct of daily life. However, inequalities in accessibility and affordability of key energy services including mobility persist (Simcock and Mullen, 2016; Mattioli et al., 2018). Adoption of new technology and innovation for energy transition may constitute important barriers that can generate further exclusions. On the other hand, sustainable transport systems that rely predominantly on private vehicles compromise mobility justice (Mullen and Marsden, 2015).

Consequently, transformative and structural societal change requires addressing the existing inequalities to contribute toward more comprehensive policy making at multi-levels of governance frameworks. Exploration and anticipation of ethical implications in the framework of sustainability transitions can contribute to ex-ante mitigation policies in order to prevent further exclusionary policy action from early stages. Indeed, adoption of a bottom-up approach that treats sustainability transition as a prospective problem rather than the ultimate solution necessitates consideration of the most vulnerable segments of society. Novelty of such contributions will be identification of community-based solutions that include normative values of social justice on the path toward zero-carbon and more inclusive societies. Bridging the gap between top–down policy making and societal frameworks is essential if we really want to build better futures.

Development of Renewable Energy Policies in Turkey

Turkey's national energy policy has aimed at decreasing its import dependence and enhancing energy security through diversifying its energy imports, ensuring integration among its regional markets, scaling up its domestic energy production with coal, lignite, nuclear energy and renewables as well as improving energy efficiency (OECD, 2019a,b). Despite significant policy changes of the past, it is worth questioning why the past efforts resulted in so little change in terms of successful sustainability transition.

Remarkable renewable energy potential of Turkey has not been fully utilized yet and insufficient number of measures have been adopted in line with privatization efforts since the 1980s (Bilgen et al., 2008). Although acknowledging the significance of political drivers for change as provided by the theoretical contribution of sustainability transition, there are number of multi-level challenges including adoption of new scientific knowledge that is necessary to achieve practice changes. Therefore, explanation of the existing mismatch between policies and practices in Turkey will be key to identify the recurring shortcomings for further development of renewable energy innovations including those required for electrification of the transport sector.

Reduction of capital costs at the early stage of new renewable energy technologies require supplementary fiscal support mechanisms for them to have economies of scale whether through tax exemptions, specified feed in tariffs, or market guarantees (Apak and Atay, 2013). Since 2001, Turkish government has been giving importance to full liberalization of its internal energy market (Mete and Heffron, 2015). Power plants installed by renewable energy have been integrated into the distribution system with various efficiency targets. The legal basis aimed at scaling up the investments of renewable energy sources within electricity generation was enacted in 2005 through "Law No. 5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy."

Turkey aims at increasing the share of renewables in its total primary energy supply with a target to produce 30% of its electricity from renewable energy sources by 2023. However, electricity demand from local coal reserves amounted to 37% of the total generation in 2019, which signal major setback in achieving clean and sustainable energy use[1].

[1] *Turkish Electricity Transmission Corporation, Electricity Generation—Transmission Statistics of Turkey.*

"Energy Efficiency Law No. 5627" was also introduced in 2007 with the ultimate purpose of enhancing efficiency of energy sources in order to prevent energy waste, promote environmental protection as well as remove the extra burden of energy costs weighing on the economy[2]. Indeed, advancements of energy efficiency may lead to reduction of energy consumption levels and costs borne by different economic sectors through technological promotion. More concrete energy efficiency targets were later reinforced to provide a guideline for transport sector and decrease its energy density (Republic of Turkey, 2012-2023).

In accordance with the Law No. 5346, feed-in-tariffs were put forward with purchase guarantees for electricity generated from renewable sources[3]. However, investments of renewable energy technologies did not improve due to high technology costs that were not covered by the proposed tariff levels in 2005–2010. Therefore, the existing legislation was amended in 2010 with "Law No. 6094" that introduced new incentive mechanisms with higher feed-in-tariff rates in order to attract more investors[4]. Turkey has already achieved its 2023 target of 30% electricity generation from the renewables partially stemming from the introduced feed-in-tariffs for investment support (OECD, 2019a,b). Accordingly, the Renewable Energy Resources Support Mechanism was established to determine the guaranteed purchase tariff rates for electricity generation from different renewable energy resources. The new feed-in tariff program incorporated use of diverse technologies and bonus promotions for utilization of local equipment with the aim of boosting the national industry. Use of nationally manufactured equipment during the installation phase enables price subsidy per product for a maximum of 5 years. Additional incentives are provided for R&D activities of domestic renewable energy development. However, the designated timeframe of this support scheme is restricted to facilities commissioned until December 2020. The funding of investments cannot exceed 10 years which has been perceived as one of the most discouraging factors for projects with longer life cycles (Varlik and Yilmaz, 2017).

Existing targets set to reinforce electricity generation from renewable energy sources comprise of 34.500 total installed power capacity in hydro (53% increase compared to current level), 20.000 MW in wind (625% increase), more than 1.000 MW in geothermal (223% increase), 5.000 MW in solar and 1.000 MW in biomass (346% increase) to be achieved throughout 2013–2023. Investors have the option to select among the fixed feed-in tariffs or make sales directly at the power market (Mete and Heffron, 2015). The investors face the challenge of making the most cost-effective investment decisions. For instance, ambitious target set to increase wind power capacity is deemed to be pretty challenging to attain, mainly due to lack of access to adequate financial resources.

Low feed-in-tariff rates along with bureaucratic obstacles for licensing are regarded to hamper instead of incentivising renewable energy investments in Turkey (Mete and Heffron, 2015; Richert, 2015). Livingston (2018) concludes that continual weakness of Turkish lira and challenging macroeconomic conditions provide further financial limitations for renewable energy development (Livingston, 2018; Mahmud and Sirin, 2018).

Establishment of a conducive political and economic environment to renewable energy investments is one of the greatest obstacles to overcome in Turkey. Financial barriers persist against the government's plans to increase renewable energy output (Beck and Martinot, 2004; Kalehsar, 2019, p. 13). Limited financing is exacerbated by lack of alternative sources including for energy efficiency investments (Taranto and Dinçel, 2019). Solar energy target at 5,000 MW is also deemed very ambitious despite the fact that solar PV technologies enabled decrease in investment costs. In contrast to great availability of solar power utilization in Turkey the main barrier in deployment of PV technologies is related to the power limit of 600 MW that has been imposed through "Law No. 5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy." Biomass sources are widely used in Turkey despite high tariff rates, but their advancement is linked to access to raw materials and their relative technology. On the other hand, investments of geothermal energy and hydro power are widely considered feasible for electricity generation.

Another important policy mechanism was established through Renewable Energy Resource Areas that enabled land use fee incentives with a discount rate of 85% applied to lease and permission fees including for treasury owned or state properties with great potential for renewable energy facilities during the first 10 years of projects comprising of the investment and operational phases[5]. Despite existing incentives, the main obstacles that hinder renewable energy deployment in Turkey include insufficient tariffs, unsuitable network connections, difficulties in storage and transfer, inadequacy of research and development funds, high cost of technologies as well as the limitations that investors have to face in sustainable financing (Varlik and Yilmaz, 2017). Acknowledging the stringent factors on public financing mechanisms, Uyar (2017) finds the solution in promotion of energy efficiency targets through utilization of effective technologies such as smart grid and energy storage in industry, buildings as well as in transport sector.

National Renewable Energy Action Plan (Republic of Turkey Ministry of Energy and Natural Resources, 2014a) became one of the main pillars of Turkey's energy policies in alignment with the European Union (EU)'s Directive 2009/28/EC on promotion of the use of energy from renewable sources. It introduced key strategies for increased share of renewables within the electricity generation, enhanced technological and industrial deployment of renewable energy sources taking into account mitigation efforts for climate change until 2023. Energy efficiency audits

[2]Law No.5627 (2007). *Energy Efficiency Law*. Available online at: https://www.resmigazete.gov.tr/eskiler/2007/05/20070502-2.htm

[3]Law No.5346 (2005). *Law on Utilization of Renewable Energy Sources for the Purpose of Generating Electrical Energy*. Available online at: https://www.mevzuat.gov.tr/MevzuatMetin/1.5.5346.pdf

[4]Law No.6094 (2010). *Amending the Renewable Energy Law*. Available online at: https://resmigazete.gov.tr/eskiler/2011/01/20110108-3.htm

[5]Regulation No. 29852 (2016). *Renewable Energy Resource Areas*. Available online at: https://resmigazete.gov.tr/eskiler/2016/10/20161009-1.htm

and energy management systems became obliged for certain industrial enterprises.

Use of renewable energy in the buildings and full utilization of renewable sources in transportation to achieve 10% share have been among the main objectives with the target of implementing European Union's directives (National Renewable Energy Action Plan, 2014-Republic of Turkey Ministry of Energy and Natural Resources, 2014).

Sectoral Targets for Transport Under National Energy Efficiency Action Plan

Share of road transport in energy demand exceeds 90% in Turkey where passenger cars and freight transport play a major role (Saygin et al., 2019). Turkish government have adopted a strong focus of achieving transition in transport sector although the existing policy frames are still at an infant stage.

Policy mechanisms that introduced mandatory biofuel use with the tax exemptions has been a step forward. Legislative measures aimed at increasing the use of renewable energy and enabling progressive integration of biofuels in the transport sector include bioethanol obligation and tax exemptions (National Renewable Energy Action Plan, 2014-Republic of Turkey Ministry of Energy and Natural Resources, 2014). Mandatory bioethanol content in gasoline for road fuel/petroleum produced from domestic products and supplied to the market was set with a target of 2% since January 2013, and 3% as of 2014 in accordance with the decisions of Energy Market Regulatory Authority.

Energy Market Regulatory Authority also mandated special consumption tax exemptions for use of 2% bioethanol, that have been produced from domestic products and mixed with petroleum. National Energy Efficiency Action Plan, 2018-Republic of Turkey Ministry of Energy and Natural Resources (2018) puts industry, technology and transportation at its focal point for promotion of best practices and know-how in energy efficiency and environmentally friendly energy usage. Energy efficiency has been among the key objectives of Turkey's energy policies due to energy intensity of the industries as well as the transport sector.

Achieving sustainable energy transition and energy efficiency in transport sector, particularly in line with the weight of road transport which is a major consumer of petroleum products are among the government's policy priorities (National Energy Efficiency Action Plan, 2018-Republic of Turkey Ministry of Energy and Natural Resources, 2018). Energy supply security, environmental pollution, and related health problems as well as degradation of biodiversity because of inefficient practices held in transport sector are underlined with this regard.

Energy consumption by transport sector has been growing and it is estimated to keep increasing in the near future considering high dependence on oil and petroleum imports in transportation. Therefore, National Climate Change Action Plan 2017–2023 sets forth determined targets to reduce old vehicle models and support alternative fuel options with enhanced energy efficiency over the period of 2017–2023 (Climate Action Tracker, 2019). In this perspective, raised points include rebalancing the distribution of different modes of transport through development of combined utilization in passenger and freight transport (National Energy Efficiency Action Plan, 2018-Republic of Turkey Ministry of Energy and Natural Resources, 2018).

The role of road transportation is aimed to be diminished through expanded and modernized railway networks as well as frequent use of maritime transport within the public transportation systems. Reduction of the weight of road transportation to below 60% for the freight and below 72% for the passenger transport are intended targets by 2023.

Acknowledging the need for shift to sustainable transport systems, Turkey has been aiming to plan suitable infrastructures with integrated modes of transport while lowering the vehicles' unit fuel consumption levels. Strategical purposes to be achieved by 2023 include abatement of per unit fossil fuel consumption from motorized vehicles, increasing the role of public transportation including on the highways and sea transport in order to decrease the fuel intensity in urban transport systems (Republic of Turkey, 2012-2023). Significance of technological advancements along with extended financial tools are underlined to achieve these targets. Energy efficiency in transportation is particularly encouraged with integration of smart management systems and competent infrastructure. Determined activities are set forth in line with the EU regulations on CO_2 emission standards to be able to reduce fossil fuel use in motorized vehicles (Republic of Turkey, 2012-2023)[6].

Accordingly, fuel cell and hybrid electrical vehicles with smaller motor size are strongly promoted with legislation of an accompanying bill to be developed in accordance with the implementation of environmental taxes of vehicles in the EU and other OECD members. Use of biofuels and synthetic fuels are also aimed to be encouraged in transport systems with excise tax discounts as long as their domestic productions are not detriment to the national agricultural sector. Policy measures for the achievement of promoting use of renewable energy sources related to transport sector encompass biofuels obligations and tax exemptions (National Renewable Energy Action Plan, 2014-Republic of Turkey Ministry of Energy and Natural Resources, 2014).

Guidelines described under the subsequent National Energy Efficiency Action Plan are in line with the Energy Efficiency Strategy targets to promote sustainable and energy efficient transport systems in Turkey. The priority areas identified to improve energy efficiency of vehicles are advancement of research development on alternative fuels and their technologies, build-up of bicycle transport options and elimination of passenger cars to curtail the traffic congestion.

The market outlook for electric vehicles is positive as there are several initiatives that already took place with forward looking targets to be achieved until 2030. Accordingly, pilot projects for

[6]*Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles. & Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO2 emission performance standards for new heavy-duty vehicles.*

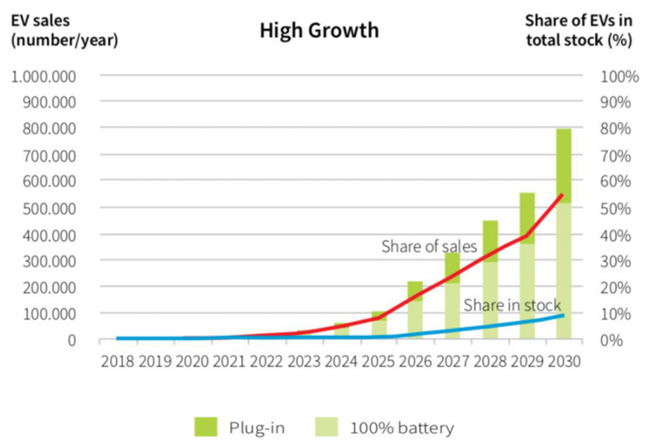

FIGURE 1 | Total number of electric vehicle car estimations until 2030 in Turkey. Source: Shura Energy Transition Center, Transport Sector Transformation: Integrating Electric Vehicles into Turkey's Distribution Grids, 2019.

distribution grids have been designated in multiple areas in line with a high growth scenario that foresee 65% of vehicle sales to be made for electric vehicles including battery and plug-in hybrids in the **Figure 1**. Turkey has recently ventured on producing its own zero emission electric passenger car, TOGG which will be launched in 2022.

It is expected to be chargeable in varied charging stations and at a rapid speed in less than half an hour. The expected surge in the share of electric vehicles can be observed in the below graph although such projections do not include non-passenger light duty vehicles with commercial objectives at the moment.

Tax incentives are commonly prioritized for encouragement of energy efficient and low emission vehicles such as electric, hybrid, hydrogen or natural gas fired ones in the world, and particularly in the European Union. In line with such developments, Turkey attempted to introduce some incentives to promote electric and hybrid vehicles. Special excise tax law has also been enacted to provide tax exceptions for electric and hybrid vehicles in Turkey[7]. However vehicle taxations system is calculated upon the age and motor power of vehicles.

The special excise tax has been criticized to promote shift to older second-hand models with higher emissions, as older cars have less motor vehicle taxes (Senzeybek and Mock, 2019). Differentiated taxation mechanisms shall be evaluated in conformity with fuel consumption as well as CO_2 emissions of vehicles. Establishment of a database that records CO_2 emissions of every vehicle at the market shall enable reinforcement of planned tax system.

Assessment of prominent policies for renewable energy development and decarbonisation efforts of fossil fuel dependent road transport systems provide a guideline for future implications. Despite current considerations for decarbonisation of energy and transport systems, there are multiple challenges to be addressed.

Main arguments that hamper renewable energy development in Turkey are centered around inadequacy of fiscal incentives, whereas lack of regulatory standards for CO_2 emissions and clean alternatives are the major stumbling blocks to build sustainable road transport systems.

ACTIONABLE RECOMMENDATIONS

Political nature of transition processes necessitates facilitating regulatory frameworks that shall have the adequate capabilities to address technical, administrative as well as justice aspects of systemic change. Presented findings in the previous section provide a direction for effective policy making in energy and transport sectors to reformulate the existing policy frameworks in line with carbon-free and equitable energy transition pathways. Building on the argument that there is potential for improvement, the following section integrates these recommendations with the alternative innovative and cost-effective solutions for decarbonisation of road transport systems. Accordingly, actionable policy recommendations are summarized in a table followed by presentation of the findings.

Environmental Performance Review of Turkey by the (OECD, 2019a,b) calls for a reform of the vehicle and fuel taxation system with emission criterions while fossil fuel tax exemptions for industrial and residential use shall be eliminated. It is argued that reducing the emissions from transport sector can enhance environmental quality with mitigated air pollution while electric mobility can ensure decarbonisation of the power sector (Saygin et al., 2019). Therefore, it is possible to assume that large scale implementation of electrified transport options provides a series of benefits in the form of energy savings, but also for prospective renewable energy deployment.

It is important to stress that low-emission vehicles (electric or hybrid vehicles) are currently not affordable by low-income individuals and effectiveness of governments' incentive policies in contributing to equity is controversial unless their mass production is ensured to reduce costs (Mullen and Marsden, 2016, as cited in Mattioli et al., 2018). Alternative ways to advance sustainable mobility such as bicycle and pedestrian transport options, promotion of green transport in urban and regional systems should be addressed to reduce inequalities. Traffic density is another major problem of the road transport in most cities which in return exacerbate the air pollution.

Implementation of control systems through smart parking spaces at high fees in urban areas and enhanced public transport with better infrastructure are among the alternative practices to prevent increased congestion (WRI Turkey Sustainable Cities, 2018). Introducing new mobility procedures while supporting more sustainable modes of transport through car-sharing with the use of advanced technologies are among the considered policies for decarbonising the road sector in Turkey. However, strong policy planning objectives do not match with the required technology production capacity (Varlik and Yilmaz, 2017).

Environmental Performance Review of Turkey by the (OECD, 2019a,b) points out to the need for increased volumes of eco-innovation policies and spending on R&D activities accompanied

[7] *Law No.197 Motor Vehicle Taxes.*

with more support to national innovators which would inevitably fortify the domestic markets on the path toward green growth.

Innovative and Cost-Competitive Solutions for Sustainable Road Transport in Turkey

In Turkey, energy use problems exacerbated by the technological incapacity of current transport systems dominated by mostly old and inefficient vehicles that lack any fuel standards lead to unnecessary fuel use and highly wasted consumption levels with detrimental impact on the environment (Szyliowicz, 2004, p. 30). Even though transport sector is considered difficult to decarbonise due to many reasons that include restricted presence of alternatives, there are a number of proposed solutions[8] within the current policy agendas of countries (Lehtveer et al., 2019). Upon this background, it is imperative to draw an outline of the external landscape developments and technological niches that have impact over the dynamics of road transportation system.

Clean and low-carbon transport solutions are intertwined with technological advancements. In other words, electric and hybrid vehicles, hydrogen cars or efficient combustion engines incorporate innovative results (Apak and Atay, 2013). Vehicles that work with electricity provided through on or off-grid and supplied with battery packs are called electric vehicles, even though different electrification options exist in alignment with diverse battery durations (IRENA, 2013). According to the International Energy Agency (IEA), batteries and electrolysers are suitable technologies for mass manufacturing of electric vehicles, although they are currently at different stages of development. On the other hand, costs of lithium-ion batteries, that are essential technological advancements for electrified transport options, have recently been decreased due to widespread production. Electrolysers also hold the capacity for further cost reductions. Moreover, batteries can be used in the power sector with integration of different renewable energy sources in electricity generation which make lithium-ion batteries feasible to use in the energy systems apart from their utilization in transportation.

In line with such technological developments and prospective decline in production costs, governments have been introducing policies targeted at promotion of sustainable transport options with increased attention to electric cars in various countries. International Energy Agency describes achievement of adequate manufacture capacity of batteries as crucial for sustainable electrification in the road transport which will hold a fundamental role in future markets. Currently, global manufacturing capacity of batteries is largely led by China which has about 70% of all volumes, whereas the United States shares 13% and the European Union 4%. Europe is the global leader in production of electrolysers that are used for fuel cell passenger cars (IEA, 2020). The major obstacle in promotion of use of electrical vehicles is the costs of lithium-ion batteries, apart from the pre-requisite of mass standardization and manufacturing (European Commission, 2017).

Support mechanisms by governments through various incentives to boost manufacturing of battery and electrolyser products in order to reduce costs may alter the national attitudes and convey a substantial message for domestic automotive industry. It can steer the shift toward electrified vehicles along with prospective creation of new jobs and employment opportunities.

Introduction of specified standards on low-carbon fuels, subsidies for purchase of electric cars as well as facilitated tax credits are alternative methods to encourage their demand.

Another important barrier in broad use of electric vehicles is the complementary need for suitable public infrastructures in the form of public charging stations which may be challenging to develop in the short run. Indeed, electrification of medium-long haul and heavy freight vehicles confronts more obstacles in terms of battery use at adequate ranges.

Large-scale adoption of electric vehicles depends upon supplementary charging infrastructures and in a variety of locations (IRENA, 2013). There are a number of viable solutions in line with different charging rates, such as normal, medium or high-level power charging points that may be available at home, work or public parking areas, and require peculiar investments to access the network at ranged costs. As a result, costs may vary and appear non-incremental if charging stations are at home, whereas costs for those that are placed at workplace parking areas may differ depending on availability of infrastructures and distance from the electricity distribution network. Interestingly, IRENA (2013) points out that diffused use of electric vehicles does not necessarily require mass installment of public charging stations at the initial stage and instead displays an exponential increase. Moreover, since access to private parking spaces at homes or workplaces is an issue in developing countries, public charging stations attract more attention for investments (Saygin et al., 2019). It is positively relevant in planning of future charging station deployments in Turkey which shall be taken into consideration together with the peculiarities of its urban areas.

Use of hydrogen also provides great opportunity if met with the necessary stimulus packages and policy actions aimed at benefiting from large scale manufacturing of battery and electrolysers, although they remain as capital intensive investments. Hydrogen can be utilized for decarbonisation of various sectors comprising of long-haul transport and help to reduce air pollution. International Energy Agency (IEA) stresses that is not only light and easy to store, but also does not generate pollutants and GHGs, which means that hydrogen can play a fundamental role in sustainable energy transition when used in various sectors. Support policies for investments in technology of hydrogen have been scaling up along with the rising demand, while policy incentives are being centered around transport sector in which current mechanisms are targeting mostly passenger cars, vehicle refueling stations and buses in a number of countries (IEA Report on the Future on Hydrogen, 2019-IEA, 2019). However, hydrogen can be produced from a range of sources such as renewables, coal, natural gas, oil as well as nuclear energy. It is possible to

[8]Directive 2009/28/EC of the European Parliament and of the Council (2009). Promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. http://data.europa.eu/eli/dir/2009/28/oj

transform hydrogen into transport fuels for different vehicles or electricity for power generation at home or industries (Lehtveer et al., 2019).

Hydrogen demand has been on the rise since some time, but its production is largely dependent on fuel costs as the biggest price component which creates further obstacles. As a result, hydrogen is vastly produced from fossil fuels, in major part from natural gas and coal due to lower production costs at the current level. Varied costs of hydrogen production by production source reveals that its use for low-carbon energy transition remains to be an issue for cost competitiveness. Because hydrogen production mostly relies on coal and natural gas at the moment[9]. However, it may change with further reductions in the cost of renewable energy productions. An additional alternative for sustainable road transportation may be use of electro fuels that are essentially carbon-based and generated from renewable electricity along with CO_2 from biomass. Electro fuels are feasible for a wide range of transport methods and in conformity with the combustion engine, which means that big scale infrastructure investments are not necessary (Lehtveer et al., 2019). However, the most fundamental input that determines electro fuel costs are electrolysers and price of electricity that shall provide cost-effective solutions in transport sector.

Biofuels produced from biomass are also largely utilized for decarbonisation of transport sector and to substitute fossil fuels without the necessity for large scale investments in infrastructure. Biofuels can be used in road and rail transport as an alternative to electrification, however sustainable use of biofuels for conservation of adequate food production and livestock is an important issue to be addressed[10]. Furthermore, costs of biofuels are affected by volatile price levels of feedstocks. Total production costs for liquid biofuels including ethanol and biodiesel are largely based on prices of feed crops (IRENA, 2013). Due to such limits, biofuels can be utilized in specific sectors that are particularly deemed difficult to decarbonise (Lehtveer et al., 2019). In terms of biofuels use in Turkey, the degree they can grant an alternative solution to fossil fuel sources are questionable in terms of sustainable and extended use of biomass for production of biofuels.

In light of varied and rapidly changing technological advancements that offer prospective breakthroughs it is imperative to mention the current state of sustainability attempts in Turkish transport sector. Share of hybrid and electric vehicles is currently lower than 0.1%, but it is expected to increase in the near future that shall reach about 2.5 million electric vehicles by 2030 according to the high growth scenario (Saygin et al., 2019). Although there are some initiatives aimed at progress toward electrification of the transport sector as evident in several policy implementations such as tax benefits to electric and hybrid vehicles as mentioned earlier, additional policy designs should be considered including through differentiated taxation mechanisms that shall take into account vehicle fuel consumptions and emission levels. Since electric and hybrid cars are expected to take up their share in Turkey, further considerations include compatible infrastructural installments.

National benchmarks relating to electric vehicle charging do not exist yet, mostly because of limited degree of installments at current level. However, Energy Market Regulatory Authority introduced the draft regulation on connection to the distribution system for charging of electric vehicles[11]. Although it is possible to assert that there are some steps taken toward low carbon transition of the transport systems in Turkey, there is still much room for improvement in terms of technological growth, compatible policy practices as well as equity implications. Despite availability of various low emission alternatives to fossil fuels, their cost competitiveness remains an issue to be tackled for large-scale adoption of sustainable transport solutions also at the global scale. It remains as a challenge to be tackled in Turkey and largely relies on international advancements on international battery technologies that shall introduce cost reductions.

Global market uptake of electric vehicles is estimated to increase as more than half of passenger vehicles sold will be electrified by 2040 (BloombergNEF, 2020). Despite expected cost reductions in batteries, another thing that may reduce their competitiveness is the volatile oil prices which would significantly alter economics of zero-emission vehicles. Apart from the essential technological advancements, policy mechanisms that offer a variety of incentives through subsidies in taxation, purchase bonus or elimination schemes are vital to reduce the high initial capital costs of not only the renewable energy investments, but also zero-emission vehicles.

Against the backdrop of analyzed policy mixes along with rapid technical improvements a myriad of inferences can be made to target development of renewable energy and sustainable transport in Turkey. The results of this policy review can be considered as merely a first step toward systematizing national renewable energy policies based on preliminary investigations of sustainable energy transition and decarbonised road transport systems with connotations of equality.

Considering such shortcomings, actionable policy recommendations across dual policy issues of socio-technical system change of energy and road transport in Turkey are summarized in the **Figures 2**, **3**.

DISCUSSION: CAN TURKEY PROMOTE SUSTAINABLE AND INCLUSIVE ROAD TRANSPORT SYSTEMS IN THE NEAR FUTURE?

Introducing the required affirmative legal and regulatory measures to signal for behavioral change in consumer habits and provide for cost effective clean alternatives are

[9] IEA, *Hydrogen production costs by productionsource, 2018*, IEA, Paris.

[10] Directive 2009/30/EC of the European Parliament and of the Council (2009). *Amending Directive 98/70/EC as Regards the Specification Of Petrol, Diesel and Gasoil and Introducing a Mechanism to Monitor and Reduce Greenhouse Gas Emissions and Amending Council Directive 1999/32/EC as Regards the Specification of Fuel Used by Inland Waterway Vessels and Repealing Directive 93/12/EEC.* Available online at: http://data.europa.eu/eli/dir/2009/30/oj

[11] Energy Market Regulatory Authority (2011), Draft Text of Procedures and Principles Regarding Electric Vehicles Charging Station.

Policy Issue.1: Current legislative framework concerning renewable energy development in Turkey lacks the capacity to incentivize further investments. Deployment of renewable energy sources are hampered by inadequate funding opportunities and restricted technology transfer. Dependence on fossil fuels fostered by government's continuous support to power generation from coal and nuclear results in great vulnerability for climate change and energy security vis-à-vis growing national energy demand.

Objective: Projected increase in Turkey's energy demand should be met from utilization of great renewable energy potential of the country. It is imperative not only for energy independence but also to reduce GHG emissions originating from energy sector. Energy transition policies of Turkey shall incorporate a justice perspective in order to prevent exacerbation of existing inequalities.

Pre-condition: Turkey must ratify Paris Agreement. Having a longer-term energy transition framework embedded in a forward-looking agenda with comprehensive sectoral transformation outlook that considers social injustices and distributional implications of mitigation policies is mandatory.

Possible Actions

- Legislative and regulatory framework concerning renewable energy development as well as energy efficiency mechanisms should be re-evaluated with stable and diversified financing options.
- Comprehensive incentive mechanisms to address multiple risks of investments should be introduced for renewable energy projects. Ensuring grid integration of electricity produced from renewable energy in urban and rural areas is essential to ensure spatial energy justice.
- Challenges in adoption of technological innovations shall be addressed with longer term commitments to research and development activities while providing persistent support to national innovators.
- Turkish government must stop encouraging electricity generation from coal power. Accordingly, coal subsidies to energy poor households shall be eliminated. Fossil fuel tax exemptions for industrial and residential use shall be replaced with renewable energy incentives.
- Energy transition policies shall address energy justice through equitable access to clean resources without putting extra burden on the most vulnerable sections of the society. Accessibility and affordability of modern energy services can be promoted through policies such as tax exemptions, subsidies, grants, and other redistributive mechanisms.

FIGURE 2 | Actionable Policy Recommendations for Renewable Energy Transition in Turkey.

among the most important parameters for sustainable transition of mobility systems in Turkey. Policy measures that include mandatory CO_2 standards, CO_2 based vehicle taxation and improved CO_2 labeling schemes[12] that shall include quantitative information on estimated running costs can provide leverage effect (Mock, 2016). One of the greatest novelties to be introduced with innovative, clean and cost-effective solutions in transport systems is

[12]Directive 1999/94/EC of the European Parliament and of the Council (1999). *Relating to the Availability of Consumer Information on Fuel Economy and CO2 Emissions in Respect of the Marketing of New Passenger Cars.* Available online at: http://data.europa.eu/eli/dir/1999/94/2008-12-11

Policy Issue.2: Transport is responsible for 21% of GHG emissions in Turkey. Road transport is fossil fuel dependent and particularly difficult to decarbonize due to restrictive presence of alternatives. High fuel prices and current tax scheme result in use of less environment friendly vehicles in Turkey.

Objective: Reduction of soaring energy need from fossil fuel dependent road transport systems, where current demand exceeds 90%. Addressing increasing energy need of passenger and freight transport is necessary to curb GHGs and provide clean alternatives.

Pre-condition: Electrification of road transport systems, investments in complementary infrastructure and clean fuel alternatives shall be coupled with political and economic incentives to signal for behavioural change. Reliance on merely private low emission vehicles can widen the existing socio-economic inequalities.

Possible Actions

- Path-dependence of technological and infrastructural obstacles should be addressed to create investment opportunities for building of electrified road transport systems to deliver the 10% target of renewable sources utilization in transportation.
- Bottlenecks concerning digitalization, adoption of technological innovations as well as necessary research and development practices require closer cooperation among national and international stakeholders. Turkish government should foster political engagement for construction of such coalitions at different levels of socio-technical landscapes.
- Vehicle taxation system has to be reformed in order to prevent use of older vehicles which emit more GHGs. Additional policy mechanisms including carbon pricing, fuel efficiency standards, mandatory CO_2 regulations for manufacturers of commercial and passenger vehicles should be introduced.
- Zero to low emission vehicles shall be incentivized through tax reductions or subsidies, but it does not solve the problems of congestion or air pollution in cities. Electric and hybrid vehicles can perpetuate existing inequalities and create new distributional injustices.
- Justice implications of accessibility and affordability of decarbonised mobility systems infer better planning in urban areas through establishment of smart cities and promotion of clean alternative such as widely electrified public transport systems, cycling, walking or shared riding options to prevent further exclusionary policies.

FIGURE 3 | Actionable Policy Recommendations for Decarbonization of Road Based Transport in Turkey.

the multiple gains to the benefit of different stakeholders including energy companies, investors, manufacturers as well as service providers.

Transformation of the transport sector shall create positive effects on multiplied value chains with the possibility to enhance economic growth in a sustainable manner while creating new job opportunities. As Turkey is one of the most important manufacturers and exporter of vehicle and vehicle parts in the world; the automotive sector constitutes an essential part of the economy (Mock, 2016). Against this backdrop and in line with the global market shifts in the automotive sector that is increasingly adopting sustainable solutions with the latest technological advancements, Turkey has made some progress in catching up with such trends. Nevertheless, current policies appear as limited in scope.

Growing population of Turkey matched with the swift urbanization trend implies significant benchmarks for the build-up of necessary infrastructure aimed at larger-scale deployment of electric vehicles that shall meet the diverse needs of different end-users. Aggregate acceptance of electric vehicles also depends on presence of complementary infrastructure to ensure interoperability and harmonization of standards. The market report on transport sector transformation prepared by Shura Energy Transition Center (Saygin et al., 2019) therefore assumes the home charging stations to lag behind the public ones by 2030, while the public ones will be spatially restricted to shopping malls, main highways and gas stations. In fact, current eight pilot regions represent 35% of the national energy consumption and 33% of the total population with a variety of residential, industrial and commercial customer portfolios. The model predicts a yearly 5% increase in total demand of electricity during 2018–2030 on distribution grid of the pilot regions that is based on differentiated charging venues and patterns including peak hours. Such increase in energy demand in pilot regions is planned to be met through additional renewable energy integration to the system that will be generated from solar and wind power whose baseline is very limited at the current state and by local lignite sources to some extent.

Evidently, it is significant to meet increased energy demand of electrified transport systems from domestic renewable energy sources to provide multiple offerings to national energy security and GHG emissions. Energy generation from renewable resources necessitate incentivising renewable energy investments and spatial assessment of their grid integration. Incorporation of technological solutions can provide supplementary leverage effects.

The study conducted by Shura Energy Transition Center (Saygin et al., 2019) includes energy storage through battery systems and estimate its positive impact together with renewable energy use to relieve the distribution grid except for peak hours and at the absence of any incentive mechanisms. For instance, alternative solutions that will enable investment cuts and prevent the peak loads on the grid are being developed in Germany, which leads sustainable energy transition under Energiewende. It includes smart charging practices such as integration to an optimisation mobile application in order to estimate the most cost-effective charging times (Agora Energiewende, 2019). However, one important point to draw attention is that the modeling of distribution grids of each pilot regions in Shura Energy Transition Centre's study takes GDP per capita into account, development coefficient and other socio-economic indicators including the education level in chosen cities as the multiplication factor to project the number of electric vehicles and required charging points. Therefore, a positive correlation is estimated between higher GDP and development standards for expected portion of the population that will likely use electric vehicles (Saygin et al., 2019). Evidently, such projections neglect poorer households and imply multiple externalities for equitable transition.

Analysis of electric vehicle uptake through a justice lens implies that despite its environmental benefits, EV use can be exclusionary and create further distributional injustices (Jenkins et al., 2018).

Accordingly, climate mitigation policies shall be approached with their potential consequences on inequality. Policy actions aimed at low carbon energy transitions should incorporate practices of acceptance, mobilization, and empowerment to address justice (McCauley et al., 2019). Markkanen and Anger-Kraavi (2019) conceptualizes maximized positive social co-benefits whereby policy design, implementation and mitigation action are inclusive. Acknowledging that the notion of social justice is intrinsically non-separable from environmental sustainability, social and spatial vulnerabilities are compounded at the juncture of gender, race, and indigeneity. Therefore, policy measures for energy transition should not be detriment to the most vulnerable people. These include adoption of alternative measures in planning of local mobility systems to promote walking, cycling and use of public transport rather than solely relying on private low emission vehicles (Mullen and Marsden, 2015). It is important to stress that market-based instruments such as environmental taxes can create economic burdens and increase existing vulnerabilities of low-income households. Bardazzi and Pazienza (2014) makes a comparison on use of market-based instruments for design of energy policies in Turkey and the EU whereby a price signal is sent to consumers with the attempt of achieving behavioral change for fuel substitution; however, it appears controversial in terms of justice implications.

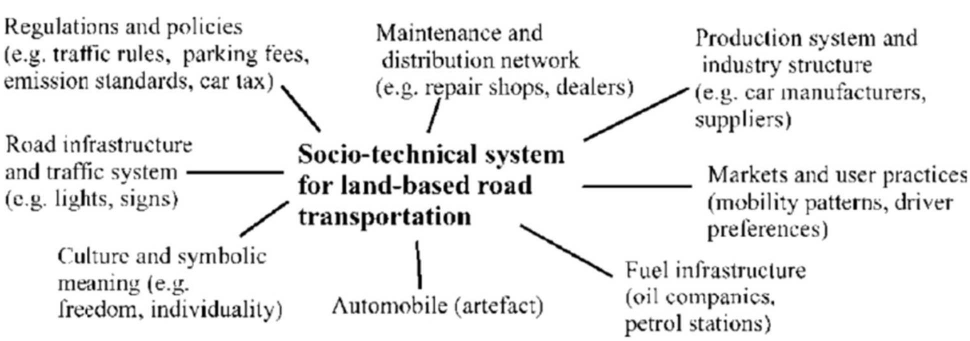

FIGURE 4 | Socio-technical system transition in the context of modern road transportation. Source: Geels (2005).

Indeed, policy instruments aimed at shift to clean energy should primarily consider the energy poor in the society (Berry et al., 2016).

On the other hand, transition management at multi-level governance frameworks can facilitate transition toward just and low carbon energy systems by multi-stakeholder engagement.

Indeed, socio-technical transitions occur through multi-actor processes among different social groups as it is highlighted in **Figure 4** (Geels, 2005). Socio-technical system transition for sustainable road transportation can be achieved through a combination of command-and-control schemes and market-based instruments incorporating car labeling, emission standards and taxation tools to encourage low emission mobility among passenger and freight vehicle users as well as car manufacturers. Mobility patterns, role of culture, user practices also play a key role in transition processes.

Relationship among different social groups such as policy makers, market regulators, automotive manufacturers, energy companies, innovators, investors, and users that interplay at various levels is key in attaining inclusive socio-technical regime transition of land-based road transportation. For instance, public procurement practices by municipalities can serve as a strong tool to establish markets for low emission alternatives. Further incentives can be implemented by regional governances on top of government subsidies although, it implies careful examination of characteristics of each city or town (Heinrich Böll Stiftung, 2012).

CONCLUSION

Some degree of political will is demonstrated by Turkish government to decrease its energy dependence, step up its climate change action namely through enhanced energy efficiency and shift to renewable sources including in transport sector. However, persistent policy gaps exist.

As a result of this policy and practice review, it is concluded that there are mainly four issues relating to sustainability of transport systems integrated with renewable energy use in Turkey.

Firstly, the current policy framework de-incentivizes renewable energy use through support of fossil fuel and coal subsidies provided to different consumers; secondly current vehicle and fuel taxation system and CO_2 standards hamper behavioral change which led consumers to opt for less environment friendly options; thirdly, there is need for advanced technology cooperation to develop innovative and cost competitive clean alternatives. Lastly, justice implications of energy transitions shall be embedded in ex-ante mitigation policies in order to prevent exacerbation of existing socio-economic inequalities.

Upgrading the regulatory and policy framework as well as increasing public awareness is much needed to overcome the persisting challenges of renewable energy use and sustainable transport in an inclusive fashion. The existing Turkish policy agenda for climate change is not only weak in terms of its pledge but also short-sighted. Turkish government's reluctance to ratify Paris Agreement further reiterates its unwillingness toward mitigation efforts. Turkey urgently needs a forward-looking climate mitigation strategy that incorporates necessary measures to prevent adverse effects of transition processes on people who are disproportionately more vulnerable at the face of climate change. Ensuring accessibility and affordability of key energy services, including mobility is imperative in order to address justice implications of sustainability transitions. Policies such as tax exemptions, subsidies, grants, or other redistributive mechanisms can provide equitable and affordable means of access to clean energy and decarbonised transport solutions without putting extra burden on the most vulnerable sections of the society. However, promotion of non-car modes of transportation is also important. Design of clean mobility options that provide alternative solutions through electrified public transport systems, development of urban spaces with walking, cycling and shared riding possibilities can contribute to just transition pathways toward sustainable transport systems.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

ACKNOWLEDGMENTS

The author thanks Meltem Erdogan for her ongoing support, her professors Maria Grazia Pazienza as well as Alberto Tonini for the inspiration and critical comments.

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Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.