

Vehicular energy electrification in Palestine oriented to enhance socio-economic development: A focus on solar electrical energy potential for powering PHEVs and EVs

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Abstract – This contribution is a policy recommendation paper that focuses on the enormously positive implications of vehicular energy transition on local socio-economic development, if some tailored and incentivizing policies aimed to encourage public-private partnerships and projects directed to develop this highly energy-dependent sector are adopted. PENRA website reports that in 2020 about 87% of energy comes from Israeli sources, and energy consumption by vehicular sector is 42% of the total energy [1]. Given its largest size of energy consumption and will increase in size as the registered vehicles increases, which will worsen the current situation of dependency on supplies from Israel, the Palestinian Authorities (PA) needs to design and implement policies aimed to encourage renewable energy production and usage in all forms, especially solar electrical power for vehicular sector usage, knowing that only 4% of the total electric power is renewable according to Palestinian Energy and Natural Resources Authority (PENRA) statistics in 2021 [1]. Fortunately, vehicle modern technologies facilitate the adoption of transport sector electrification policies such as Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Drive Electric Vehicles (EVs). Finally, PA through tailored and incentivizing policies aimed to encourage public-private partnerships directed to develop PV plants, through reduction of wheeling costs and taxation, will increase the employment of young graduates and helps to develop remote areas. While this allowed to happen and with the increase of the economic cycle size, the PA revenues will certainly increase from all the benefited sectors exceeding all the exempted costs.

I. INTRODUCTION

The vulnerability and lack of sustainability of the energy sector in Palestine are the direct outcomes of the current energy policies that are largely depending on Israeli sources and the regulations that do not incentivize private investment and technology shifts towards more integration of local renewable energy sources. This contribution is a policy recommendation paper oriented for developing an adaptive energy infrastructure that helps to bridge the relevant technology gaps and to introduce a regulatory framework to overcome energy supplies challenges, while at the sometime enhances socio-economic development. Indeed, Palestinian dependency on Israeli energy sources has placed all socio-economic aspects of life in a very vulnerable situation. The very recent example of fuel supplies shortages due to the erupted military confrontation between Israel and Iran has forced Palestinians to queue in long waiting lines for having partial tank filling. This situation has disrupted many aspects of life, waiting lines resulted into blocking streets, wasting of working time for the very people who should

run production and services, difficulties to reach work places, etc. Similar situations related to energy supplies disruption continuously happen, especially during winter seasons, due to shortages in fuel, gas, and electricity supplies, which lead also to increase in energy costs to levels that makes Palestinians life more difficult.

Given the fact that efficient transport system is an essential factor for socio-economic development, transport sector needs to be modernized in a way that limits dependency on Israeli sources as soon as possible. Considering the available solutions such as building large power plants or importing fuels from Arab countries, Israel still in control of all borders and blocks such projects and initiatives. However, a partial but effective way-out from this situation is the vehicular energy electrification using solar energy. It could be an effective solution of the vehicular energy problem, if it is supported by the necessary policies and regulations that encourage private-public partnerships for solar electric energy production, storage and transfer.

For the matter of fact, having wider private capital investment in solar electrical energy production will certainly increase job creation and youth employability, which will widen the economic circle and national GDP size. Given only 4% of the total electric power is renewable according to Palestinian Energy and Natural Resources Authority (PENRA) statistics in 2021 [1], vehicular energy electrification using solar electrical power will have an enormous positive impact of local socio-economic development, while at the same time reduces dependency on Israeli sources that amount to 87% according to PENRA 2020 report.

Currently, energy consumption of vehicular sector is 42% of the total energy [1] that goes to power the 86.1% of the registered vehicles in West-Bank (Jerusalem not included) as shown in Fig. 1, which are private owned vehicles according to Palestinian Central Bureau of Statistics (PCBS) report of 2023 [2]. Given this fact added to current trend of increasing rate of private vehicles that is about 10% in 2022 according to the Ministry of Transport report 2023 [3], of which 0.21% EVs and 1.69% PHEVs with a total of 1.9% as shown in Fig. 2, the conventional energy demand will increase; therefore, to avoid worsening the current situation of dependency on supplies from Israel, the Palestinian Authorities (PA) needs to design and implement policies aimed to encourage renewable energy production and usage in all forms, especially for the vehicular consumption, including Plug-in Hybrid Electric Vehicles (PHEV) and Battery Drive Electric Vehicles (EV).

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Furthermore, passenger transport sector failing to provide efficient and scheduled departure times has caused citizens to lose confidence in the public sector, thus increasing the inclination to own private vehicles, which contribute to the worsening situation of vehicular energy dependency on Israeli sources in addition to the socio-economic impact due to the spending on means of transport amounts for 14.2% [4]. Accordingly, it is imperative that PA policies should be tailored to modernize transport sector including the increase of local solar electrical energy production parallel to facilitating and encouraging the ownership and usage of PHEVs and EVs, which surely results in less dependency on Israeli sources.

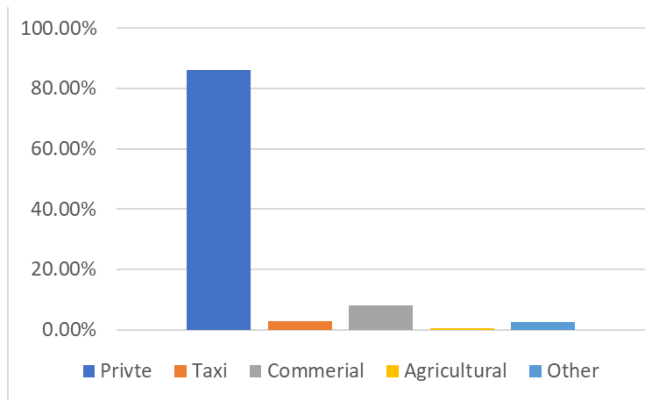


Figure 1: Percentage distribution of licensed vehicles in the West Bank (Jerusalem not included) by vehicle type, 2023 [2].

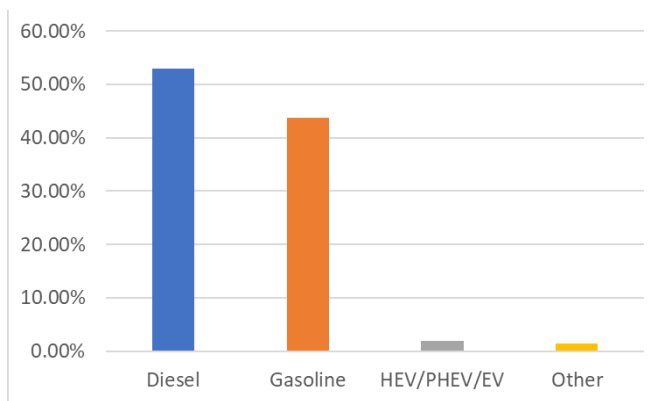


Figure 2: The relative distribution of licensed vehicles in the West Bank (Jerusalem not included) by fuel type, 2023 [3].

Palestinian territories are considered among the regions of high solar energy potential with about 3000 sunshine hours per year and a solar radiation ($\text{kWh/m}^2/\text{day}$) recorded for year 2013 of 8.27 in Ramallah, 7.51 in Hebron [5,6]. But sadly only 4.1% of electricity is generated locally, therefore, it is essential to adopt a new action plan to address energy independency and sustainability through accelerating investment in renewable energy sector [7]. Fortunately, PV systems are quite affordable to many middle-class income Palestinians, including those who live in remote villages and less developed urban areas. In fact, the techno-economic impact of electrification of small communities using micro-grid PV systems is feasible according to recent local and international studies [8,9], which could form an effective leverage for socio-economic

development. Thus, adopting incentivizing policies that allow remote villages to benefit from free of charge transfer of electric generated using PV power plants to PHEVs and EVs charging stations will exponentially accelerates the modernizing of transport fleet, thus increasing the economical circle, which allow the PA to recover indirectly the exempted costs of using the grid freely to transfer the locally produced solar electricity. In this way, Palestinians will enjoy multi benefits: less dependency on Israel, less use of carbon-fuels, wider private capital investment. Indeed, establishing a private-public partnership that is aimed to increase investment in electric solar energy production and usage will lead to develop the needed ecosystem for creating an enormous spectrum of jobs almost in every relevant field: finance, insurance, higher and technical education, vocational training, transport, dealerships, aftersales and indirect services, infrastructure construction, research and development, innovative solutions and products development, etc., therefore, more jobs and more SME creation, and ultimately more taxes will be paid to PA.

Based on the given overview, this paper will analyze four pillars that makes the bases for vehicular energy electrification policy and will present some direct and indirect results.

II. VEHICULAR ENERGY ELECTRIFICATION PILLARS

Vehicular energy electrification in Palestine requires by default modernizing the vehicles fleet, and such transition consequently requires transforming the energy sector. This paper presents four pillars for a successful transformation policy that the PA should implement without delay. The authors acknowledge the difficulties, given that Israel control of land and is often hinder PA interventions, but Palestinian have gained experience overtime to creatively overcome such situations, and continue to develop all aspects of socio-economic life. Considering the statistics on transport fleet and energy demand in Palestine, the current and future estimates shows more dependency on Israeli sources, but if the PA adopts a transition policy that encourages modernization of vehicular fleet to include higher percentage of PHEVs and EVs along with increasing the solar electrical energy production, it could be considered as critical primer that should be treated as bases for socio-economic development and less dependency on Israeli sources. Thus, an integrated ecosystem for developing the infrastructure public-private-partnerships is required to overcome the funding gap for providing the investments needed to finance projects and create more job opportunities.

A. First Pillar: Energy Demand

Having established the fact that 86.1% of vehicular fleet in Palestine is private, and the electrical energy demand. To better understand the energy requirements, it would be useful to recall briefly the main specifications as summarized in the very recently published book, which particularly covered the trends of energy for wheel at vehicle [10]. Energy requirements for EVs: About 100 Wh/km/ton (0.1 Wh/km/kg), 15 kWh/100 km for medium-sized car, and 150 kWh/100 km for medium-sized bus. Power requirements for EVs: About 40 kW/ton for a medium-sized car (40 W/kg), 10 kW/ton for an urban bus, and 20 kW/ton for an extra-urban bus. Storage requirements in terms of specific energy: For EVs 100 Wh/kg for 100 km and for PHEVs 20-23 Wh/kg for 100 km. Based on the presented energy and power specifications, and the fact that most of the

vehicular fleet is private owned for private use, it can be concluded that the majority of PHEVs and EVs owners use only part of the capacitance provided on onboard these vehicles by design requirements.

Thus, to determine the actual energy requirement for most of owners in order to propose a possibility of off-grid charging systems, a graduation project by Automotive Engineering Students with one of this paper authors as supervisor have carried-out a series of tests, over one month use, on five different vehicles that travel from different places in the region of Hebron Governorate [11]. The results for the energy requirement per daily drive distance are shown in Table 1.

TABLE I. ENERGY REQUIRMENT PER DAILY DRIVE RANGE [11]

No.	Drive Test Details		
	Vehicle type	Range (km)	Energy (kWh)
1.	BMW 4302 PHEV	24 – 86	6.60 – 9.84
2.	Hyundai IONIQ 5 EV	35 - 100	6.96 - 20.03
3.	Peugeot 3008 PHEV	46 - 96	6.35 - 13.25
4.	Hyundai Kona EV	46 - 109	7.54 - 17.98
5.	Geely Geometry C EV	59 - 109	7.95 - 14.84

The results compatible with standards, while differences are due to the drive route. Therefore, based on these results the required energy could be supplied using small PV plant, either off-grid as suggested in the project or on-grid, which implies that adopting energy transition policy the incentivize the electric vehicles ownership a long with facilitating the access to grid will accelerate the vehicular energy electrification and decrease the dependency on Israeli sources. Indeed, increasing EVs and PHEVs share from less than 2% up to 10% of the newly registered vehicles will increase the electrical energy demand each year, thus opens an enormous opportunity for investment in solar electricity production, creating a variety of relevant jobs, while at the same time reducing dependency on carbon-fuels and positively affects environment by reducing the CO₂ emissions.

B. Second Pillar: Regulations

Enhancing energy security in Palestine is an essential factor for socio-economic development, which is the very reason this paper targets current regulations that should be improved to increase the renewable energy share in the overall energy supplies. Indeed, several studies have concluded that regulatory support for renewable energies and financial incentives have so far been somewhat limited and vague, among which a very detailed study titled as Sustainable Transformation of Palestine’s Energy System [12]. The study stressed that PA should implement more ambitious incentivizing polices to get the energy transition underway at all levels, which helps to convert Palestine's energy supply to a system based on 100% renewable energy. PA main target should embrace long-term policies for wide socio-economic development. Such polices helps to reduce energy dependence on Israel as well as the fiscal burden of high-priced carbon-fuels imports. Switching to renewable energy could not only helps to ensure a cost-effective energy supply, but also increase

private sector participation. To this extent, many international examples can be found that confirm the importance of involving private sector. For example, as extensive survey study of relevant research “A Distributed Energy Future for the UK” has concluded that a decentralized energy future will mean a greater role for, and use of, local energy assets and management of the local distribution networks for electricity. The grid should become smart to enhance its function in real time, and in turn facilitates greater flexibility, connectivity, and deployment of energy storage devices [13].

Considering the case in Palestine, the Council of Ministers has adopted several regulations and extensions to the regulations, but still not incentivizing the private participation in the production of solar electricity. The regulation adopted in 2020 for buying produced electricity from solar energy at 85% of the price of electricity from Israeli sources is not incentivizing price for encouraging private investment [14]. The same case of discouraging the small private investments due to the taxation imposed by regulation adopted in 2021 that range from 5% up to 16%, which should be designed to incentivize the private investment [15]. But the imposed taxes and the lower buying price will turn the private investment not profitable, and therefore discourage private participation. Furthermore, the adopted regulation for net zero energy calculation allows the distributor to cut 12% from the energy supplied to the grid by the private producers adding to another negative factor [16]. Accordingly, most of the private PV plants installed in Palestine are for own needs give the high costs of electrical energy, either at the personal level or the industrial scale, but not dedicated to supply the grid for profit.

Considering the case of Jordan as a close neighboring country with same potential of electrical energy, the regulation there have been designed to encourage private participation through tailored policies based on the tariff on time of use and demand range [17]. The buying price is higher than most of the regular private users as well as exempting small private produces from wheeling costs. Indeed, the adopted policies encourage low-income citizens to actively participate and will indirectly increase the public awareness and the knowledge about the energy efficient techniques and technologies.

C. Third Pillar: Socio-Economic

Reviewing the PCBS official statistical report on the performance of Palestinian economy in 2024 [18,25], a very disappointing conclusion can be drawn; Energy sector in not included as an economic activity in Palestinian official employment statistical reports as shown in Fig. 3. Given the fact that no private significant participation in this sector, it is treated as service economic activity that include energy, transport and distribution, but no production. Therefore, job creation in this field is very limited due to low and unequal investments in this sector, combined with obvious disparities in economic opportunities, which leads to increasing inequalities and stratification across the Palestinian territories. Over time, the fragmented low income, labor-intensive and low-tech economy not only continues, but also negatively affects the sought socio-economic benefits, and will result in conflict and unrest within the society. But having established the fact that technological development of vehicular energy through electrification with larger share of private investments in solar electricity plants, with a focus on local issues around

low-income areas and allow for on-grid and off-grid charging stations, will create employment opportunities for young graduates and trained workers.

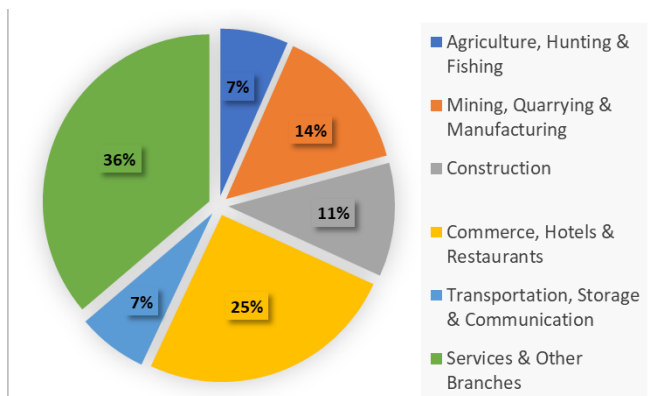


Figure 3: Percentage distribution employment individuals per economic sector (Jerusalem not included), 2024 [25].

Considering international cases, European Commission has addressed this issue extensively and funding programs for research in this field such as Horizon SERENE project [19]. The project addresses the issues related to implementation of local citizen-centered energy systems. Specifically, forging socio-economic, governance and regulatory factors; The interactions between socio-economic, technology and market factors influence energy consumption patterns and can create incentives for investments in the local energy system, which highlights the need to balance transition and equity. Indeed, long-term socio-economic benefits can outweigh immediate PA taxation benefits, which makes incentivizing long-term solar electric energy projects for transforming energy sector is extremely attractive.

Furthermore, to overcome funding issues for solar energy projects, PA could solve this obstacle through incentivize public-private partnerships. Such policies help to develop the energy market and to attract investments, which is core factor for functioning ecosystem as explained in the literature [20]. As a matter of fact, a just energy transition is critical to all societies around the globe. Considering the case of neighboring country like Egypt with significantly large population number; American University in Cairo has published a research report of research project Alternative Policy Solutions: Necessitating a Just Energy Transition for Inclusive and Sustainable Development, 2024 [26], in which it stresses on the economic growth and sustainable future based on energy transition that is done in a fair manner that leaves no person behind, including protections for workers across sectors and engaging all stakeholders in the decision-making process.

D. Fourth Pillar: Technical-Educational

To establish a vibrant ecosystem for vehicular energy electrification, developing human resources should be addressed within a flexible and agile framework that is based on Quintuple Helix Approach, which involves Universities, Authorities, Businesses, Media, and Environment. The

universities should align their programs for the market needs and the authorities should implement policies and programs allow creating new jobs while pushing for energy transition, businesses should participate in the investment and creating jobs for young graduates and trained workers in all fields related to EVs and PHEVs. Literature stresses the importance of broad pooling of technological expertise beyond the energy sector needs to support the innovation ecosystem. Urban areas, including large and small communities, with experienced local businesses or university departments with the relevant skill sets and technological capacity are core to functioning transition. Local authorities can directly support sharing of experiences through public-private partnerships [21].

III. EXPECTED RESULTS

The previous section of this paper provided insights into the required pillars that PA should takes into account to benefit from the potentials of vehicular energy electrification using solar energy. Modernizing passenger transport sector to become greener and energy-efficient, which is mainly dependent on privately owned vehicles, by facilitating the ownership of PHEVs and EVs will contribute to sustainability and less dependency on Israeli sources. These pillars would result in a significant socio-economic improvement due to enhanced businesses productivity, economic growth and job creation. Examples from around the world have been reported in the literature such as “When do states disrupt industries? Electric cars and the politics of innovation” [22]. This study concludes that political coordination can lead to technological transformations, where authorities can effectively engage in sectoral intervention to drive technological change. In another study on decentralized energy networks, that bring energy technologies closer to where people live and work, will encourage people to benefit from every socio-technical solution, from rooftop solar panels and EV chargers to battery storage facilities [23,24]. However, Palestine is always a particular and unique place in the world, where success of initiatives should not be taken-forgranted, but there are always risks of various types, but any policy should produce at least the following direct and indirect significant results:

1. Increasing public awareness and knowledge about the energy efficient techniques and technologies will result in wider public acceptance of modern vehicular technologies and endorsement of new regulations.
2. Modernizing the local transport fleet, which is mainly dependent on privately owned vehicles will ultimately contributes to energy security and less dependency on Israel, in addition to reduction of the energy cost.
3. Helps low-income citizens to actively participate in modernizing transport fleet through buying PHEVs or EVs as result of electrical power availability and lower costs as well. On the other hand, higher-income citizens will tend to participate through buying PHEVs or EVs mainly for the attractive modern technological feature as well as the lower vehicular energy costs.
4. Encourage all citizens to adapt their life habits either by using energy efficient systems or through shifting consumption times to lower costs hours (e.g. charging PHEVs or EVs), even some citizens could start using

electrical energy storage systems to help reduce energy bill, which will reduce demand during peak hours.

5. Creating a wide range of new jobs that are not only for young graduates and trained workers but also in all relevant fields such as education and TEVT, vehicles dealerships, aftersales services, insurance businesses, solar electrical power production and storage, PHEVs and EVs charging stations, household systems, etc.
6. Reducing carbon dioxide emissions as well as toxic emissions from the old vehicular fleet due to the electrification of vehicular and household energy, as well as due to using more energy efficient technologies and integration of solar electrical energy.

IV. CONCLUSION

This paper presented a multi-dimensional review that included a survey of some case-specific reports and papers, which are prepared by national and international institutions that focus on energy politics and their socio-economic benefits, to help decision-makers in identifying policies that promote renewable energy production and accessibility for the vulnerable urban areas on one hand. But, on the other hand, the paper gave also insights where policy-driven socio-economic development using vehicular energy electrification economy could bring enormous benefits at the national level. Incentivized production of solar electrical energy and incentivized ownership of PHEVs and EVs will surely help creating a wide range of new jobs that are not only for young graduates and trained workers in the targeted fields, but also in all relevant fields: expand all sorts of relevant economic activities, improve public and private educational outcomes, and lower CO₂ and toxic emissions.

This contribution presented insights into core four pillars that could help decision-maker of the PA to adopt policies and strategies for socio-economic development and for reducing energetic dependency on Israel, emphasizing and facilitating community engagement, workforce and institutions capacity building, and financial tools identification and implementation as key factors for success. The given insights underscore the transformative potential of using solar mini-grids for private needs that facilitates the ownership of PHEVs and EVs as an expected result, as well as using energy efficient households.

Finally, adopting vehicular energy electrification, using local solar energy production as a mean for socio-economic development and energy independency, will enhance energy access everywhere in Palestinian territories, thus helps for sustainable and inclusive economic growth.

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