An-Najah National University
Faculty of Engineering & Information Technology
Energy and Environment Department

Graduation Project 2

LCC investigation of PEV and EV family cars in Palestine

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A Graduation Project submitted to Energy Engineering and Environment Department partial fulfillment of the requirements for Bachelor degree in Energy Engineering and Environment.

Dec- 2019

Dedication

الإهداء
أُهدي مِن القلب إلى القَلب إليكم دائماً
إلى أحب العالمين عَلى قَلبي , إلى أقربهم وأوفاهم
إلى أكثرهم حناناً
إليكِ أُمّي
إلى الذي كان حاضِراً دائِماً
سَنداً وجَبلاً
إلى أعظم أبّ , وأجمل حُب
إلى أعظم الرجال في حياتي
إليكَ أبي
أمنحكم لَقب المهندسين قَبل أن يُمنح لي !
إلى الأصدقاء الأوفياء
إلى مشرف المشروع , الدكتور الرائع محمد السيد
إلى التفاصيل الأخرى في الحياة
إلى الجَميع أهدي هذا الجُهد المتواضع

Disclaimer

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Abstract

In this research, we study the feasibility of the electric and hybrid cars in compression with the fuel one in Palestine from economically and environmentally view. Economically, by calculated total cost of ownership (TCO). Environmentally, by calculated the amount of the carbon dioxide emissions
released.

We started by doing a survey about the car types in Palestine and the most common ones. Then we took all the information about each type of cars from different companies like Nissan , Hyundai , etc as the Purchase price, Licence and the annual operation cost like fuel consumption, maintenance, insurance.

After that we analyzed the data and calculated the TCO for each car in two scenarios , first one for the Cash Prices and the second one is payment in installments with the

travels 10,000 km/year, 20,000 km/year and finally 30,000 km/year.

Finally, we draw the curves to view the results, which indicate that the electric cars are visible if the car travels anuualy more that 10,000 km. from environmet view, the amount of carbon dioxide released are more than gasoline cars and that is because of the uses of the fossil fuels to generate electricity here in Palestine.

Introduction

In recent years the number of private cars has increased dramatically, as almost everyone is seeking to have a personal car. That's mean increasing of fuel consumption and environment pollution. So there was a pressure on car makers to find new car technologies have a less fuel consumption and impact on the environment, more commercial and have same efficiency of conventional cars, like a hybrid and electric cars. Given the large number of research published in this field, this is proof that electric cars are the solution.

According to Palestinian National Information Center the total number of licensed vehicles in the West Bank reached 254,497 vehicles at the end of 2018. The "relative distribution of vehicles by type" shows that the vast majority of them are private cars, with a percentage of 83.1 %.*(Pcbs.gov.ps. (2018).*

The energy consumption in Palestine is increased and the Vehicles sector form nearly 33% of the total consumption. Given the large proportion of the transportation sector in total energy consumption, this encouraged researchers to turn to this sector. Car companies in Palestine started to cope with this development in the field of cars, as they started to introduce this technology recently to the region, where some companies entered electric cars and hybrid cars, as citizens began to increase awareness of the importance of acquiring these cars from an environmental and economic point of view. Since there is no research in Palestine take the comparison between electric cars and conventional cars in economic and environmental terms. This encouraged us to do this research.

This research will investigate the feasibility of electric, hybrid, diesel and gasoline cars that have been marketed and sold in the local market in Palestine. We did this comparison by calculated the total cost of ownership. Total cost of ownership is a methodology and philosophy which looks beyond the price of a purchase to include many other purchase related costs. This approach has become increasingly important as organizations look for ways to better understand and manage their costs.*(Ellram, L. (1995).*

Literature review

It was clear that the electric vehicles are less preferred than the conventional cars after doing an estimation of the willingness to pay of representative sample if the consumers want to buy a car in Poland by using a discrete choice especially the electric vehicles (battery, hybrid and plug in hybrid vehicles). Moreover, the marginal willingness to pay for increasing the driving range, reductions in charging time, the availability of fast-mode charging stations, and the provision of policy incentives was studied. As a result a scenario with the slow-mode and availability of several levels of fast-mode charging stations and examination of the extent to which the heterogeneity of consumer preferences is driven by place of residence (urban, suburban, rural), intention to buy a new versus a used car, and the annual mileage was presented *(Ščasný, Zvěřinová and Czajkowski, 2019)*.

The current and future prospects of electric cars in Italy were calculated by using the, we total cost of ownership (TCO) model, which includes stochastic and non-stochastic variables, vehicle usage and contextual assumptions. It was found that electric cars are currently not cost-competitive in Italy with the conventional petrol or diesel cars. However, they are cost-competitive with the hybrid electric cars when more than 10,000 km are annually traveled. However, electric cars are expected to gain market share in the year 2025 if fuel prices follow past trends, even without subsidies. (*Danielis, Giansoldati and Rotaris, 2018)*.

The Swedish car market was studied in order to learn more on how the individual car buyer deliberates when considering buying a new automobile and if them. Have there been any substantial changes in preferences, especially in regard to car size, engine choice and the type of fuel (energy source) used to propel the vehicle? Around the individual consumer there are a number of stakeholders that have a vested interest in affecting the choice of the individual consumer. This study is taking place in the midst of the present debate on global warming and increased fuel prices, which enhances the interest from most parties and stakeholders to navigate in these turbulent times of changing consumer preferences and car-buying patterns.*(Sprei and Wickelgren, 2010)*.

Theoretical background

Hybrid Electric Vehicles (HEVs) are a cross between an electric car and an internal-combustion car. They combine the electric motor and battery of an electric car with a small internal-combustion engine. The electric motor receives power from the batteries which are charged by the internal-combustion engine batteries as needed. (Wouk, V (1997).

The main advantage an HEV provides is increased fuel efficiency. This leads to fewer emissions and fuel savings so they are great for our environment, in addition to the lack of noiseespecially when operating their electric motor typically at low speeds.*(Maxwellford.com, 2019)*

Actually there are disadvantage for the hybrid cars one of them that Servicing and maintenance charges can be higher because there are two engines and there is quite a bit of tech in those engines, maintenance costs can be higher. And they are not as powerful so, if the customer is more into performance and power than he/she is eco-friendliness then a hybrid isn't for him/her.*(Reşitoğlu, Altinişik and Keskin, 2015)*.

The electric car (also known as electric vehicle or EV) uses energy stored in its rechargeable batteries, which are recharged by common household electricity. Unlike a hybrid car which is fueled by gasoline and uses a battery and motor to improve efficiency an electric car is powered exclusively by electricity. The main advantages for the electric cars that they're easier on the environment, Electricity is cheaper than gasoline, Maintenance is less frequent and less expensive. But although of that there are some disadvantages like recharging can talk a while and Most EVs have pretty short ranges.*(Reşitoğlu, Altinişik and Keskin, 2015)*.

Conventional cars (diesel and gasoline) diesel engines and gasoline engines are quite similar. They are both internal combus-tion engines designed to convert the chemical energy available in fuel into mechanical energy. This mechanical energy moves pistons up and down inside cylinders. The pistons are connected to a crankshaft, and the up-and-down motion of the pistons, known as linear motion, creates the rotary motion needed to turn the wheels of a car forward. *(Reşitoğlu, Altinişik and Keskin, 2015)*.

Both diesel engines and gasoline engines convert fuel into energy through a series of small explosions or combustions. The major difference between diesel and gasoline is the way these explosions happen. In a gasoline engine, fuel is mixed with air, compressed by pistons and ignited by sparks from spark plugs. In a diesel engine, however, the air is compressed first, and then the fuel is injected. Because air heats up when it's compressed, the fuel ignites. *(Berman, 2019)*.

The advantages for the conventional cars are Better fuel economy, Lower taxes, better power and better speed, Greater torque. But it also have some disadvantages starting with it's not environment friendly since it's have high pollutions and Harmful emissions to the air, and need high maintenance.*(Berman, 2019)*.

Problem statement and objectives

Given that the car agencies companies in Palestine recently brought electric and hybrid cars to the market. And work to market them with diesel and gasoline cars.
There is no scientific research or feasibility study for these cars, whether economically or from an environmental point of view, so we in this project have carried out a study and comparison between electric, hybrid and conventional cars based on the total cost of ownership equation.

Our Objective

Investigate economic and environmental visibility of hybrid and electric cars that exists in the market in comparison to the fossil fuel cars using total cost of ownership equation.

Scope of work

In economic terms, we did life cycle cost $/km. all the prices that were taken in this report include customs, insurance and licensing of the car. The comparisons were made based on the purchase price that reached the consumer, not the manufacturing price, until the vehicle is disposed of and sold after six years. Actually, Two scenarios were taken, the first being the cash price, and the second the installment payments over a period of 6 years with the bank. The most economical cars have been judged by how much dollars they are spent per km.

It is worth noting that the total cost of ownership has been calculated on 10,000 km, 20,000 km and 30,000 km annually.

Environmentally, the comparison is based on the amount of carbon dioxide produced by cars during the operating time. Thus, the manufacturing process of cars or engines was not taken into consideration.

Methodology

In this research we have followed this steps, we initially identified the names of electric and hybrid cars that exist in Palestine, their types and manufacturers, then we listed the types of best-selling cars in Palestine and the most widespread and circulating in this region, where from each brand we took three categories of cars to be compared to each other, where we took an electric or hybrid car from every company, a traditional family-sized car, and a larger car.

At the second step, We visit the car companies and took the information of all cars and their prices as we took the price of the car in the market in cash and installment in the bank over a period of six years .as most of the customers deal through installments with the bank, the cost of comprehensive insurance, licenses, maintenance prices, and data sheets for each type As we took from it the car carbon dioxide (CO_2) production.

Then we unloaded the data collected on Excel and analyzed it, we estimated the total cost of ownership TCO per km. we calculate the TCO and dividing it by the annual kilometers traveled (AKT). Formally, the TCO model*(Danielis, Giansoldati and Rotaris, 2018)*can be written as follows:

$$\frac{TCO}{km} = \frac{(MSRP - RV * PVF) * CRF + \frac{1}{N}\sum_{n=1}^{N}\frac{AOC}{(1+i)^n}}{AKT}$$

Where the MSRP is the manufacturer's suggested retail price, RV is the resale value and we estimated it as 45% for 10,000 AKT, 40% for 20,000 AKT, 35% for 30,000 AKT, PVF is the present value factor, CRF is the capital recovery factor = (i$(1+i)^N)/((1+i)^N-1)$, AOC is the annual operating cost, i is the discount rate and we take it 10%, and N is the vehicle holding period of the first owner and we take it 6 years.

Finally, the relationships for the results have drawn to get the exact and final results. So the relation between TCO and the cars types in three scenarios10,000, 20,000 and 30,000 AKT were drawn, the relation between the carbon dioxide and cars types were drawn.

Results and discussion

We have started collecting data from car agencies located in the West Bank, starting with Nissan cars. We have taken the expected cost of annual maintenance on three possibilities.

The first is that the car walks 10,000 km annually; the second possibility is 20,000 km/year, and the last at 30,000 km/year.

We took two types of prices, the first prices are in Cash, and the second is in installments over six years, as shown in Tables 1 through 12.

We calculated the resale value after 6 years.

In addition to maintenance, we calculated the price of fuel needed to fill the tank, and then we took into consideration when calculating the total cost of ownership that the car is walking inside the country a number of kilometers different from the highways outside the country.

We found that the Pulsar car runs 10 km/litter on the internal roads and 12 km/litter on the external road outside the country.

The Qashqai car runs 9 km/litter on the internal roads and 10 km/litter on the external roads.

In order to be the comparison fair in all respects, we took the amount of carbon dioxide that the car produced.

Nissan cars

Table 1: Data for Nissan Cars at 10,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
leaf	150,000	42,148	18,960	2,290.75	0.95078	126
Pulsar	120,000	33,707	15,168	3,724.34	0.9498	119
Qashqai	160,000	44,943	20,224	4,082.19	1.17804	129

Table 2: Annual operation cost for Nissan Cars at 10,000 km/year Cash Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	Wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	80.23	111.94	513.21	33.7	0	0	1,086	210.6	0.0255
Pulsar	224.55	111.94	513.21	33.7	64.6	101.1	880.6	210.6	0.1583
Qashqai	224.55	111.94	513.21	33.7	64.6	101.1	1,358	210.6	0.1464

Table 3: Data for Nissan Cars at 20,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
leaf	150,000	42,148	16,853.9	3,117.82	0.53039	126
Pulsar	120,000	33,707	13483.1	6,154.51	0.60733	119
Qashqai	160,000	44,943	17,977.5	6,392.67	0.71191	129

Table 4: Annual operation cost for Nissan Cars at 20,000 km/year Cash Scenario.

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	140.5	204.45	898.8	67.4	0	0	1,086	210.6	0.0255
Pulsar	393.2	204.45	898.8	67.4	12.2	202.2	880.6	210.6	0.1583
Qashqai	393.2	204.45	898.8	67.4	129.2	202.2	1,358	210.6	0.1464

Table 5: Data for Nissan Cars at 30,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
leaf	150,000	42,148	14,747.1	3,979.87	0.39143	126
Pulsar	12,000	33,707	11,797.7	8,629.6	0.49467	119
Qashqai	16,000	44,943	15,730.3	8,748.05	0.56762	129

Table 6: Annual operation cost for Nissan Cars at 30,000 km/year Cash Scenario

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	209.4	280.9	1,326.8	101.1	0	0	1,086	210.6	0.0255
Pulsar	580.53	280.9	1,326.8	101.1	129.2	303.3	880.6	210.6	0.1583
Qashqai	580.53	280.9	1,326.8	101.1	129.2	303.3	1,358	210.6	0.1464

Table 7: Data for Nissan Cars at 10,000 km annuallyinstallmentPayment Scenario

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Leaf	178,800	50,224	22,601	2,460.09	1.10628	126
Pulsar	143,024	40,175	18,078	3,837.54	1.07189	119
Qashqai	190,720	53,573	24,107	3,952.14	1.31283	129

Table 8: Annual operation cost for Nissan Cars at 10,000 km/year installment Payment Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	80.23	111.94	513.21	33.7	0	0	1,255.3	210.6	0.0255
Pulsar	224.55	111.94	513.21	33.7	64.6	101.1	993.8	210.6	0.1583
Qashqai	224.55	111.94	513.21	33.7	64.6	101.1	1,228.1	210.6	0.1464

Table 9: Data for Nissan Cars at 20,000 km annuallyinstallmentPayment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
leaf	178,800	50,224	20,089	3,287.16	0.61077	126
Pulsar	143,024	40,175	16,070	6,267.71	0.67047	119
Qashqai	190,720	53,573	21,429	6,262.62	0.78930	129

Table 10: Annual operation cost for Nissan Cars at 20,000 km/year installment Payment Scenario

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	140.5	204.45	898.8	67.4	0	0	1,255	210.6	0.0255
Pulsar	393.2	204.45	898.8	67.4	12.2	202.2	993.8	210.6	0.1583
Qashqai	393.2	204.45	898.8	67.4	129.2	202.2	1,228	210.6	0.1464

Table 11: Data for Nissan Cars at 30,000 km annuallyinstallmentPayment Scenario

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Leaf	178,800	50,224	17,578	4,148.2	0.44676	126
Pulsar	143,024	40,175	14,061	8,742.8	0.53816	119
Qashqai	190,720	53,573	18,750	8,618	0.61629	129

Table 12: Annual operation cost for Nissan Cars at 30,000 km/yearinstallmentPayment Scenario.

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
leaf	209.4	280.9	1,326.8	101.1	0	0	1,255.34	210.6	0.0255
Pulsar	580.53	280.9	1,326.8	101.1	129.2	303.3	993.8	210.6	0.1583
Qashqai	580.53	280.9	1,326.8	101.1	129.2	303.3	1,228.1	210.6	0.1464

Renaults cars

The second company is Renaults cars, we collected the same data as Nissan company at 10,000, 20,000, 30,000 km annually, with Cash and payment with the bank for six years scenario.
Sandero Dacia runs 12 km/ litter inside the country and 16 km/litter on the high ways but Clio runs 10/litter, 14 km/ litter inside and outside the country(EV Database, 2019).

Table 13: Data for Renaults Cars at 10,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	120,000	33,707	15,168	1,970.35	0.7744	121
Sandero dacia	70,000	19,662	8,848	3,124.37	0.64923	116
Clio	100,000	28,089	12,640	3,516.8	0.83821	120

Table 14: Annual operation cost for Renaults Cars at 10,000 km/year Cash Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
ZOE	80.23	111.94	513.21	33.7	0	0	880.6	210.6	0.01400
Sandero dacia	224.55	111.94	513.21	33.7	64.6	101.1	606.7	210.6	0.12578
Clio	224.55	111.94	513.21	33.7	64.6	101.1	782.3	210.6	0.14741

Table15: Data for Renaults Cars at 20,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	120,000	33,707	13,483	2,682.4	0.4337	121
Sandero dacia	70,000	19,662	7,865	5,228.4	0.43619	116
Clio	100,000	28,089	11,235	5,837.7	0.54156	120

Table 15: Annual operation cost for Renaults Cars at 20,000 km/year Cash Scenario.

	AOC /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
ZOE	140.5	204.45	898.8	67.4	0	0	880.6	210.6	0.01400
Sandero dacia	393.2	204.45	898.8	67.4	12.2	202.2	606.74	210.6	0.12578
Clio	393.2	204.45	898.8	67.4	129.2	202.2	782.3	210.6	0.147471

Table17: Data for Renaults Cars at 30,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	120,000	33,707	11,797	3,429.4	0.32133	121
Sandero dacia	70,000	19,662	6,882	7,377.4	0.36667	116
Clio	100,000	28,089	9,831	8,203.5	0.44597	120

Table 16: Annual operation cost for Renaults Cars at 30,000 km/year Cash Scenario.

	AOC /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
ZOE	209.4	280.9	1,326.8	101.1	0	0	880.6	210.6	0.014
Sandero dacia	580.53	280.9	1,326.8	101.1	129.2	303.3	606.74	210.6	0.12578
Clio	580.53	280.9	1,326.8	101.1	129.2	303.3	782.3	210.6	0.14747

Table 17: Data for Renaults Cars at 10,000 km annually installmentpayment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	140,800	41,797	18,808	2,181	0.9341	121
Sandero dacia	86,800	24,382	10,971	3,269	1.1445	116
Clio	124,000	34,831	15,674	3,704	1.12701	120

Table 18: Annual operation cost for Renaults Cars at 10,000 km/year installment payment Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
ZOE	80.23	111.94	513.21	33.7	0	0	1,091	210.6	0.014
Sandero dacia	224.55	111.94	513.21	33.7	64.6	101.1	752.3	210.6	0.12578
Clio	224.55	111.94	513.21	33.7	64.6	101.1	970	210.6	0.14747

Table 19: Data for Renaults Cars at 20,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	140,800	41,797	16,719	2,893.7	0.5162	121
Sandero dacia	86,800	24,382	9,752	5,374	0.6855	116
Clio	124,000	34,831	13,932	6,025	0.69084	120

Table 20: Annual operation cost for Renaults Cars at 20,000 km/year installment payment Scenario.

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
ZOE	140.5	204.45	898.8	67.4	0	0	1,091	210.6	0.01400
Sandero dacia	393.2	204.45	898.8	67.4	12.2	202.2	752	210.6	0.12578
Clio	393.2	204.45	898.8	67.4	129.2	202.2	970	210.6	0.14747

Table 21: Data for Renaults Cars at 30,000 km annually installmentpayment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
ZOE	140,800	41,797	14,629	3,640	0.3780	121
Sandero dacia	86,800	24,382	8,533	7,523	0.5338	116
Clio	124,000	34,831	12,191	8,391	0.5469	120

Table 22: Annual operation cost for Renaults Cars at 30,000 km/year installment payment Scenario.

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	License	fuel consumption ($/km)
ZOE	209.4	280.9	1,326.8	101.1	0	0	1,091	210.6	0.01400
Sandero dacia	580.53	280.9	1,326.8	101.1	129.2	303.3	752	210.6	0.12578
Clio	580.53	280.9	1,326.8	101.1	129.2	303.3	970.052	210.6	0.14747

Peugeot Citroens

We collected the same data as Nissan company at 10,000, 20,000, 30,000 km annually, with Cash and installment payment with the bank over 6 years scenario.

Partner runs 14 km/litter inside the country and 16 km/litter on the high ways but Peugeot 3008 runs 10/litter, 13 km/litter inside and outside the country.

Table 23: Data for Peugeot Citroen Cars at 10,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	116,000	32,584	14,662	2,291	0.99882	165.7
Partner	93,000	26,123	11,755	3,023	1.1096	181
Peugeot 3008	159,000	44,662	20,098	3,408	1.0401	121

Table 24: Annual operation cost for Peugeot Citroen Cars at 10,000 km/year Cash Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	License	fuel consumption ($/km)
Partner tepee	80.23	111.94	513.21	33.7	0	0	1,039.3	210.6	0.03025
Partner	224.55	111.94	513.21	33.7	64.6	101.1	833.7	210.6	0.09300
Peugeot 3008	224.55	111.94	513.21	33.7	64.6	101.1	1,179.7	210.6	0.03025

Table 25: Data for Peugeot Citroen Cars at 20,000 km annually Cash Scenario

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	116,000	32,584	13,033	3,166	0.5537	165.7
Partner	93,000	26,123	10,449	4,799	0.6521	181
Peugeot 3008	159,000	44,662	17,865	5,224	0.6253	121

Table 26: Annual operation cost for Peugeot Citroen Cars at 20,000 km/year Cash Scenario

	AOC /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Partner tepee	140.5	204.45	898.8	67.4	0	0	1,039.3	210.6	0.03025
Partner	393.2	204.45	898.8	67.4	12.2	202.2	833.7	210.6	0.09300
Peugeot 3008	393.2	204.45	898.8	67.4	129.2	202.2	1,179.7	210.6	0.03025

Table 27: Data for Peugeot Citroen Cars at 30,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	116,000	32,584	11,404	4,075	0.40649	165.7
Partner	93,000	26,123	9,143	6,620	0.5011	181
Peugeot 3008	159,000	44,662	15,632	7,084	0.48853	121

Table 28: Annual operation cost for Peugeot Citroen Cars at 30,000 km/year Cash Scenario.

	AOC /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Partner tepee	209.4	280.9	1,326.8	101.1	0	0	1,039.3	210.6	0.03025
Partner	580.53	280.9	1,326.8	101.1	129.2	303.3	833.7	210.6	0.09300
Peugeot 3008	580.53	280.9	1,326.8	101.1	129.2	303.3	1,179.7	210.6	0.03025

Table 29: Data for Peugeot Citroen Cars at 10,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	139,000	39,044	17,570	2,516	0.9836	165.7
Partner	114,000	32,022	14,410	3,223	1.1368	181
Peugeot 3008	166,000	46,629	20,983	3,689	1.0567	121

Table 30: Annual operation cost for Peugeot Citroen Cars at 10,000 km/year installmentpayment Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Partner tepee	80.23	111.94	513.21	33.7	0	0	1,264	210.6	0.98361
Partner	224.55	111.94	513.21	33.7	64.6	101.1	1,033	210.6	1.1368
Peugeot 3008	224.55	111.94	513.21	33.7	64.6	101.1	1,460	210.6	1.05673

Table 31: Data for Peugeot Citroen Cars at 20,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	139,000	39,044	15,617	3,390	0.54819	165.7
Partner	114,000	32,022	12,808	4,999	0.65721	181
Peugeot 3008	166,000	46,629	18,651	5,505	0.63425	121

Table 32: Annual operation cost for Peugeot Citroen Cars at 20,000 km/year installmentpayment Scenario.

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Partner tepee	140.5	204.45	898.8	67.4	0	0	1,264	210.6	0.03025
Partner	393.2	204.45	898.8	67.4	12.2	202.2	1,033	210.6	0.09300
Peugeot 3008	393.2	204.45	898.8	67.4	129.2	202.2	1,460	210.6	0.03025

Table 33: Data for Peugeot Citroen Cars at 30,000 km annuallyinstallment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Partner tepee	139,000	39,044	13,665	4,300	0.40421	165.7
Partner	114,000	32,022	11,207	6,820	0.49885	181
Peugeot 3008	166,000	46,629	16,320	7,365	0.49492	121

Table 34: Annual operation cost for Peugeot Citroen Cars at 30,000 km/yearinstallment payment Scenario.

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Partner tepee	209.4	280.9	1,326.8	101.1	0	0	1,264	210.6	0.03025
Partner	580.53	280.9	1,326.8	101.1	129.2	303.3	1,033	210.6	0.09300
Peugeot 3008	580.53	280.9	1,326.8	101.1	129.2	303.3	1,460	210.6	0.03025

Hyundai

Elantra runs 8 km/litter, 10 km/litter and Tosan runs 8km/litter inside the country and 11 km/litter outside the country.

Table 35: Data for Hyundai Cars at 10,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	126,000	35,393	15,926	2,982	1.0515	85
Elantra	120,000	33,707	15,168	4,158	1.1789	190
Tosan	172,00	48,314	21,741	4,341	1.1120	151

Table 36: Annual operation cost for Hyundai Cars at 10,000 km/year Cash Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Ionic Hybrid	80.23	111.94	513.21	33.7	64.6	101.1	983.1	210.6	0.07398
Elantra	224.55	111.94	513.21	33.7	64.6	101.1	955	210.6	0.19439
Tosan	224.55	111.94	513.21	33.7	64.6	101.1	1,221	210.6	0.18594

Table 37: Data for Hyundai Cars at 20,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	126,000	35,393	14,157	4,568	0.6165	85
Elantra	120,000	33,707	13,483	6,948	0.7399	190
Tosan	172,00	48,314	19,325	7,046	0.7046	151

Table 38: Annual operation cost for Hyundai Cars at 20,000 km/year Cash Scenario.

	AOC /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Ionic Hybrid	140.5	204.45	898.8	67.4	129.2	202.2	983.1	210.6	0.07398
Elantra	393.2	204.45	898.8	67.4	129.2	202.2	955	210.6	0.19439
Tosan	393.2	204.45	898.8	67.4	129.2	202.2	1,221	210.6	0.18594

Table 39: Data for Hyundai Cars at 30,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	126,000	35,393	12,387	6,199	0.473049	85
Elantra	120,000	33,707	11,797	9,784	0.595067	190
Tosan	172,00	48,314	16,910	9,797	0.573424	151

Table 40: Annual operation cost for Hyundai Cars at 30,000 km/year Cash Scenario.

	AOC /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Ionic Hybrid	209.4	280.9	1,326.8	101.1	129.2	303.3	983.1	210.6	0.07398
Elantra	580.53	280.9	1,326.8	101.1	129.2	303.3	955	210.6	0.19439
Tosan	580.53	280.9	1,326.8	101.1	129.2	303.3	1,221	210.6	0.18594

Table 41: Data for Hyundai Cars at 10,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	148,000	41,573	18,707	3,095	1,095.5	85
Elantra	148,000	41,573	18,707	4,299	1,095.5	190
Tosan	194,000	54,494	24,522	4,433	1,314.6	151

Table 42: Annual operation cost for Hyundai Cars at 10,000 km/year installmentpayment Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	License	fuel consumption ($/km)
Ionic Hybrid	80.23	111.94	513.21	33.7	64.6	101.1	1,095.5	210.6	0.07398
Elantra	224.55	111.94	513.21	33.7	64.6	101.1	1,095.5	210.6	0.19439
Tosan	224.55	111.94	513.21	33.7	64.6	101.1	1,314.6	210.6	0.18594

Table 43: Data for Hyundai Cars at 20,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	148,000	41,573	16,629	4681	0.60615	85
Elantra	148,000	41,573	16,629	7,089	0.72656	190
Tosan	194,000	54,494	21,797	7,139	0.68618	151

Table 44: Annual operation cost for Hyundai Cars at 20,000 km/year installment payment Scenario.

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Ionic Hybrid	140.5	204.45	898.8	67.4	129.2	202.2	1,095.5	210.6	0.07398
Elantra	393.2	204.45	898.8	67.4	129.2	202.2	1,095.5	210.6	0.19439
Tosan	393.2	204.45	898.8	67.4	129.2	202.2	1,314.6	210.6	0.18594

Table 45: Data for Hyundai Cars at 30,000 km annually installment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Ionic Hybrid	148,000	41,573	14,550	6,312	0.46745	85
Elantra	148,000	41,573	14,550	9,924	0.58785	190
Tosan	194,000	54,494	19,073	9,890	0.56716	151

Table 46: Annual operation cost for Hyundai Cars at 30,000 km/year installmentpayment Scenario.

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Ionic Hybrid	209.4	280.9	1,326.8	101.1	129.2	303.3	1,095.5	210.6	0.07398
Elantra	580.53	280.9	1,326.8	101.1	129.2	303.3	1,095.5	210.6	0.19439
Tosan	580.53	280.9	1,326.8	101.1	129.2	303.3	1,314.6	210.6	0.18594

Volkswagen

Polo runs 10 km/litter inside the country, 15 km/litter on the highway outside the country while Golf runs 8km/litter inside the country and 9 km/litter outside, Seat Ateca runs 9 km/litter inside and 15 km/ litter outside.

Table 47:Data for Volkswagen at 10,000 km annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	97,000	27,247	12,261	3,181	1.1189	104
Golf	138,000	38,764	17,443	3,594	1.0931	116
Seat Ateca	159,000	44,662	20,098	3,825	1.0818	126

Table 48: Annual operation cost for Volkswagen Cars at 10,000 km/year Cash Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	150.7	111.9	358.1	50.5	58.9	75.8	739.3	210.6	0.14255
Golf	150.7	174.6	403.7	36.5	64.6	84.2	969.1	210.6	0.15005
Seat Ateca	176.4	137.6	513.2	58.9	66.0	89.2	1,072	210.6	0.15005

Table 49: Data for Volkswagen at 20,000 km annually Cash Scenario

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	97,000	27,247	10,898	5,539	0.6861	104
Golf	138,000	38,764	15,505	6,033	0.6810	116
Seat Ateca	159,000	44,662	17,865	6,173	0.6727	126

Table 50: Annual operation cost for Volkswagen Cars at 20,000 km/year Cash Scenario

	AOC /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	264.0	204.45	898.8	101.1	117.9	151.6	739.3	210.6	0.14255
Golf	264.0	318.9	898.8	73.0	129.2	168.5	969.1	210.6	0.15005
Seat Ateca	308.9	251.4	898.8	117.9	132.0	179.7	1,072	210.6	0.15005

Table 51: Data for Volkswagen at 30,000 km Annually Cash Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	97,000	27,247	9,536	7,780	0.53805	104
Golf	138,000	38,764	13,567	8,392	0.54104	116
Seat Ateca	159,000	44,662	15,632	8,558	0.53736	126

Table 52: Annual operation cost for Volkswagen Cars at 30,000 km/year Cash Scenario.

	AOC /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	389.7	280.8	1,326.9	151.6	176.9	227.5	739.3	210.6	0.14255
Golf	389.7	438.2	1,326.9	109.5	193.8	252.8	969.1	210.6	0.15005
Seat Ateca	456.1	345.5	1,326.9	176.9	198.0	269.6	1,072	210.6	0.15005

Table 53: Data for Volkswagen Cars at 10,000 km annually insallment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	120,280	33,786	15,203	3,209	1.0836	104
Golf	171,120	48,067	21,630	3,633	1.0427	116
Seat Ateca	197,160	55,382	24,921	3,868	1.2356	126

Table 54: Annual operation cost for VolkswagenCars at 10,000 km/year insallmentpayment Scenario.

	AOC /10,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	150.7	111.9	358.1	50.5	58.9	75.8	767.4	210.6	0.14255
Golf	150.7	174.6	403.7	36.5	64.6	84.2	1007.8	210.6	0.15005
Seat Ateca	176.4	137.6	513.2	58.9	66.0	89.2	1115.1	210.6	0.15005

Table 55: Data for Volkswagen Cars at 20,000 km Annually insallmentpayment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	120,280	33,786	13,514	5,567	0.67064	104
Golf	171,120	48,067	19,226	6,072	0.65887	116
Seat Ateca	197,160	55,382	22,152	6,216	0.64710	126

Table 56: Annual operation cost for Volkswagen Cars at 20,000 km/year insallmentpayment Scenario.

	AOC $ /20,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	264.0	204.45	898.8	101.1	117.9	151.6	767.4	210.6	0.14255
Golf	264.0	318.9	898.8	73.0	129.2	168.5	1007.8	210.6	0.15005
Seat Ateca	308.9	251.4	898.8	117.9	132.0	179.7	1115.1	210.6	0.15005

Table 57: Data for Volkswagen Cars at 30,000 km annuallyinsallment payment Scenario.

	MSRP (NIS)	MSRP($)	RV	AOC Total	TCO/km	CO2 (gm/km)
Polo	120,280	33,786	11,825	7,808	0.52909	104
Golf	171,120	48,067	16,823	8,431	0.52826	116
Seat Ateca	197,160	55,382	19,383	8,600	0.52285	126

Table 58: Annual operation cost for Volov Wagen Cars at 30,000 km/year insallment payment Scenario.

	AOC $ /30,000 km annually								
	Brakes	Drums	wheels	HVAC filter	Air filter	Oil+Oil Filter	Insurance	license	fuel consumption ($/km)
Polo	389.7	280.8	1,326.9	151.6	176.9	227.5	767.4	210.6	0.14255
Golf	389.7	438.2	1,326.9	109.5	193.8	252.8	1007.8	210.6	0.15005
Seat Ateca	456.1	345.5	1,326.9	176.9	198.0	269.6	1115.1	210.6	0.15005

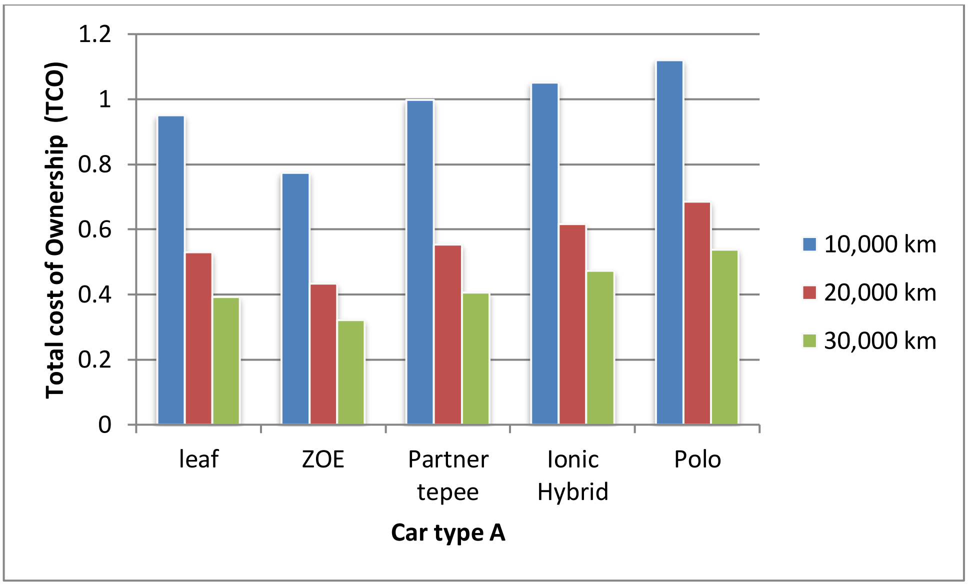

Figure 1The relationship between car type and total cost of ownership at different Scenarios type A At Cash Scenario.

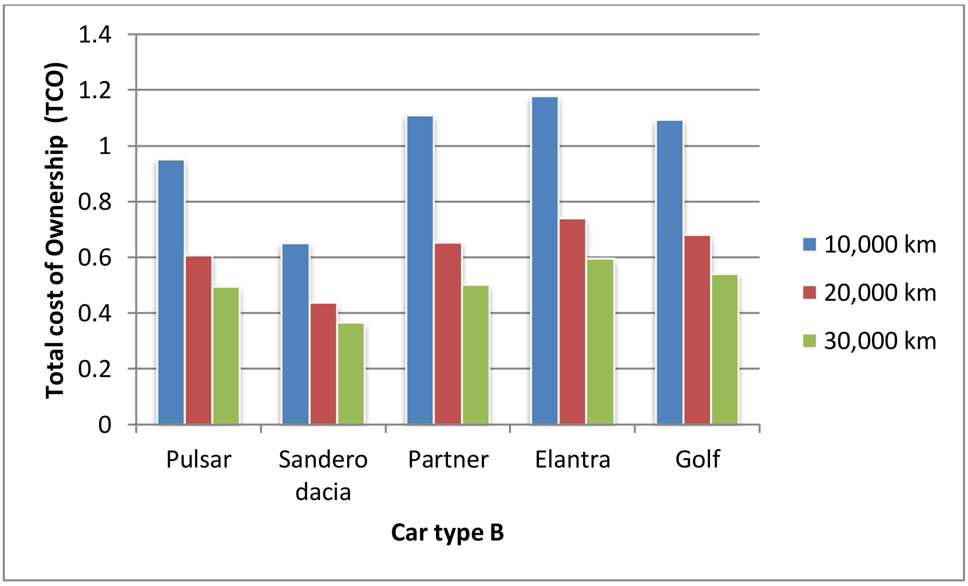

Figure 2: The relationship between car type and total cost of ownership at different Scenarios type B At Cash Scenario.

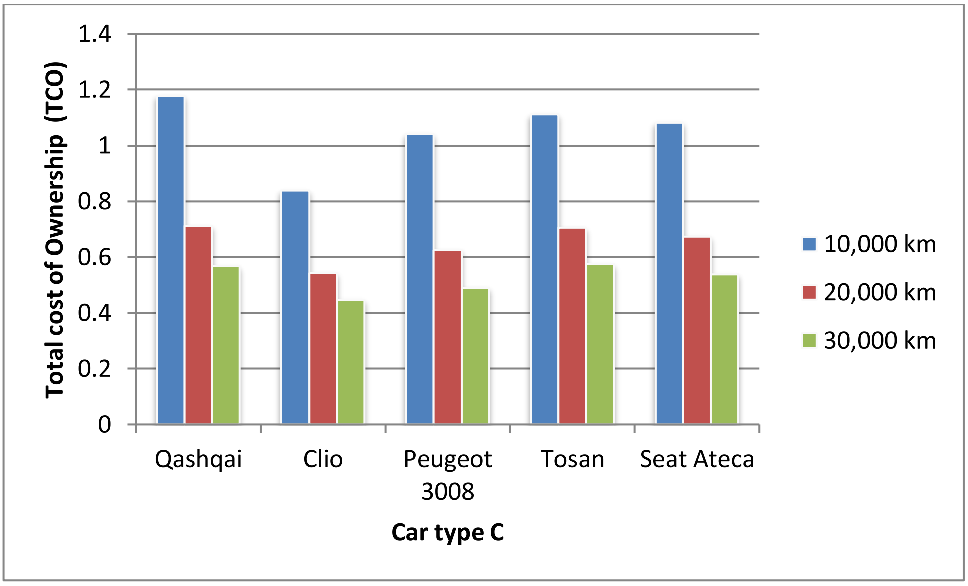

Figure 3: The relationship between car type and total cost of ownership at different Scenarios type C At Cash Scenario.

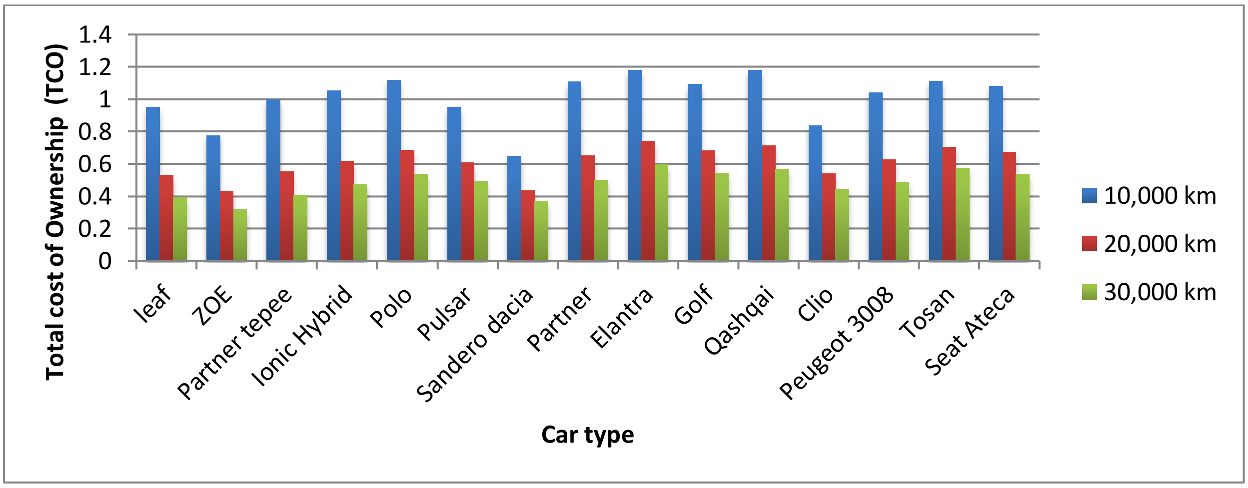

Figure 4: The relationship between All cars type and total cost of ownership at different Scenarios with Cash Prices

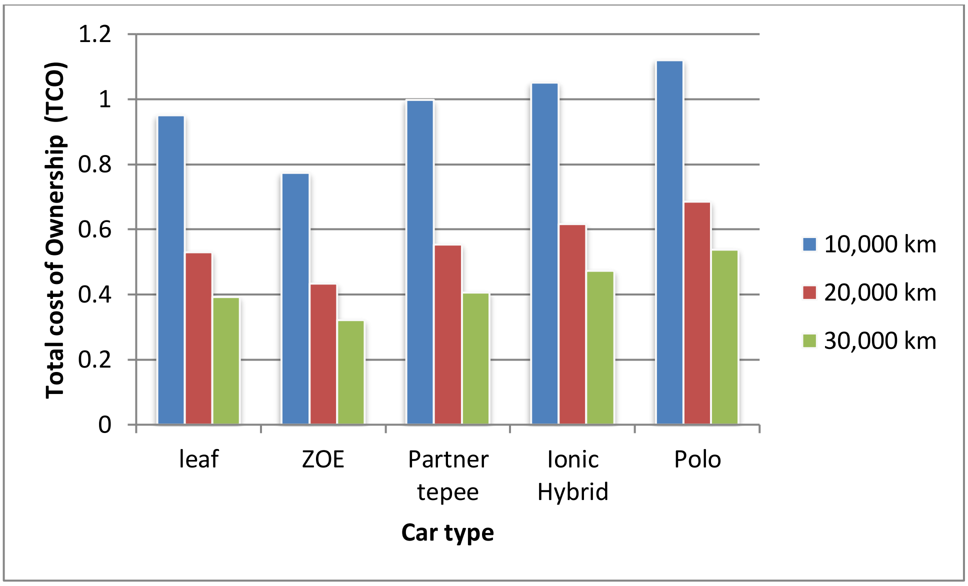

Figure 3: The relationship between car type and total cost of ownership at different Scenarios type an installment payment with the bank.

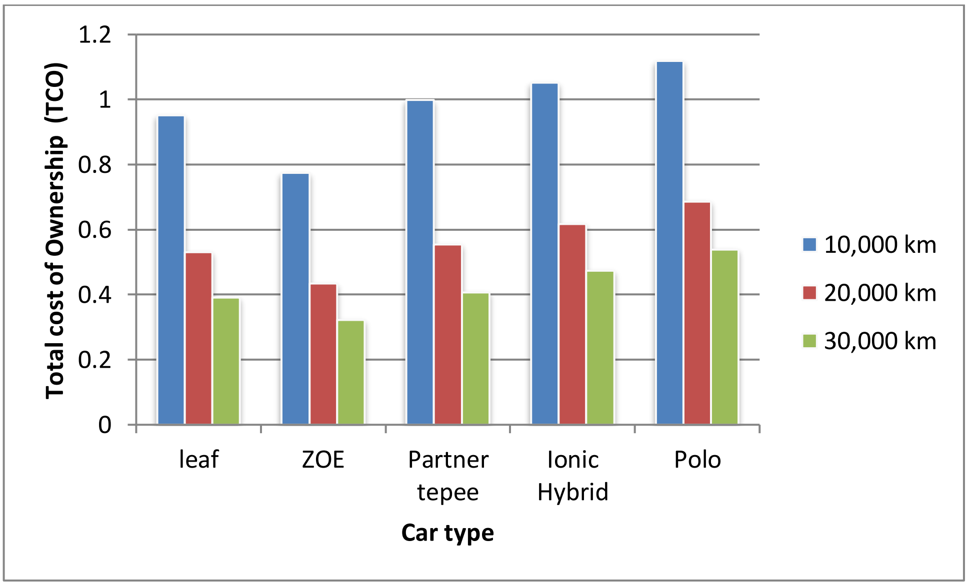

Figure 4: The relationship between car type and total cost of ownership at different Scenarios type B installment payment with the bank.

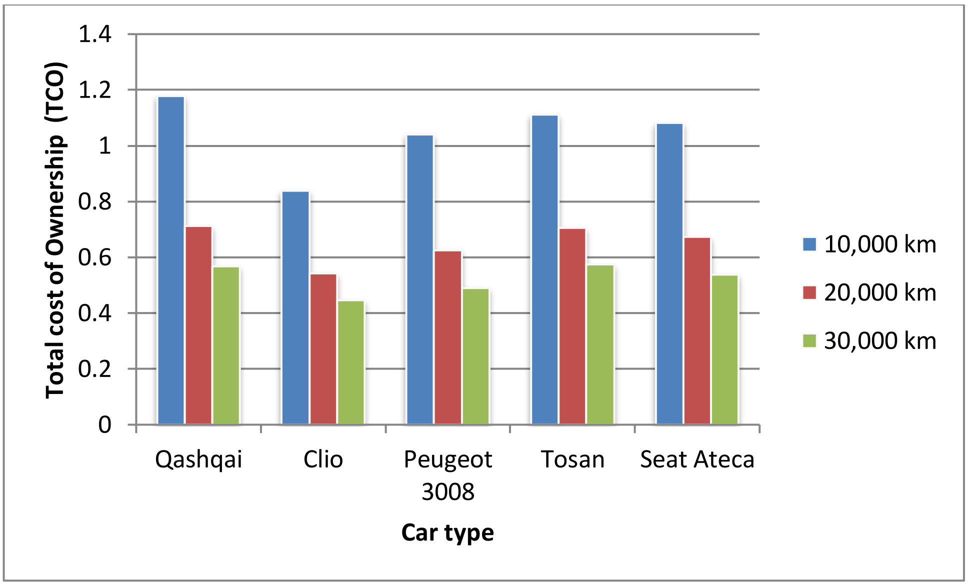

Figure 5: The relationship between car type and total cost of ownership at different Scenarios type C installment payment with the bank.

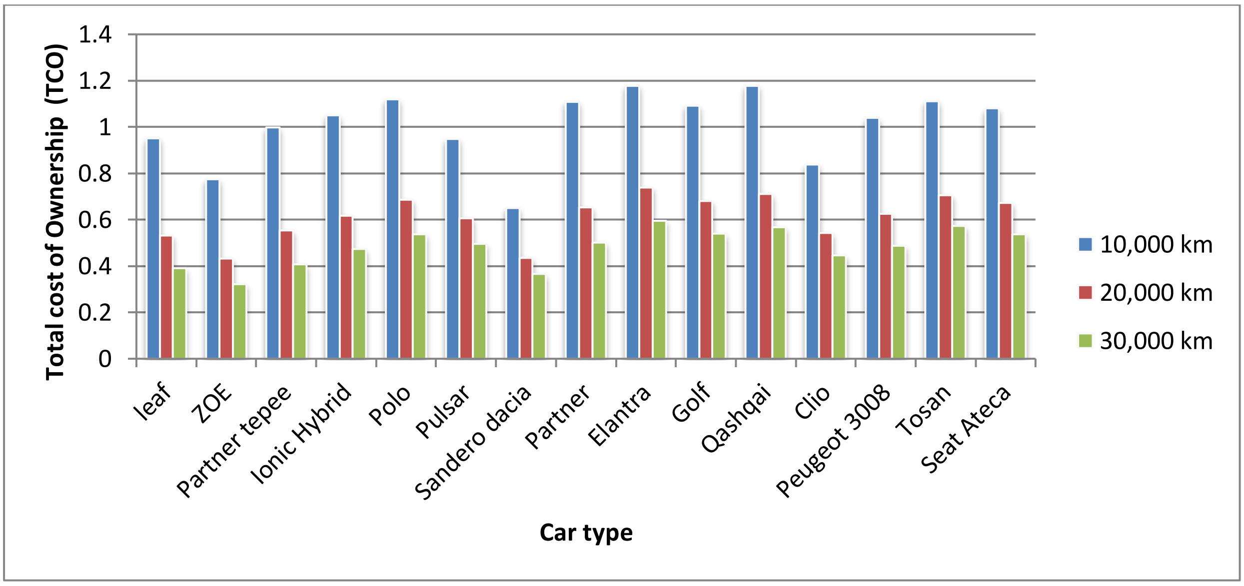

Figure 6: The relationship between All cars type and total cost of ownership at different Scenarios installment payment with the bank .

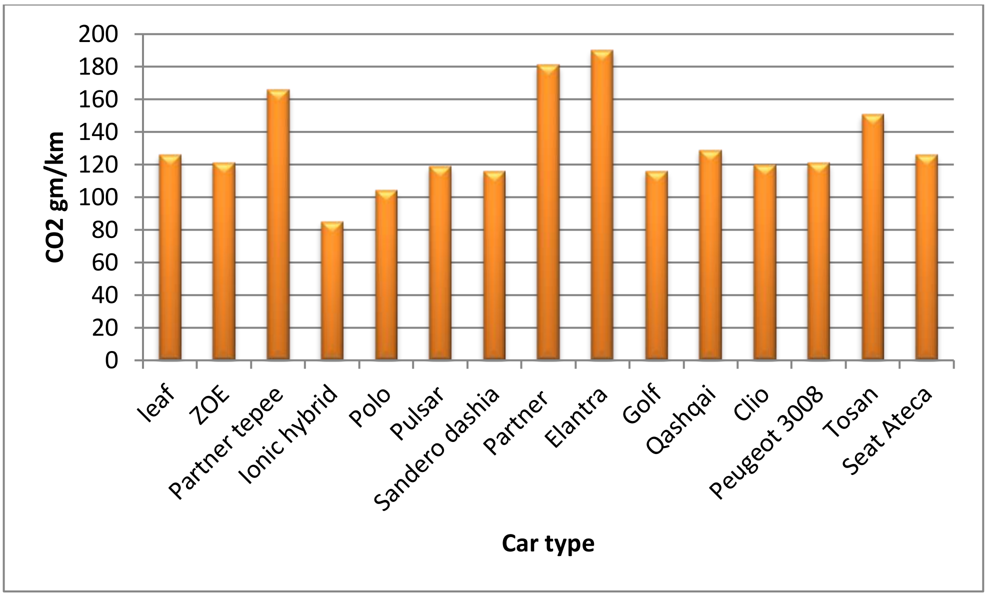

Figure 7: The relationship between car type and the CO_2 released.

Main discussion

Type A consists of leaf,Zoe, Partner tepee, polo and Ionic hybrid cars.
Type B consists of Pulsar, Sandero Dacia, Partner, Elantra and Golf cars.
Type C consists of Qashqai,Clio, Peugeot 3008, Tosan and Seat Ateca cars.

1- As shown in figure 1 the highest TCO from the cars type A is for **Polo** car at the 10,000 km scenario with TCO equal 1.12, 0.68 and 0.54, but the highest one between the electric and hybrid is **Ionic hybrid** with TCO equal 1.08, 0.62 and 0.467. Thelowest one is for **ZOE** which is also the lowest one at three scenarios in compression with electric and hybrid cars and the TCO equal 0.77, 0.434 and 0.32.

2- As shown in figure 2 which for cars type B, the highest TCO is for the **Elantra** at three scenarios with TCO equal 1.22, 0.75 and 0.595. The lowest one is for **Sandero Dacia** also at three scenarios and with TCO equal 0.649, 0.436 and 0.3667. .

3- As shown in figure 3 which is for cars type C, the highest TCO is for the **Qashqai** car at three scenarios with TCO equal 1.178, 0.719 and 0.567. The lowest one is for **Clio** at three scenarios with TCO equal 0.833, 0.542 and 0.446.

4- Figure 4 show the compression between the all cars types. As we shown the **Elantra** car is have the highest TCOat three scenarios which equal 1.223, 0.751 and 0.595. The lowest at 10,000 km is **Sandero Dacia** with TCO=0.649, at 20,000km is **Sandero Dacia** with TCO= 0.436 but it competitive with the electric **ZOE** with TCO= 0.434, and at 30,000km is **ZOE** with TCO= 0.321. As shown in this figure the electric and hybrid cars are competitive at annual distance travels large than 10,000 km.

5- In figure 5,6,7,8 are show us the relations between the TCO and the cars types but in payment with the bank not in cash. The results in these figures it as the results in figures 1,2,3,4 but the TCO is greater at each state.

6- Figure 9 show the relation between the cars types and the carbon dioxide CO_2emissions. As we shown the best cars in the environment view and have the lowest amount of emissions is **Ionic hybrid** with 85 gm/km and the highest one is **Elantra** car with 190gm/km. that’s mean that the electric and hybrid cars it's not the best cars for the environment in this situation but if we use the renewable energy or less polluting fuel for the environment than fossil fuel to generate the electricity it will be the best.

7- As shown in the previous results the TCO is decreased for all cars types when the annual kilometers travels are increased.

Conclusion

We have two main conclusions in this research, from economical view and the environmental one.
Economically, electric and hybrid cars are more feasible than conventional cars, but for people who use them less than 10,000 km/year are not economically feasible so the conventional cars is better for them.

For the environmental aspect, if the cars are taking electricity from the electricity generated in Israel that depends on fossil fuels especially coal, they are looking for more emissions than modern gasoline cars, so a national plan must be done. This problem will be decrease in future because electricity generation will changed from the fossil fuel to natural gas.

Recommendation

- It is very necessary to be in the awareness of people economically, provided that he does not use these cars except those who walk more than 10,000 a year and external roads.
- Environmental sector is very necessary to have integrated plans from the Energy Authority so that it supports renewable energy for the automotive sector, as it must be in coordination between the Energy Authority and the Ministry of Transportation and that cooperation between them is made as part of the renewable energy sector covers the automotive sector. For example, operate a battery charging station or charge the electrical cars by renewable energy.
- The recommendations of the Ministry of transportation should establish a condition whereby each one buys an electric car in return for which there is a renewable energy system in the region of approximately five kilowatts
- Every person who buys an electric car takes a discount and facilities, for example, on customs, taxes, shipping and parking.
- Place points for charging electric cars at fuel stations

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