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An Integrated Approach That Combines EV Operation with a Conceptual Design for Taxi Services

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Abstract: The implementation of a sustainable transportation environment through EV utilization, however, requires the addressing of certain cost and environmental concerns such as limited driving range and battery-charging issues before its full potential can be realized. Nevertheless, the use of a specific type of EVs in the taxi services, will elicit positive public opinion, as it promises a commitment toward sustainability in urban life. In light of this, this study proposes an integrated approach that combines EV operation with a conceptual design for taxi services. As some productivity loss may be naturally expected due to the time spent in charging, it is important to look at whether such performance loss from the passenger and system standpoints can be offset with ingenuity in operational design. In this study, an EV taxi charge-replenishing scheme that can be coupled with a real-time taxi-dispatch algorithm is designed. The proposed EV charging schemes for taxi services are studied via simulations and the effects of the limited driving range and battery-charging details are examined from a system performance viewpoint. The simulation study also reveals illustrative results on the impact of the EV taxi fleet's operation on the charging system. In addition, the importance of projected charging demands and queue delays at different charging locations are also addressed. Some limitations and a future research agenda are also discussed. Finally, Mathematical Modelling of computing the car travel distance per full charge for each Tesla model S type. The results of this model will help estimating the cost per distance travelled.

Key words: Electric Vehicles · Vehicle battery · Charging cost · Tesla EV · Travel distance per charge

INTRODUCTION

Electro-mobility offers an unequalled solution to make Dubai’s transport more efficient and less polluting. The electrification of transport is needed to realize the Dubai Carbon Abatement Strategy, which aims to reduce the carbon emissions by 16% by 2021. The Supreme Council of Energy (DSCE) issued the Directive number 1 of 2016 to set a target for the government. Therefore, at least 10% of all newly-purchased cars will be electric or hybrid from 2016 to 2020. The proportion of electric and hybrid cars will rise to 2% by 2020 and 10% by 2030 [1].

Dubai Taxi Corporation (DTC) is thepioneer in hybrid technology in Dubai since 2009 and now is seeking to lead the electric vehicles revolution. The challenges of operating the electric vehicle as taxi are vary and this research study was key to solve these challenges toward a new success story. The followings goals had been achieved:

- Conduct a benchmarking analysis between the models of electric vehicles in order to understand the features of each technology features and disadvantages.
- Study the operating system of battery and the mechanism of charging and management of high efficiency and the factors that affect the battery life.
- Develop a model capable of calculating the estimated distance that a vehicle can travel by a set of variables to serve the operations.
- Calculate the cost of charging based on different units in order to estimate the operation cost.

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Literature Review

Electric Vehicles: A vehicle's inlfuence on the environment depends on its source of energy [3]. Land vehicles heavily depend on oil, potentially driving a shortage of crude oil in the foreseeable future [2]. The energy uses for transport have expanded, leading to problems in energy security and environmental sustainability [4]. As a result, people are looking for solutions for several different problems and consider the EV to be one of the most optimized alternatives [5]. Though EVs still face technological and economic barriers [5], they can reduce dependency on fossil fuel and create opportunities to decrease greenhouse gas emissions from the transportation sector [6]. Furthermore, the running cost for EVs is projected to drop by approximately 75% by 2030 [7]. Other significant strengths of EVs compared with internal combustion engine vehicles have also been studied by researchers [6]. EVs have been introduced into the public market and are expected to contribute to the mitigation of traditional fuel consumption [4] with the help of a variety of political supports [5-7].

Electric Vehicle Taxis: To fulfill public needs, various countries have adopted EVs as taxis in local provinces [8]. Compared to the US and the EU, East Asian countries have more actively introduced and expanded the use of EVs due to sustainability issues such as the Fukushima accident, environmental pollution and over dependency on fossil fuel. The Chinese government is executing one of the most active and aggressive action plans, with major subsidies and regulations to adopt EV taxis and expand their use. In particular, the Chinese government is strongly encouraging local governments to buy local brand EVs [9], which are mostly produced by BYD [10].

Electro-mobility offers an unequalled solution to make UAE's transport more efficient and less polluting. But the market for electric vehicles (EVs - both battery and plug-in hybrids) has had several false dawns. In this research study, many topics regarding the EV will be introduced and EV Future Models, Performance of Vehicle Battery Systems and many other topics. Performance of Vehicle Battery Systems will be discussed as well as Charging Methods. Focusing on Tesla EV, Tesla battery charging and Charging a Tesla Model S will be introduced.

EV Future Models: In 2016, there are 34 EV models on the European market across the main car segments (Element Energy 2016). However, recent developments in battery prices and performance have generated a flood of new company plans and announcements over the past year. Some of the most notable developments are outlined below.

- Volkswagen, In June 2016 VW group unveiled details of its Strategy 2025 business plan for the Audi, Porsche, SEAT, Skoda and Volkswagen brands. The plan includes announcements of over 30 new electric models expected to launch by 2025, with these new 'e-vehicles' using more efficient battery technology to allow greater all-electric range than in the brand's current offerings.
- Audi has also announced ambitious plans to have three electric car models on sale by 2020 and for electric vehicles to account for 25 to 30% of all its car sales by 2025,
- Tesla a relative newcomer to the car market and tiny in global terms (50,000 cars sold in 2016, Volt - also sold as the Ampera in Europe. From 2017, however, it will be launching the Bolt as an all- electric five-door hatchback. With a range rated at 238 km by the EPA (equivalent to at least 400km in EU tests),
- Nissan has announced a 200-km (up to 400km) option for the second-generation of its flagship Leaf BEV. Production is expected in 2018, featuring a larger battery pack than the current one to increase power and range.
- Meanwhile its partner Renault is expected to place a new battery-electric small car on the market, possibly as early as 2017 and may even have a sporty Gordini version available at the same time.

In all, as result of this flurry of new activity, at least two dozen electric cars were exhibited at the 2016 Paris Motor Show. Plans do not necessarily translate into production models in all cases. However, there are strong reasons to believe that this upsurge in interest is not merely greenwashing but represents a step- change in the scale and sophistication of the EV market.

Performance of Vehicle Battery Systems: Each specific type of battery has characteristics which make it either more or less desirable to use in a specific application. Cost is always a major factor and the NiMH battery tops the list in price with flooded lead acid batteries being the most inexpensive. What is lost in the cost translation is the fact that NiMH batteries yield nearly twice the performance (energy density per weight of the battery) than do conventional lead acid batteries. Another factor that must be considered when making a battery comparison is the recharge time. Lead acid batteries require a very long recharge period, as long as 6 to 8 hours. Lead acid batteries, because of their chemical makeup, cannot sustain high current or voltage continuously during charge. The lead plates within the batteries heat rapidly and cool very slowly. Too much heat results in a condition known as "gassing" where hydrogen gas is released from the battery's vent cap. Over time, gassing reduces the effectiveness of the battery and also increases the need for battery maintenance. Batteries such as NiCad and NiMH are not as susceptible to heat and can be recharged very quickly, allowing for high current or high voltage charges which can bring the battery from a 20% state of charge to an 80% state of charge in as quick as 20 minutes.

The overall battery pack voltage varies from one vehicle to another. Discussions are currently in progress with EV manufacturers in an attempt to standardize a vehicle's nominal battery voltage. EV visionaries hope to have vehicle recharging stations available in parking lots throughout a city. If EV's have a set battery pack voltage range, all vehicles would be able to use the same chargers. Battery charger manufacturers are currently developing "smart" chargers that are microprocessor based. The "smart" charger would access the particular vehicle's data bank and be able to regulate the charge accordingly.

New technology battery systems are also driven by a microprocessor. The microprocessor receives data from sensors within the battery pack. Temperature, current output, battery voltage and fault detection are all fed back to the microprocessor which can then calculate how much energy is remaining in the battery as well as how much has been consumed. Monitoring the temperature and the resistance to the vehicle's ground protects both the battery pack and the passengers from danger.

Battery configurations also vary greatly depending on the vehicle and the desired redundancy of the system. Battery packs can be tied together in one long series circuit so that the total pack voltage is the sum of all the cells in the series. Other systems use multiple packs that are of equal voltage and parallel the multiple packs. This provides redundancy to the system. If a cell goes bad in a single pack, the battery management system can disable the output from that pack and the vehicle can continue to be driven off of the remaining battery packs. The vehicle will lose the energy from the faulty pack and range will be affected.

Factors That Influence Battery Selection for Specific Applications

Comparison of Energy Densities: For pure electric vehicles, battery selection is a primarily a function of energy density. Energy density is defined as the amount of energy stored in a cell or battery as a function of the weight or volume. The ideal battery would therefore be the battery that yields the most energy, occupies the smallest space and weighs theLeast (disregarding cost). The most promising battery technologies available today are Lead-Acid (Pb-acid), nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium polymer and lithium ion batteries.

Fig. 1: Battery location and safety seal in Tesla S Model (source: teslarati.com)

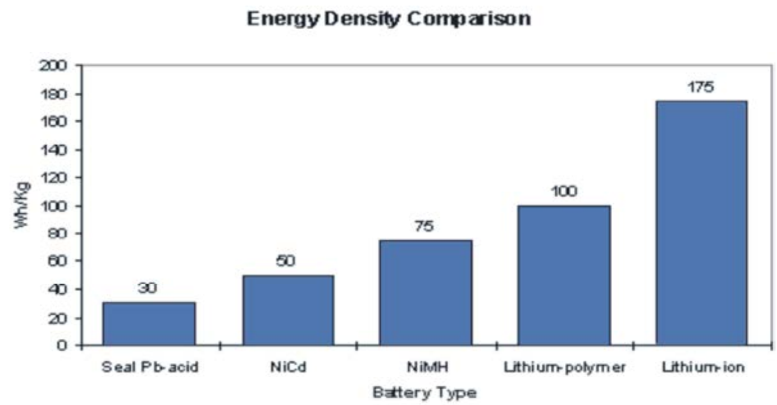

Fig. 2: Energy density comparison(source: College of Engineering & Computer Science [11])

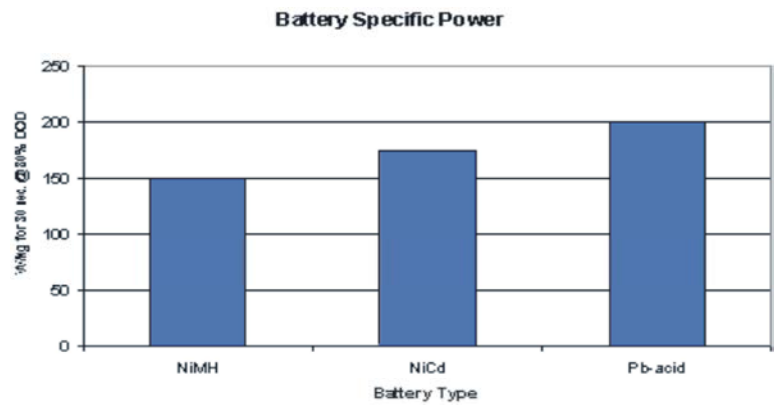

Fig. 3: Battery specific power source (College of Engineering & Computer Science [11])

A comparison of energy densities is shown in the chart above. There are many factors besides energy density that influence the type of battery selected for use in an electric vehicle. These include cost, cycle life (the number of charge-discharge cycles before the capacity diminishes from the original 100% to 80%), fast or rapid charge time and specific power (the maximum load current the battery can provide for a very short duration).

Battery's Specific Energy: Another criterion for selecting a battery type that is closely related to energy density is a battery's specific energy.

Specific energy is energy density as a function of time measured in watt-hours per unit mass. Specific energy is important because it affects the number of batteries necessary in a particular application and in turn the mass or weight of the batteries that a vehicle needs to carry on-board to end up with a certain electric-only range. It is the most important factor for EVs because it determines their total range, but not as critical for HEVs which carry the majority of their energy in the form of a gaseous or liquid fuel. Instead, for HEVs, a battery's specific power becomes the critical parameter in selecting a battery.

Since HEVs utilize two different energy sources, energy demands from the batteries are much less than in EVs. Because hybrids normally only depend on the electrical energy stored on-board to provide power for acceleration and hill climbing, batteries are sought that have a high specific power rating and less mass. Specific power, is power per unit mass, so the ability of the battery to enable high current draws for short durations with less weight is the desired goal for HEVs. Shown at above is a chart which compares specific power between battery types. No information was available for the lithium batteries at this time.

The study started by making a list of only 100% electric cars, what people call Battery Electric Vehicles (BEVs). The hybrids and other types were cut out as their batteries would be smaller and they would be less dependent on the quality of the battery. It ended up with 10 cars in the list. All the cars in the list use Lithium-ion

Table 1: The basic information on battery size(source: teslarati.com [6])

Car (BEVs only)	Battery Size (kWh)	EPA Electric Range (miles)	MPGe	EPA range/kWh	Max Home Charge (kw)
Tesla Roadster	53	244	119	4.60	16.8
Smart Electric Drive	17	68	107	4.12	3.3
Chevrolet Spark EV	21	82	119	3.85	3.3
BMW i3	22	81	124	3.68	7.4
Tesla Model S 60	60	208	95	3.47	22.0
Ford Focus Electric	23	76	110	3.30	6.6
Nissan Leaf	24	75	114	3.13	6.6
Tesla Model S 85	85	265	89	3.12	22.0
Mercedes B-Class Electric Drive	28	85	84	3.04	10.0
Toyota RAV4 EV	42	100	78	2.39	10.0

Table 1: Deep-dive Analysis*(source:* teslarati.com *[6])*

Car (BEVs only)	Battery Size (kWh)	EPA Electric Range (miles)	MPGe	EPA range/kWh	Curb weight range/kWh	Pound-mile/kWh	Cargo Room (cu ft)	cu. Ft. mile/kWh	Max Home Charge (kW)
Tesla Toaddter	53	244	119	4.60	2,723	12,536	6.0	27.6	16.8
Smart Electric Drive	17	68	107	4.12	2,108	8,688	7.8	32.1	3.3
Chevrolet Spark EV	21	82	119	3.85	2,989	11,507	9.6	37.0	3.3
BMW i3	22	81	124	3.68	2,635	9,702	11.8	43.4	7.44
Tesla Model S 60	60	208	95	3.47	4,647	16,110	31.6	109.5	22.0
Ford Focus Electric	23	76	110	3.30	3,691	12,196	14.5	47.9	6.6
Nissan Leaf	24	75	114	3.13	3,291	10,284	24.0	75.0	6.6
Tesia Model S 85	85	265	89	3.12	4,647	14,488	31.6	98.5	22.0
Mercedes B-Class Electric Drive	28	85	84	3.04	3,900	11,839	23.5	71.3	10.0
Toyota RAV4 EV	42	100	78	3.39	3,440	8,230	36.4	87.1	10.0

batteries reported to have the highest energy and power density combined of any energy-storage medium. Each vendor uses various methodologies to achieve the best efficiency and performance, not limited to lay out of the batteries, heating and cooling as well as how charge min and max charge levels are controlled.

Number of online sources were used to collect the basic information on battery size, EPA range, MPGe rating, max charge rate, etc. and came up with the following list.

The Tesla Roadster, with its low weight and relatively large battery, is much more efficient than the Model S and was the most efficient car in this group.

- Second place in km/kWh is the Smart Electric Drive. Another low weight small car Smaller, lighter cars lead the pack on km/kWh efficiency.
- Tesla's all have the largest batteries and furthest range of any EV.
- Also, battery size directly correlates with range.
- The Model S is not the most efficient car in terms of converting kWh to km driven.
- The Model S is also not the most efficient car in terms of MPGe ratings.
- The larger the battery, the larger the charge rate the vendor seems (needs?) to support.
- Tesla has the largest battery packs on the market, at least 2x any competitor.

From this data, it seems that Tesla has an edge in size and/or charge rate but not efficiency (the way it's measured in the chart).

Deep-Dive Analysis: The amount of passenger and cargo weight you're able to move with those kWh used is not clearly outlined in the competitive analysis. You can make an extremely efficient electric bike but it is not very practical for moving your family around or hauling groceries. With this additional data we start to see different leaders emerge. The larger batteries add a lot of extra weight of their own, but even with that, the Model S is more efficient at moving a pound of weight over a km per kWh than any other EV. Other vendors aren't too far off with the Ford Focus Electric in second place followed closely by the Mercedes B-Class.

Moving weight around is useful, but that needs to translate into utility. Looking at how efficiently the EVs move a cubic foot of cargo space Tesla also comes out on top. Interestingly, in every efficiency category it is found the 60kWh Model S beats the 85 kWh Model S. Like weight, some competitors are not far behind like the Mercedes B-Class at 71 vs 98 for the Model S 85.

Collecting the data and reviewing it took long. In raw efficiency terms, the Model S doesn't have an edge on competition. When you factor in utility you can see a bit of an edge in having the Model S, but that utility alone is not likely going to justify the price difference between the Model S and the close competitors. From the data, my main conclusion around battery technology is that for the Model S, battery size (and range) is the key differentiator by the largest factor. This may not accurately reflect the difficulty and intellectual property around building batteries that are > 2x larger than the competition or supporting the necessary higher charge rates, physical layouts, etc., but it is what is visible to the consumer. Personally, The Model S is bought because it is the only EV currently on the market that can handle thekmage. The EPA ranges you see often quoted are under pretty ideal conditions. Add some cold weather in, drive a bit faster than 55 MPH, or otherwise change those calculated factors and your actual range limit could be quite a bit lower than the numbers quoted.

The Model S isn’t the most efficient EV on the market, but for some people range is king. For those that don’t need the range, it’s going to come down to picking an EV that can comfortably handle their needed range and fits their style. One thing that Tesla has done very well is deliver a complete package competitive battery technology, a nicely styled car, leading driver interfaces and all in a luxury sedan.

Tesla Battery Charging: There are three basic options when it comes to recharging a Model S, each has its own benefits and drawbacks.

Option 1: Plug into a household outlet. Technically this is two options in one a standard 120v outlet (like the one you plug your phone charger into) or a 240v outlet (i.e. the kind a clothes dryer plugs into). Now, we're not saying not to use it, but charging off a 120-volt outlet would be our last choice if we had other options, because you'll get about 3-4 km of range per hour of charging. If you have a Model S 90D, that will take roughly three days for a full recharge. Alternatively, if you can find and plug into a 240-volt outlet, you'll see substantially-faster charging up to 29 km per hour, good for a 10-hour charge time.

The 240v option is also what the Tesla Wall Connector runs off of. And if your car is equipped with dual chargers (that's an internal option, not double charging port connectors), it can recharge off the Wall Connector at 80km per hour.

Option 2: They're not quite yet everywhere, but they're spreading rapidly public EV charging stations. For the average driver, even the 240-km range of the base Model S 70D is more than enough for daily driving needs; the average commute distance in the United States is 25 km. But if you happen to be away from your home charger and are seeing the battery gauge dipping to uncomfortable levels, you'll find public charge stations a helpful friend. They're compatible with the Model S via an adapter (which is included when you buy the car) and most will provide about 20 to 30 km per hour of charging some higher amperage chargers will charge even faster.

Tesla has also partnered with businesses across the world to install "Destination Charging Stations". These 240v stations use the same Wall Connector chargers as mentioned in option one, so you can expect to plug in and get charged back up in no time often at no cost (though they may be reserved for the use of the business's customers).

Option 3: Tesla Supercharger Stations. This rapidly-expanding network of high-voltage DC chargers across North America, Europe and Asia (More than 600 Supercharger stations are installed globally) is meant to enable long-distance travel for Tesla owners and that's because they are simply the fastest way to charge your Tesla.

And by fast, we mean fast. 480 volts and 200 amps fast. 170 km in 30 minutes fast which Tesla says should be enough to get you to the next Supercharger station. That first half hour is when the car will charge fastest; the engineers at Tesla want your battery pack to last as long as possible and while a depleted pack can take energy at a high rate, once it is closer to full they have to be smart about how quickly additional energy is added. Taking a 90kWh Model S as an example, Tesla touts 40 minutes to get the battery pack to 80%, after which point the remaining capacity will take another 35 minutes to charge.The average cost per kilowatt-hour in the United States is just \$0.12; recharging a 90kWh Model S would cost roughly \$10 for 294 km of range, or \$0.034/km. Consider that the average personal vehicle in the United States manages around 8km per liter of gasoline, which works out to \$0.08/km at \$0.5/liter. Unless your internal combustion car gets 60mpg, charging a Tesla will cost less than fueling a car. Though that does point out one other disadvantage to electric cars versus gasoline and that's the time to refuel. Completely filling the tank on a gas-powered car is relatively quick in just a few minutes you can pump several liters of gas, take a bathroom break, grab some snacks and be on your way. If your Model S needs a full recharge to get where you need to go, it'll take over an hour. Thankfully, Tesla is attempting to place their Supercharger stations within walking distance of things to do and places to eat, so at least you won't be stuck fiddling your thumbs while you wait.

Case study, Modeling of Charging Tesla Model S: When you fill up a normal ICE car you know exactly what your costs are for the fuel. With an electric vehicle, it is not that simple. There is a charging efficiency factor that comes into play which means that the reported amount of energy used could be understated and lower than the actual energy used. Installing an EKM Digital Submeter on NEMA 14-50 outlet to measure actual power usage of the Model S against the reported power displayed on the driver's digital dash display.

Test Setup: Charging at home 99% of the time and in the last three months It was logged 7,500+ km driven, one trip to the Supercharger and two visits to the Tesla store's High-Power Wall Connector. Next professionally installed NEMA 14-50 outlet at home. Using the factory supplied Universal Mobile Connector (UMC) as the cable between the outlet and the car. An EKM digital sub meter measures actual draw from the outlet and is accurate to within 1% and does not add any measurable load of its own.

Methodology: On the "anniversary date" of taking delivery of Model S were recorded with all of the pertinent info that was displayed before resetting the Trip A meter. Before driving the next day, the reading on the EKM meter will be recorded. Following that way, the mileage and the Tesla reported power usage over the period driven. This process will let us see a bunch of information that was planned on tracking over time, as follows:

- Monthly km driven
- Monthly kWh used as reported by the Model S
- Monthly kWh used as reported by the EKM meter
- Monthly Average energy used

The plan on using this information to look at how average energy used changes as the months/temperature changes and perhaps as the Model S gets more km on it. While the car was not driven consistently on any given day (test drives, special trips and the like), the numbers will average out and driving style is not likely to change much after 30 years of driving. Also, the car was driven pretty consistent patterns of commuting with a lot of km to the same places which helps average out the special trips to locations with different terrain/conditions.

Table 2: Tesla Model S averages and data from real world testing

Item	Reading
Total KM	12,451
Delta	2,417
Total Energy kWh	728
Avg Energy Wh/km	301
kWh meter reading	1,249
Actual kWh used	894
Charge Efficiency	81.5%
Electric AED/kWh	0.589
Electricity cost	AED 525
Cost per km	AED 0.2202
Gas cost est.	AED 1,754
Savings	AED 1,229

Basically, while the conditions aren't perfectly stable over time, the averages and data from this real-world testing will be pretty accurate.

The Data: The last period of 30 days was the first full period with both the car and the EKM meter. A month of driving and charging, especially with the km and kWh's involved. The data is shown in Table 3:

In Table 3, you can see that the Model S reported 728 kWh used during the period but the meter reported 894 kWh used. This means my charging efficiency is only about 82% and electric usage (and cost) is 23% higher than may have expected based on the readings the Model S provides. For that month, this is an extra 95AED of charging cost which is a small number but a notable percentage of the total. The good news is that even using this larger kWh number, the savings versus driving the old ICE car for energy alone comes in at 1,229AED. Saving 1,229AED/month in driving Model S.

Research suggests that an average charging efficiency loss ranges between 10-12%. Over this one month period of over 2,400 km is seeing an 23% loss using the standard home charging setup that Tesla recommends. Many people quote an 85% charge efficiency for Tesla and Tesla's own charging calculator appears to assume a 91% charging efficiency which is quite different than the 82% actual charge efficiency was measured and significantly worse than the average industry charging efficiency. It would be great to see another Model S owner do a similar test using the HPWC setup at home and see if they get results similar to what Tesla is providing. From the results above, the conclusion is that the Model S charging efficiency using the standard home setup is 5-10% worse than other EVs on the market.

Mathematical Model: Data was collected from Tesla manufacturer to calculate the distance Tesla S electric vehicle can travel per each full charge with various battery

Table 3: The results of the model

Model S						
Battery type	60					
Outside Temperature	40°					
Speed Km/hr	70	80	90	100	110	120
Range per charge KM	442	408	376	342	310	280
Model S						
Battery type	60D					
Outside Temperature	40°					
Speed Km/hr	70	80	90	100	110	120
Range per charge KM	449	416	383	350	319	288
Model S						
Battery type	75					
Outside Temperature	40°					
Speed Km/hr	70	80	90	100	110	120
Range per charge KM	535	494	455	414	375	338
Model S						
Battery type	75D					
Outside Temperature	40°					
Speed Km/hr	70	80	90	100	110	120
Range per charge KM	549	509	468	427	389	352
Model S						
Battery type	100D					
Outside Temperature	40°					
Speed Km/hr	70	80	90	100	110	120
Range per charge KM	714	660	605	548	500	454

types and different driving speeds. The model was built and a special program in Matlab software was simulated and solved. The results of this model were essential to calculate the cost of each km traveling distance and also it was helpful to calculate the amount saving using electric vehicle rather than using normal gasoline IC cars.The results of the model were tabled for each type as follows: AC on all the time

Results and Analysis: The average cost per kilowatt-hour is just 0.44 AED; recharging a 90kWh Model S would cost roughly 36.7 AED for 294 km of range, or 0.125AED/km. Consider that the average vehicle manages around 8km per liter of gasoline, which works out to 0.25AED/km at 2AED/liter. (EV 50 % Less than PetrolVehicle)Unless your internal combustion car gets 60mpg, charging a Tesla will cost less than fueling a car.

The average KM in DTC drives per year for each vehicle 200,000 kilometers and spends on average AED 50,000 on gasoline per year. In comparison, the cost of electricity to power Model S over the same distance is up to 2 times lower. Over the three-year average length of taxi ownership, that's approximately AED 75,000 in gasoline savings.

It isassumed that a fuel economy of 8 liters/100 km for a comparable gasoline powered premium sedan. It is also assumed that the national average of AED 0.44 per kilowatt-hour for electricity and AED 2 per liter for premium gasoline over the next three years

CONCLUSION

All the EPA range per kWh results look somewhat similar. The worst is the RAV-4 but the others are all within 30% of the best, the Tesla Roadster. In second place is the Smart Electric Drive. Some other things stand out from this data. The Tesla Roadster, with its low weight and relatively large battery, is much more efficient than the Model S and was the most efficient car in this group. Second place in km/kWh is the Smart Electric Drive. Another low weight small carSmaller, lighter cars lead the pack on km/kWh efficiency. Tesla's all have the largest batteries and furthest range of any EV. Also, battery size directly correlates with range. The Model S is not the most efficient car in terms of converting kWh to km driven. The Model S is also not the most efficient car in terms of MPGe ratings. The larger the battery, the larger the charge rate the vendor seems to support. Tesla has the largest battery packs on the market, at least 2x any competitor. From this data, it seems that Tesla has an edge in size and/or charge rate but not efficiency (the way it's measured in the chart.

The larger batteries add a lot of extra weight of their own, but even with that, the Model S is more efficient at moving a pound of weight over a km per kWh than any other EV. Other vendors aren't too far off with the Ford Focus Electric in second place followed closely by the Mercedes B-Class.

The average cost per kilowatt-hour is just 0.44 AED; recharging a 90kWh Model S would cost roughly 36.7AED for 294 km of range, or 0.125AED/km. Consider that the average personal vehicle in the United States manages around 8km per liter of gasoline, which works out to 0.125AED/km at 2AED/liter. Unless your internal combustion car gets 60mpg, charging a Tesla will cost less than fueling a car.

The average person in Dubai drives 200,000 kilometers and spends on average AED 50,000 on gasoline per year. In comparison, the cost of electricity to power Model S over the same distance is up to 2 times lower. Over the three-year average length of taxi ownership, that's approximately AED 75,000 in gasoline savings.

It is assumed that a fuel economy of 8 liters/100 km for a comparable gasoline powered premium sedan. It is also assumed that the national average of AED 0.44 per kilowatt-hour for electricity and AED 2 per liter for premium gasoline over the next three years.

Future researches will cover environmental topics aboutdelaying action on car emissions will make United Arab Emirates more vulnerable, and also there will be other researchesdelivering the infrastructure, research and development support and incentives to switch to greener taxi cars. Finally,to research and deploy technologies that enhance the performance of electric drive vehicles.

REFERENCES

1. The Supreme Council of Energy Directive number 1 of 2016.
2. Neil Roland (2012-08-09). Feds Researching Fire Risks from EV Batteries". MSN Autos. Retrieved 2013-06-23.
3. China Autoweb (2012-05-28). "Initial details on fiery crash involving BYD e6 that killed 3". Green Car Congress. Retrieved 2012-08-13.
4. Christopher Jensen (2013-10-02). "Tesla Says Car Fire Started in Battery". The New York Times. Retrieved 2013-10-05.
5. Blanco, Sebastian. "Second Tesla Model S fire caught on video after Mexico crash". Autoblog Green. Retrieved 2013-11-09.
6. Tesla's Third Model S Fire Brings Call for U.S. Inquiry". loomberg.com. Retrieved 2013-11-08.
7. General Motors (2011-01-19). "Detroit First Responders Get Electric Vehicle Safety Training". General Motors News. Retrieved 2011-11-12.
8. Insurance Institute for Highway Safety. 2009. Car size and weight are crucial. Status Report, 44(4): 1-7.
9. Insurance Institute for Highway Safety. 2015. Saving lives: improved vehicle designs bring down death rates. Status Report, 50(1): 1-7.
10. Highway Loss Data Institute. 2011. Injury odds and vehicle weight comparison of hybrids and conventional counterparts. HLDI Bulletin, 28(10): Arlington, VA.
11. https://www.utc.edu/college-engineering-computer-science/research-centers/ last time visited December 12, 2017.