PRE-RELEASE VERSION

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Better Place:

The Electric Vehicle Renaissance

This case was written by Prash Pokala and Disha Gupta, INSEAD MBA 2010, under the guidance of Professors Karan Girotra and Serguei Netessine. It is intended to be used as a basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

"How do you make the world a better place by 2020?" [1]

This profound question, posed by Klaus Schwab at the 2005 World Economic Forum in Davos, Switzerland, got the Israeli entrepreneur, Shai Agassi thinking. With a passion for tackling large-scale challenges, Agassi sought to answer this question with a pragmatic solution to free cars from oil, reduce harmful tailpipe emissions, and usher in an era of sustainable transportation.

After considering various different alternatives, Agassi zeroed in on Electric Vehicles. Today, he works with government leaders, auto manufacturers, energy companies and others to make his vision—zero-emission vehicles powered by electricity from renewable sources—a reality in countries around the globe.

Agassi founded Better Place and, in 2007, officially launched the company. In 2008, Israel became the first country—and Renault the first carmaker—to embrace the Better Place model of building open network infrastructure to enable mass adoption of electric vehicles and delivering transportation as a sustainable service. Denmark, Australia, California, Hawaii, and Ontario have followed suit. Today, Agassi and Better Place are in discussions with many countries, carmakers and other potential partners around the globe.

In March 2008, Deutsche Bank analysts issued a glowing report stating that the company's approach could be a "paradigm shift" that causes "massive disruption" to the auto industry, and which has "the potential to eliminate the gasoline engine altogether."[2]

Industry Background

An electric car is a plug-in battery powered automobile which is propelled by electric motor(s).

Electric cars have the potential of significantly reducing city pollution by having zero tail pipe emissions. [3] Vehicle greenhouse gas savings depend on how the electricity is

generated. With the current U.S. energy mix, using an electric car would result in a 30% reduction in carbon dioxide emissions.[4] Given the current energy mixes in other countries, it has been predicted that such emissions would decrease by 40% in the UK and [5] 19% in China,[6].

Electric vehicles first came into existence in the mid-19th century and electric cars enjoyed popularity between the mid-19th century and early 20th century, when electricity was among the preferred methods for automobile propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time. Advances in internal combustion technology soon rendered this advantage moot; the greater range of gasoline cars, quicker refueling times, and growing petroleum infrastructure, along with the mass production of gasoline vehicles by companies such as the Ford Motor Company, which reduced prices of gasoline cars to less than half that of equivalent electric cars, led to a decline in the use of electric propulsion, effectively removing it from important markets such as the United States by the 1930s.

However, during the last few decades, increased concern over the environmental impact of the petroleum-based transportation infrastructure, along with the spectre of peak oil, has led to renewed interest in an electric transportation and infrastructure. Electric car technology has caught up with ICE and many electric cars have large motors and brisk acceleration. In addition, the relatively constant torque of an electric motor, even at very low speeds tends to increase the acceleration performance of an electric vehicle relative to that of the same rated motor power internal combustion engine. Nissan CEO Carlos Ghosn has predicted that one in 10 cars globally will run on battery power alone by 2020. [7] However, the adoption of Electric cars so far has been slow.

Electric cars are generally more expensive than gasoline cars. The primary reason is the high cost of car batteries. A survey taken by Nielsen for the Financial Times has shown that 65% of Americans and 76% of Britons are not willing to pay more for an electric car above the price of a gasoline car. [8] Also a report by J.D. Power and Associates claims that about 50 percent of U.S. car buyers are not even willing to spend more than US$5,000 on a green vehicle above the price of a petrol car despite their concern about the environment. [9]

Also, lack of a quick way to recharge a battery (equivalent to filling up gas at a gas station) makes long distance travel especially a hassle – a problem known as ‘range anxiety’. This is a reason that many automakers marketed EVs as "daily drivers" suitable for city trips and other short hauls. [10] The average American drives less than 40 miles (64 km) per day; so the GM EV1 would have been adequate for the daily driving needs of about 90% of U.S. consumers. [11]

Current battery technology has evolved to a point where it takes a few hours (5-6 hours) to charge a fully-depleted battery that lasts for about 100 miles. Also, the added advantage to the power grid is that EVs mostly absorb the off-peak excess energy or the variable renewable energy to charge, thus making it environmentally attractive. More electrical power to the car reduces charging time. Even if the electrical supply power can be increased, most batteries do not accept charge at greater than their ‘charge rate’ because high charge rates have an adverse effect on the discharge capacities of

batteries. [12] Additionally, the prior advantage of absorbing non-peak electricity from the grid would disappear, making the technology “less” environment friendly.

Shai Agassi, an Israeli entrepreneur, realized that in order for a significant shift to occur from gas-powered or ICE vehicles to EVs, with the current limitations on charging time and battery range, electric vehicles cannot be offered as stand-alone products but instead they need to be part of a transportation infrastructure. With the objective of eliminating both these dissatisfiers, Agassi founded Better Place, a company based in Palo Alto, California, to develop the EV network. The company was publicly launched, as ‘Project Better Place’ (and later dropped ‘Project’), on October 29, 2007. As of April 2009 it has already raised $400 million and several countries and states have offered tax breaks. [13]

Better Place Business Model

Better place decided to do a few things differently to give customers the same freedom as owning and driving a conventional engine car.

Better Place anticipates implementing a business model wherein customers enter into contracts to purchase driving distance similar to the mobile telephone industry where customers contract for minutes of airtime. The electric cars will be built and sold separately from their Better Place battery pack "fuel" akin to the way that petrol cars are sold separately from their fuel. (As you don't own the fuel but pay for it a few times a month, you don't own the battery and pay for it once a month to Better Place, including its daily charging and battery swaps.) Customers will not be allowed to purchase battery packs; instead, they will be leased as a part of this contract with Better Place. The initial cost of an electric vehicle may also be subsidized by the ongoing per-distance revenue contract just as mobile handset purchases are subsidized by per-minute mobile service contracts. The goal is to sell the EV at $5,000 cheaper than the price of the average gasoline car. [14]

Also, Better Place will install an extensive charging infrastructure. Customers will be provided with a personal Better Place 220V charge spot for their homes (garage, carport or otherwise). Early data shows, and Better Place expects, that EV drivers will primarily use personal home charge spots, plugging in their cars at night, and waking up the following morning to a fully charged battery. Better Place will also install charge spots at workplaces, in public parking lots, and along urban streets so that EV drivers have convenient access to energy away from their homes. [1] To eliminate range anxiety and to facilitate long distance travel, Better Place is installing a network of battery switch stations that use an ingenious robotic system to switch new batteries for depleted ones, cool and charge the batteries in inventory, and manage the complex logistics to ensure that each EV gets a fully-charged battery each time the vehicle arrives at a station. Better Place is working with automakers to ensure that EVs and battery switch stations are compatible.

Finally, Better Place will install proprietary in-car dashboard system that will connect the car to the Better Place charging infrastructure. [1] Customers will receive messages such as “x% charge remaining” or “Swap station y km away”. This system will also be

connected to the electricity grid. The idea is to allow for highly cost effective recharging of batteries and management of grid capacities, and to overcome concerns about the potential impact of rapid proliferation of EVs that might recharge unpredictably and impact the electric grid.

A potential side-benefit is that as opposed to a fixed battery in a car, batteries that are exchanged at Better Place switch stations are charged in a well-managed and temperature-controlled environment, ensuring optimal conditions that prolong their life.

Consequently, Better Place believes purchasing an EV can be a sound cost/price decision as well as a decision to go green, get a better driving experience, and enhance energy security. As represented in **Exhibit 1**, Better Place will allow customers to make a more apples-to-apples comparison when they choose between ICE and electric vehicles.

Better Place and Israel

The first step to take in proving this unique EV network is to test it in a small, controlled environment where the technology and robustness of the business model can be tested with minimal risks. The first full-scale Better Place network is currently under development in Israel. In addition to the fact that Shai Agassi is from Israel, There are many reasons why Israel is an ideal market for this business model.

Israel's area is approximately 20,700 square kilometres (7,992 sq mi) stretching 424 kilometres (263 mi) from north to south, and its width ranges from 114 kilometres (71 mi) to, at its narrowest point, 15 kilometres (9.3 mi). (It is slightly smaller than the state of New Jersey.) The south of Israel is dominated by the Negev desert covering some 12,000 square kilometres (4,633 sq mi), more than half of the country's total land area. **(Exhibit 2).**

In 2009, the population of Israel was 7.5 million people. The country has 74 cities, with more than 70% of the population living in and around the four big cities: Tel Aviv (population 3,150,000), Haifa (population 996,000), Jerusalem (population 763,600) and Be'er Sheva (population 531,600). The total road length in the country is 18,096 kilometres (11,244 miles) with 344 kilometres of motorways connecting the major cities.

First, the small size of the country means that the distance people drive in any direction does not exceed roughly 250 km. Very few people cross the border to neighbouring countries due to the political conditions. Secondly, due to its geopolitical situation Israel has committed to achieve oil independence by 2020, which means that it must rapidly replace its gas-powered vehicles with zero-emission vehicles.

The Better Place Battery and Swap Station Infrastructure

While Better Place is excited to start operations in Israel, the management has some key decisions to make regarding the infrastructure investments.

Batteries

Finding the economic balance of range against performance, energy density, and accumulator type versus cost challenges every EV manufacturer. While most current highway-speed electric vehicle designs focus on lithium-ion and other lithium-based variants a variety of alternative batteries can also be used.

Flat or 'pancake' batteries under the floor of a car allow the cars to have a lower center of gravity, improving handling and increasing interior packaging flexibility. In addition to the performance benefits, an easily accessible location simplifies manufacturing and will reduce maintenance costs.

The investment in batteries is the most substantial investment for a Better Place network. [2] According to the Deutsche Bank analysts, the underlying battery price projections are $14,000 per battery purchased in 2011; $13,000 in 2012; $11,500 in 2013; $10,500 in 2014; $9,500 in 2015. Also, they incorporate an 8 year depreciation schedule for the battery into their earnings and balance sheet forecasts. The battery investment also includes extra batteries required at battery swap stations.

Battery Swap Stations (BSS)

To provide seamless driving experience for an EV, Better Place is installing a network of battery switch stations that use a ground-breaking robotic system to switch new batteries for depleted ones, cool and charge the batteries in inventory, and manages the complex logistics to ensure that each EV gets a fully-charged battery each time the vehicle arrives at a station.

At Better Place battery switch stations, drivers enter a lane and the station takes over from there. The car proceeds along a conveyor while the automated switch platform below the vehicle aligns under the battery, washes the underbody, initiates the battery release process and lowers the battery from the vehicle. The depleted battery is placed onto a storage rack for charging, monitoring and preparation for another vehicle. A fully-charged battery is then lifted into the waiting car. The switch process takes less

time than a stop at the gas station and the driver and passengers may remain in the car throughout. The total service time for the visit is as low as 5 minutes.

The initial investment required to install the complex machinery per switching station lane has been estimated to be roughly US $500K. Better Place plans an initial deployment of 50 swap station lanes, at an initial investment of $25 million, since Better Place believes that this should be sufficient to establish infrastructure on every major inter-city route in Israel, at an interval of 20 km between each facility, and at strategic locations within cities. [2] (Overall expected Income statement in **Exhibit 3**)

Better Place will charge customers on per-mile-driven basis. The general mileage trend is that 90% of the population only drives relatively short distances on average of ~40 miles/day, and a small portion of the population drives long distances. Also occasionally the customers would pursue long distance travel. Hence, capturing this audience is critical for Better Place.

To ensure adoption by this segment, Better Place needs to assure the long-distance travelers that there will be enough BSS and the wait times are under control. Hence, determining the optimal number of lanes in every switching station and consequently the level of inventory of batteries per switching station, depending on the traffic density, traffic peaks during the week and weekends, and real estate costs is equally critical to ensure service levels. At the same time, like any other start-up, Better Place has limited capital resources.

Better Place estimates that a minimum of 12 batteries must be kept in inventory per swap lane in order to ensure battery availability: This is based on an assumption that a fully depleted battery can be charged over 1 hour. Therefore, in the worst case scenario, if all of the returned batteries are fully depleted, 12 batteries would ensure that a fully charged battery will be available once every 5 minutes. Proliferation of vehicle models will require higher inventory of batteries "standing by" in each lane, but statistical modelling suggests that this will not be linear. Deutsche Bank estimates assume that the network in this region offers 4 different models by year-end 2014, and 5 by year-end 2015.

Other challenges and questions to consider

While there are many short-term questions regarding Better Place, its pricing model, the quality of the batteries after switching and the relative convenience/inconvenience of charging at home every night, there are other bigger and longer-term challenges that Better Place faces.

Transferability of the business model

Following the launch in Israel, Better Place plans to introduce its system to the Danish market and eventually in Canberra (Australia), Hawaii and the San Francisco Bay Area by 2012. In Canada, Better Place has partnered with the government of Ontario to develop more EV models as Ontario has a very strong automotive industry. However, as Better Place moves into more expansive geographies (Israel and Denmark are compact, urbanized, developed countries), such as the United States, that require a more

elaborate infrastructure and the population has different driving patterns, will this business model still work and be profitable?

Israel to US size ratio: 1:437 [15]

Other Statistics for Israel compared to a country like the US [16]

	Israel	**US**
Length of road network (km)	17,686	6,430,351
Length of motorways (km)	344	75,008
Length of road per capita	2.51	21.69
Number of cars sold in 2009	145,364	10,400,000

Battery technology evolution and risk of obsolescence

The future of battery electric vehicles depends primarily upon the cost and availability of batteries with high energy densities, power density, and long life, as all other aspects are fairly mature and cost-competitive with internal combustion engine components. Li-ion, Li-poly and zinc-air batteries have demonstrated energy densities high enough to deliver range and recharge times comparable to conventional vehicles.

Also, the Ultra-battery combines a super-capacitor and a battery in a single unit, creating an electric vehicle battery that lasts longer, costs less and is more powerful than current technologies used in plug-in hybrid electric vehicles. [17] Also, certain Tesla models (Model S and Raodster) are already providing a range of up to 160-220 miles. [18] Likewise, for charging technology, General Motors announced a version of its "Magne Charge" system which could recharge NiMH batteries in about ten minutes, providing a range of 60 to 100 mi (100 to 160 km). [19]

There are several other such disruptive battery technologies in the pipeline, in different stages of development. Some of them could serve as EV game changers. Since Better Place owns the batteries and leases it out to the customers, how will this impact the investments as the battery technologies evolve and get better? As the charging capacity

of the batteries increases with research and development, this might render the initial capital investments in setting up futile.

Global oil independence and greener environment

Electric cars produce no pollution at the tailpipe, but their use increases demand for electricity generation. The amount of carbon dioxide emitted depends on the emission intensity of the power source used to charge the vehicle, the efficiency of the said vehicle and the energy wasted in the charging process.

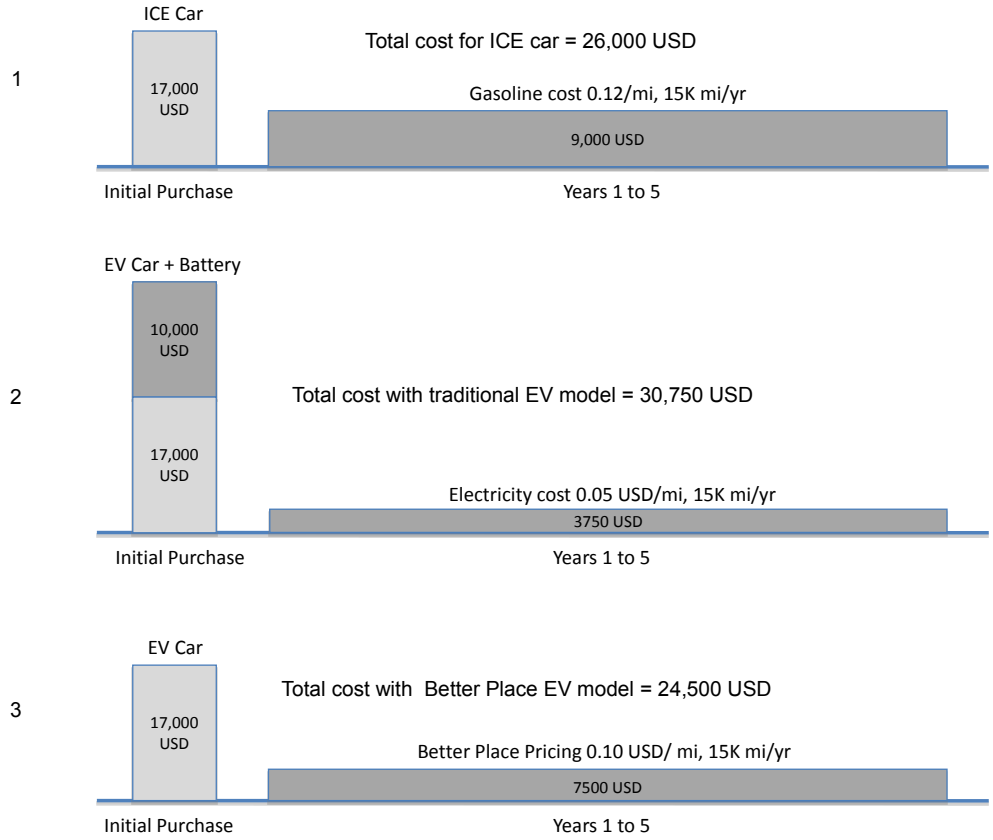
For mains electricity the emission intensity varies significantly per country and within a particular country it will vary depending on the time of day and even over the course of the year depending on the availability of renewable sources and the efficiency of the fossil fuel-based generation used at a given time. Charging a vehicle using off-grid renewable energy yields very low carbon intensity (only that to produce and install the off-grid generation system e.g. domestic wind turbine).

An EV recharged from the existing US grid electricity emits about 115 grams of CO2 per kilometre driven, whereas a conventional US-market gasoline powered car emits 250 g(CO2)/km (most from its tailpipe, some from the production and distribution of gasoline).[20] The savings are questionable relative to hybrid or diesel cars, but would be more significant in countries with cleaner electric infrastructure.

In a worst case scenario where incremental electricity demand would be met exclusively with coal, a 2009 study conducted by the WWF, World Wide Fund for Nature, and IZES found that a mid-size EV would emit roughly 200 g(CO2)/km, compared with an average of 170 g(CO2)/km for a gasoline powered compact car.[21] This study concluded that introducing 1 million EV cars to Germany would, in the best case scenario, only reduce CO2 emissions by 0.1%, if nothing is done to upgrade the electricity infrastructure or manage demand.

Also, assuming that EVs make owning and driving more cost-efficient, will this drive up the total miles driven? Will going the EV-way actually make the world *a better place*?

Exhibit 1: Economics of ICE vs. EV – How Better place changes things



Source: Author's estimates based on revised assumptions from [2] and [19]; Expected Better Place pricing: USD 0.10/mile

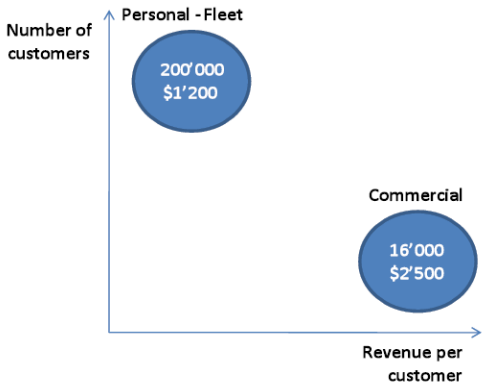
Exhibit 2: Map of Israel [23]

Exhibit 3: Better Place Income Statement Projections

		2012	2013	2014	2015	2016
New subscribers	K	14	16	22	25	30
Total subscribers	K	14	30	52	77	107
Better Place revenue/vehicle/yr	$	4 550	4 550	4 550	4 550	4 550
Revenues	$M	64	137	237	350	487
Variable costs/yr/customer						
Electricity cost/customer	$	475	472	469	466	463
Personnel cost/customer	$	350	350	350	350	350
Marketing cost/customer	$	138	133	128	123	118
Maintenance cost/customer	$	138	133	128	123	118
Other overhead/customer	$	421	436	451	466	481
Total var cost/yr	$M	21	46	79	118	164
EBITDA	$M	42	91	157	233	323
Cum. Capex						
Batteries for car	$M	196	404	657	920	1 205
Batteries for swap stations	$M	6	7	8	10	16
Swap lanes	$M	18	20	23	25	30
Charging spots	$M	53	68	83	98	113
TOTAL		272	499	771	1 052	1 364
Depreciation	$M	31	58	91	126	164
EBIT	$M	12	33	66	107	159
EBIT Margin	%	18%	24%	28%	31%	33%

Source: Author's estimates based on [2] with modified assumptions; to calculate depreciation,useful life of batteries (for cars): 8 years; Batteries (for swap stations): 4 years; Swap lanes: 15 years; Charging spots: 15 years; No residual value of these assets

Exhibit 4: Estimated market size, attractiveness and accessibility for Israel



Source: Author's estimates based on roughly 263 cars per 1000 people in Israel; By the end of Year 5, 20% of Urban and 10% of Rural car users would switch to the Better Place model expected annual revenue of $2,500 per customer for 16K customers, compared to $1,200 for the 200K personal-fleet segment. Assuming $0.10 charge per mile

References

1. Better Place official website, http://www.betterplace.com
2. “Vehicle Electrification”, Deutsche Bank Industry Update, March 2010
3. "Should Pollution Factor Into Electric Car Rollout Plans?". Earth2tech.com. 2010-03-17
4. "Plug-in Hybrid Cars: Chart of CO2 Emissions Ranked by Power Source". TreeHugger.
5. "Less CO2". My Electric Car.
6. http://www.mckinsey.com/locations/greaterchina/mckonchina/pdfs/China_Charges_Up.pdf
7. "/ Reports - Electric and hybrid: Sales feed off hype and subsidy". Ft.com. 2010-10-01.
8. "Buyers loath to pay more for electric cars". 2010-09-19.
9. "Future Global Market Demand for Hybrid and Battery Electric Vehicles May Be Over-Hyped; Wild Card is China". 2010-10-27
10. "More range anxiety with the Mitsubishi iMiEV"
11. Erickson, Glenn (10 January 2009). "DVD Savant Review:Who Killed the Electric Car?". dvdtalk.com
12. Buchmann, Isidor (November 2006), *The high-power lithium-ion*, BatteryUniversity.com (sponsored bv Cadex Electronics Inc.)
13. Clive Thompson (2009-04-16). "Batteries Not Included". New York Times
14. "Shai Agassi interviewed on MSNBC's Morning Joe"
15. http://www.iris.org.il/sizemaps/usa.htm
16. http://en.wikipedia.org/wiki/List_of_OECD_countries_by_road_network_size
17. tp://www6.lexisnexis.com/publisher/EndUser?Action=UserDisplayFullDocument&orgId=101846&topicId=103840033&docId=l:732161238
18. http://gigaom.com/cleantech/battle-of-the-batteries-comparing-electric-car-range-charge-times/
19. http://en.wikipedia.org/wiki/Electric_car
20. "Wheel to Well Analysis of EVs" (PDF). *MIT Electric Vehicle Team*. MIT. April 2008
21. Palm, Erik (1 May 2009), *Study: Electric cars not as green as you think*, CNET Networks, retrieved 2009-05-04
22. “Shai Agassi's bold plan for electric car”, TED.com http://www.ted.com/talks/shai_agassi_on_electric_cars.html, Feb 2010
23. http://www.topnews.in/regions/hebron