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Fulfilling the Promise to Go Oil-Free: A Nationwide Network Case Study

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Abstract

In January 2008, the Prime Minister of Israel proclaimed, "By the end of the next decade, we will be completely free of petroleum and its by-products as the fuel which powers transportation in Israel." To drive toward that oil-free goal, the CEO of Better Place committed to deploy a privately financed nationwide network to make electric cars more convenient than those powered by petroleum-based fuels and use an innovative model to make them more affordable. For his part, Carlos Ghosn, CEO of Renault and Nissan, committed to supplying vehicles at volume that could take full advantage of networked infrastructure that includes not only charge spots, but also fully automated, battery switch stations. The target timeline: four years.

Four years later, delivery of the first mass-produced vehicles with switchable batteries for instant range extension (a fully charged battery in less time than it takes to refill a fuel tank) will begin, the electric-car network will go live, drivers will have a real choice, gasoline will have real competition, and Israel will begin achieving its ambitious goal.

How was this point reached? What happened along the path of this four-year journey?

This case will seek to answer these and other questions, while outlining some of the key steps taken, milestones reached, challenges encountered, and system integration and testing conducted. It will conclude by sharing some lessons learned regarding market penetration beyond the early adopters and the applicability of this network approach to far larger countries.

Keywords: battery, business model, EV, infrastructure, range

1 Introduction

Better Place Founder and CEO Shai Agassi was inspired by a profound question posed at the 2005 World Economic Forum in Davos, "How do you make the world a better place by 2020?" With a passion for tackling large-scale challenges, he ultimately sought to answer this question with a

pragmatic solution to free cars from oil, enable the mass-market adoption of electric cars, and usher in an era of sustainable transportation. One key to the solution involved separating the battery from the car, both physically and financially, through an innovative, battery-switch model that addresses the historical barriers to electric-car adoption: cost; and convenience (due primarily to limited range, the time required for recharging when a driver does not have time to spare, and the lack of infrastructure).

In 2008, Israel became the first country — and Renault the first major carmaker — to embrace the model. At the time, the Prime Minister of Israel proclaimed, "By the end of the next decade, we will be completely free of petroleum and its by-products as the fuel which powers transportation in Israel." To drive toward that oil-free goal, Agassi committed to deploy a privately financed nationwide network of charge spots and automated, battery-switch stations (BSS) to make electric cars more convenient and affordable than those powered by petroleum-based fuels. For his part, Carlos Ghosn, CEO of both Renault and Nissan, committed to supplying cars at volume that could take full advantage of the network. The target timeline: four years.

1.1 Four-Year Journey

Fast-forward four years and Better Place is demonstrating a working solution in Israel, and the first 100 Renault sedans with switchable batteries are on the road. After tens of thousands of hours of design, problem solving, engineering and rigorous testing, we have designed a complete solution and, with automotive partner Renault, we've brought a fantastic car to market – a true accomplishment. Perhaps most important, Better Place has created, for the first time, a real competitive alternative to gas-powered cars and demonstrated market demand from both fleet and consumer buyers.

We will begin here by reviewing the four-year journey at a very high level and drawing loose comparisons to the planning and construction of a building.

1.1.1 2008: Creating an ambitious and tangible vision

In support of the vision, the blueprint called for a solution that makes driving an electric car more affordable and convenient than a gasoline one. While it is clearly ambitious, it is sufficiently tangible and specific to help guide the countless decisions along the journey.

As mentioned, battery-car separation was a central building block, but the initial blueprint also needed to provide for scalability, the ability for replication (beyond Israel), and things like networked intelligence, including management and monitoring of the infrastructure and energy management at country scale, to ensure smooth operation and an experience for drivers that would compel them to recommend it to others.

Building to that blueprint, and eventually duplicating the end result in other markets, would require an organization able to drive a global movement toward sustainable transportation in a profitable way (a profitable model is critical to attract the private capital necessary to fund nationwide network deployment, and then scale). It also would require relationships with visionary partners at the global and local level to support the proof of a better mobility paradigm. Carlos Ghosn and Renault were in a sense "anchor tenants" in this area of the building. And although Israel provided no direct government support to Better Place, the country secured its anchor-tenant status by conveying such a strong desire to end its oil addiction and offering itself as the proving ground.

1.1.2 2009: Establishing framework

If 2008 was the blueprint year, the focus shifted to the foundation in 2009.

Foundational elements included designing boundary conditions, building and, in some cases, demonstrating sub-systems, and establishing some of the supply-chain and other aspects with particularly long lead times.

Setting boundary conditions sounds simple enough, but in many ways the process determines whether and how quickly a big, complex goal is achieved. The conditions help guide countless decisions and, in some cases, sacrifices along the rest of the journey. With mass adoption in mind, our conditions centered around low cost, high scalability, conversion of complexity into simplicity and ease for drivers, and competitiveness with gas-powered alternatives.

By virtue of the timeline, many things had to happen on parallel tracks and solution development was in process. Teams began

building some of the key sub-systems for the overall network solution.

These included some of the systems covering monitoring and energy management to support operation of what essentially would be the world's single largest electric-car park, as well as the battery-switch system that would be developed further for production of commercial BSS. In May, at the invitation of the Japanese government, we showed the speed and ease of the automated switch system in a public demonstration in Yokohama that ran for a few months.

In this foundation year, Better Place also lined up the supply of key solution elements with long lead times. These included volume agreements for cars and charge spots. In September, when Renault officially unveiled the first switchable-battery car for Israel and Denmark (the second Better Place market and first in Europe), the Fluence Z.E., Better Place and Renault announced an expanded agreement that committed the partners to at least 100,000 switchable cars for Israel and Denmark by 2016. A separate agreement with contract-manufacturer Flextronics called for developing and stress-testing 1,000 charge spots on the road to scale up to 100,000 standards-based, production-grade charge spots.

With a solid foundation in place, the building process could continue.

1.1.3 2010: Building driver-centric solution

Focus began to shift to structural elements in 2010. These included not only the nationwide rollout and deployment plans for Israel, but also more of the solution elements that would be important for the driver experience. Significant effort also was made to raise awareness and educate consumers, conditioning the market and the support such a major transition to electric cars (see section 1.3.2 below).

The first and second generation BSS were developed as well as a suite of applications for the network's operations center to monitor the health of all components, remotely address issues, and manage the level of service during charging and switching across the network.

In April, following 2009's successful switch demonstration in Japan, we launched a commercial taxi program in Tokyo to demonstrate switchable batteries with a BSS in a real-world, high-mileage application. Taxis cover many times the kilometers per day that the average consumer does. Building on the Yokohama demonstration, the BSS in Tokyo featured the integration of battery storage and quick-charging with optimal thermal management capabilities to maintain battery life. More than 3,500 automated switches were performed over the course of the program. The average switch time was about 59 seconds.

Tokyo was a key milestone on the road to a complete system test of all the solution components in Israel, where development continued.

1.1.4 2011: Conducting system integration and testing

In year four, a key focus area was the solution's structural integrity and finishing touches in preparation for full system integration and testing.

While there are far too many to list here, these "touches" included network-asset monitoring, energy supply and battery switch service level management, automatic over-the-air software upgrade and provisioning for charge spots, remote BSS management and monitoring, and over 100 mainly automated business processes spanning customer-relationship management (CRM), vehicle management, ordering, billing, and call center, among many areas.

When the complete solution passed the "operation ready" milestone, it moved from the lab environment to Israel's roads for final testing, a process that scaled over many months as Renault ramped up manufacturing and began to deliver pre-production cars.

1.1.5 Key lesson

Looking back, it is difficult to draw just one lesson from all of the effort over the last four years but, from an overarching standpoint, we think it is this: thoughtful planning, with appropriate flexibility, is what enabled the setting of such an ambitious timeline and the execution on so many fronts that followed.

1.2 Solution

Rather than focus on one element of electric cars, we took a systems approach to overcoming the

barriers to adoption. The network solution developed for Israel (and other markets) integrates many elements, including charge spots, BSS, batteries, cars, network software, and in-car software, to make the driving experience simple and convenient and avoid requiring massive behavioural shift for mass-market consumers. In integrating these elements, teams were working across multiple dimensions, such as partner (OEM chief among them), design, hardware, and software. Each is touched on briefly below.

It would be difficult to overstate the scale and scope of the integration effort. Among other things, it involved over 100 business processes, many of which were integrative between information systems and engineering and/or operations systems. To help facilitate, a programming and object language was developed to enable these different systems to communicate with each other via one set of objects.

1.2.1 OEM

In working with car partner Renault, we had to remain focused on the end goal of making an electric car appealing to the mass market to maximize impact and help Israel get off oil. To that end, we needed a car that could be the number one or only car for a family, as well as one that could serve high-mileage drivers (who consume a disproportionate share of gasoline and pay the highest fuel bills). While battery switch can enable other market segments, such as taxis and service fleets, to go electric, this was not the primary focus.

There was (and remains) close collaboration with Renault related to the battery, battery-switch components, and the necessary interfaces. The main interfaces are between the vehicle and the network infrastructure itself, which can deliver energy to the car's power train via charging or battery switching.

There is also an important interface with the Better Place in-car connected platform, known as Oscar. It is a key driver interface as well, combining navigation and energy management, communicating with the network and guiding drivers to charging and switching locations based on mobility needs and patterns, and predicting range.

1.2.2 Design

To achieve the goal in Israel and make electric cars appealing to the mass market, design and usability were critically important. We aim to be more convenient and user-friendly than gasoline-powered alternatives. The driver is top of mind at every step of the process.

For example, the charge spots were designed to be simple, approachable and easy to use, without screens, buttons, and credit-card interfaces. Drivers begin charging by tapping a card with RFID functionality on the front of the charge spot. Additional functionality and complexity is kept away from the user. Better Place charge spots are standard, level 2 chargers.

Design was also a key consideration from a network operations standpoint, recognizing the need for charge spots and BSS deployed nationwide to be serviced efficiently.

1.2.3 Hardware

While charge spots were touched on above, developing the BSS was a different and far more complex challenge. The main objective was overcoming the range limitations of electric cars that inhibit adoption and make them less competitive with gas-powered cars when it comes to range extension. To achieve this, we developed a system that could remove and replace a battery automatically, quickly, and safely. Drivers enter a lane in the BSS, which then does the rest. An automated switch platform below the car aligns itself under the battery, washes the undercarriage, initiates the battery release process and lowers the battery from the vehicle. A fully charged battery is then lifted into the waiting car. The process meets or exceeds the benchmark for mass-market drivers today: the five-minute fill-up via a gas station fuel pump.

Among other things, the switch system required: remotely monitored and controlled robotics for automatic battery removal within minutes; battery storage; the ability to cool and quick charge batteries within a BSS under controlled conditions (to avoid battery degradation); battery distribution logic; and the ability for relatively quick deployment. Of course, BSS also must meet all industry safety and reliability standards.

It also was key to design and engineer the BSS to handle battery enclosures of different shapes and

sizes. Some falsely assume Better Place BSS require standardized batteries. We strongly support complying with international automotive and electro-technical standards (and participates in the major standardization bodies to establish standards where they don't yet exist), but we have always maintained that automakers will require different battery form factors, even within their own product lines. Accordingly, accommodating multiple battery types has been a core-engineering requirement from the beginning.

1.2.4 Software

Due to the need to scale, to integrate so many elements, and to make the experience simple and convenient for mass-market drivers, a tremendous amount of software development was required.

Oscar was developed on an Intel-based platform with Windows software and head-unit hardware from Continental. It is a driver support system that delivers navigation, energy management, infotainment, and customer care through the web and mobile devices, as well as the in-dashboard unit. Oscar does everything from trip planning and state-of-charge monitoring to charging and battery switch scheduling to accessing 24x7 support and roadside services. Consistent with the design parameters, it was developed as an open, extensible platform.

Software for the operations center, which manages and functions as the brains of the entire network, is another important element of the solution. We essentially developed a master data center, where the network's intelligence primarily resides. The operations center allows Better Place to monitor the network, including all the batteries in the system, optimize "smart" charging, troubleshoot, interface with the electric grid, and avoid straining it. The operations center software was developed to provide energy services, mobility services for drivers, CRM and billing, roaming, and managed grid services for utilities. The software was developed with a number of global IT partners.

1.2.5 Key lesson

Given the aggressive goal and timeline, the key lesson demonstrated in this area was the importance of setting your parameters and principles (such as scalability and convenience for drivers), from which you cannot deviate, and then adhering to them throughout the journey.

1.3 Go-to-Market Approach

Our go-to-market approach in Israel is somewhat unique, driven in part by the fact that Better Place is importing and selling the Renault Fluence Z.E., as well as kilometer-based membership packages (see "pricing" below). By contrast, in Denmark and Australia, our partnership with Renault leverages the Renault dealer channel, which sells the cars and collaborates with Better Place in marketing the membership packages and unlimited range enabled by battery switch.

How the car is sold and who sells it is certainly one important aspect. However, developing a comprehensive solution, deploying and operating a nationwide network, making electric cars a mass-market proposition, and serving a large number of drivers required Better Place to rely on an ecosystem approach. The rest of this section will highlight a few aspects of this ecosystem.

1.3.1 Fleets

In addition to mass-market consumers, we focused on corporate fleets in Israel at the beginning to line up early demand and prepare for commercial launch. In early 2009, we announced the first group of about 20 "vision partners." These organizations agreed to start converting their employee fleets to electric cars once available. Today, over 400 of the top corporations in Israel, representing about 80,000 potential employee cars, have signed letters or intent to do so. These companies include Cisco, Computer Associates, FedEx, Intel, IBM, Microsoft, Motorola, and Orange. These sophisticated consumers were motivated primarily by the reduced costs. These companies' employees will be among the first wave of drivers.

1.3.2 Experience center

In early 2010, near Tel Aviv, the first Better Place Center opened to the public. This experience center began to expose consumers in Israel to electrified transportation and the network solution that Better Place was developing. Visits culminated with plugging in and test-driving an electric car. More than 75,000 people had visited by the time the center was transformed into a showroom in 2011. Today, drivers are visiting and placing orders for the Renault Fluence Z.E. and a

kilometer-based membership package from Better Place.

1.3.3 Agreements with municipalities and others

At the municipal level, the network is a massive infrastructure project, involving a range of stakeholders in the public and private sectors (more on network planning and deployment follows in Section 1.4).

To facilitate deployment and ensure sufficient network coverage for commercial launch, partnerships and agreements were absolutely necessary. These included partnerships with some of Israel's gas station operators for the deployment of BSS, hundreds of agreements with municipalities and parking lot owners to deploy charge spots, and an agreement with Israel Railways and Better Place to deploy network infrastructure in parking lots at train stations.

As we have learned along the way and we will discuss later, charge spots at public locations are somewhat helpful, but not critical for mass adoption. It is far more important for drivers to have charge spots at home and/or at work, combined with access to BSS for immediate range extension.

1.3.4 Pricing

Data consistently show that cost is a significant barrier to wide-scale adoption of electric cars. To move beyond early adopters and succeed in the mass market, electric cars must be cost-competitive with the cars they seek to replace, on an apples-to-apples basis.

In Israel, we have offered consumers the opportunity to save up to 20 percent on total ownership cost, versus a comparable gas car, when they buy a Renault Fluence Z.E. and a Better Place membership package. They buy the car without the battery and sign up for a membership based on the number of kilometers driven. In this regard, the model is loosely similar to the mobile industry, but drivers pay for kilometres rather than minutes.

By separating ownership of the car and the battery, we are able to offer a competitive alternative to oil, without the volatility of fuel prices (cost is fixed over the duration of the membership). Drivers pay a monthly fee based on how much they drive (less than 20,000 km/year, for example), and then access the network as needed.

The focus is delivering an integrated offering that is more convenient than the alternative. Membership includes energy usage, installation of a personal charge spot, unlimited access to the rest of the network (charge spots and BSS), an inventory of batteries with a guaranteed service level, and 24-hour customer service and support.

The economics of the model work because driving a kilometer powered by electricity is cheaper (cost of electricity plus portion of the battery) than driving a kilometer powered by gas. Those who drive more and consume the most oil, have the opportunity to save the most by switching to electric.

1.3.5 Key lessons

Giving drivers — who live with the short-term volatility (and long-term rise) of oil and fuel prices — the option of locking in a flat monthly rate over a multi-year period is proving to be particularly attractive to many and contributing to overall demand.

Another lesson: approaching corporate-fleet customers first with a more economical solution was important to build early demand well before commercial launch.

1.4 Network planning and deployment

Of course, given the scale involved, the network planning and deployment processes are critical. While both charge spots and BSS are deployed, the planning and deployment phases for switching infrastructure are more complex and therefore require longer lead times, given the spatial, construction and technical components. Key objectives include the application of a scalable, common approach that enables repeatability and consideration for the existence of market-specific requirements and local regulations.

1.4.1 Key steps

Key steps in the planning and deployment process are outlined briefly below:

Network Design – The definition of the quantity and spatial distribution of facilities (BSS and

public charge spots) needed to optimally serve Israel or another given market.

Localization – The definition of elements that must be adjusted. Localization begins with a design review for each facility.

Site Evaluation / Selection – The review of an individual site considers implementation issues such as site access and egress, owner / operator willingness, an initial assessment of engineering, technical considerations and cost estimates. This step includes preparation of a preliminary concept design of the facilities on the site.

Site Acquisition – This step includes preparation of the necessary commercial and legal documentation to acquire a site.

Site Engineering / Permitting – Completion of the site design and development of detailed engineering, using previously localized BSS building designs. This step involves preparation of final engineering work packages that incorporate fabrication, assembly and installation drawings. It also includes any information needed for site construction, such as testing and activation procedures. Building permits must be secured for every site targeted, before initiating site installation activities. Permitting processes vary from city to city, which makes the details a more localized effort.

Construction / Installation – Deployment of infrastructure on-site includes site preparation, building construction for BSS, installation of mechanization modules, site enhancements, inspection, testing and activation.

Network Integration – This step prepares the facility for operation by establishing all the communications channels between the facility and the network's operations center. This also includes final stages of testing and verification.

1.4.2 BSS locations

Better Place uses a BSS Location Optimization Tool to address the challenge of planning the BSS network, considering the geographical complexity of the road network and travel patterns. The model takes into account the paths of drivers from their origins to destinations, the volume of trips on each path, vehicle driving range, and the need for multiple BSS stops on longer round trips. Once locations are defined, it is important to evaluate the applicability of a particular site to meet the functional definitions of the network model design. These considerations mostly concern the driver experience specific to the site, but also include site availability and access to the electrical grid and water supply system.

1.4.3 Key lessons

Given the innovative nature of this nascent industry, local governments are faced with applying existing statutory land-use and environmental planning and permitting processes to infrastructure that has never been encountered. These are precedent-setting initiatives being handled by local governments, and the process is often unchartered. The results are increased costs and extended time lines in the deployment process.

As mentioned, another lesson is that public charge spots are not critical for mass adoption of electric cars if drivers can charge at home and/or at work and access BSS. Public charge spots can serve some supplementary needs, such as longer-distance travel to "work-alternative destinations" (e.g., convention and conference centers, government office complexes, health and educational facilities) as well as communal parking in high-density, residential areas (a variation on home charging facilities). Public charge spots also can help increase visibility and awareness.

1.5 Summary

Four years into the journey, we are entering a new chapter that includes commercialization of the solution. Beginning in 2008, we focused on designing, developing and testing the solution. The next few years are about commercializing the solution in our "proof" countries and scaling. While this is a very exciting time, we also expect challenges as we launch the first mass-market solution for electric cars.

The commercial phase begins with a controlled launch, as we continue to focus on solution readiness. We are not constrained by demand. During this phase, we will continue to raise the bar on performance, organizational readiness, and the level of service for drivers.

In the past, consumers have been forced to compromise on cost, convenience or both when buying an electric car. For the first time, consumers have the option of buying an electric

car that is more affordable than a comparable gasoline-powered car and offers the same freedom of drive.

While much work remains, Better Place owes a huge debt of gratitude to its employees, partners, investors and others for their tireless work and support during these critical first four years.

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Wolf is vice president of North America for Better Place. Previously, he was president of Sterna Technologies USA, the pioneer of Business Positioning Systems software, and held numerous positions during a 10-year career at SAP AG, including senior vice president of Strategic Initiatives and senior vice president of New Product Introductions.