EV Wireless Charging Adapter

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1. Executive Summary

While peak oil is a major sustainability concern, it will also present significant business opportunities. Rising gasoline pries will hasten the shift to electric vehicles (EVs), causing great demand for EV charging stations. The EV charging station market is estimated to grow at a rate of 32% reaching $400 million annually in North American by 2015.

One disadvantage of the current EV charging stations is that they have to be plugged into the car each time it is used. While this might not be bothersome to lead users of EVs, it will present an unmet need when moving into the early adopter market and beyond.

Wireless charging of EVs is practical and the EasyCharge unit can be manufactured for about $1,000, wholesaled for $1,500 and retailed for $2,000. The business opportunity for EasyCharge is about $140 million in five years.

There is not much competition in the wireless charging market. However, there are some patents around wireless power transfer technology and it will likely need to be licensed from others.

To penetrate the market, it will be necessary to first train and incentivize EV dealers to educate EV buyers on why they want the EasyCharge wireless charging adapter. Later, direct marketing campaigns can bring this message directly to potential EV buyers. Eventually, car manufacturers can be enlisted to OEM EasyCharge and build it into their EVs.

2. Market Research & Customer Need Analysis

Our initial market research focused on finding out how to make home charging as convenient and efficient as possible.

We first concentrated on informational interviews. We contacted several people in different stakeholder groups and conducted informal informational interviews regarding their needs, thoughts and expectations of home EV charging stations. The first part was open-ended questions and then specific questions were asked.

The information interviews produced some specific and interesting findings. Firstly, safety was a common concern. Secondly, it was suggested that it would be helpful if the EV was able to plug itself in "like a Roomba" (the robotic vacuum). Thirdly was definitive price information that stated that intelligent charging was worth $200 to $400 to them and that the auto-plug feature would be worth $1,000 to $2,000.

From the informational interviews and EV forum analysis, we created composite profiles of potential customers. As we moved through the design process, we kept coming back to these user profiles to make sure that the product filled their needs.

Nathan is 45, lives in Berkeley and has a high-tech job. He is very green-minded and loves his RAV4 EV. He doesn't mind plugging it in and spends a lot of time in the garage anyways tinkering with things. Because of his concern about the environment, he thinks that off-peak charging should be mandatory. In the summer, he waits until right before he goes to bed at midnight to come out to the garage to plug in his car.

Morgan is 40 and married to Nathan. She wasn't very keen on the idea of having to plug it in all the time (and is a little scared of electricity), so her husband promised to do it for her. Once, both Nathan and Morgan forgot to unplug the car and Morgan drove away ripping out the plug! (Luckily this caused just a little damage to the plug that Nathan was able to fix.)

Sean is 26 and lives in LA. While not mechanical or particularly green-minded, he still thinks it would be cool to have an EV. He has been doing a lot of research but hasn't decided on which EV he wants to buy. He realizes that he will have to have a home charging station installed in his garage and his main concern is that it is safe, but he also would like it to be convenient too. He is not sure if he needs auto plug-in, so he will try it first and add it later if he gets tired of plugging it in all the time.

Bethany is 58 and lives in Sacramento. She doesn't think much about the environment but will sometimes buy eco-friendly products if they don't cost much more. She makes lot of short trips and really hates to go to the gas station because of the smell and the $40 fill up cost. She likes the idea of an EV but was surprised to learn that she might have to plug in her EV every night.

We initially considered an automated charging interface that would involved a robotic mechanical arm that would insert the standard charging plug. (The industry has standardized on the SAE J1772 connector, which will fit all of the electric vehicles that will begin shipping later this year.) In our research effort, we found a solution that already uses a similar methodology to automate fueling gasoline based cars. Unfortunately, it sells for over $100,000 and we don't anticipate that the cost would ever come down sufficiently for it to be affordable for private use. Therefore, we decided to focus on wireless charging through magnetic induction.

To determine demand for a wireless charging system, we initially focused on lead users - those that already had EVs. We discovered that very few of these users would be willing to buy the EasyCharge. However, since these were lead users and EVs were not yet available, we felt that this fell into the category of issues that are well represented by Dr. Rafinejad's statement "Customers may not always be able to articulate or recognize their needs." (Rafinejad, 2007).

Later, we surveyed a group of likely early adopters and received a 42% positive result. Future surveys should include early and late majority users to determine if those groups would have an even higher positive response rate.

While the target retail price of $2,000 seemed high to many users, this could be rolled into the financing of the vehicle and add only $50 per month to the total payment. In addition, users often pay up to $5,000 additional for convenience packages that include power windows among other conveniences (Gold, n.d.).

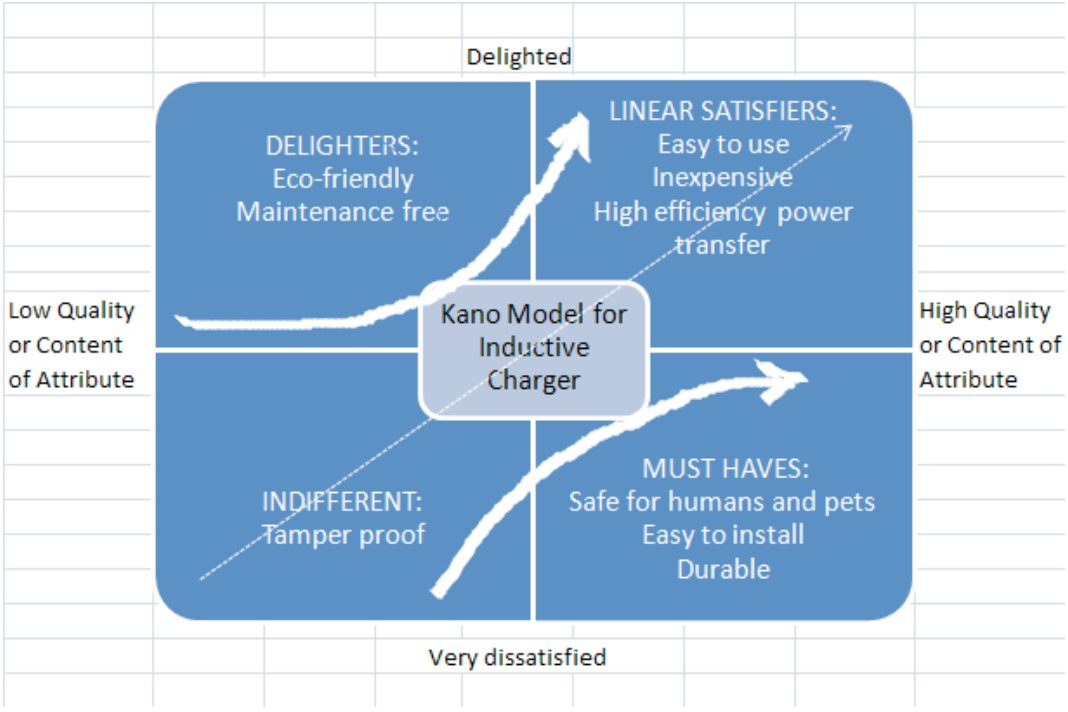
3. Product Performance Requirements & Competitive Differentiators

The main competition for the EasyCharge will be manual chargers. Therefore, the competitive differentiator will be that the EasyCharge avoids the burden of having to plug and unplug the EV each time it is used.

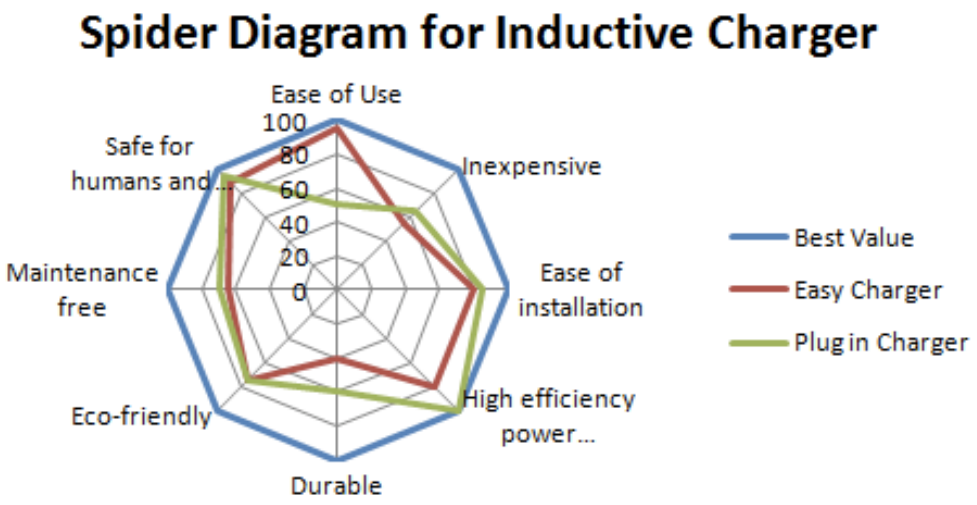
Here are the product performance requirements:

- **Safe**: Cannot pose danger to humans, pets or property
- **Rugged**: Needs to survive 150,000 miles of normal driving as well as hitting a curb once a month for 10 years.
- **Environmentally friendly**: Cannot contain harmful materials and needs to comply with RoHS and WEEE (RoHS & WEEE, n.d.).
- **Efficient**: Can only require 20% more power than a manual plug-in charger
- **Easy to use**: Drivers need to be able to park the car in the correct charging position with no training and only a simple explanation of the parking requirements.

Kano Diagram



Spider Map


Spider Diagram for Inductive Charger
Ease of Use
Inexpensive
Ease of installation
High efficiency power...
Durable
Eco-friendly
Maintenance free
Safe for humans and...
100
80
60
40
20
0
Best Value
Easy Charger
Plug in Charger

4. Product Design Description and Operating Features

4.1 Product Design Overview

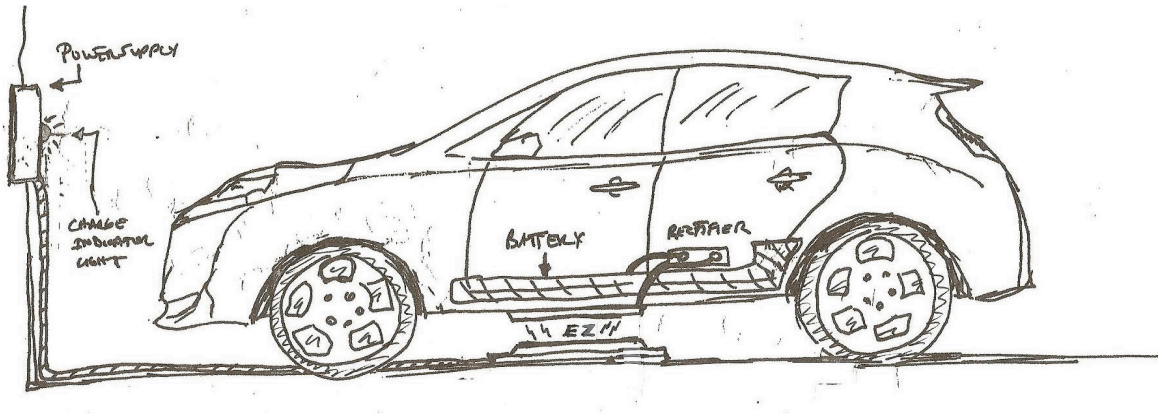
Wireless charging, also referred to as inductive charging, transmits power over a limited distance using magnetic resonance. A coil at the transmitting end is attached to an oscillator that allows transmission at a specific frequency. A magnetic field is generated in the coil, which is similar to the wound coil that appears at either end of a power transformer. This field moves through short distances with minimal degradation and is safer then the radio waves that move through our atmosphere. Another coil, tuned to the same frequency, receives the signal and converts it back into electricity.

In order to use this technology in an electric vehicle, the receiving coil is attached to the underside of the vehicle and connected in parallel to the charging connector, allowing the charging socket to be used when necessary.

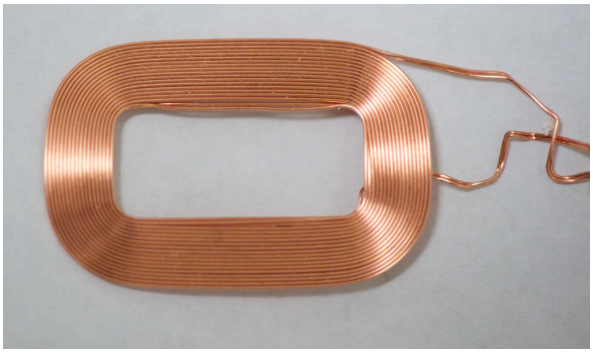
A transmission coil is typically placed on the floor of the garage in a specific area to allow it to be close to the receiving coil while the vehicle is parked. Once the transmission coil detects that the vehicle is present, it activates the charging process, which from the vehicle's perspective is identical to what would occur if the vehicle were directly plugged in. If the vehicle is programmed to delay charging until rates are low, the system will respond accordingly and wait to begin the charging process.

4.2 Product Prototype

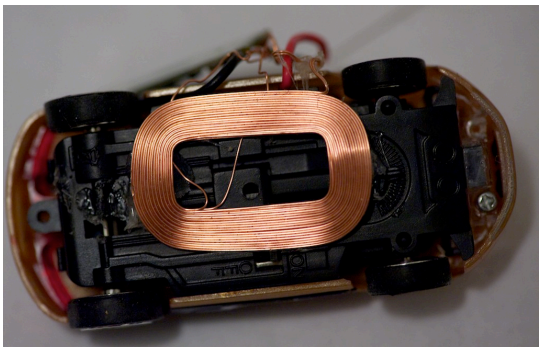
We considered a number of ideas for our concept, the first of which places the receiving coil directly under the car with the complementary coil on a mat located on the floor of the garage.



Our proof of concept is based on a small radio controlled car, and as in our planned implementation, the receiver coil is wired in parallel with the charging plug on the vehicle. The charger coil is on the floor of the garage and located in an embedded charging unit. This bench prototype embeds the charger and the charging coil into the same unit. The actual product will integrate into an existing charging station as shown in the drawing above

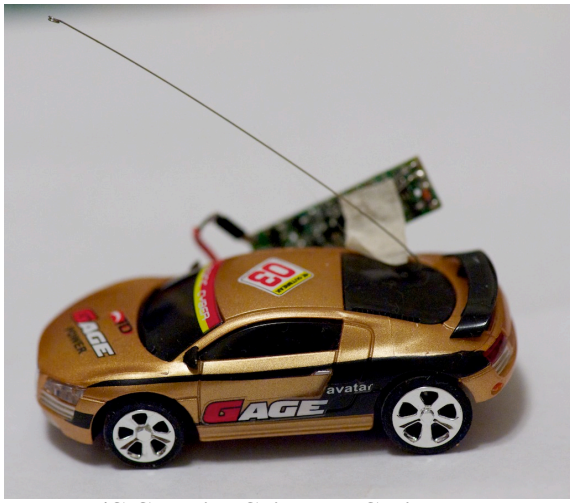


Receiver Coil

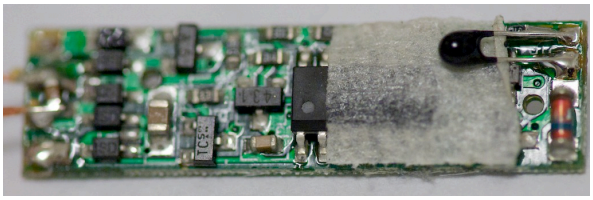


Underside of R/C Car

Energizer Inductive Charger



R/C Car with Coil and PCB installed



Receiver PCB

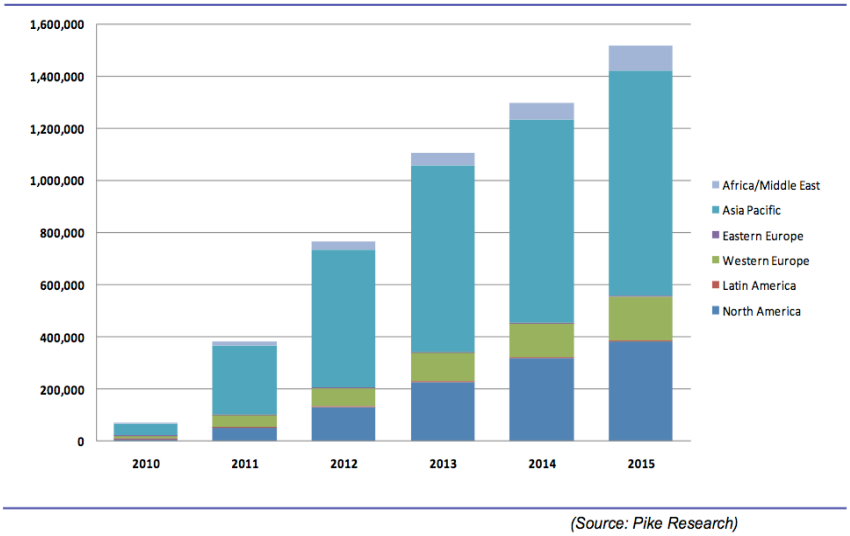
Prototype Garage with Charger and Car

5. Business Model

5.1 Market Size

A 2009 study from Pike Research estimates that the EV charging station will start growing slowly in 2010, double each year for the next few years, and then reach a 32% growth rate in 2013. By 2015, the annual, worldwide rate will reach 1.5 million EV charging stations, which represents a $1.9 billion market (Gartner & Wheelock, 2009).

Chart 1.1 Total EV Charging Station Unit Sales by Region, World Markets: 2010-2015

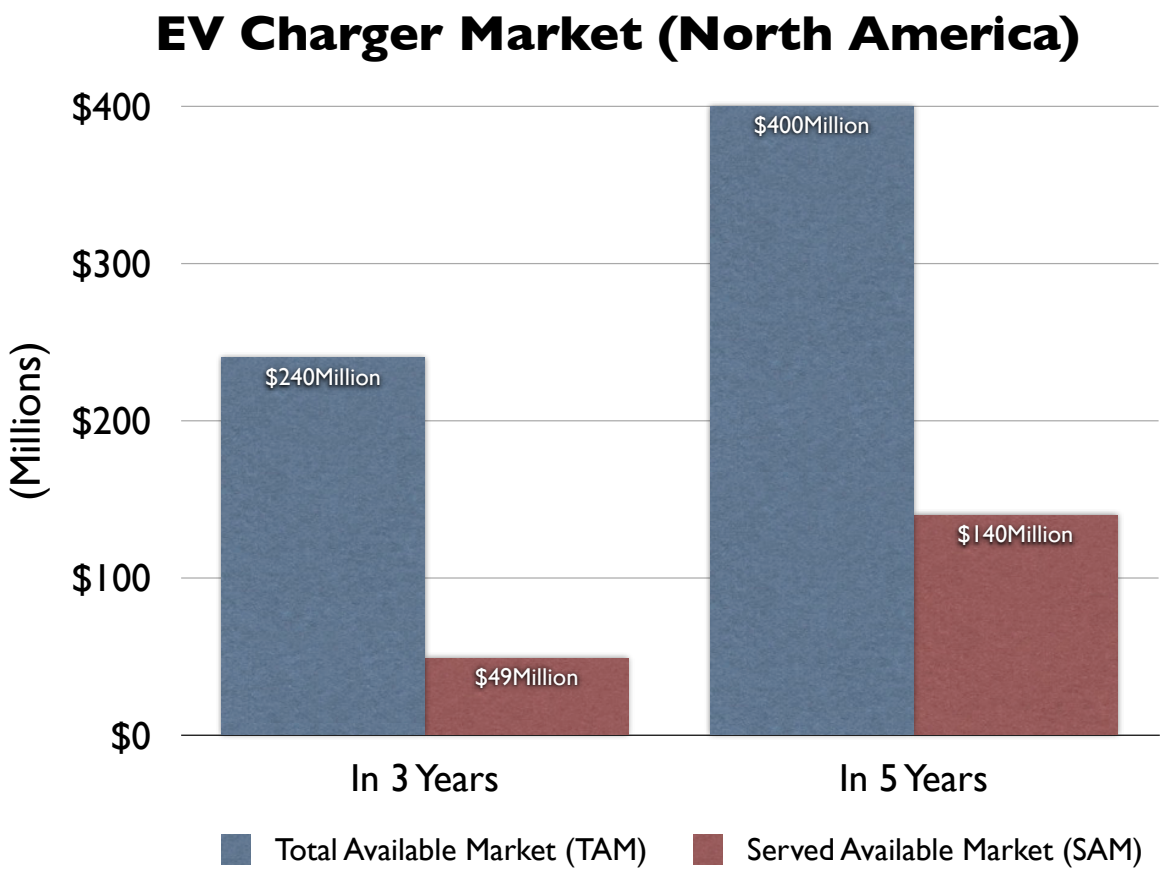


(Source: Pike Research)

(Gartner & Wheelock, 2009)

The majority of this growth will be in the Asia Pacific market, while the total available market (TAM) in North America is expected to reach $400 million by 2015 (Gartner & Wheelock, 2009) Of this, 51% are estimated to be residential chargers and we expect to gain a 40% market share of those (Survey, April 24, 2010) in 3 years and 70% share in 5 years, putting the served available market (SAM) size at $140 million in 5 years.

Market Size	**In 3 Years**	**In 5 years**
TAM	$240 million	$400 million
Home Chargers	51%	51%
Market Share	40%	70%
SAM	$49 million	$140 million



5.2 Competitors

Currently, there is not much competition in the wireless charging market. The primary competitor is Evatran with their PlugLessPower solution. They are currently doing limited field trials with their wireless charging product and plan to have a production product ready in early 2011. Their solution specifically targets public charging with installation in parking lots. They will be installing a receiver coil on the vehicle and the charging coil will be embedded within a concrete bumper, which the car will be parked against in the parking lot. Potential competitors in the future may include industrial producers of inductive charging equipment as well as the manufacturers of the electric vehicles themselves. Nissan has already discussed development of an inductive charging solution, but no plans to introduce it commercially have been announced (See Appendix A: Competitor SWOT).

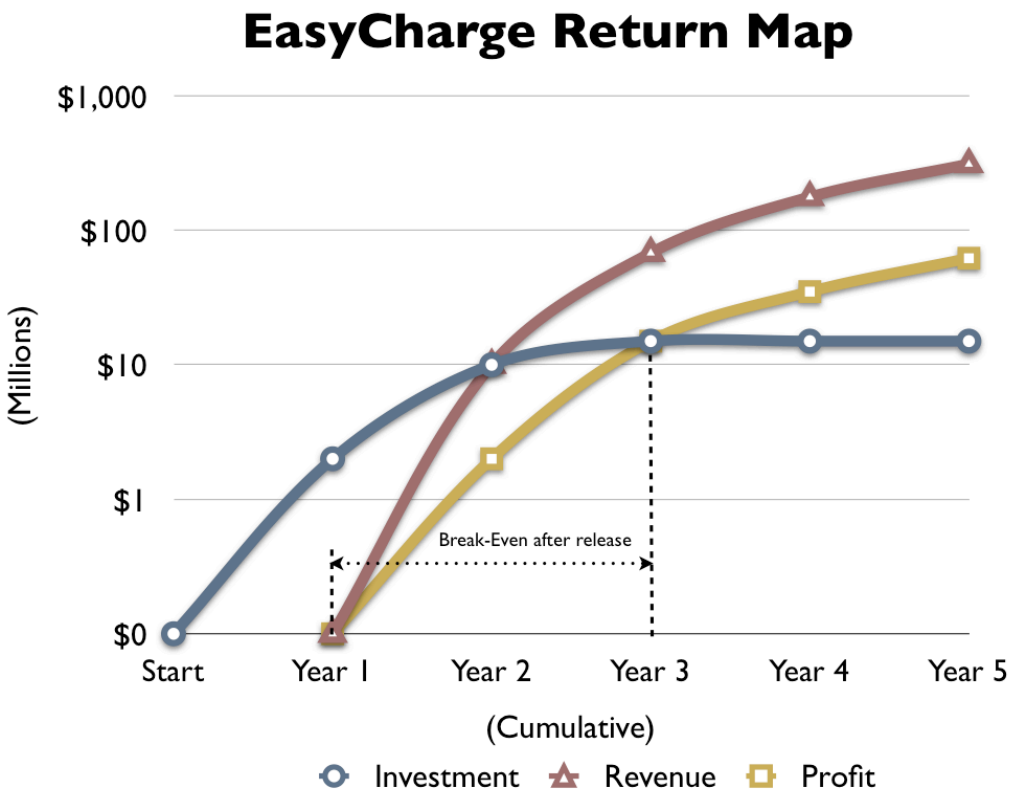
While it is likely that the automotive manufacturers will be looking into this and may come out with some products, they will likely be specific to their brand, which will limit their market acceptance (See Appendix A: Context SWOT).

5.3 Return Map

Our financial return analysis calls for a $15 million total investment with the first product shipped one year after start and a break-even time after product release (BEAR) of three years.

Assumptions

- Revenue is the SAM
- Net margin is 20%
- $15 million total investment



6. Market Penetration Strategy

6.1 Point of Sale Promotion

The compelling reason for the customer to buy an EasyCharge unit is for convenience and assurance that their vehicle will always be charged.

Product Value Matrix

	Stakeholder				
	PEV Buyer	**PEV Dealer**	**PEV Mechanic**	**PEV Homeowner**	**Future Society**
Purpose	Charging	New revenue stream	Labor	Safer product	Recycle
Physical	Convenience	Inventory space	Tool space	More aesthetic installation	Minimal landfill
Cognitive	Parking PEV	Product knowledge	Installation knowledge	Energy efficiency knowledge	Energy efficiency knowledge
Emotional	Prestige	Prestige	Task Satisfaction	Prestige	Pride in recycling

Since EV buyers will have no experience with plugging in the EVs after each trip, they will not be able to reliably predict how much of an inconvenience this will be. So in order to penetrate this market, it will be necessary to enlist the car dealer to explain the advantages at the point of purchase and motivate the dealer to do so by providing a large commission.

Actors

Initiator	Car Dealer
Influencer	Car Dealer
Decider	Reluctant user
Purchaser	Couple
User	Reluctant user

In addition, selling EasyCharge as a dealer add-on means that it can be rolled into the financing of the car and cost less than $50 per month. There may also be a federal tax credit that can be applied to half the cost of the unit.

6.2 Roadmap

As the market moves from lead users to early adopters and then early majority, the marketing strategy will change. For the lead users, the above strategy of enlisting the car dealer to push the product at the point-of-sale will be the dominant strategy. As the market moves into the early adopter phase, marketing can be done to potential EV buyers to develop demand for wireless charging. Then, as the market matures into the early majority phase, car manufacturers will be targeted to build the EasyCharge receivers directly into their EVs.

In addition, while this report focuses on home charging, public wireless charging has even more potential due to aggravation and danger of high power charging cords snaking through public space. However, in order for public wireless charging to become widespread, standards will need to be developed so that all charging station transmitters and car receivers will inter-operate.

7. Product Development Plan

Our technology will require the following components: Two flat, large gauge wires to create the coils, an oscillator circuit to create the correct frequency to transmit the energy, and a receiving circuit that converts the energy into a form that can be utilized by the vehicle's charging system. The coils will need to be encased in a resin (or similar substance) that will protect them but not interfere with their function. A special plastic plate will further protect the coil and electronics module when they are installed on the underside of the vehicle.

Unknowns include: The cost of licensing the required technology, most likely from Witricity, the specific gauge required for the wires, the frequency required for optimal transmission, the conditioning, if any, that will be required prior to deliver the energy to the vehicle's rectifier circuit, and the method we will employ for attaching this to the underside of the vehicle.

We have created a prototype to demonstrate this technology. The prototype has been created using an inductively enabled battery back designed for the Nintendo Wii video game system. We have installed the coil and electronics from the battery pack onto a radio controlled model car. We have also built a model garage around the inductive charger and will illustrate wireless transfer of power between the vehicle and charger. This technology is a simplified and scaled down version of the technology we propose for our new product.

7.1 Design/Development Tasks

- Evaluate existing technologies, determine potential to scale up to full level 2 charging capacity
- Evaluate cost for licensing existing technology (Witricity) and perform cost/benefit analysis of using it vs. developing new proprietary technology
- Determine standardized mounting method and location on vehicle for receiver coil. Determine how to minimize potential loss to vehicle clearance while providing a rugged, protective cover with minimal thickness.
- Performance Requirements
    - Socket connector for J1772 plug attached to pad (transmitter)
    - Cover for wire to avoid trip hazard on garage floor
    - Must provide Level 2 charging capability (220 volts, 30 amps)
- Determine how to insure that optimal connection is made assuring a successful charge.

7.2 Prototyping Plans

Alpha Prototype Plan

- Create agreement with Witricity to utilize their technology for an alpha product
- Work with Witricity to determine optimal integration of their technology in our application
- Hire/contract engineering team to implement technology
- Engage local dealership(s) as design partner
- Identify materials required including circuitry, encasing and mounting requirements
- Obtain EV to use for alpha implementation
- Produce alpha product
- Document lessons learned
- Expand relationships in preparation for Beta prototype.

Beta Prototype Plan

- Enhance design based on input from alpha process
- Produce beta product
- Identify beta user group
- Deploy beta product and capture feedback
- Finalize and release product documentation
- Assess profitability based on revised data captured from customer feedback
- Produce report of product compliance

7.3 Required Resources

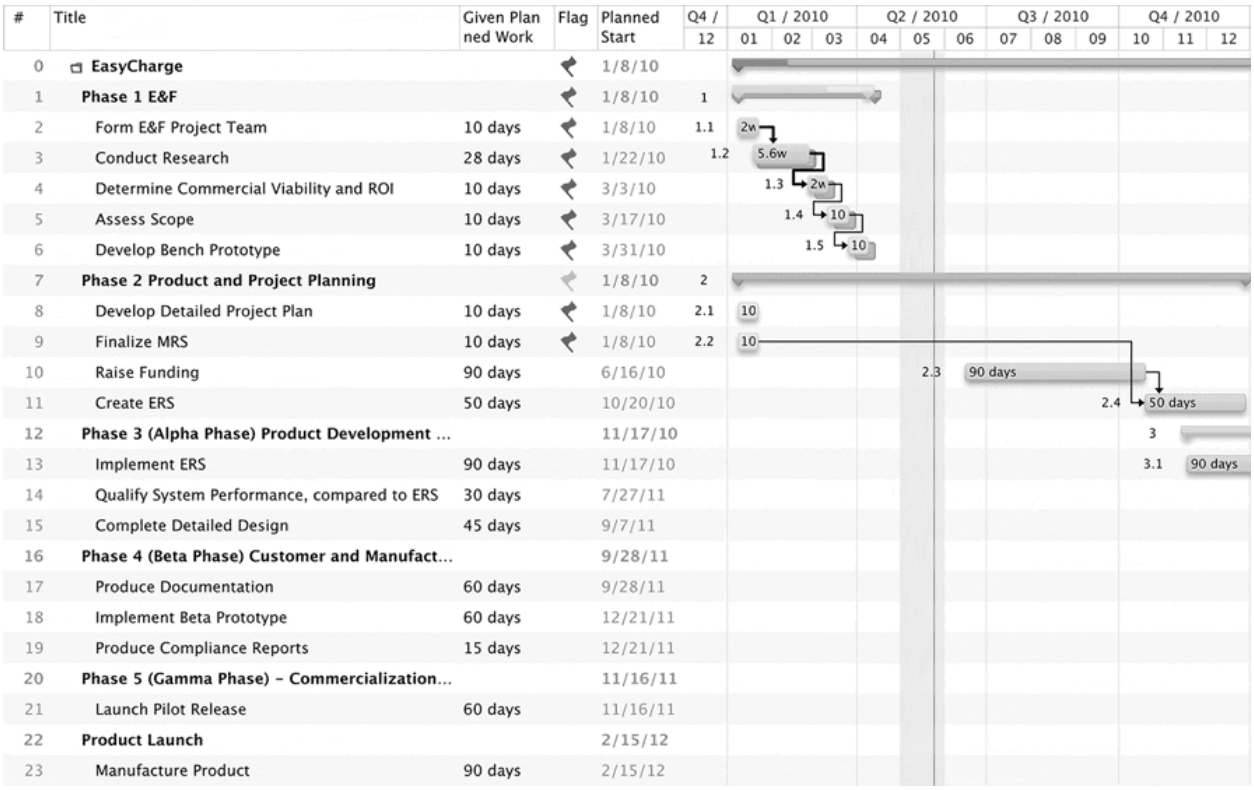
- Electrical Engineer
- Working garage space
- Electric car
- Charging station
- Materials (TBD)

7.4 Development Schedule

Activity	Planned Work	Planned Start
Phase 1 E&F		**Jan 8, 2010**
Form E&F Project Team	10 days	Jan 8, 2010
Conduct Research	28 days	Jan 22, 2010
Determine Commercial Viability and ROI	10 days	Mar 3, 2010
Assess Scope	10 days	Mar 17, 2010
Develop Bench Prototype	10 days	Mar 31, 2010
Phase 2 Product and Project Planning		**Jan 8, 2010**
Develop Detailed Project Plan	10 days	Jan 8, 2010
Finalize MRS	10 days	Jan 8, 2010
Raise Funding	90 days	Jun 16, 2010
Create ERS	50 days	Oct 20, 2010
Phase 3 (Alpha) Product Development and Characterization		**Nov 17, 2010**
Implement ERS	90 days	Nov 17, 2010
Qualify System Performance, compared to ERS	30 days	Jul 27, 2011
Complete Detailed Design	45 days	Sep 7, 2011
Phase 4 (Beta) Customer and Manufacturing Qualifications		**Sep 28, 2011**
Produce Documentation	60 days	Sep 28, 2011
Implement Beta Prototype	60 days	Dec 21, 2011
Produce Compliance Reports	15 days	Dec 21, 2011
Phase 5 (Gamma) - Commercialization and Production Ramp		**Nov 16, 2011**
Launch Pilot Release	60 days	Nov 16, 2011
Product Launch		**Feb 15, 2012**
Manufacture Product	90 days	Feb 15, 2012

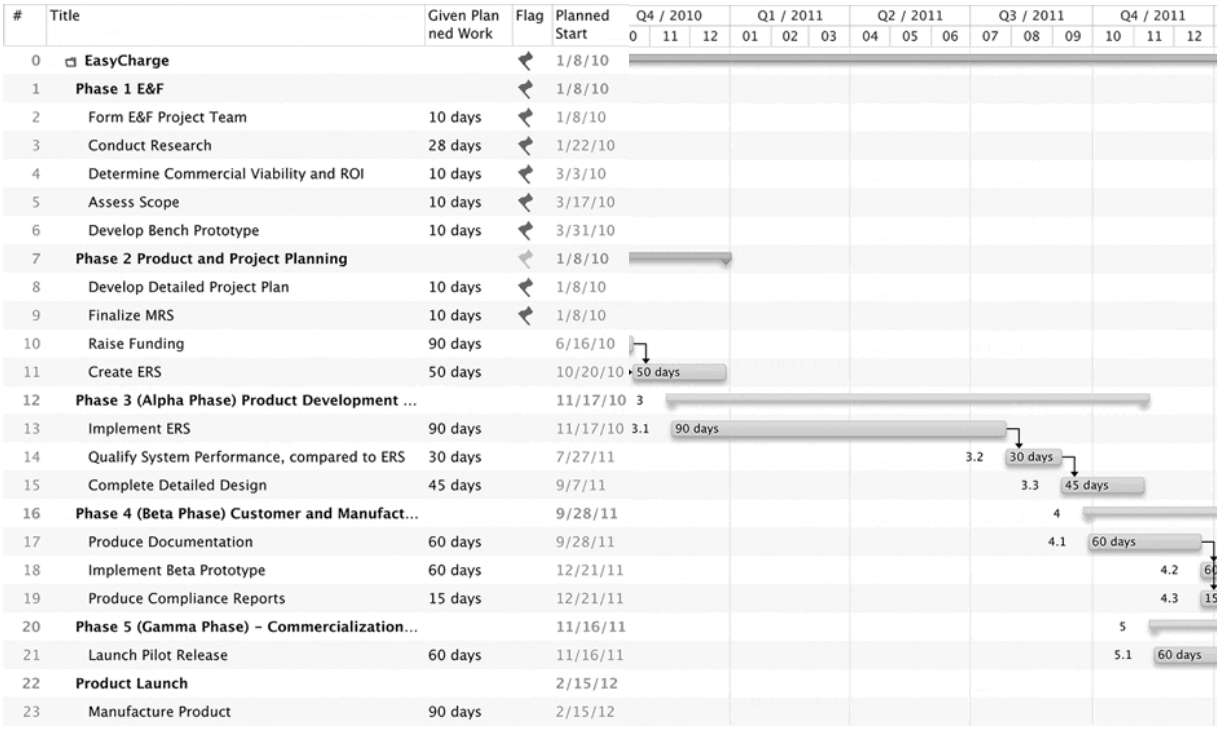
7.5 Gantt Chart

First Year



#	Title	Given Planned Work	Flag	Planned Start	Q4 / 12
0	**EasyCharge**			1/8/10	
1	**Phase 1 E&F**			1/8/10	1
2	Form E&F Project Team	10 days		1/8/10	1.1
3	Conduct Research	28 days		1/22/10	1.2
4	Determine Commercial Viability and ROI	10 days		3/3/10	
5	Assess Scope	10 days		3/17/10	
6	Develop Bench Prototype	10 days		3/31/10	
7	**Phase 2 Product and Project Planning**			1/8/10	2
8	Develop Detailed Project Plan	10 days		1/8/10	2.1
9	Finalize MRS	10 days		1/8/10	2.2
10	Raise Funding	90 days		6/16/10	
11	Create ERS	50 days		10/20/10	
12	**Phase 3 (Alpha Phase) Product Development ...**			11/17/10	
13	Implement ERS	90 days		11/17/10	
14	Qualify System Performance, compared to ERS	30 days		7/27/11	
15	Complete Detailed Design	45 days		9/7/11	
16	**Phase 4 (Beta Phase) Customer and Manufact...**			9/28/11	
17	Produce Documentation	60 days		9/28/11	
18	Implement Beta Prototype	60 days		12/21/11	
19	Produce Compliance Reports	15 days		12/21/11	
20	**Phase 5 (Gamma Phase) – Commercialization...**			11/16/11	
21	Launch Pilot Release	60 days		11/16/11	
22	**Product Launch**			2/15/12	
23	Manufacture Product	90 days		2/15/12	

Second Year



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3	Conduct Research	28 days		1/22/10
4	Determine Commercial Viability and ROI	10 days		3/3/10
5	Assess Scope	10 days		3/17/10
6	Develop Bench Prototype	10 days		3/31/10
7	**Phase 2 Product and Project Planning**			1/8/10
8	Develop Detailed Project Plan	10 days		1/8/10
9	Finalize MRS	10 days		1/8/10
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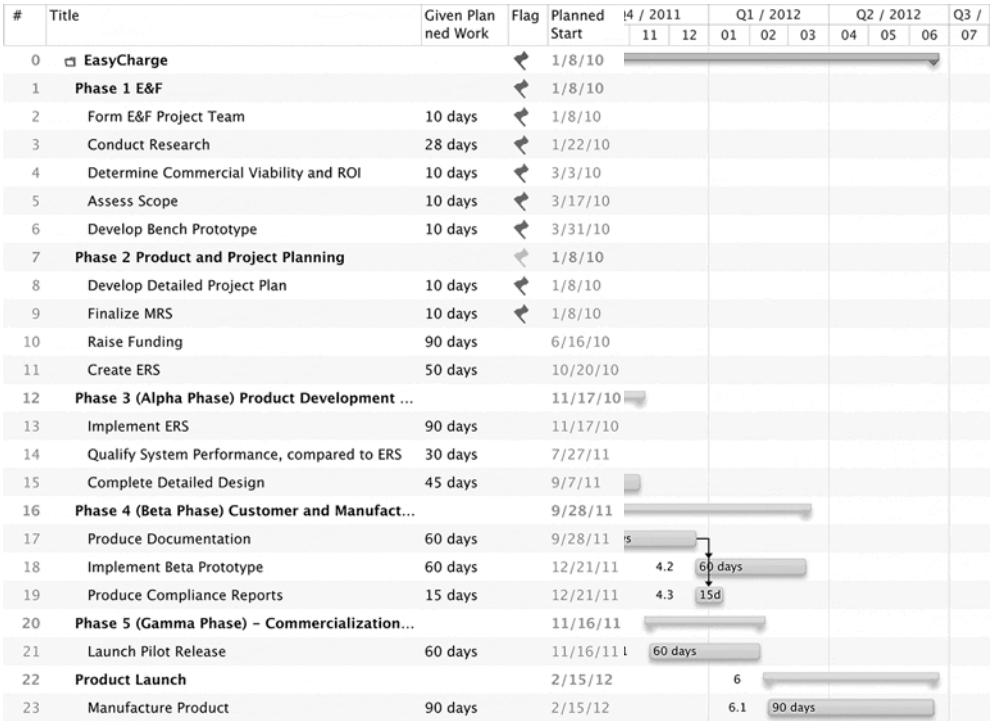
19	Produce Compliance Reports	15 days		12/21/11
20	**Phase 5 (Gamma Phase) – Commercialization...**			11/16/11
21	Launch Pilot Release	60 days		11/16/11
22	**Product Launch**			2/15/12
23	Manufacture Product	90 days		2/15/12

Third Year



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0	**EasyCharge**			1/8/10
1	**Phase 1 E&F**			1/8/10
2	Form E&F Project Team	10 days		1/8/10
3	Conduct Research	28 days		1/22/10
4	Determine Commercial Viability and ROI	10 days		3/3/10
5	Assess Scope	10 days		3/17/10
6	Develop Bench Prototype	10 days		3/31/10
7	**Phase 2 Product and Project Planning**			1/8/10
8	Develop Detailed Project Plan	10 days		1/8/10
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Appendix A: SWOT

(SWOT = Strengths, Weaknesses, Opportunities, Threats)

Context SWOT

- **Strength-Opportunity Strategies**
    - **Leadership**: Use leadership position as first-mover automotive dealer partner to offer inductive chargers for EVs.
    - **Convenience**: Inductive charger product increases consumer time efficiency and eliminates risk of failure to charge vehicle.
    - **Safety and Reliability**: Inductive charger product provides complete consumer and animal safety from shocks, with no moving parts and or exposed contact surfaces unlike other charging products. Minimal moving parts increases product reliability.
    - **Aesthetics**: Inductive charger product eliminates tripping hazard of charging cable.
    - **Marketing**: Inductive charger pads offer subtle and unobtrusive branding opportunities for inductive charger product or other business partners.
    - **Adaptation**: Inductive charger product enhances EV adoption rates by making charging seamless to the consumer.
    - **Eco-friendly and Universal**: Inductive charger product utilizes non-toxic and renewable materials and fully meets RoHs and WEEI requirements, while its design is easily adaptable to any make or model of EV.
- **Strength-Threat Strategies**
    - **Reduce solvency anxiety**: Promote self-sustaining business model that leverages first mover dealer relationships to improve cash flow from product sales (front-end) and residual income from multiple branding opportunities for charger pads (back-end).
- **Weakness-Opportunity Strategies**
    - **Alignment**: Small brand equity can be enhanced by aligning with and leveraging larger brands to increase brand awareness and equity transference opportunities.
    - **Social media**: Expand use of social media tools like Facebook, Twitter and Green blogs to aggressively build brand awareness and number of touch points with targeted market segments.

- **Weakness-Threat Strategies**
    - **Convenience**: Promote convenience over power transfer efficiency losses to mitigate perception of reduced ROI over long-term energy use.
    - **Endorsements**: Promote celebrity endorsed product use of charging product to enhance premium pricing for targeted market segments, since potential downward pricing pressure may exist once comparable products exist in the marketplace.

Competitor SWOT

- **Evatran Plugless Power**
    - **Strengths**: This competitor represents a similar size and scope of our company. Evatran has a website and is promoting the field-testing of its products.
    - **Weaknesses**: Small size. Response: Grow our market share faster.
    - **Opportunities**: East coast based and can expand into West coast.
    - **Threats**: Preliminary products being still being field-tested. Response: Finish our prototypes and start testing as soon as possible.

- **Conductrix Wampfler IPT**
    - **Strengths**: Worldwide MNC with deep pockets.
    - **Weaknesses**: May not be a niche player. Response: We need to be the first mover.
    - **Opportunities**: Experienced IPT technology in industrial settings and can readily transfer into new markets.
    - **Threats**: Niche players.

- **Uniservices IPT**
    - **Strengths**: Technology and design.
    - **Weaknesses**: Based in New Zealand. Response: Build out the North America market first.
    - **Opportunities**: Can leverage other players.
    - **Threats**: Niche players.