Wireless Charging System for Electric Vehicles

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Commercialization Manager: David Sims
Electric Vehicles are gaining popularity...

...but you can't go very far!
The solution has been around for 100 years!
ORNL has a suite of technologies for wireless vehicle charging

ORNL scientists have developed a suite of technologies to solve the problem of wirelessly charging electric vehicles while parked *or in motion*

- Light weight air-coupled system with operating frequency optimized for maximum transfer*
- Nano-technology improved charging coils for reduced energy loss*
- Wireless alignment system to maximize charging efficiency*
- Suite of communication and testing methods and tools*

*Patent Pending*
Technology Opportunity

• Stage of development
  – Today: TRL 4-5
  – July target: TRL 7
  – A laboratory prototype charging system has been developed

• Next Steps
  – Design and fabricate next-gen coils
  – Integrate system on “mule” vehicle
  – Identify industrial partner to integrate system into a Plug-in Electric Vehicle (PEV)

• Opportunities & Challenges
  – No “show stoppers”
  – ORNL is in a technology leadership position
  – The space is becoming crowded
  – New vehicle deployment requires EV partner
## Technology Leadership

<table>
<thead>
<tr>
<th>Unique Technology Features</th>
<th>Performance Indicators</th>
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<tbody>
<tr>
<td>Minimum component count on vehicle</td>
<td>Lower cost&lt;br&gt;Lower weight&lt;br&gt;Increased reliability&lt;br&gt;Scalability&lt;br&gt;Adaptability</td>
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<tr>
<td>Optimized charging frequency</td>
<td>Improved charging efficiency&lt;br&gt;Reduced crosstalk</td>
</tr>
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<td>Carbon nanotube or graphene wire coating</td>
<td>Reduced “skin effect” losses in transmitting and receiving coils (research in progress)</td>
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<td>Novel positioning and control technologies</td>
<td>Increased charging efficiency; clear path to in motion (dynamic) charging</td>
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<tr>
<td>Designed to work with any power input</td>
<td>Increased versatility</td>
</tr>
<tr>
<td>System design approach</td>
<td>Comprehensive solution attacking all aspects of wireless charging problem</td>
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### Applications – Target Customers – Current Practice

<table>
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<tr>
<th>Application Description</th>
<th>Target Customers</th>
<th>Current Practice</th>
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<tbody>
<tr>
<td>After-market stationary wireless vehicle charging system</td>
<td>Plug-in Electric Vehicle Owners (private and fleet)</td>
<td>Plug-in</td>
</tr>
<tr>
<td>Closed route electric vehicles (e.g. airport bus) with “bus stop” charging pads</td>
<td>Airports, municipalities, universities, etc.</td>
<td>Gasoline vehicles; pause-to-charge plug-in</td>
</tr>
<tr>
<td>Parking lot pay-per-charge systems</td>
<td>Federal / State / Local Government</td>
<td>Pilot plug-in charging stations</td>
</tr>
<tr>
<td>OEM Electric Vehicles</td>
<td>OEM EV Manufacturers</td>
<td>Plug-in; internal technology development</td>
</tr>
<tr>
<td>Street / highway in-motion charging systems</td>
<td>Federal / State / Local Government</td>
<td>Pilot plug-in charging stations</td>
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**Market Adoption Path**

1. PEV After market retrofit
2. Closed route electric vehicles
3. Wireless charging parking facilities
4. Dynamic charging

**Plug-in Electric Vehicle Sales**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales</th>
</tr>
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<tbody>
<tr>
<td>2011</td>
<td>114,000</td>
</tr>
<tr>
<td>2017</td>
<td>5.2 million</td>
</tr>
</tbody>
</table>

-Pike Research, August 2011

(http://www.pikereresearch.com/)
## Competitive Differentiation

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Manufacturer</th>
<th>Relevance</th>
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<tbody>
<tr>
<td>Delphi Wireless Charging System</td>
<td>Delphi Partner with startup WiTricity (MIT technology licensee). WiTricity also engaged with Toyota.</td>
<td>Sharply resonant magnetic coupling (not inductive); 3.3 kW across 20 cm air gaps; product in development – early launch in progress</td>
</tr>
<tr>
<td>Plugless Power</td>
<td>Evatran Partner with Yazaki</td>
<td>PEV retrofit solution. 3.3kW output; 90% transfer efficiency claimed (earlier reports indicated 70%); product launch in April 2012. $5000 projected installed price.</td>
</tr>
<tr>
<td>Volvo C30 Electric</td>
<td>Volvo Partner with Belgium's state-owned Flanders' Drive</td>
<td>OEM wireless charging solution.</td>
</tr>
<tr>
<td>TBD</td>
<td>Siemens &amp; BMW</td>
<td>90% transfer efficiency @ 15 cm; 3.6 kW; in development with prototypes deployed.</td>
</tr>
<tr>
<td>ORNL Project</td>
<td></td>
<td>90-94% transfer efficiency @ 25 cm air gap; &gt;4 kW demonstrated; 7 kW targeted in 2012</td>
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</tbody>
</table>
The Tier Ones are finding partners
Revenue and Profit Potential

• What is the estimated ($ range) that the product/service will sell for?
  – Vehicle receiver: <$500
  – Power converter: ~$3000

• What is the estimated ($ range) that the product/service will cost?
  – Vehicle receiver: ~$250; Transmitter: ~$1500
Electric vehicle charging is a rapidly growing market

Estimated EV charging station global market:

- 2010: $69 M
- 2013: $1.1 B
- 2015: $6.5 B

$7.00
$6.00
$5.00
$4.00
$3.00
$2.00
$1.00

148% CAGR

Late breaking news

Qualcomm acquires 18 month old Auckland University wireless charging startup. Deal rumored to be valued at $35M.

University sells off wireless technology

Catherine Harris

Last updated 05:00 10/11/2011

In what is claimed to be the biggest commercial deal by a New Zealand university or Crown research institute, Auckland University has sold its spinoff HaloIP to a wireless technology giant.

The sale to US Nasdaq-listed Qualcomm – a mobile phone computer chip company – could eventually lead to cheaper electric cars by making wireless charging technology for them more readily available.

Terms of the deal are under wraps but Peter Lee, chief executive of UniServices, the university’s commercial arm, said it was larger than any done before by a New Zealand university or CRI. Just before the dot-com crash, Australian telco Telstra bought Victoria University’s internet service provider company, Netlink, for A$21 million.

This year, Crown research institute IRL sold a controlling stake in its superconductor technology firm HTS-110 to Dunedin’s Scott Technology for $4.4m.

But an outright sale was unusual in the academic world, said Mike Doig, a policy analyst with Science New Zealand, formerly the Association of Crown Research Institutes. “A company going strictly from university ownership into somebody else’s ownership – that’s quite a rare event.”

HaloIP was set up about a year ago as a joint venture between engineering consultancy Arup and Auckland UniServices to commercialise the Halo technology.

Under the Qualcomm deal, Arup and two seed capital funds will leave the company but Auckland University will retain the intellectual property rights and receive royalties.

Qualcomm will own the assets and licensing right of HaloIP and will commit $500,000 towards supporting further research at Auckland over the next four years. Six staff building prototypes would be kept on.

US financial website Forbes.com said it was an unusual deal for Qualcomm, but “you can certainly imagine how it might be useful for a mobile company to have expertise in wireless charging technology”.

Lee said Halo emerged from 20 years of research at the university’s “power electronics” lab.

The breakthrough came three years ago after scientists Professor John Boys and Associate Professor Grant Covic explored the idea of wireless chargers for electric bikes in China.

After investing $1 million in a demonstration model, Auckland University wowed attendees at a vehicle show in Norway.
Summary

- ORNL has technical leadership in wireless charging
  - Fundamental understanding of the technology
  - Simplest possible vehicle system
  - Software replaces hardware to reduce costs
- ORNL has four patent applications in
- The market is projected to grow rapidly (148% CAGR for all charging stations)
- Until recently the market was owned by start-ups, but the big boys are moving in
- The opportunity to enter the market with disruptive new technology will disappear once the major players have staked out their territory and the standards are established
- A strategy of partnering with Tier One player is critical to success
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www.ornl.gov/partnerships