



Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets

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Project ID #
APE032

SYNTHESIS PARTNERS, LLC



Overview

Timeline

- Start: Oct. 2011
- Finish: Sept. 2012
- Percent complete: 40%

Budget

- Funding for FY12: \$475K

Barriers Addressed

- Paths to radical reductions in automotive electric propulsion systems costs.
- R&D milestones required to achieve the DOE 2015 (\$5/kW) and 2020 (\$3.30/kW) power electronics-only cost targets
- Automated foreign literature search and analysis on power electronics and electrical machine activities of direct interest to DOE

Partners

- Interactions/ collaborations:
 - OEMs, Tier 1 and 2 suppliers, USCAR, University of Maryland, ORNL, Ames Research Lab, VivoMind™ Research LLC
- Project lead: Synthesis Partners, LLC

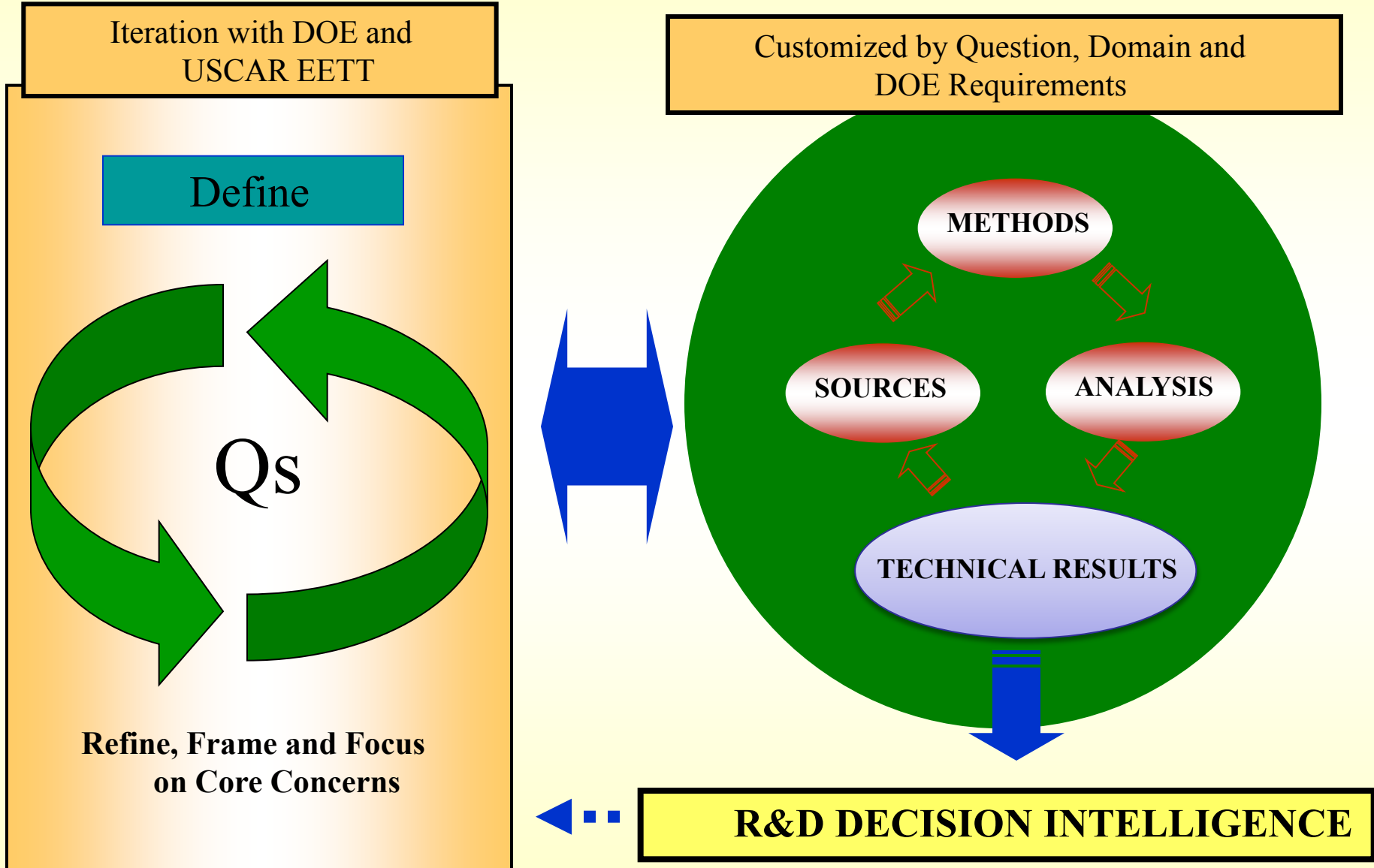
Study Objectives

- Global Automotive Power Electronics R&D Relevant to DOE 2015 and 2020 Cost Targets
 - Roadmap R&D milestones relevant to DOE 2015 (\$5/kW) and 2020 (\$3.30kW) cost targets.
 - Assess breakthrough technology developments needed to overcome core cost barriers that prevent achievement of DOE cost targets in 2015 and 2010.
 - Coordinate and collaborate with the USCAR Electrical/Electronics Technical Team (EETT).
- Foreign Literature Search on PEEM R&D Using Automated Methods
 - Apply integrated human and proprietary machine multi-lingual science and technology (S&T) literature search and analysis approach.
 - Rapidly and efficiently find and report relevant information from Asian-language texts concerning PEEMs of particular interest to DOE.

Research Milestones

- Roadmap of Automotive Power Electronics R&D Relevant to DOE 2015 and 2020 Cost Targets
 - Sept. '11 – May '12: Coordination, Collection & Analysis
 - May – Aug.'12: Initial Results
 - Aug. – Sept. '12: Report Findings
- Roadmap of Potential Breakthroughs in Automotive Power Electronics R&D Relevant to Core DOE Cost Target Barriers
 - Sept. '11 – May '12: Coordination, Collection & Analysis
 - May – Aug. '12: Initial Results
 - Aug. – Sept. '12: Report Findings
- Foreign Language Automated Literature Search
 - Sept. '11 – May '12: Coordination, Collection & Analysis
 - May – Aug. '12: Initial Results
 - Aug. – Sept. '12: Report Findings

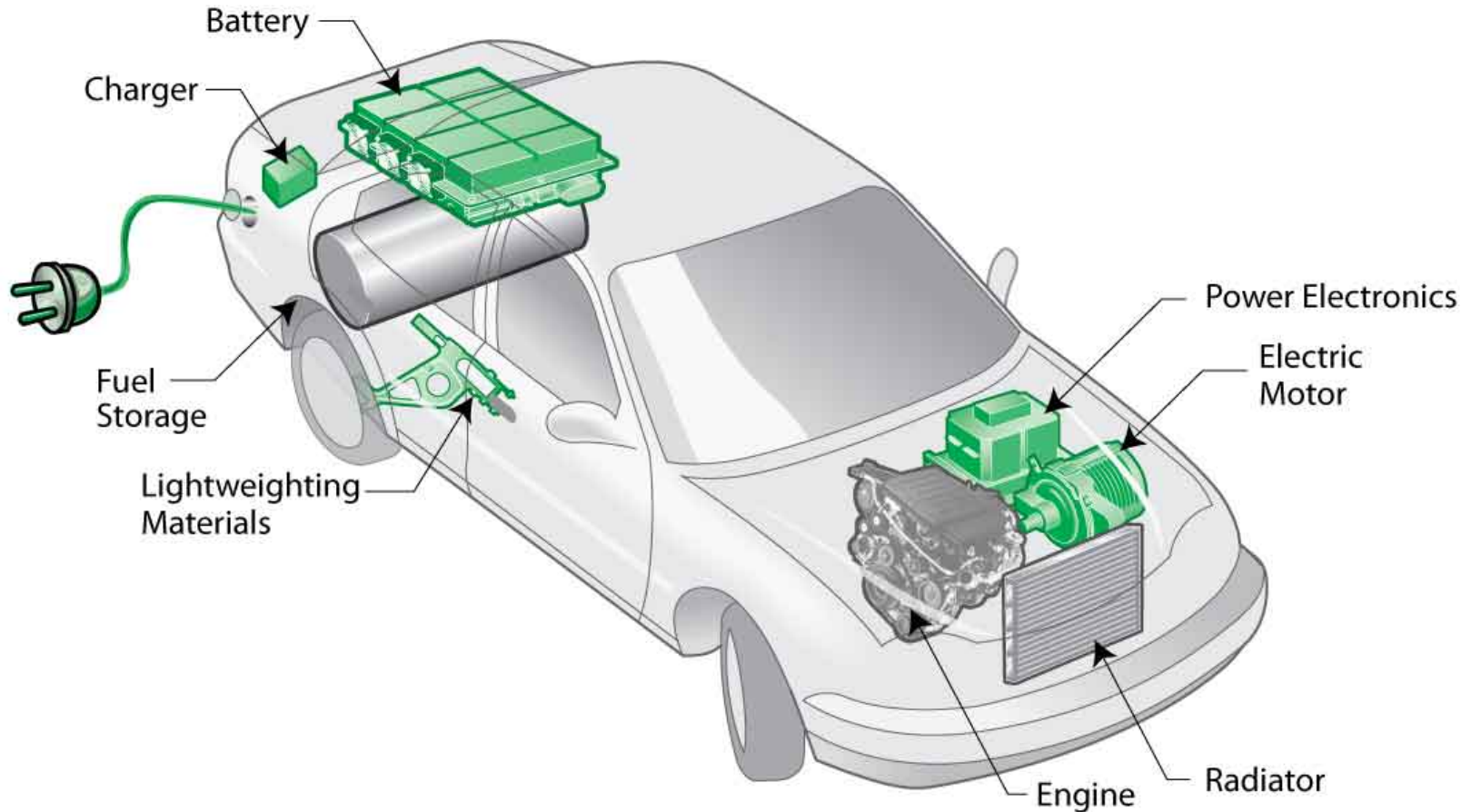
General Approach



Interim Findings: Power Electronics Roadmap

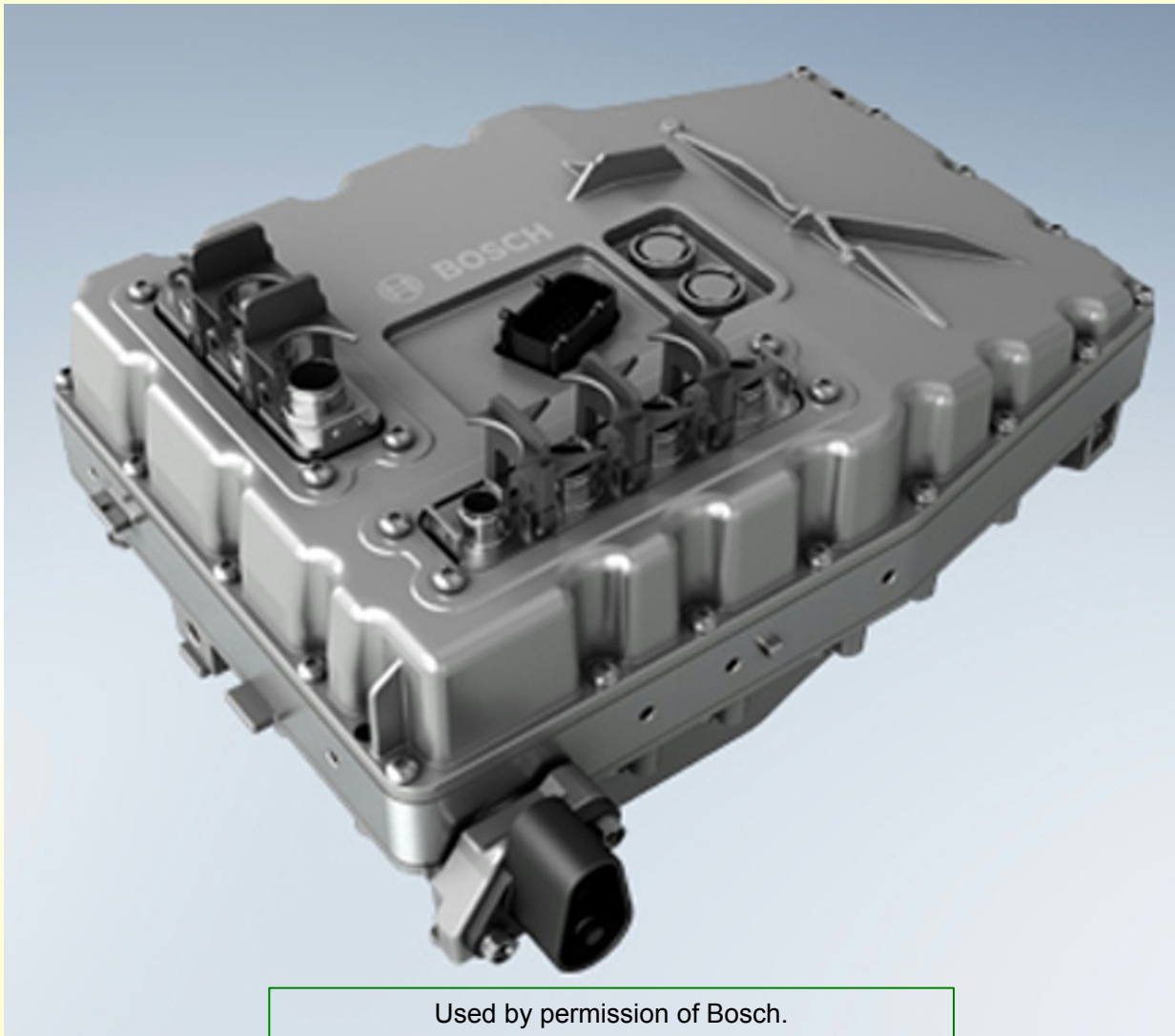
- Detailed findings under development
- Following slides provide initial findings
 - Data provided as of Mar. 16, 2012 and subject to change
- Discussion to clarify context of data and provide interpretation of chart information

Power Electronics



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Power Electronics



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Analyzing Barriers to Cost Reduction

- Top-level findings:
 - Differences in architecture (dual vs. single inverter, integrated functions vs. individual components) make accurate comparisons difficult
 - Obtuse or inadequate common vocabulary makes it very difficult to compare public data on costs!
 - Nascent automotive power electronics industry has opportunity to build database for “apples-to-apples” comparisons of key costs and cost drivers
 - Systematic comparison between best-available cost analyses is needed on periodic basis to drive healthy debate

Analyzing Barriers to Cost Reduction

Source	Methodology	Component	Estimated Volume	Manufacturing Cost Estimate*
SP Analysis (2011)	Analysis of current market prices and cost drivers, third party analyses of inverter systems, and analysis of the effect of varying production levels provided by the inverter industry	Single inverter/DC converter unit	100K	\$614.50
			400K	\$484
Tier 1 Manufacturer (2011)	Real world example	Single inverter	100K	\$600
FEV Analysis (2011)	Component teardown / comparisons with databases for materials, labor, manufacturing overhead, and mark-up costs and proprietary modeling system	Power Electronics/ Inverter & Controls Subsystem	450K	Power Electronics/ Inverter & Controls Subsystem \$263.03 – 298.11
		Voltage Inverters/ Converters Subsystem.		Voltage Inverters/ Converters Subsystem \$111.86 – 177.59

* Baseline definition of manufacturing costs varies by source.

Selected Global Roadmap Activity

Title	Source	Date
Automotive Australia 2020: Technology Roadmap	Automotive Australia 2020	June 2010
Electrical and Electronics Technical Team Roadmap	US Department of Energy	December 2010
Technology Roadmap: Electric and plug-in hybrid electric vehicles	International Energy Agency	June 2011
Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security	Electrification Coalition	November 2009
International Technology Roadmap for Semiconductors	ITRS	2011*
Power Technology Roadmap Trends 2010 - 2015	Power Sources Manufacturers Association	2011

* Completely revised during odd-numbered years with an update in even-numbered years

Technology Roadmap Elements

- Many types of Technology Roadmaps (TRMs)
 - Multi-layered time-based charts to enable technology developments to be aligned with market trends, technology and market drivers and decision needs
- TRMs have similar core objectives
 - If it does not support investment decisions, it is not a good or effective TRM!
 - TRMs need to be useable, flexible and targeted to decisions
- Technology-driven innovation drives constant re-alignment of TRMs
 - Pragmatic benefit depends on continuous refresh and re-alignment, as the cost, complexity and pace of power electronics technology change only increases

“All information is perishable.”

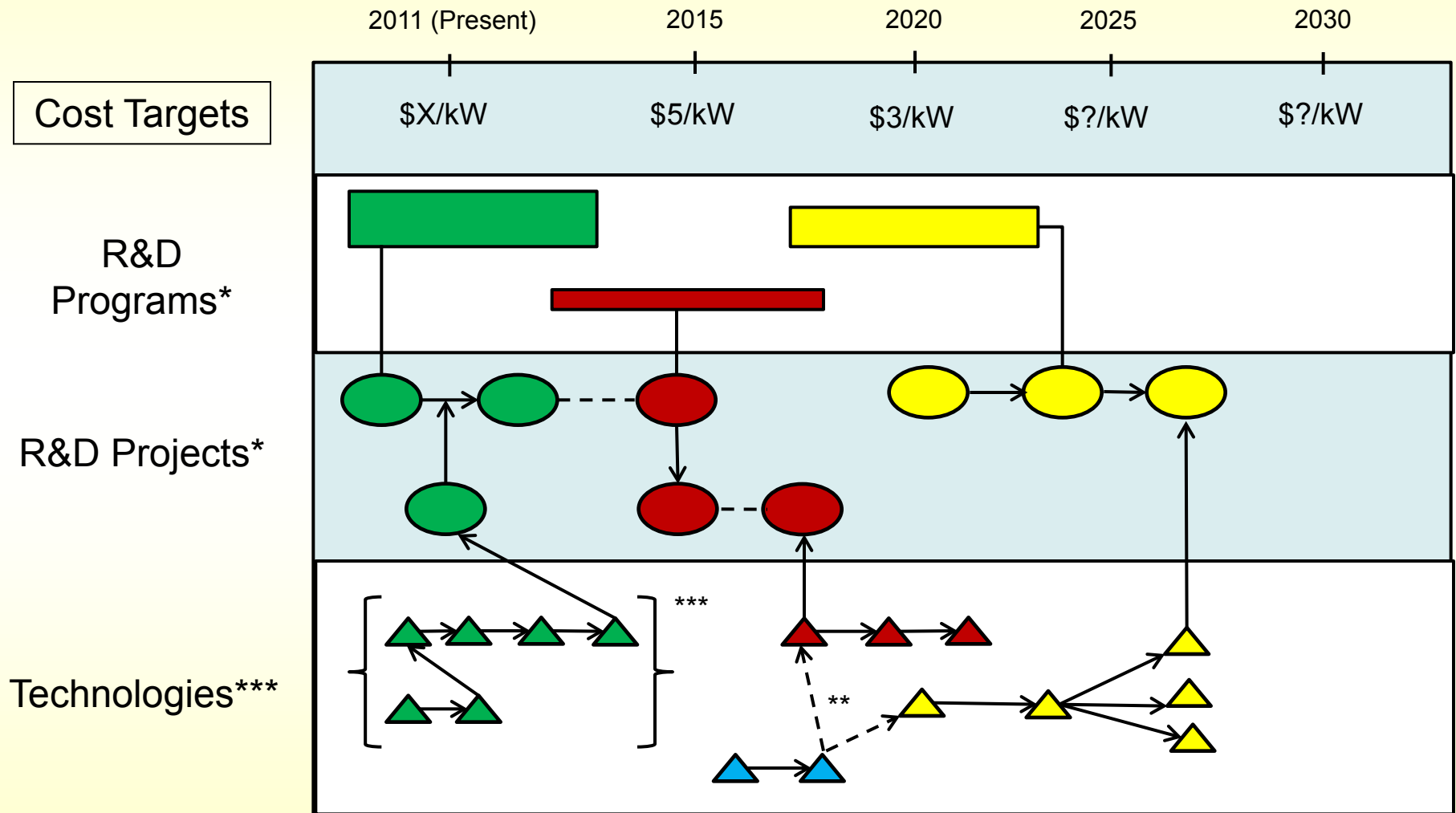
Technology Roadmap Elements

- Technology Components: 2015-2020
 - R&D related to core components in P/HEV power electronics systems
 - R&D related to systems-level design approaches in P/HEV power electronics
- Systems Engineering Elements: 2015-2020
 - Systems and systems-of-systems addressed in the design and manufacture of P/HEV power inverters, power electronics and electrical machines
 - Core trade-offs to be considered in P/HEV power electronics system development
- Cost Analysis Elements: 2015-2020
 - Relative importance of cost drivers, by components (or category) in P/HEV power electronics
 - Cost trend lines for key components or systems in P/HEV power electronics
 - Projected impact of major cost barriers (those cost thresholds that prevent achievement of major cost reductions), and their impact on key components in P/HEV power electronics

Technology Roadmap Analysis

Notional Example: R&D Aligned With Cost Targets

→ Time
\$/kW



*Size = Resources
Color = Institution

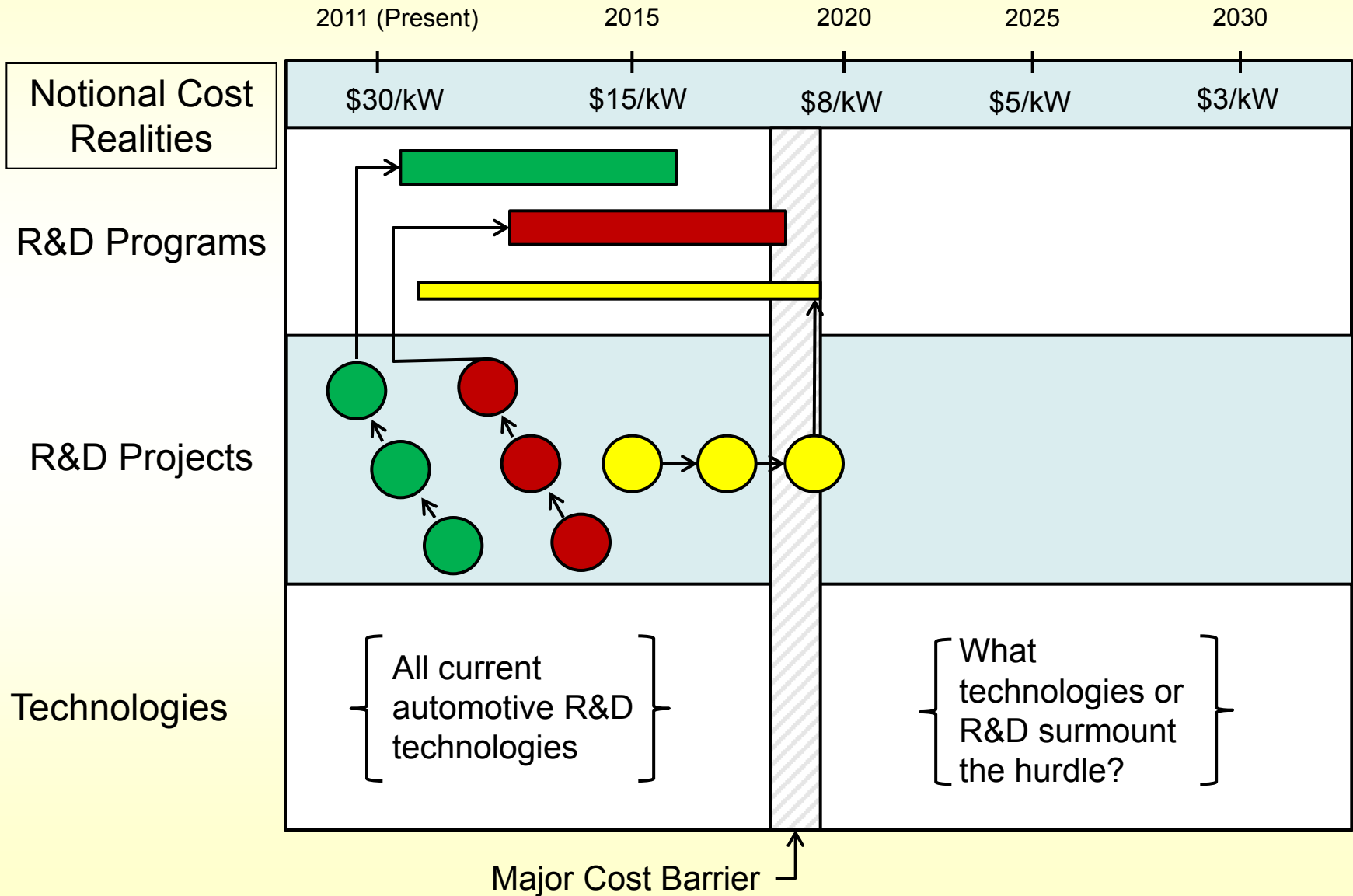
**Solid Line = Dependency
Dotted Line = Potential Dependency

***Linked Technologies = System View

Technology Roadmap Analysis

Notional Example: Cost Barriers That Must Be Overcome

→ Time
\$/kW



Foreign Literature Search Results

- Detailed findings under development
- Assessment of global data sources in progress as of Mar. 16, 2012
- Discussion today to clarify progress, data availability and early findings

Collaborations

- Close coordination and involvement with USCAR Electrical/Electronics Tech Team
- Close coordination with industry, universities, federal laboratories, and subject matter experts on both public and proprietary basis
- Collection from sources outside the DOE-Vehicle Technologies Program to identify low-cost technology development opportunities in support of DOE goals
- Industry: Global OEMs, Tier 1 and 2 suppliers, technology developer networks, VivoMind™ Research
- Federal Research Labs: ORNL, Argonne, Ames Research Lab and international S&T labs (TBD)

Proposed Future Work

- Discussions with DOE are ongoing.

Summary

- Research findings are under development
 - Roadmap of Automotive Power Electronics R&D Relevant to DOE 2015 and 2020 Cost Targets
 - Roadmap of Potential Breakthroughs in Automotive Power Electronics R&D Relevant to Core DOE Cost Target Barriers
 - Foreign Language Automated Literature Search findings