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Transportation Electrification Curriculum Development

Brett Williams
J.R. DeShazo
Alan Kerbel
Shein
Tongxin Xu

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Transportation Electrification (TE) Curriculum Development

Background Research, Stakeholder Engagement, and Path Forward for Training the Plug-in-Electric-Vehicle, Charging, and Smart-Grid Workforces

ABSTRACT

In the first three years of the "post-modern" plug-in electric vehicle (PEV) market, roughly 160,000 PEVs had been sold in the U.S., representing more than $6 billion in gross revenues [1]. PEV adoption is widely expected to increase significantly in the coming years. California alone has policies in place to encourage the expected use of 1 million or more PEVs by 2025 [3]. Over time, the types of PEVs being offered are evolving as the technology advances and multiplying as automakers target an increasing variety of market segments with vehicles of various size, aesthetics, and electric-drive capabilities. Over a dozen diverse models are now available; in the next two years, that number could double. Further, as the market matures, new challenges are emerging outside of the dealership in sectors related to vehicle use and uncertain secondary markets.

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DISCLAIMER

The UCLA Luskin Center appreciates the contributions of the aforementioned individuals and their agencies and organizations. This document, however, does not necessarily reflect their views or anyone else other than those of the authors. Anyone other than the authors make no claims regarding the accuracy or completeness of the information in this report. Any errors are the responsibility of the primary authors.

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innovation.luskin.ucla.edu J.R. DeShazo deshazo@ucla.edu

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1.1.1 The Context

In the first three years of the "post-modern" plug-in electric vehicle (PEV) market, roughly 160,000 PEVs had been sold in the U.S., representing more than $6 billion in gross revenues [1]. PEV adoption is widely expected to increase significantly in the coming years. California alone has policies in place to encourage the expected use of 1 million or more PEVs by 2025 [3]. Over time, the types of PEVs being offered are evolving as the technology advances, and multiplying as automakers target an increasing variety of market segments with vehicles of various size, aesthetics, and electric-drive capabilities. Over a dozen diverse models are now available; in the next two years, that number could double. Further, as the market matures, new challenges are emerging outside of the dealership in sectors related to vehicle use and uncertain secondary markets.

As electric vehicles enter the market, the California and national electric grid is undergoing modernization as it meets the need to achieve environmental objectives, increase efficiency, maintain data privacy, and manage the complex communication protocols all under the pressure to reduce costs.

1.1.2 The Problem

Workers requiring a wide range of sometimes non-traditional skills support the PEV supply chain and electric grid. As the PEV auto supply chain supports a larger flow of more advanced PEVs, and the grid modernizes—and becomes more specialized—training will be needed. Growing and broadening the educational offerings for this evolving workforce in-step with industry growth will remain challenging.

1.1.3 A Solution

Through the engagement of educational, industry, and other collaborators, this project aims to seed a multi-phase process of transportation-electrification (TE) curriculum development. To inform and start an ongoing discussion of what needs to be done, it asks: "What parts of the future workforce will be most impacted by TE and grid modernization?" and "What is currently being done to educate and train them?" It then builds on stakeholder input to highlight opportunities and next steps. It starts this process with a focus on the southern California region and includes:

- A description of the occupation categories most directly affected by TE;
- A review of existing and related TE educational initiatives and strategies;
- Matching of educational offerings to impacted occupations and identification of gaps; and
- Stakeholder guidance on curriculum development opportunities and important next steps.

1.2 Findings

This project produced outcomes from two major types of activities: 1) analysis of the existing state of TE-specific education and training and 2) recommendations developed out of stakeholder engagement.

1.2.1 TE-impacted occupations and existing TE-specific training

Analysis was conducted to provide a common framework and terminology, collect background information, and provide characterizations of TE-impacted occupations, existing TE educational offerings, and their nexus.

48 occupational categories have been identified as most directly affected by TE and characterized by industry sector, supply-chain stage, wage and employment levels, and entry-level education requirements. Engineering, computer, production, and technician occupations likely to be important to the production and repair of vehicle and grid systems are well represented in available characterizations. Under represented are non-conventional, advanced-technology, and smart-grid related sub-categorizations and, more generally, occupations that will support emerging but less-developed secondary markets, vehicle retirement, recycling, etc.

Additionally, existing educational offerings were examined for their relevance TE, focusing on southern California but including select programs throughout the state and nation. 205 educational offerings were identified and characterized by industry sector, supply-chain stage, and location, including:

- 61 organizations,
- 33 centers,
- 9 degree programs,
- 21 certificate programs,
- 65 courses,
- 12 workshops/short courses, and
- 4 EV teams/clubs.

Many of these offerings, particularly TE-specific degree and certificate programs, are found in regional community colleges and serve automotive mechanic and similar technician occupations. Evaluation of training and education offered in graduate and research contexts is more difficult. It requires a more national perspective to characterize a more mobile element of the workforce, and, with the exception of several notable state and national programs and centers characterized herein, requires more in-depth examination of related course content and pedagogies.

By matching occupations with existing training products, an analysis was conducted to identify potential gaps in TE-specific education and opportunities for supplementation. Further, gaps that impact "priority" occupations—defined here as those for which TE will cause appreciable change in the nature of the job, not just an increase in the number of capable bodies needed in that job by industry—were highlighted. These include a lack of identified TE-specific educational products (degrees, certificates, short-courses, and EV teams/clubs) for:

- Architects,
- Chemists,
- Computer systems administrators & analysts, programmers,
- Engineers: materials, chemical, computer,
- Material scientists,
- Operations research analysts,
- Power-plant operators,
- Power distributors and dispatchers, and
- Software developers.

Future analytical needs. Additional, in-depth analysis by stakeholders may be useful on two fronts: 1) to prioritize gaps based on additional/alternative criteria and 2) to evaluate the nature and quality of the product offerings in detail. The latter would form the basis of a deeper dive in each distinct educational context into curriculum development by educators. The former, prioritization, could begin with additional input from industry with clearly identified needs. For example, measures of criticality could be alternatively developed to characterize "rate limiters" or "bottlenecks" to the expansion of TE commercialization in one specific way, or to highlight those occupations where dramatic shortfalls in supply are identified or expected.

1.2.2 Stakeholder engagement

Building upon the analytical foundation described above, stakeholders from educational/training, governmental, industry, and other workforce organizations were engaged to have an informed discussion about TE curriculum needs. A workshop was held on February 18, 2014, at Southern California Edison's Energy Education Center in Irwindale, California. Several key issues and related next steps emerging from stakeholder conversions detailed in this report can be grouped into the following categories:

- Problems of occupational and educational data availability and usefulness.
- The need for clear problem definition and communication.
- The need for additional support for professors and other educators.
- Opportunities to generate and channel student demand for TE and TE offerings.

More specifically, this report summarizes and develops this discussion into several overall themes and identifies possible action items. Themes include:

- Inadequate information and communication characterizing future TE occupations and characterizing specific shortfalls in the TE workforce.
- The need for a more focused and differentiated approach to addressing problems particular to each educational context.
- Inadequate incentives and support for educators, both those pioneering TE training as well as those that would find adding TE education offerings challenging.
- The lack of an overall TE workforce-development strategy for the region and state with consistent aims and funding.
- A desire for increased industry/stakeholder engagement with educators, educational leadership, and students.

Possible action items include:

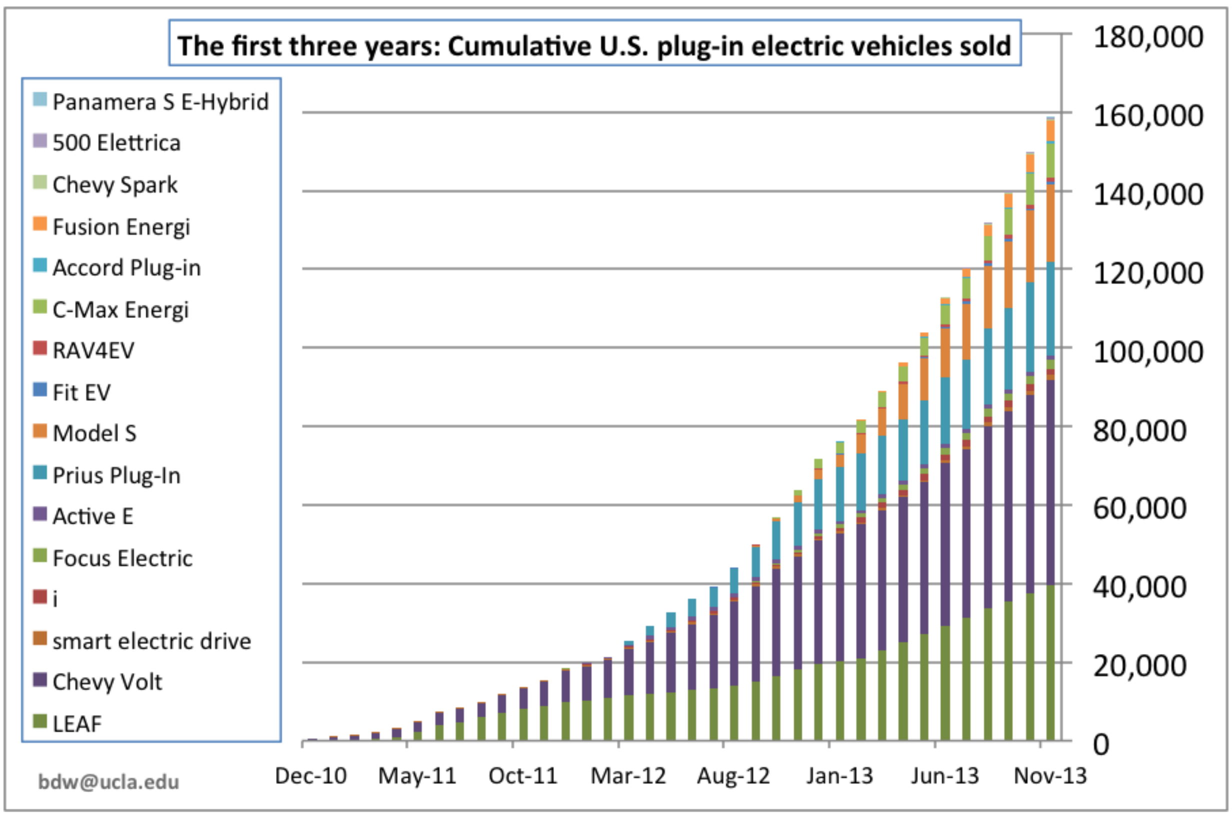
- The formation of a high-level position responsible for developing state or regional TE workforce development strategy and coordinating related efforts with grid modernization.
- The formation of communities of educators and TE stakeholders, to facilitate information flow, curriculum development, and the securing of adequate resources.
- The formation of TE curriculum-development advisory boards or task forces to identify educational-context-specific informational and curriculum development needs and facilitate implementation.
- The execution of additional research to address informational needs identified herein or in support of TE-czar, community, advisory-board, or task-force priorities.
- Industry-led initiatives to engage with educational leadership in support of TE training, TE-themed "challenges," and industry-university collaboration.
- Increased TE technology and information transfer to educational institutions in support of TE education.
- The creation of incentives and other resources to reduce the "start-up" costs of TE educational offerings and improve "marketing" to students and the community.
- An initiative aimed at increasing student "exposures" to TE technologies, to improve understanding of TE and stimulate demand for related educational offerings and subsequent job opportunities (e.g., showcases, demonstrations, internships/externships, college/university implementation of TE technologies, use of TE equipment in courses, research funding/collaborations, etc.), and to duplicate the above with students to recognize the complexity and opportunities that exist with grid modernization.

2. Introduction and Project Overview

2.1 The Context

A new era in the commercialization of plug-in electric vehicles (PEVs)—both all-battery and plug-in hybrid electric vehicles—has begun. By the end of November 2013, roughly 160,000 plug-in electric passenger vehicles had been sold in the U.S., representing more than $6 billion in gross revenues—see Figure 2-1 from [1]. These vehicles alone will shift billions of miles of driving from combustion of gasoline to clean electric-drive operation with energy-security, climate, and air-pollution benefits across the nation. Although PEV markets are still young and require patient nurturing [2], PEV adoption is widely expected to increase significantly in the coming years. California alone has policies in place to encourage the expected use of 1 million or more PEVs by 2025 [3].

Figure 2-1: Cumulative U.S. plug-in electric vehicle sales, October 2012-November 2013



Over time, the types of PEVs being offered are evolving as the technology advances, and the number multiplying as automakers target an increasing variety of market segments with vehicles of various size, aesthetics, and electric-drive capabilities. Over a dozen diverse models are now available; in the next two years that number could double. Further, as the market matures, new challenges are emerging outside of the dealership in sectors related to vehicle use and uncertain secondary markets.

2.2 The Problem

This early progress has been achieved in spite of educational deficiencies in the workforce supporting nascent PEV supply chains. The PEV supply chain is supported by workers requiring a wide range of sometimes non-traditional skills, including electricians, electronic system technicians, computer communication specialists, infrastructure installers, PEV-readiness planners, utility planners, corporate strategic planners, and scientists developing the next generation of technology. As PEV markets strive to mature, there remain relatively few educational and vocational programs dedicated to TE-relevant training currently available to the workforce. Broadening and growing these in-step with the industry is and will likely remain challenging. As the supply chain supports a larger flow of more advanced PEVs, more specialized training will be needed.

Further, outreach initiatives (for example those by automakers, Plug-in America, Go Electric Drive, environmental NGOs, etc.) are beginning to create widespread but general awareness about PEVs—including in the student population itself. Students have begun demonstrating interest in, and demand for, training and education about the latest mobility and energy technologies, but often lack specific knowledge and understanding of PEVs, recharging infrastructure, and the smart grid. Meanwhile, informal indications point to a high unreplenished rate of retirement of senior talent in key positions in utilities, exacerbating the need for TE-savvy personnel.

2.3 A Solution

Enhanced and evolving educational offerings are critical to the continued rapid and responsible commercialization of PEVs and related technologies. The UCLA Luskin Center for Innovation has teamed with Edison International and Southern California Edison to help set the direction for the creation of a wide array of fit-for-purpose and supportive educational offerings. Though beginning at a high level, the project acknowledges the different opportunities for four related but distinct educational contexts:

1) Vocational/technical training,
2) Community-college transferable credit and undergraduate general education,
3) Advanced undergraduate or general master's education, and
4) Focused graduate education and TE-related research programs.

Through the engagement of educational, industry, and other collaborators, the project hopes to start a multi-phase, multi-stakeholder process of TE curriculum development. To inform the discussion of what needs to be done, it asks: "What parts of the future workforce will be most impacted by TE and what is currently being done to educate and train them?" It starts with a focus on the southern California region and includes:

- A description of the workforce most directly affected by TE.
- A review of existing and related TE educational initiatives and strategies.

- Collaborator guidance on curriculum development opportunities.
- Implementation guidance, both for broader engagement of southern California education institutions and for the phased implementation of a nationwide initiative aimed at supporting local development and adoption of PEV education tailored to regional needs and talents.

2.4 Report overview

Section 3 of the report assesses the current state of TE education and training. It does so in three steps: 1) by examining the workforce for key occupations significantly impacted by TE, 2) by identifying and characterizing existing TE-specific educational offerings, with a focus on southern California, and 3) matching existing TE educational offerings to impacted occupations to identify gaps and other opportunities for curriculum development.

2.4.1 TE occupations

A database of occupations, thought to be particularly impacted by TE, was constructed for this project. Section 3.1 of this report draws upon that database to characterize 48 occupational categories by:

- Industry sector (PEV, charging, grid)
- Supply-chain stage (design/engineering/manufacturing, sales & finance, use, and retirement)
- Occupational group
- Employment data: Wages and employment numbers for LA, CA, and the U.S.
- Entry-level education requirements and on-the-job training

2.4.2 Existing TE training and education in southern California

A database of existing TE educational offerings was constructed for this project, focusing on southern California but including select programs throughout the state and nation. Section 3.2 characterizes 205 records coded by industry sector, supply-chain stage, and location, including:

- 61 organizations,
- 33 centers,
- 9 degree programs,
- 21 certificate programs,
- 65 courses,
- 12 workshops/short courses, and
- 4 EV teams/clubs.

2.4.3 Occupation/training matching

By matching occupations with existing training products, the analysis in section 3.3 identifies potential gaps in TE-specific education and opportunities for supplementation. A scoring system was developed to characterize the number of offerings directly or indirectly helpful to each occupation. Those occupations with scores of zero represent clear gaps and were called out in section 3.3. Those occupations with low total scores or low counts of certain types of core educational products represent opportunities to supplement current offerings.

Coding the opportunities characterized in section 3.3 for their "priority" identifies "critical gaps" in TE-specific educational products (degrees, certificates, short-courses, and EV teams/clubs).

Section 3.3 also identifies additional, in-depth analysis needs to support stakeholder-informed prioritization of TE curriculum needs and detailed, context-specific curriculum evaluation and enhancement.

2.5 Stakeholder engagement

Sections 3.1–3.3 provide a common framework and terminology, collect background information, and provide analysis characterizing TE-impacted occupations, existing TE educational offerings, and their nexus.

With this foundation, stakeholders from educational/training, governmental, industry, and other workforce organizations were engaged to have an informed discussion about TE curriculum needs. Section 4.1 includes a summary of a workshop held on February 18, 2014, at Southern California Edison's Energy Education Center in Irwindale, California. An agenda and confirmed participant list for the event are included in the appendices. Section 4.2 of the report discusses several key issues and related next steps emerging from stakeholder conversions, grouped into several categories.

Section 4.3 also summarizes and develops this discussion into several overall themes and identifies possible action items.

2.6 Appendices

Appendix A includes a participant list and agenda from the workshop. Appendix B builds upon the findings of this report and collects several recommended next steps into an illustrative proposal for "phase 2" of this TE Curriculum Development effort.

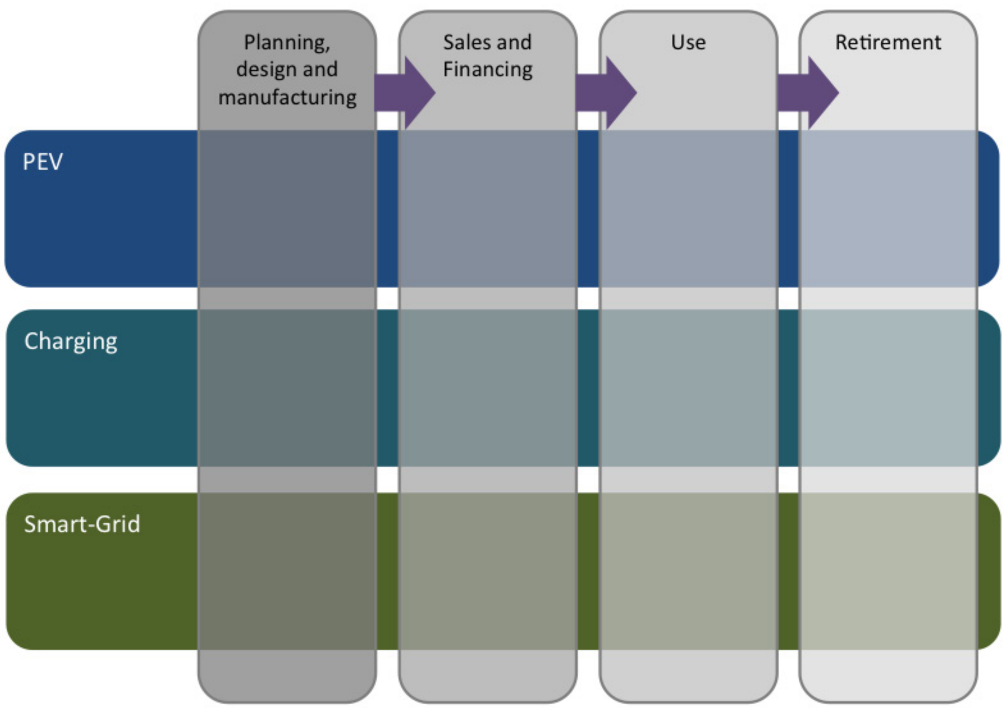
3. TE Occupations and Existing Education Initiatives in Southern California

This section: 1) gathers information on plug-in electric vehicles, charging infrastructure and smart-grid/utility labor forces, and their educational requirements, 2) reviews TE-related educational activities already underway, with a focus on southern California, and 3) matches existing training to TE-impacted occupations to help identify educational gaps and opportunities for further development.

3.1 The TE labor force

This section characterizes the TE labor force. To provide a framework for this discussion, Figure 3-1 illustrates a simplified TE "supply chain."

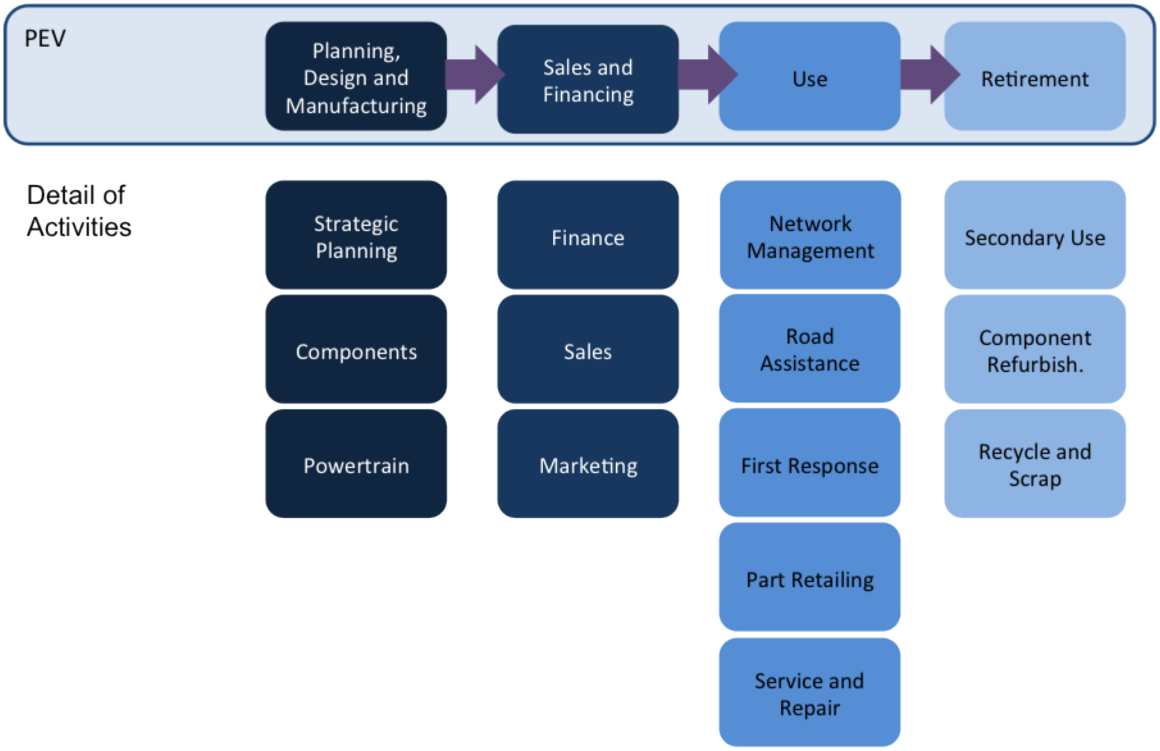
Figure 3-1: The TE supply chain



Each of the three major TE industry sectors is addressed in turn: that for plug-in electric vehicles (PEVs), electric-fuel charging infrastructure, and the smart grid/utilities.

3.1.1 The PEV supply chain

Figure 3-2: The PEV supply chain



The PEV-specific supply chain consists of:

Vehicle planning, design and manufacturing:

- PEV component design/engineering and manufacture, chiefly of batteries, electric motors, power electronics, and communications/control systems
- PEV powertrain design/engineering and integration
- PEV strategic planning, product planning, market research, and business development

Vehicle sales and financing:

- PEV marketing
- PEV sales
- PEV finance

Vehicle use:

- Network operation:
  - Charging control

- Vehicle software updates
- Vehicle data collection & analysis
- Vehicle network management
- Emergency dispatch

- Emergency response:
  - PEV incident first responders
  - PEV towing and roadside assistance
- Vehicle service and repair:
  - PEV service and repair
  - PEV parts retailing

Vehicle and component retirement:

- PEV component refurbishment
- PEV secondary use
- PEV recycling and scrappage

Occupations impacted by TE that exist within the PEV supply chain are described in Table **3-1**, which builds upon work by the U.S. Bureau of Labor Statistics (BLS) [4]. Note that, as TE-specific data are not gathered, the statistics given relate to the occupation category as a whole.

Table 3-1: PEV-related occupations and employment statistics (1 of 3)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Architecture and engineering group:						
Chemical engineers	660	$102,464	2,210	$100,530	33	$94,350
Electrical and electronics engineering technicians	4450	$66,131	21,310	$62,280	147	$57,850
Electrical engineers	5690	$106,177	24,110	$107,280	166	$87,920
Electromechanical Technicians	220	$55,549	3,640	$54,270	17	$51,820
Electronics engineers (not in BLS data)	NA	NA	NA	NA	NA	NA
Electronics engineers, except computer	6040	$101,740	30,140	$107,450	140	$91,820
Industrial engineers	5440	$97,802	20,680	$97,450	223	$78,860
Materials engineers	1240	$104,195	2,850	$98,380	23	$85,150
Mechanical drafters	1150	$54,714	4,500	$57,660	67	$50,360
Mechanical engineering technicians	870	$58,652	5,040	$56,840	48	$51,980
Mechanical engineers	6260	$93,988	23,900	$94,420	258	$80,580
Computer and mathematical group:						
Computer programmers	9350	$84,566	41,540	$87,160	344	$74,280
Computer soft-/hardware engineers (4)	13280	$115,531	22,360	$114,560	83	$100,920
Computer system analysts	12480	$92,801	61,430	$90,120	521	$79,680
Network and computer systems administrators	9660	$81,552	40,080	$84,400	366	$72,560
Operations research analysts	1360	$86,422	7,300	$87,670	73	$72,100
Software developers, application	15670	$94,537	88,260	$105,120	613	$90,060
Software developers, systems software	13280	$115,531	80,130	$115,440	405	$99,000
Construction and extraction group:						
Electricians	9810	$64,707	41,900	$63,820	584	$49,840

Table 3-1: PEV-related occupations and employment statistics (2 of 3)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Installation, maintenance, and repair group:						
Automotive service technicians and mechanics	13160	$39,278	54,700	$43,710	701	$36,610
Electric motor, power tool, and related repairers	410	$55,234	1,550	$46,820	21	$36,240
Electronic equipment installers and repairers, motor vehicles	280	$31,107	1,480	$34,000	15	$31,340
Telecom equipment installers and repairers, except line installers	8190	$56,608	27,430	$57,100	217	$54,530
Life, physical, and social science group:						
Chemists	2160	$69,875	11,640	$79,900	88	$71,770
Material scientists	350	$86,782	1,240	$94,010	8	$88,990
Urban and regional planners	1990	$76,962	8,650	$80,750	39	$65,230
Management group:						
Industrial production managers	4820	$101,558	17,420	$105,400	173	$89,190
Office and administrative support group:						
Customer service representatives	56710	$38,114	200,450	$38,860	2,363	$30,580
Production group:						
Computer-controlled machine tool operators, metal and plastic	3100	$37,754	9,610	$38,080	140	$35,580
Electrical and electronic equipment assemblers	4260	$30,774	25,390	$31,480	198	$28,810
Electromechanical equipment assemblers	1130	$29,211	6,260	$31,910	51	$31,460
Machinists	8610	$38,221	32,040	$41,740	398	$39,500
Team assemblers	21320	$26,912	78,930	$27,890	1,032	$27,640

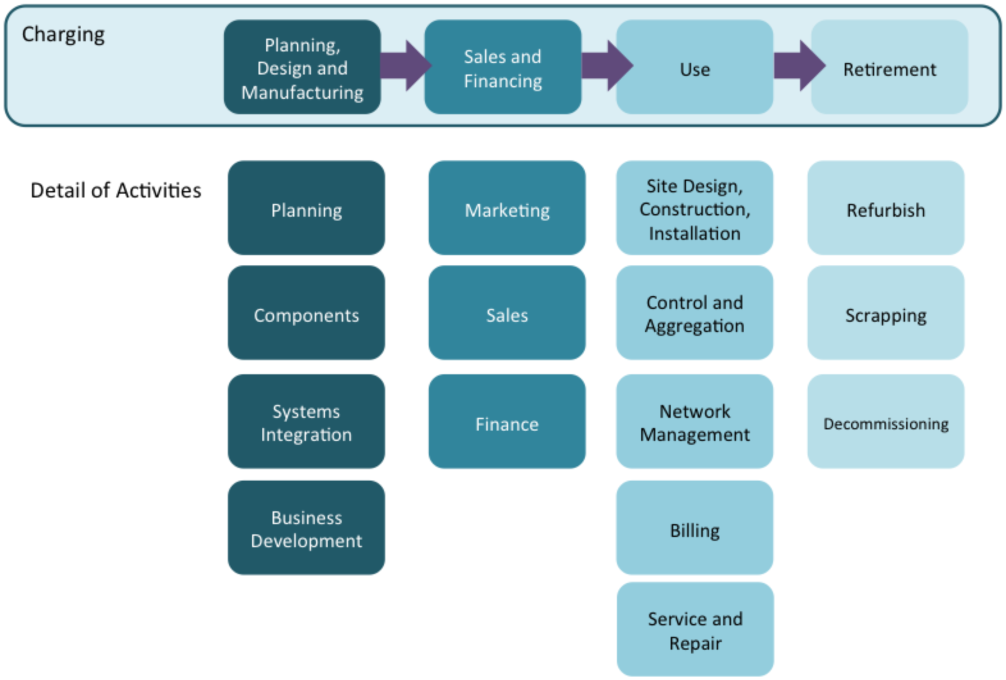
Table 3-1: PEV-related occupations and employment statistics (3 of 3)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Protective services group:						
Fire fighters	7150	$84,294	26,550	$72,540	307	$45,250
Police and sheriff's patrol officers	24590	$85,898	69,740	$84,320	654	$55,270
Sales and related group:						
Retail sales persons	120620	$25,833	448,440	$26,170	4,447	$21,110

(1) http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=1009
(2) http://www.bls.gov/oes/current/oes_ca.htm
(3) http://data.bls.gov/projections/occupationProj
(4) LA County data characterizes computer software engineers; CA and U.S. data characterizes hardware engineers.

3.1.2 The electric-fuel charging-infrastructure supply chain

Figure 3-3: the charging supply chain



The electric-fuel-charging-specific supply chain consists of:

Charging-station and electric vehicle service equipment (EVSE) planning, design, and manufacturing:

- EVSE component design/engineering and manufacture, chiefly of chargers and, in some cases, networking technologies
- EVSE systems integration
- EVSE strategic planning, product planning, market research, and business development

EVSE sales and financing:

- EVSE marketing
- EVSE sales
- EVSE finance

Charging-station use:

- Charging-facility installation:
  - o Site design
  - o Construction

- Electrical panel upgrades and wiring

- EVSE service and repair:
    - EVSE service and repair
    - EVSE parts retailing
- Network operation:
    - EVSE control
    - EVSE aggregation
    - EVSE network management
    - EVSE billing

EVSE decommissioning:

- EVSE component refurbishment
- EVSE recycling and scrappage

Occupations within the charging supply chain are described in Table 3-2, which adapts and builds upon work done by BLS for green construction [5]. Note that, as TE-specific data are not gathered, the statistics given relate to the occupation category as a whole.

Table 3-2: Charging-related occupations and employment statistics (1 of 2)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Architecture and engineering group:						
Architect	3050	$92,285	10,270	$92,000	107	$73,090
Electrical and electronics engineering technicians	4450	$66,131	21,310	$62,280	147	$57,850
Electrical engineers	5690	$106,177	24,110	$107,280	166	$87,920
Electronics engineers (not in BLS data)	NA	NA	NA	NA	NA	NA
Electronics engineers, except computer	6040	$101,740	30,140	$107,450	140	$91,820
Arts, design, entertainment, sports, and media group:						
Commercial and industrial designers	1290	$57,913	3,370	$64,950	39	$59,610
Computer and mathematical group:						
Computer programmers	9350	$84,566	41,540	$87,160	344	$74,280
Computer software (LA) / hardware (CA, U.S.) engineers (4)	13280	$115,531	22,360	$114,560	83	$100,920
Computer system analysts	12480	$92,801	61,430	$90,120	521	$79,680
Network and computer systems administrators	9660	$81,552	40,080	$84,400	366	$72,560
Operations research analysts	1360	$86,422	7,300	$87,670	73	$72,100
Software developers, application	15670	$94,537	88,260	$105,120	613	$90,060
Software developers, systems software	13280	$115,531	80,130	$115,440	405	$99,000
Construction and extraction group:						
Electricians	9810	$64,707	41,900	$63,820	584	$49,840

Table 3-2: Charging-related occupations and employment statistics (2 of 2)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Installation, maintenance, and repair group:						
Electrical & electronics repair, commercial & industrial equip.	1530	$54,744	7,100	$57,690	69	$52,650
Electrical power-line installers and repairers	1360	$86,428	7,260	$87,870	115	$63,250
Telecom equip. installers & repairers, except line installers	8190	$56,608	27,430	$57,100	217	$54,530
Life, physical, and social science group:						
Urban and regional planners	1990	$76,962	8,650	$80,750	39	$65,230
Management group:						
Construction manager	4460	$106,192	22,100	$105,700	485	$82,790
Office and administrative support group:						
Customer service representatives	56710	$38,114	200,450	$38,860	2,363	$30,580
Procurement clerks	2160	$38,916	7,590	$41,630	72	$38,220
Production group:						
Computer-control, machine tool operators, metal and plastic	3100	$37,754	9,610	$38,080	140	$35,580
Electrical and electronic equipment assemblers	4260	$30,774	25,390	$31,480	198	$28,810
Team assemblers	21320	$26,912	78,930	$27,890	1,032	$27,640
Protective service group:						
Fire fighters	7150	$84,294	26,550	$72,540	307	$45,250
Sales and related group:						
Retail sales persons	120620	$25,833	448,440	$26,170	4,447	$21,110

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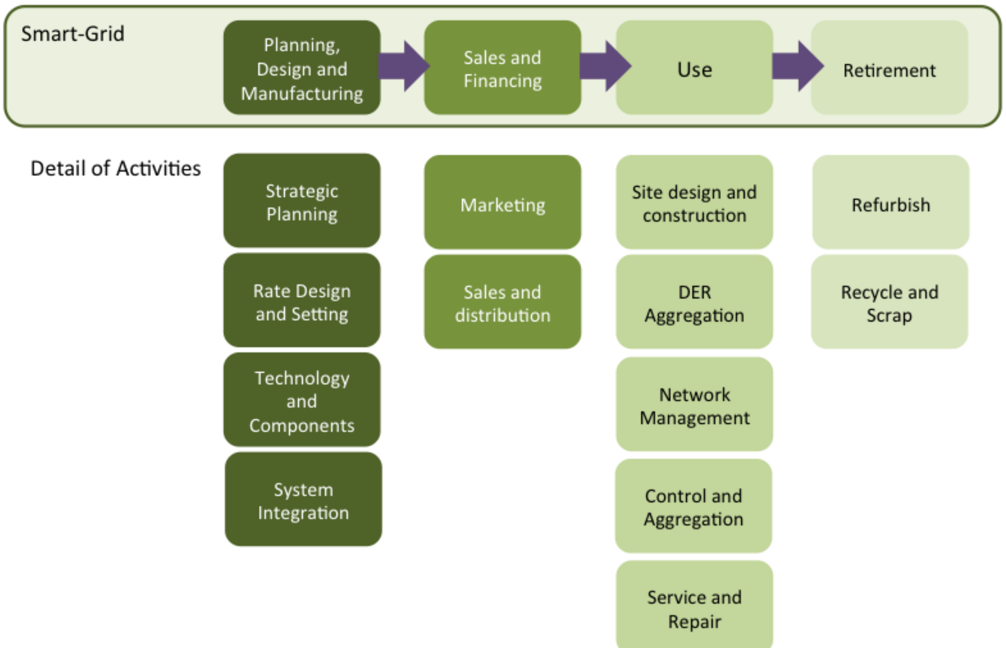
(2) http://www.bls.gov/oes/current/oes_ca.htm
(3) http://data.bls.gov/projections/occupationProj
(4) LA County data characterizes computer software engineers; CA and U.S. data characterizes hardware engineers.

3.1.3 The smart-grid/utility TE supply chain

Figure 3-4: the smart-grid/utility TE supply chain



To the electrical utility system, PEV charging represents a heterogeneous and evolving host of new electrical loads with unique timing and power characteristics that must be accommodated and planned for over time. These demands can perhaps be more efficiently met with a smart grid that utilizes metering, communications, and control technologies to monitor and adjust power supply, consumption, and quality throughout the system. To such an electrical system, vehicle charging can also represent a potentially flexible distributed resource that could be modulated to help balance local and regional requirements and provide valuable services to the grid and electricity consumers [6]. The smart grid can also better accommodate greater penetration and use of variable, intermittent renewable energy, providing a lower-carbon, cleaner fuel source for transportation. Regardless of how "smart" the grid is, these loads and resources are expected to play an increasingly important role in utility operations.

The smart-grid/utility TE-specific supply chain consists of:

Grid planning, design, and manufacturing:

- Grid planning:
    - Grid strategic planning, policy analysis
    - Rate design and setting

    - Smart-gird technology market research, and business development
- Smart-grid technology design and manufacturing:
    - Smart-grid component design/engineering and manufacture, chiefly of smart meters and distributed electrical resources (DER) management technologies
    - Smart-grid systems integration

Smart-grid technology sales:

- Smart-grid marketing
- Smart-grid sales, distribution, and support

Smart-grid use:

- Smart-grid technology installation, repair, and upgrades
    - Site design
    - Construction
    - Meter upgrades, wiring, DER support-systems installation
    - Smart-grid service and repair
- Network operation:
    - Smart-grid control
    - DER aggregation
    - Smart-grid network management

Overall, work developing and operating the smart grid will involve a variety of occupations and, according to one estimate by DNV KEMA, result in some 280,000 new positions [7].

Important occupations impacted by TE that exist within the smart-grid supply chain are described in Table 3-3, which builds upon work by the U.S. Bureau of Labor Statistics (BLS) [7]. Note that, as TE-specific data are not gathered, the statistics given relate to the occupation category as a whole.

Table 3-3: Smart-grid/utility TE-related occupations and employment statistics (1 of 2)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Architecture and engineering group:						
Electrical and electronics engineering technicians	4450	$66,131	21,310	$62,280	147	$57,850
Electrical engineers	5690	$106,177	24,110	$107,280	166	$87,920
Electronics engineers (not in BLS data)	NA	NA	NA	NA	NA	NA
Electronics engineers, except computer	6040	$101,740	30,140	$107,450	140	$91,820
Electromechanical technicians	220	$55,549	3,640	$54,270	17	$51,820
Electrical and electronics drafters	1340	$56,951	4,210	$60,040	30	$55,700
Arts, design, entertainment, sports, & media group:						
Commercial and industrial designers	1290	$57,913	3,370	$64,950	39	$59,610
Computer and mathematical group:						
Computer programmers	9350	$84,566	41,540	$87,160	344	$74,280
Computer software (LA) or hardware (CA, U.S.) engineers (4)	13280	$115,531	22,360	$114,560	83	$100,920
Computer system analysts	12480	$92,801	61,430	$90,120	521	$79,680
Network and computer systems administrators	9660	$81,552	40,080	$84,400	366	$72,560
Operations research analysts	1360	$86,422	7,300	$87,670	73	$72,100
Software developers, application	15670	$94,537	88,260	$105,120	613	$90,060
Software developers, systems software	13280	$115,531	80,130	$115,440	405	$99,000
Construction and extraction group:						
Electricians	9810	$64,707	41,900	$63,820	584	$49,840

Table 3-3: Smart-grid/utility TE-related occupations and employment statistics (2 of 2)

Occupation	LA County employment (1)	LA County mean wage (1)	California employment (2)	California mean wage (2)	U.S. employment (thousands) (3)	U.S. median annual wage (3)
Installation, maintenance, and repair group:						
Electrical & electronics repairers, powerhouse, substation, and relay	430	$87,693	1,500	$74,490	25	$68,810
Electrical & electronics repair, commerc. & industrial equip.	1530	$54,744	7,100	$57,690	69	$52,650
Electrical power-line installers and repairers	1360	$86,428	7,260	$87,870	115	$63,250
Electric motor, power tool, and related repairers	410	$55,234	1,550	$46,820	21	$36,240
Telecom. equip. install. & repair, except line install.	8190	$56,608	27,430	$57,100	217	$54,530
Life, physical, and social science group:						
Urban and regional planners	1990	$76,962	8,650	$80,750	39	$65,230
Office and administrative support group:						
Meter readers, utilities	1050	$47,171	4,700	$49,380	40	$35,940
Customer service representatives	56710	$38,114	200,450	$38,860	2,363	$30,580
Production group:						
Electromechanical equipment assemblers	1130	$29,211	6,260	$31,910	51	$31,460
Power distributors and dispatchers	240	$94,304	950	$86,700	12	$71,690
Power plant operators	1270	$85,336	4,280	$78,770	42	$66,130
Computer-control. machine tool operators, metal & plastic	3100	$37,754	9,610	$38,080	140	$35,580
Electrical and electronic equipment assemblers	4260	$30,774	25,390	$31,480	198	$28,810
Protective service group						
Fire fighters	7150	$84,294	26,550	$72,540	307	$45,250

(1) http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=1009
(2) http://www.bls.gov/oes/current/oes_ca.htm
(3) http://data.bls.gov/projections/occupationProj
(4) LA County data characterizes computer software engineers; CA and U.S. data characterizes hardware engineers.

3.1.4 All TE-specific occupations by entry-level training

Table 3-4 categorizes TE occupations (from all three industry sectors) according to entry-level education requirements and on-the-job training.

Table 3-4: All TE occupations: entry-level education and on-the-job training (1 of 2)

Occupation	Typical entry-level education (1)	Typical on-the-job training (1)
Architecture and engineering group:		
Architect	Bachelor's degree	Intern./residency
Chemical engineers	Bachelor's degree	None
Electrical and electronics drafters	Associate's degree	None
Electrical & electronics engineering techs	Associate's degree	None
Electrical engineers	Bachelor's degree	None
Electromechanical technicians	Associate's degree	None
Electronics engineers (not in BLS data)	Bachelor's degree	None
Electronics engineers, except computer	Bachelor's degree	None
Industrial engineers	Bachelor's degree	None
Materials engineers	Bachelor's degree	None
Mechanical drafters	Associate's degree	None
Mechanical engineering technicians	Associate's degree	None
Mechanical engineers	Bachelor's degree	None
Arts, design, entertainment, sports and media:		
Commercial and industrial designers	Bachelor's degree	None
Computer and mathematical group:		
Computer programmers	Bachelor's degree	None
Computer soft-/hardware engineers (4)	Bachelor's degree	None
Computer system analysts	Bachelor's degree	None
Network & computer systems admin.	Bachelor's degree	None
Operations research analysts	Bachelor's degree	None
Software developers, application	Bachelor's degree	None
Software developers, systems software	Bachelor's degree	None
Construction and extraction group:		
Electricians	High school diploma	Apprenticeship
Installation, maintenance, and repair group:		
Automotive service techs and mechanics	High school diploma	Long-term
Electric motor, power tool, and related repairers	Postsecondary non-degree	Long-term
Electrical and electronics repairers, commercial and industrial equipment	Postsecondary non-degree	Long-term

Table 3-4: All TE occupations: entry-level education and on-the-job training (2 of 2)

Occupation	Typical entry-level education (1)	Typical on-the-job training (1)
Installation, maintenance, and repair group (cont.):		
Electrical and electronics repairers, powerhouse, substation, and relay	Postsecondary non-degree award	Long-term
Electrical power-line install. and repair	High school diploma	Long-term
Electronic equip. install. and repairers, vehicles	Postsecondary non-degree	Short-term
Telecommunications equipment installers and repairers, except line installers	Postsecondary non-degree	Moderate
Life, physical and social science group:		
Chemists	Bachelor's degree	None
Material scientists	Bachelor's degree	None
Urban and regional planners	Master's degree	None
Management group:		
Construction Manager	Bachelor's degree	Moderate
Industrial production managers	Bachelor's degree	None
Office and administrative support group:		
Customer service representatives	High school diploma	Short-term
Meter readers, utilities	High school diploma	Short-term
Procurement Clerks	High school diploma	Moderate
Production group:		
Computer-controlled machine tool operators, metal and plastic	High school diploma	Moderate
Electrical & electronic equipment assemblers	High school diploma	Short-term
Electromechanical equipment assemblers	High school diploma	Short-term
Engine and other machine assemblers	High school diploma	Short-term
Machinists	High school diploma	Long-term
Power distributors and dispatchers	High school diploma	Long-term
Power plant operators	High school diploma	Long-term
Team assemblers	High school diploma	Moderate
Protective service group:		
Fire fighters	Postsecondary non-degree	Long-term
Police and sheriff's patrol officers	High school diploma	Moderate
Sales and related group:		
Retail sales persons	Less than high school	Short-term

(1) http://data.bls.gov/projections/occupationProj

Table 3-5 organizes all TE occupations by entry-level education requirements, which will facilitate comparison to existing TE training programs in southern California in section 3.2. Table 3-5 also provides the LA County employment totals for illustrative reference. It is unknown what portion of the employment in each occupation is, or would be, needed specifically for TE.

Table 3-5: All TE occupations: entry-level education and LA County employment (1 of 2)

Occupations by entry-level education requirement (1)	Total LA County employment (2)
Less than high school	**120,620**
Retail sales persons	120,620
High school diploma or equivalent	**152,040**
Automotive body and related repairers	2,850
Automotive glass installers and Repairers	230
Automotive service technicians and mechanics	13,160
Computer-controlled machine tool operators, metal and plastic	3,100
Customer service representatives	56,710
Electrical and electronic equipment assemblers	4,260
Electrical power-line installers and repairers	1,360
Electricians	9,810
Electromechanical equipment assemblers	1,130
Engine and other machine assemblers	190
Machinists	8,610
Meter readers, utilities	1,050
Police and sheriff's patrol officers	24,590
Power distributors and dispatchers	240
Power plant operators	1,270
Procurement clerks	2,160
Team assemblers	21,320
Postsecondary non-degree award	**17,990**
Electric motor, power tool, and related repairers	410
Electrical and electronics repairers, commercial and industrial equip.	1,530
Electrical and electronics repairers, powerhouse, substation, and relay	430
Electronic equipment installers and repairers, motor vehicles	280
Fire fighters	7,150
Telecom. equipment installers and repairers, except line installers	8,190

Table 3-5: All TE occupations: entry-level education and LA County employment (2 of 2)

Occupations by entry-level education requirement (1)	Total LA County employment (2)
Associate's degree	**8,030**
Electrical and electronics drafters	1,340
Electrical and electronics engineering technicians	4,450
Electromechanical technicians	220
Mechanical drafters	1,150
Mechanical engineering technicians	870
Bachelor's degree	**116,540**
Architect	3,050
Chemical engineers	660
Chemists	2,160
Commercial and industrial designers	1,290
Computer programmers	9,350
Computer software engineers	13,280
Computer system analysts	12,480
Construction manager	4,460
Electrical engineers	5,690
Electronics engineers (not in data)	-
Electronics engineers, except computer	6,040
Industrial engineers	5,440
Industrial production managers	4,820
Material scientists	350
Materials engineers	1,240
Mechanical engineers	6,260
Network and computer systems administrators	9,660
Operations research analysts	1,360
Software developers, application	15,670
Software developers, systems software	13,280
Master's degree	**1,990**
Urban and regional planners	1,990
Grand Total	**417,210**

(1) Occupation and occupation-group categories based on those used by the U.S. BLS.
(2) Not TE-specific. The total LA County employment is given as an illustrative reference. The portion of total employment needed for TE is unknown. Source: http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=1009

3.2 Existing TE-specific training in Southern California

This section catalogs and characterizes existing TE-related educational institutions and activities, focusing on southern California but including select programs throughout the state and nation. It draws upon a database constructed for this project that includes 206 records that can be analyzed by industry sector, supply-chain stage, location, and record type, including:

- 61 organizations,
- 33 centers,
- 9 degree programs,
- 21 certificate programs,
- 65 courses,
- 12 workshops/short courses, and
- 4 EV teams/clubs.

(Additionally, the database also contains web addresses, city, state, and some additional information.)

Table 3-6 lists the organizations identified to offer TE-related educational products, grouping them by organizational type: technical school/community college, teaching university, research university, non-college/university training organization, and an "other" category that includes national labs, research consortia, national associations, industry, and utilities. Table 3-6 also summarizes the activities catalogued to date by presenting the number of records in each of several categories: institutions, centers/departments/institutes, degree programs, certificate programs, courses, workshops, and an other category that includes student electric-vehicle teams/clubs.

Table 3-6: Organizations with existing TE-related educational offerings and the number of records catalogued to date (1 of 3)

Organization	Orgs.	Cntrs.	Degrees	Certs.	Courses	Work-shops	Other	Grand Total
Tech. school/ community colleges	**14**	**9**	**3**	**12**	**32**	**2**		**72**
Cerritos College	1	1		2	6			10
City College of San Francisco	1			1	2			4
College of the Desert	1			1	3			5
Cypress College	1	1			1			3
El Camino College	1	1				1		3
Fresno City College	1	1			2			4
Glendale Community College	1				1	1		3
J. Sargeant Reynolds Community College	1			1				2
Long Beach City College	1	1	2	2	7			13
Los Angeles Trade-Technical College	1	1		1	3			6
Modesto Junior College	1	1			3			5
Pierce College	1			3	1			5
Rio Hondo College	1	1	1	1	2			6
Yuba College	1	1			1			3
Universities-teaching	**14**	**1**			**15**		**3**	**33**
California Baptist University	1							1
California Polytechnic State University, San Luis Obispo	1				4		2	7
California South Bay University	1							1
California State Polytechnic University, Pomona	1				1			2
California State University, Fullerton	1							1
California State University, Long Beach	1				3			4
California State University, Los Angeles	1				1			2
California State University, Northridge	1				3			4
California State University, Sacramento	1	1			1			3
Loyola Marymount University	1				1		1	3

Table 3-6: Organizations with existing TE-related educational offerings and the number of records catalogued to date (2 of 3)

Organization	Orgs.	Cntrs.	Degrees	Certs.	Courses	Work-shops	Other	Grand Total
National University	1							1
Pomona College	1							1
San Diego State University	1				1			2
University of San Diego	1							1
Universities-research	**22**	**23**	**8**	**6**	**17**	**9**	**1**	**84**
California Institute of Technology	1				1		1	3
Clemson University	1	1						2
Colorado State University	1	1		1				3
Georgia Institute of Technology	1	1						2
Harvey Mudd College	1							1
Michigan Technological University	1			1				2
Missouri University of Science and Technology	1							1
Pennsylvania State University	1	3						4
Purdue University	1	1		1				3
The Ohio State University	1	1						2
University of California, Davis	1	5	1					7
University of California, Irvine	1	2			1			4
University of California, Los Angeles	1	2			7			10
University of California, Riverside	1				3			4
University of California, San Diego	1				1			2
University of California, Santa Barbara	1				1			2
University of Colorado, Boulder	1	1	1					3
University of Colorado, Colorado Springs	1	1	1	1				4
University of Michigan-Dearborn	1	1						2
University of Southern California	1	1			3			5

Table 3-6: Organizations with existing TE-related educational offerings and the number of records catalogued to date (3 of 3)

Organization	Orgs.	Cntrs.	Degrees	Certs.	Courses	Work-shops	Other	Grand Total
Wayne State University	1	1	3	2				7
West Virginia University	1	1				9		11
Training/workforce organizations	5			3	1			9
Clean Tech Institute	1			1				2
EV Infra Training Program (EVITP)	1			1				2
Key Training Corporation	1			1				2
NADA University	1				1			2
Southland Cerritos Center for Transport. Technologies	1							1
Other	**7**	**1**				**1**		**9**
Battery Innovation Center	1							1
Joint Center For Energy Storage Research	1							1
Lawrence Berkeley National Laboratory	1							1
Los Angeles Department of Water & Power	1							1
National Fire Protection Association	1					1		2
Southern California Edison	1							1
Grand Total	**61**	**33**	**9**	**21**	**65**	**12**	**4**	**205**

Table 3-7 lists the thirty-four TE-related centers, institutes, and departments with TE-specific offerings catalogued to date.

Table 3-7: Centers, institutes, and departments with TE-specific offerings (1 of 3)

Tech. school/community college
Cerritos College
Advanced Transportation Technology & Energy Center
Automotive Technology
City College of San Francisco
Automotive/Motorcycle, Construction, and Building Maintenance
Cypress College
Advanced Transportation Technology Center
Automotive Technology
El Camino College
NAFTC National and Associate Training Center
Fresno City College
Applied Technology
NAFTC National and Associate Training Center
Glendale Community College
Industrial Technology
J. Sargeant Reynolds Community College
School of Business
Long Beach City College
Advanced Transportation Technology & Energy Center
Los Angeles Trade-Technical College
Diesel, Alternative Fuel and Hybrid Vehicle Technologies Department
Modesto Junior College
Automotive Technology
NAFTC National and Associate Training Center
Pierce College
Industrial Technology
Rio Hondo College
Automotive Technology
NAFTC National and Associate Training Center
Yuba College
Automotive Technology
NAFTC National and Associate Training Center

Table 3-7: Centers, institutes, and departments with TE-specific offerings (2 of 3)

University-research
California Institute of Technology
Electrical Engineering/Mechanical Engineering
Clemson University
Department of Automotive Engineering
Colorado State University
Hybrid-Electric Vehicle Engineering
Georgia Institute of Technology
Center for Innovative Fuel Cell and Battery Technologies
Michigan Technological University
Engineering
Pennsylvania State University
Battery and Energy Storage Technology (BEST) Center
Graduate Automotive Technology Education (GATE) Center
Grid Smart Training and Application Resource Center
Purdue University
DOE Hoosier Heavy Hybrid Center of Excellence
The Ohio State University
Center for Automotive Research
University of California, Davis
College of Engineering
Communications Research in Signal Processing (CRISP):
National Sustainable Transportation Center
Plug-In Hybrid & Electric Vehicle Research Center
Policy institute for energy, environment and the economy
Sustainable Transportation Energy Pathways
University of California, Irvine
Advanced Power and Energy Program
Mechanical and Aerospace Engineering
The National Fuel Cell Research Center
University of California, Los Angeles
Chemical and Biomolecular Engineering
Luskin Center for Innovation
Luskin School of Public Affairs
Mechanical and Aerospace Engineering
Smart Grid Energy Research Center
University of California, Riverside
Chemical Engineering
Electrical Engineering

Table 3-7: Centers, institutes, and departments with TE-specific offerings (3 of 3)

University-research (cont.)
University of California, San Diego
Nano Engineering
University of California, Santa Barbara
Electrical Computer Engineering
University of Colorado, Boulder
Department of Electrical, Computer, and Energy Engineering
Renewable and Sustainable Energy Institute (RASEI)
University of Colorado, Colorado Springs
Department of Electrical and Computer Engineering
GATE Center of Excellence in Innovative Drivetrains in Electric Automotive Technology Education
University of Michigan-Dearborn
The Center for Electric Drive Transportation
University of Southern California
Electrical Engineering
USC SmartGrid
Wayne State University
Electric-drive Vehicle Engineering
West Virginia University
National Alternative Fuels Training Consortium (NAFTC)
University-teaching
California Polytechnic State University, San Luis Obispo
Electrical Engineering
Mechanical Engineering
California State Polytechnic University, Pomona
Electrical and Computer Engineering
California State University, Long Beach
Chemical Engineering
Electrical Engineering
California State University, Los Angeles
Department of Technology
California State University, Northridge
Electrical and Computer Engineering
California State University, Sacramento
California Smart Grid Center
University Enterprises, Inc.
Loyola Marymount University
Mechanical Engineering
San Diego State University
Electrical Engineering

Table 3-8 lists nine TE-specific degree programs and Table 3-9 four student EV teams and clubs. Table 3-10 lists twelve TE-specific workshops/short courses and Table 3-11 twenty-one TE-specific certificate programs. Finally sixty-five TE-related courses are listed, first by organization (Table 3-12), and then by organization type (Table 3-13). Again, it should be noted that the data collection for these tables focused on the southern California region but has been expanded to include select additions from throughout the state and country.

Table 3-8: TE-specific degree programs

Long Beach City College
A.S. with a major in Alternative Transportation Technology - Alternate Fuels
A.S. with a major in Alternative Transportation Technology - Electric Vehicles
Rio Hondo College
Alternative Fuels Technician A.S.
University of California, Davis
Transportation Technology and Policy (M.S. and Ph.D.)
University of Colorado, Boulder
Master of Science in Electrical Engineering emphasis area in Vehicle Power Electronics (MSEE-VPE)
University of Colorado, Colorado Springs
Master of Science in Electrical Engineering option in Battery Controls
Wayne State University
Associate of Applied Technology in Automotive Technology and Electronic Engineering Technology
Bachelor of Science Degree in Electric Transportation Technology
Master of Science Degree Program in Electric-drive Vehicle Engineering

Table 3-9: Student EV teams and clubs

California Institute of Technology
Caltech EV Club
California Polytechnic State University, San Luis Obispo
Electric Vehicle Engineering Club
Hybrid Vehicle Development Team
Loyola Marymount University
Eco Vehicle Project

Table 3-10: TE-specific workshops/short courses

El Camino College
Alternative Fuel First Responder Training
Glendale Community College
Developing and Enhancing Workforce Training Programs
National Fire Protection Association
Electric Vehicle Safety Training
West Virginia University
A Basic Understanding of Battery-Electric and Hybrid-Electric Vehicles
Clean Air and Energy Independence: An Overview of Alt. Fuels and Advanced Technology Vehicles
Electric Drive Vehicle Automotive Technician Training (Post-secondary)
Electric Drive Vehicle First Responder Safety Training
Electric Drive Vehicle Infrastructure Training
Introduction to Alternative Fuels and Advanced Technology Vehicles
Introduction to Battery-Powered Electric Vehicles
Introduction to Hybrid-Electric Vehicles
Petroleum Reduction Technologies

Table 3-11: TE-specific certificate programs

Cerritos College
Alternative Fuels Service Technician
EV Infra Training Program (EVITP) certification
City College of San Francisco
Automotive Alternative Fuel Technology
Clean Tech Institute
Certified Electric Vehicle Technician Training Program
College of the Desert
Automotive Alternate Fuels
Colorado State University
Hybrid-Electric Vehicle Engineering certificate
EV Infra Training Program (EVITP)
(certification provided)
J. Sargeant Reynolds Community College
Hybrid and Electric Vehicle Technology
Key Training Corporation
Smart grid
Long Beach City College
Certificate: Alternative Transportation Technology - Alternate Fuels
Certificate: Alternative Transportation Technology - Electric Vehicles
Los Angeles Trade-Technical College
Hybrid & Electric Plug-In Vehicle Technology
Michigan Technological University
Hybrid Electric Vehicle Curriculum (HEV)
Pierce College
Automotive Advanced Level Hybrid Diagnostic Technician
Automotive Alternative Diagnostic Technician
Automotive Basic Hybrid Service Technician
Purdue University
Hybrid Vehicle Systems Certificate
Rio Hondo College
Alternative Fuels Technician
University of Colorado, Colorado Springs
Graduate Certificate in Electric Drivetrain Technology
Wayne State University
EDGE Engineering Entrepreneur Certificate
Graduate Certificate Program in Electric-drive Vehicle Engineering

Table 3-12: TE-related courses: by organization (1 of 3)

California Institute of Technology
Introduction to Mechatronics (EE/ME 7)
California Polytechnic State University, San Luis Obispo
Advanced and Hybrid Vehicle Design (ME 446)
Alternative Energy Vehicles (EE434)
Alternative Energy Vehicles (EE 434)
Sustainable Electric Energy Conversion (EE420)
California State Polytechnic University, Pomona
Power Electronics (ECE 469)
California State University, Long Beach
Electric Vehicles (451)
Electronic Control of Motors (450)
Green Engineering I: Alternative Energy (533/433)
California State University, Los Angeles
Electric, Hybrid and Alternative Fueled Vehicles (TECH 470)
California State University, Northridge
Electric Power Systems (ECE 411)
Electrical Machines and Energy Conversion and Lab (ECE 410/L)
Power Electronics (ECE412)
California State University, Sacramento
University Enterprises, Inc. Developing and Enhancing Workforce Training Programs
Cerritos College
Advanced Electrical Systems (AUTO 260)
Advanced Technology Electric Vehicles (AUTO 55)
Alternative and Renewable Maintenance Training
Automotive Electricity (AUTO 160)
Automotive Electricity (AUTO 161)
Intro to Electric Vehicle (AUTO 54)
City College of San Francisco
Alternative Fuel Vehicles (AUTO 57)
Automotive Electrical (AUTO 51)
College of the Desert
Auto Electronics & Electrical Systems (AUTO 11B)
Hybrid, Fuel-Cell & Electric Technology (AUTO 43A)
Intro to Alternative Fuel Vehicles (AUTO 45A)
Cypress College
Intro to Electric/Hybrid Vehicles (AT 181C)

Table 3-12: TE-related courses: by organization (2 of 3)

Fresno City College
Advanced Clean Air Car Course (AUTOT 161B)
Basic Clean Air Car Course (AUTOT 161A)
Glendale Community College
Advanced Metering Technology (ITECH 156)
Long Beach City College
Advanced Hybrid Diagnosis & Repair (ATT 483)
Advanced Hybrid Fuel Cell & Electric Vehicles (ATT 481)
Alternative Fuels Conversion, Diagnosis & Repair (AMECH 493)
Los Angeles Trade-Technical College
Advanced Hybrid and Plug-in Electric Vehicles (DIESLTK 303)
Hybrid and Plug-in Electric Vehicle (DIESLTK 302)
Introduction to Alternative Fuel & Hybrid Vehicle Technology (DIESLTK 301)
Loyola Marymount University
Alternative Energy Systems (MECH521)
Modesto Junior College
Automotive Electricity (AUTEC368)
Automotive Electricity (AUTEC369)
Introduction to Alternative Fuels (AUTEC 211)
NADA University
Alternative Fuels 101
Pierce College
Hybrid Service and Safety (AST 55)
Rio Hondo College
Advanced Hybrid/Electric Vehicle (AUTO 260)
Introduction to Hybrid and Electric Vehicle Technology (AUTO 147)
San Diego State University
Power Electronics (EE484)
University of California, Irvine
Engineering Electrochemistry: Fundamentals and Applications (ENGRMAE 212)
University of California, Los Angeles
Design and Analysis of Smart Grids (MECH&AE C137/237)
Electrochemical Engineering (217)
Electrochemical Processes and Corrosion (C114)
Electrochemical Processes and Corrosion (C214)
Special Topics in Chemical and Bimolecular Engineering (290)
Special Topics in Public Policy: Electric-Drive Vehicles: Technologies and Policies (PUB PLC290-1)
Special Topics in Public Policy: Public Policies for Alt. Fuel Vehicles and Infrastruct. (PUB PLC290-1)

Table 3-12: TE-related courses: by organization (3 of 3)

University of California, Riverside
Electrochemical Engineering (CHE131)
Power Electronics (EE123)
Special Topics in Materials Electrochemistry (CEE 259)
University of California, San Diego
Advanced Micro- and Nano- Materials for Energy Storage and Conversion (NANO 164)
University of California, Santa Barbara
Introduction To Power Electronics (ECE142)
University of Southern California:
Electromechanics (EE 370)
Net-Centric Power-System Control (EE 527)
Power Electronics (EE528)
Yuba College
Engine Diagnosis and Rebuilding (AUTO 45)

Table 3-13a: TE-related courses by organization type: Postsecondary and associate's

Training/workforce organization	**1**
Alternative Fuels 101	1
Tech. school/community college	**24**
Advanced Transportation Technology & Energy Center	**8**
Advanced Hybrid Diagnosis & Repair (ATT 483)	1
Advanced Hybrid Fuel Cell & Electric Vehicles (ATT 481)	1
Alternative and Renewable Maintenance Training	1
Alternative Fuels Conversion, Diagnosis & Repair (AMECH 493)	1
Heavy Duty Alternative Fueled Vehicles (AMECH 491)	1
Heavy Duty Alternative Fueled Vehicles Diagnosis & Repair (AMECH 492)	1
Intro to Hybrid & Electric Vehicles (ATT 480)	1
Introduction to Alternative Fuels (AMECH 490)	1
Industrial Technology	**2**
Advanced Metering Technology (ITECH 156)	1
Hybrid Service and Safety (AST 55)	1
Automotive Technology	**11**
Advanced Electrical Systems (AUTO 260)	1
Advanced Hybrid/Electric Vehicle (AUTO 260)	1
Advanced Technology Electric Vehicles (AUTO 55)	1
Automotive Electricity (AUTO 160)	1
Automotive Electricity (AUTO 161)	1
Auto Electronics & Electrical Systems (AUTO 11B)	1
Hybrid, Fuel-Cell & Electric Technology (AUTO 43A)	1
Intro to Alternative Fuel Vehicles (AUTO 45A)	1
Intro to Electric Vehicle (AUTO 54)	1
Intro to Electric/Hybrid Vehicles (AT 181C)	1
Introduction to Hybrid and Electric Vehicle Technology (AUTO 147)	1
Diesel, Alternative Fuel and Hybrid Vehicle Technologies Department	**3**
Advanced Hybrid and Plug-in Electric Vehicles (DIESLTK 303)	1
Hybrid and Plug-in Electric Vehicle (DIESLTK 302)	1
Introduction to Alternative Fuel & Hybrid Vehicle Technology (DIESLTK 301)	1

Table 3-13b: TE-related courses by organization type: Bachelor's, master's, and PhD

University-teaching	**14**
Chemical Engineering	**1**
Green Engineering I: Alternative Energy (533/433)	1
Department of Technology	**1**
Electric, Hybrid and Alternative Fueled Vehicles (TECH 470)	1
Electrical and Computer Engineering	**4**
Electric Power Systems (ECE 411)	1
Electrical Machines and Energy Conversion and Lab (ECE 410/L)	1
Power Electronics (ECE 469)	1
Power Electronics (ECE412)	1
Electrical Engineering	**6**
Alternative Energy Vehicles (EE434)	1
Alternative Energy Vehicles (EE 434)	1
Electric Vehicles (451)	1
Electronic Control of Motors (450)	1
Power Electronics (EE484)	1
Sustainable Electric Energy Conversion (EE420)	1
Mechanical Engineering	**2**
Advanced and Hybrid Vehicle Design (ME 446)	1
Alternative Energy Systems (MECH521)	1
University-research	**17**
Chemical and Biomolecular Engineering	**4**
Electrochemical Engineering (217)	1
Electrochemical Processes and Corrosion (C114)	1
Electrochemical Processes and Corrosion (C214)	1
Special Topics in Chemical and Biomolecular Engineering (290)	1
Chemical Engineering	**2**
Electrochemical Engineering (CHE131)	1
Special Topics in Materials Electrochemistry (CEE 259)	1
Electrical Computer Engineering	**1**
Introduction To Power Electronics (ECE142)	1
Electrical Engineering	**4**
Electromechanics (EE 370)	1
Net-Centric Power-System Control (EE 527)	1
Power Electronics (EE123)	1
Power Electronics (EE528)	1
Electrical Engineering/Mechanical Engineering	**1**
Introduction to Mechatronics (EE/ME 7)	1
Mechanical and Aerospace Engineering	**2**
Design and Analysis of Smart Grids (MECH&AE C137/237)	1
Engineering Electrochemistry: Fundamentals and Applications (ENGRMAE 212)	1
Nano Engineering	**1**
Advanced Micro- and Nano- Materials for Energy Storage and Conversion (NANO 164)	1
Public Policy/Urban Planning	**2**
Special Topics in Public Policy: Electric-Drive Vehicles: Technol. & Policies (PUB PLC290-1)	1
Special Topics in Public Policy: Policies for Alt. Fuel Veh. & Infrastructure (PUB PLC290-1)	1

3.3 Occupation training matching and gap analysis

This section combines the information from the previous two sections in order to match TE-impacted occupations with TE education offerings available in southern California. In doing so, it hopes to highlight gaps and opportunities for TE curriculum development.

3.3.1 Which educational products serve which occupations?

In order to better understand what TE training already exists, each educational product (degrees, certificates, workshops, and "other") has been coded to indicate which occupations it serves. It should be noted that this process could be less straightforward than might be expected. This is due to a number of reasons, including:

- Uncertainties/lack of full information (e.g., about curricula scope, depth, and pedagogy and the applicability/transferability of training).
- The fact that many products, particularly non-vocational ones, are not as clearly targeted at specific occupations.
- The new and changing nature of many occupations and educational products, etc.

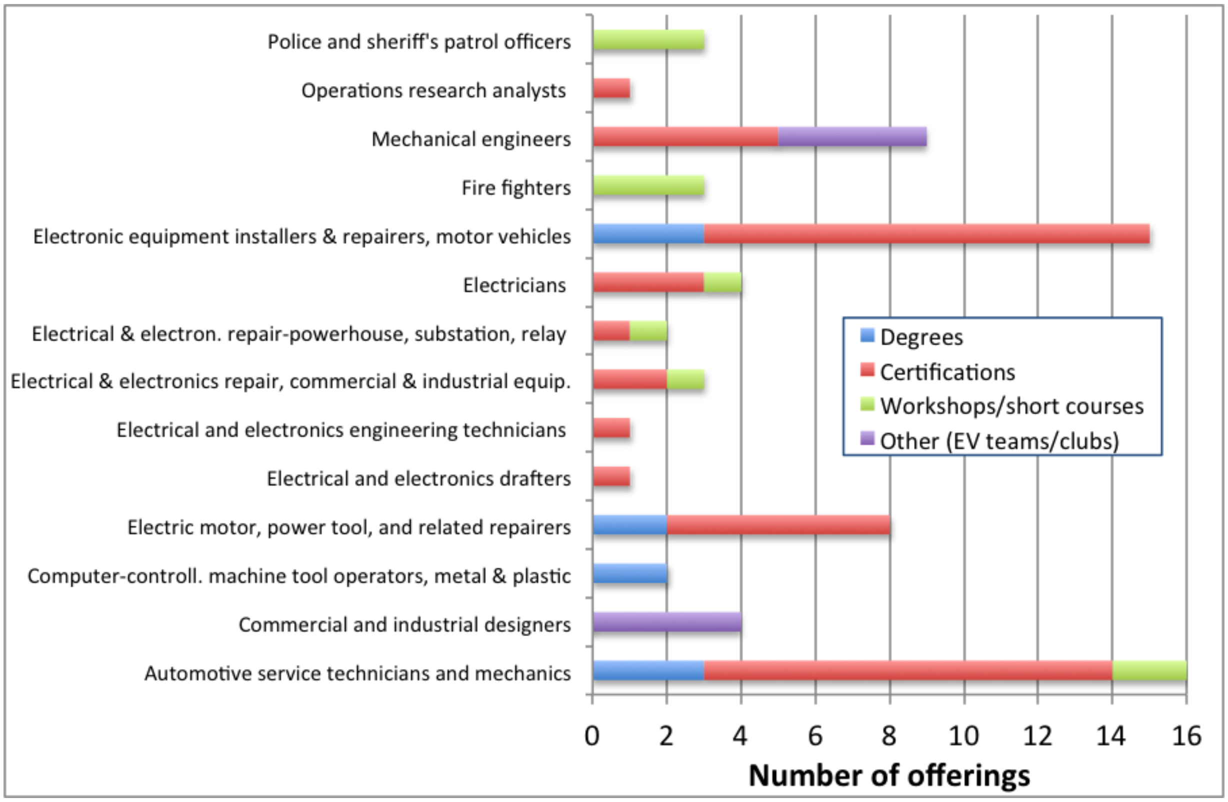
For these and other reasons, each educational product has been coded and analyzed in two ways: "Core" and "Score."

"Core"

The "Core" analysis tries to identify relatively clear matches between an occupation and an educational product. It asks, "Is this educational product for this occupation? (yes/no)." For example, the "Alternate Fuels Service Technician" certificate is clearly a Core education product for the "Auto service technicians and mechanics" occupation. Other examples can be less straightforward, but the Core determination is given to those product/occupation matches that are thought particularly reasonable.

Figure 3-5 summarizes the results of the Core analysis for southern California. It shows a relatively large number of certificate programs and several degree programs applicable to automotive and electrical equipment technicians of various types. Additionally present are a few certificate programs for engineers and workshops for first responders. Occupations not represented in Figure 3-5 lack Core products.

Figure 3-5: Core southern California TE educational product counts by occupation



"Score"

Not every occupation is going to have a core, TE-specific educational product. The "Score" analysis was developed to accommodate more uncertainty and ambiguity to answer, "Which occupations have related/helpful training?" This is done using coding that allows 3-way differentiation of TE training products along the lines of, "Is it a relatively clear match (i.e., Core), might it help educate this occupation, or is it not particularly applicable?" For a given occupation, the scoring system is as follows:

2 = the TE training is for the occupation, i.e., Core.

1 = the TE training is reasonably helpful and arguably applicable.

0 = the TE training is either not particularly applicable or above the typical education level of the occupation.

For example, trainings receiving a one for a given occupation could be more general or transferable education that is reasonably likely for someone in that occupation to have taken the time to attain before or during his or her career.

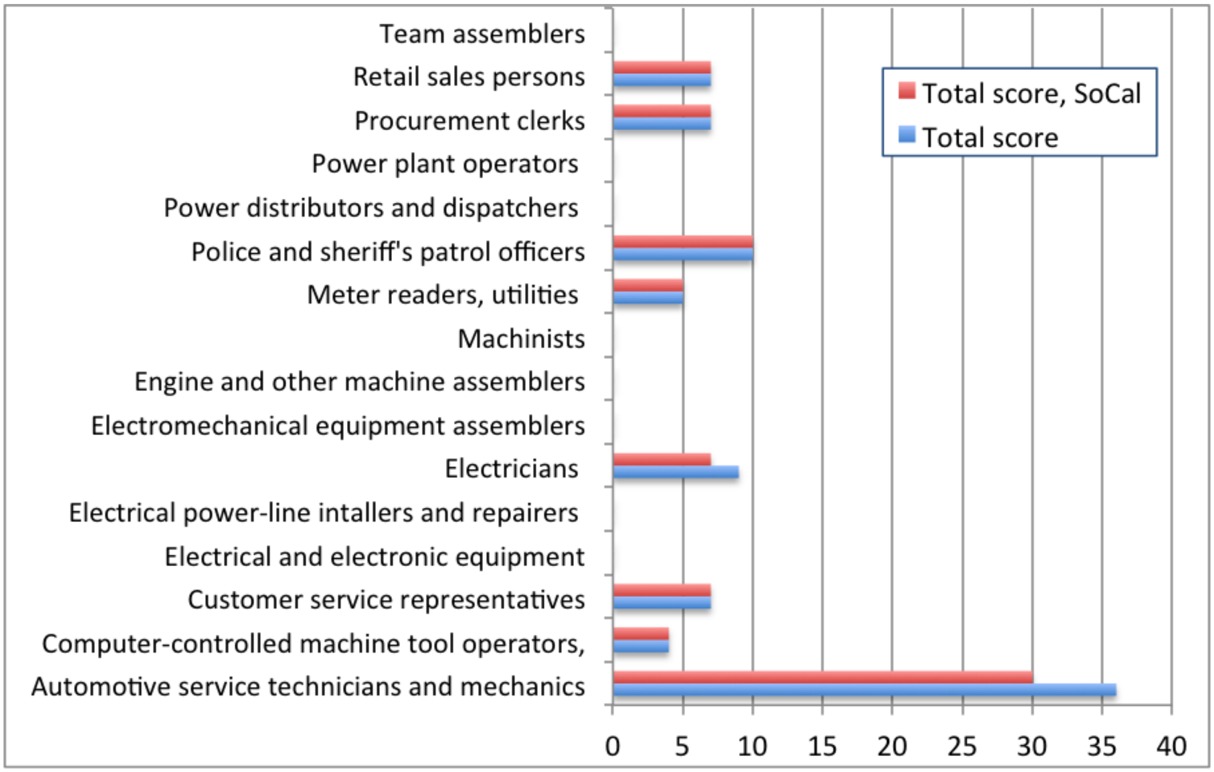
A zero might be given to a training offered at an educational level that exceeds reasonable expectations for a person in that occupation to have taken the time and effort to attain. This determination is informed by the entry-level education requirements identified in section 3.1, with some allowance for an additional level or so of educational achievement.

A zero might also be given to training that could be quite useful and attainable but is not particularly applicable (e.g., first response training for most other occupations than fire fighters and police).

After coding each occupation/training-product combination, Scores assigned for each product are summed across each occupation for each training type (degree, cert., workshop/short-course, or other) and again across all types. The resulting sums are thus more illustrative or ordinal than rigorously quantitative: a zero is informatively different than a small number, which is different than a large number.

Figures 3-6 through 3-8 summarize the total Scores given to occupations, which are grouped by entry-level education. Note that entry-level education is a way to group similar occupations and represents a typical minimum; it does not reflect the maximum level of the training products scored in a given figure. For each occupation, two Scores are given, one for TE training products in southern California (including some on-line products) and another reflecting all of the products in the southern-California-focused but national database.

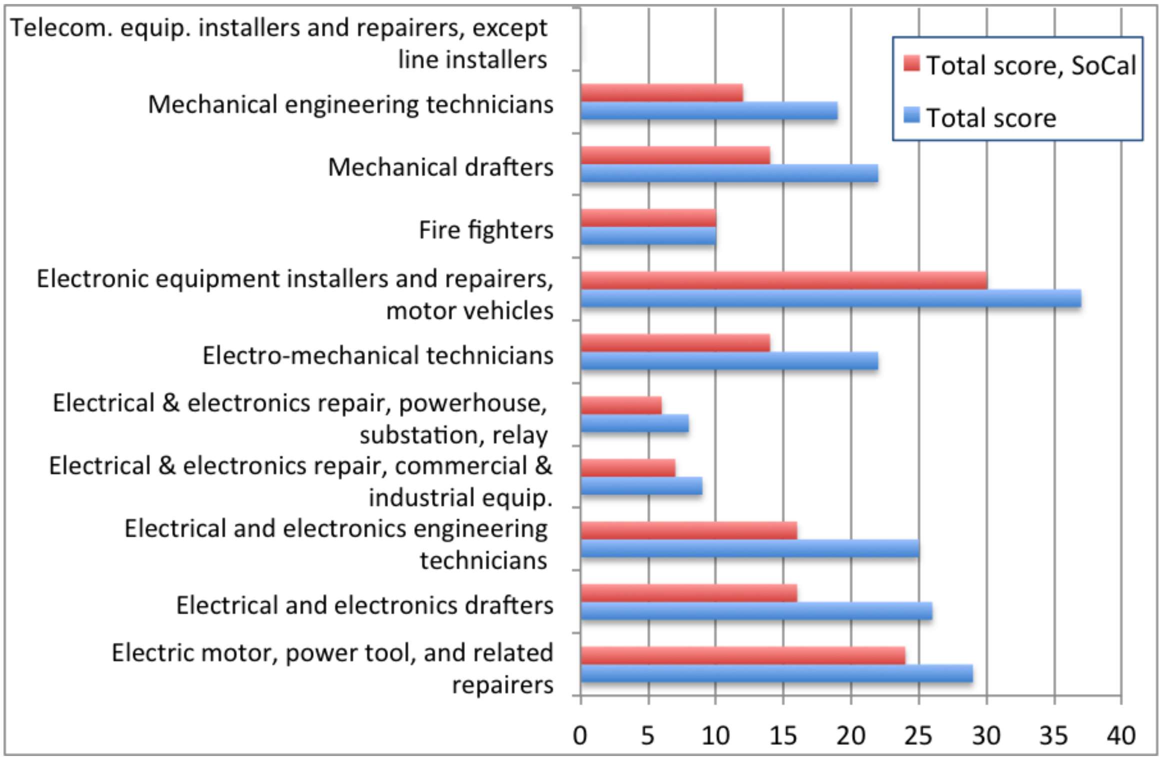
Figure 3-6: Available TE education-product Scores: high-school entry-level occupations



In this group of occupations, the following lack identified TE-specific training of the types included in the Score (degrees, certificates, short-courses, and EV teams/clubs):

- Power-plant operators,
- Power distributors and dispatchers,
- Machinists,
- Electric power-line repairers and installers, and
- Assemblers of various types: machine, electromechanical, electrical, and electronic.

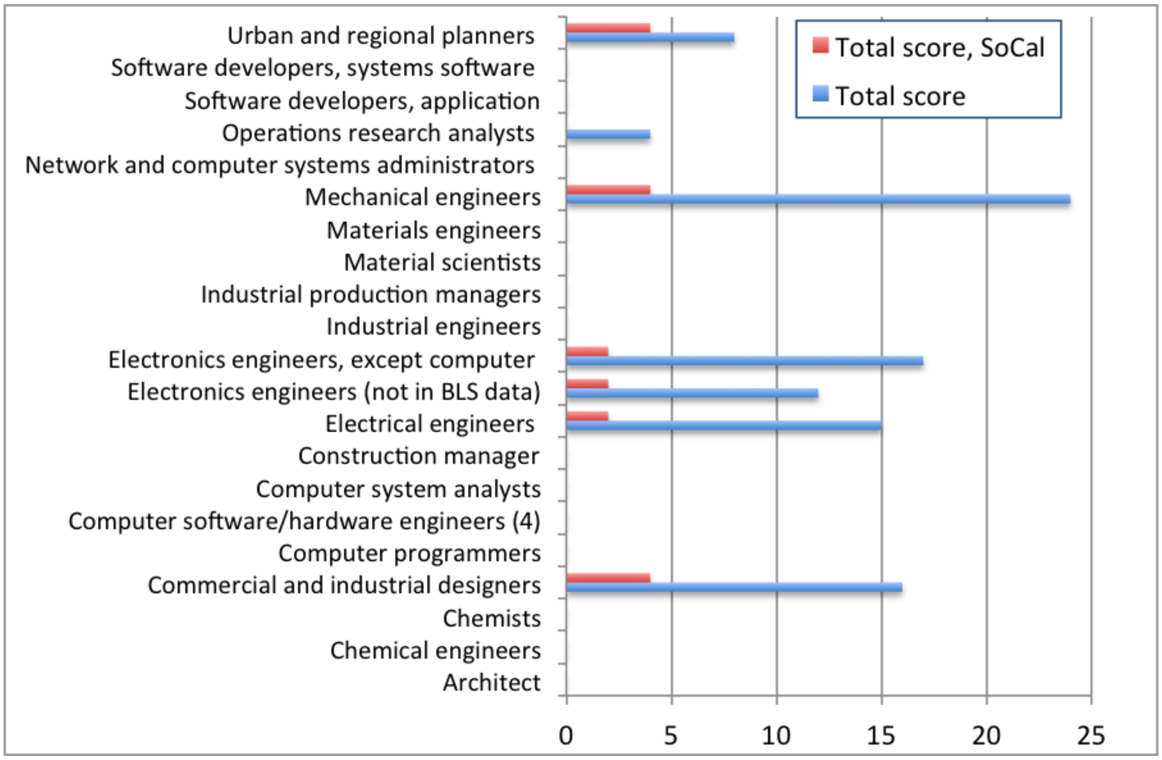
Figure 3-7: Education-product Scores: postsecondary and associate's entry-level occupations



In this group of occupations, the following lack identified TE-specific training of the types included in the Score (degrees, certificates, short-courses, and EV teams/clubs):

- Telecommunications equipment installers and repairers.

Figure 3-8: Education-product Scores: bachelor's and master's entry-level occupations



In this group of occupations, the following lack identified TE-specific training of the types included in the Score (degrees, certificates, short-courses, and EV teams/clubs):

- Software developers,
- Operations research analysts,
- Computer systems administrators, systems analysts, and programmers,
- Engineers: materials, industrial, chemical, computer,
- Material scientists,
- Industrial production managers,
- Construction managers,
- Chemists, and
- Architects.

It should be noted that detailed knowledge of individual courses (65 of which have been identified in section 3.2) would aid a thorough analysis of the gaps and opportunities in this educational context and should be considered for subsequent context-specific work on TE curriculum development.

Gaps, critical gaps, and opportunities for supplementation

The analysis in the previous section identifies potential gaps in TE-specific education and opportunities for enhancement, based on the educational products identified in the database. Those occupations with Scores of zero represent clear gaps and were called out in the bulleted lists in the previous section. Those occupations with low total Scores, or low counts of certain types of Core products represent opportunities to supplement current offerings.

Additional characterization may be useful on two fronts: 1) to prioritize gaps, and 2) that evaluates not just the amount, but the nature and quality of the product offerings, possibly including, as mentioned in the previous section, detailed analysis of individual courses (e.g., using syllabi where available, interviews and other similar methods). Stakeholders delving deeper into context-specific priorities should consider the latter for subsequent efforts.

The former front, prioritization, could be begun by stakeholders identifying gaps or needs thought to be more critical on one or more metrics. For example, measures of criticality could be defined, such as 1) gaps that are somehow identified to be "rate limiting" or "bottlenecks" to the expansion of TE in one specific way or another, 2) occupations where dramatic shortfalls in supply are identified or expected, and/or 3) training that impacts "priority" occupations, such as those for which TE will cause appreciable change in the nature of the job, not just an increase in the number of bodies in that job needed by the industry.

An illustrative attempt to code the occupations characterized above as "priority" or not in this way identifies "critical gaps" in TE-specific educational products (degrees, certificates, short-courses, and EV teams/clubs) for:

- Power-plant operators,
- Power distributors and dispatchers,
- Software developers,
- Operations research analysts,
- Computer systems administrators, systems analysts, programmers,
- Engineers: materials, chemical, computer,
- Material scientists,
- Chemists, and
- Architects.

3.4 Research questions for future work

Sections 3.1–3.3 provide a common framework and terminology, collect foundational information, and provide analysis characterizing TE-impacted occupations, existing TE educational offerings, and their nexus. These help shed light on the curriculum development needed to support the PEV, charging, and smart-grid workforces. Nevertheless, several key research questions should be addressed, or addressed in increasing detail, including:

- Where is the workforce supply chain falling short? Where might future shortfalls be expected?
- What workforce training factors might affect a smooth transition to electrified transportation?
- What opportunities exist to improve existing curricula, and what gaps identified are the highest priorities for supplementation?
- How else do these opportunities and priorities vary by educational environment (technical/vocational, undergraduate, graduate generalists, and professional/research)?
- What resources are available to answer these questions, create a differentiated yet unified workforce development strategy, and implement identified curriculum development needs?

With these questions in mind and the above background information and analysis providing a foundation, stakeholders from educational/training, governmental, industry, and other workforce organizations were engaged to have an informed discussion about TE curriculum needs. The next section summarizes and builds upon that discussion.

4. Stakeholder Engagement

4.1 Workshop overview

Hosted by Southern California Edison at its Energy Education Center in Irwindale, California, the UCLA Luskin Center for Innovation conducted a Transportation Electrification Curriculum Workshop on February 18, 2014. An agenda and confirmed participant list for the event are included in the appendices. In attendance were representatives from:

- Southern California community colleges (Cerritos, El Camino, Long Beach, and Rio Hondo), universities (Cal Poly Pomona, CSU-Los Angeles, and UCLA), and training organizations (Perfect Sky);
- Utilities (Los Angeles Department of Water and Power and Southern California Edison);
- Vehicle industry stakeholders (General Motors, Nissan of Downtown Los Angeles, and California Plug-in Electric Vehicle Collaborative);
- Governmental organizations (California Energy Commission, South Coast Air Quality Management District, Southern California Association of Governments, and Los Angeles County); and
- Other workforce-development stakeholders (e.g., Los Angeles Economic Development Corporation and California Center for Sustainable Energy).

At the event, participants were provided with background information on: the project, plug-in electric vehicle (PEV) and infrastructure markets, the future of the smart grid, and Edison International Foundation's community investments in education. They then engaged in four sessions of informed discussions, reviewing and building upon background research distributed before the event in a read ahead packet and presented at the event. The first two sessions reviewed and discussed read-ahead materials characterizing the occupations likely to be significantly impacted by Transportation Electrification (TE) and existing TE educational/training offerings in southern California. The third session presented an exercise matching impacted occupations with educational offerings to support identification key gaps and discussion of opportunities. The fourth and concluding sessions allowed discussion of priority curriculum and other needs related to TE, starting first with comments from educators and wrapping up with concluding thoughts.

4.2 Key issues and possible next steps

The following summarizes several key issues raised at the workshop and formulates possible next steps.

4.2.1 Occupational data availability and usefulness

Issues:

Several kinds of workforce data are available. Some of the data are organized by occupation (often characterizing unrelated industries together) and some by industry (making disaggregation of occupations and identification of specific supportive training needs difficult). These data are useful in painting an overall picture of the scope and nature of the TE workforce, but its usefulness can be limited by a lack of TE specificity, uncertainties surrounding the fraction that will be impacted by TE over time, and the need for new and evolving occupational and industry definitions.

Possible next steps include:

- Where more than a general characterization is justified, future work focusing on specific occupations in specific industries could take "deep dives" into the available data to answer research questions specific to those case studies. For example, vehicle repair and maintenance technicians could be differentiated by employment-industry type, the percentage or amount of each needed for electric fuel vehicles estimated as a function of expected vehicle penetration in a region, and adequate supply assessed via quantitative comparison to the training capacity in that region.
- Areas identified as potentially inadequately characterized by occupation codes that could be explored include:
  1) Additional characterization of grid-tie inspection, standards development, cyber security, construction management, TE research, TE policymakers, communications (across all three industry segments), software control, and used-product re-sale, repurposing, and recycling.
  2) Further differentiation between commercial and residential electricians, retail and fleet sales and financing, first and second responders to electric vehicle incidents, and heavy-duty and light-duty vehicle occupations.
- As part of its Alternative and Renewable Fuels and Vehicle Technologies program focus on workforce development, the California Energy Commission is gathering and generating alternative fuel specific characterizations over time. These may address certain TE curriculum development informational needs and should be drawn upon as an additional valuable resource.

4.2.2 Problem definition

Issues:

Clearer, more specific problem definitions and communication are needed from industry to seed curriculum development efforts. Aside from anecdotal evidence, it is not sufficiently clear which specific occupations will respond to TE in a conventional manner (e.g., as TE penetrates more significantly into the market more job openings will create more TE labor demand,

and educational supply will adapt over time) and which face more fundamental barriers and labor-market failures. Further, barriers and solutions vary by occupation type and educational context, sometimes dramatically. For example, a vehicle technician program may lack the tools and hardware needed to teach the latest plug-in electric vehicle repair techniques, whereas an electrical or mechanical engineering program may be inadequately training automakers of the future that are increasingly asked to be interdisciplinary, whole-systems thinkers capable of having conversations and solving problems "in between" traditional discipline boundaries.

Possible next steps include:

- To better understand the problem, educators request more proactive engagement from companies and organizations anticipating or currently experiencing TE workforce deficiencies.
- To facilitate industry communication of current and anticipated needs, venues could also be created.
  - For example, a series of targeted interviews with auto-, charging-, and grid-industry TE leadership and human resource representatives could probe needs and identify key case studies for detailed examination.
  - Task forces or advisory panels with industry participation could be created specific to each educational context (vocational/technical, undergraduate, general professional, and TE-specific research) to detail and prioritize specific problems and barriers.
  - A "TE workforce ombudsman," czar, or other official could be appointed by the governor's office or a state agency to champion TE workforce development as part of the state's integrated ZEV Action Plan to assure that aggressive policies related to zero-tailpipe-emission vehicles are successful.
- Additional background information could be collected to better illuminate possible problems and motivate curriculum development, for example on the changing age and other demographics of utility employment that may be leading to unreplenished loss of tacit knowledge as senior TE leadership retires.

4.2.3 Communicating the need

Issues:

In addition to better understanding specific problems (see "Problem definition," above), educators need general support validating their efforts to address them. Lack of centralized institutional support can present a significant hurdle.

Possible next steps include:

- Stakeholder engagement of deans, chancellors, presidents, and other educational leadership will validate the efforts of TE education pioneers, encourage additional efforts, and may lead to internal funding or initiatives/challenges/themes and other forms of industry-university collaboration.

- Additionally, conducting the activities described above to facilitate problem definition (e.g., proactive industry communication of specific needs, and facilitating and supporting engagement through creation of TE workforce venues and supportive research) will also act to validate efforts, creating legitimacy for resources devoted to TE curriculum development and deployment.

4.2.4 Characterizing different types of educational offerings

Issues:

Metrics characterizing some types of TE-related educational offerings are more straightforward to collect and understand. At colleges offering vocational/technical training, several courses, certifications, and even entire degree programs exist with explicit TE relevance and can be found and characterized via the Internet. Even then, however, details about curricula and skill development are rare or labor-intensive to collect (e.g., requiring interviews). It is also less straightforward to characterize education from private training organizations; that is ad-hoc, online, or via remote instruction; or that results from participation in faculty and graduate-student research. Further, certain, often higher-paying occupations are filled from super-regional labor pools and more emphasis is needed on national and international training to fully understand those educational contexts. Also, information about on-the-job and corporate-internal (in-house or contracted) training—often the dominant forms of firm or industry specific training—is less accessible and sometimes not generalizable.

Possible next steps include:

- Subsequent research that focuses on individual educational contexts and involves more labor-intensive methods would enhance regional understanding of TE education/training and improve gap analysis and prioritization of opportunities.
- Additional desirable data include a tracking of TE-related university research dollars, internships/externships, and industry-university collaborations to better illuminate programs that may not register in a search of TE-related degree, certificate, or course offerings.
- More background research is needed on how specific industry segments train their TE professionals outside of the college/university system.

4.2.5 Additional support for professors and other educators

Issues:

Educators have difficulty keeping up with developments and cannot always be expected to have the time, resources, and up-to-date intelligence about industry developments to develop new curricula, let alone market new courses to create and sustain high interest levels (also see next section).

Possible next steps include:

- In addition to engagement with educational leadership, direct engagement with TE-education pioneers could be explored for its potential to lead to mutually beneficial initiatives and third party funding.
- Educators have identified two areas where additional resources may be particularly helpful:
  - To help reduce "start-up costs" (e.g., for hardware-based learning, acquisition of tools or vehicles).
  - For "marketing," defined broadly, to sustain the robust and consistent demand for TE-related courses and activities that encourages departments to institutionalize the offerings. For more discussion on this front, see discussion of increasing student "exposures," below.
- Proactive supply of information to educators on not just the technologies currently on the market, but those in the pipeline, which often are different products with distinct educational and policy implications.
- Co-development of curricula for use by educators:
  - Possibly by the task forces, advisory panels, or ombudsman's office recommended above, or via another body above to champion an integrated TE workforce-development strategy for the region or state.
- The formation of other stakeholder communities to support educators in their development, marketing, and implementation of TE education and training:
  - These might be based not only on educational context, but possibly also formed around, or to encourage, certain competency "clusters" based on regional strengths and needs.

4.2.6 Generating and channeling student demand for TE and TE offerings

Issues:

Whether it is consumer demand for products, workforce demand for jobs, or student demand for courses, generating demand for TE offerings faces several hurdles, including unfamiliarity and complexity. Consumers, job seekers, and students alike poorly understand TE. Opinions may be based on relatively little information from sources of varying quality. This is exacerbated by structural problems with science, technology, engineering, and mathematics education, which inadequately position individuals to understand and take advantage of the potential attractions of TE technologies, jobs, and education/training.

Further, attitudes towards, and preferences for, TE offerings of all types change significantly, usually for the better, as individuals and groups become exposed to the technologies, their features, and potential benefits.

Possible next steps include:

- Increasing the exposure of students to TE in various ways and contexts, including:
  - o On-campus demonstrations of exciting technologies.
  - o Use of TE-related equipment in courses.
  - o Use of TE-related technologies by educational institution.
  - o Internships/externships.
  - o Industry-university collaborations.

4.3 Workshop themes and action items

In summary, several themes emerged from, or might be appropriately drawn out of, the process of stakeholder engagement at the Transportation Electrification Curriculum workshop. These include:

- Inadequate information and communication characterizing future TE occupations (e.g., new job types and those in less understood parts of the supply chain like retirement/recycling) and characterizing specific shortfalls in the TE workforce.
- The need for a more focused and differentiated approach to addressing problems particular to each educational context.
- Inadequate incentives and support for educators, both those pioneering TE training as well as those that would find adding TE education offerings challenging.
- The lack of an overall TE workforce-development strategy for the region and state with consistent aims and funding.
- A desire for increased industry/stakeholder engagement with educators, educational leadership, and students.

Possible action items developed based on these and the "possible next steps" described in the previous section include:

- The formation of a high-level position responsible for developing state or regional TE workforce development strategy and coordinating related efforts, perhaps as part of the state's ZEV Action Plan efforts to support aggressive clean-car policies (e.g., "czar," "ombudsman," agency department head, or other champion of TE workforce development).
- The formation of communities of educators and TE stakeholders, (perhaps organized around regional TE-competency clusters) to facilitate information flow, curriculum development, and the securing of adequate resources.
- The formation of TE curriculum-development advisory boards or task forces to identify educational-context-specific informational and curriculum development needs and facilitate implementation.
- The execution of additional research to address informational needs identified herein or in support of TE-czar, community, advisory-board, or task-force priorities.
- Industry-led initiatives to engage with educational leadership in support of TE training, TE-

themed “challenges,” and industry-university collaboration.

- Increased TE technology and information transfer to educational institutions in support of TE education.
- The creation of incentives and other resources to reduce the “start-up” costs of TE educational offerings and improve “marketing” to students and the community.
- An initiative aimed at increasing student “exposures” to TE technologies, to improve understanding of TE and stimulate demand for related educational offerings and subsequent job opportunities (e.g., showcases, demonstrations, internships/externships, college/university implementation of TE technologies, use of TE equipment in courses, research funding/collaborations, etc.).

5. Appendix: TE Curriculum Workshop

5.1 TE Curriculum Workshop Agenda

UNIVERSITY OF CALIFORNIA, LOS ANGELES | UCLA

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO | SANTA BARBARA • SANTA CRUZ

LUSKIN CENTER FOR INNOVATION
SCHOOL OF PUBLIC AFFAIRS
337 Charles E. Young Drive
Los Angeles, CA 90095-1656
Mail Code: 165606

UCLA Luskin School *of* Public Affairs
Luskin Center FOR INNOVATION

Transportation Electrification Curriculum Roadmap Workshop

With funding from Edison International and support from Southern California Edison, the UCLA Luskin Center for Innovation is investigating the workforce-training needs of emerging plug-in-electric-vehicle (PEV) industries.

Edison, SCE, and UCLA Luskin are hosting a one-day, invite-only **Transportation Electrification (TE) Curriculum Roadmap Workshop** on 18 February 2014 at the SCE Energy Education Center in Irwindale, California.

Key topics to be discussed at the interactive workshop include:

- What is the nature and magnitude of the automotive and utility workforces that may need (re)training about transportation electrification (TE)?
- What current efforts are underway to supply the PEV industries with a skilled workforce?
- Where is the workforce supply chain falling short? Where might future shortfalls be expected?
- What workforce-training factors might affect a smooth transition to electrified transportation?
- What opportunities exist to improve and develop adequate curricula?
- How do these opportunities vary by educational environment (technical/vocational, undergraduate, graduate generalists, and professional/research)?
- Overall focus: What is the path forward for curriculum development that will meet the needs of industries at the forefront of transportation electrification?

Workshop Agenda (subject to change)

Transportation Electrification (TE) Curriculum Development Workshop

18 February 2014

SCE Energy Education Center
6090 N. Irwindale Avenue
Irwindale CA 91702

9:00–9:30am: continental breakfast
9:30–9:50am: welcome (*JR DeShazo, UCLA Luskin Center Director, Robert Graham, EDV Commercialization, Ed Kjaer, Transportation Electrification Director, SCE, and Tammy Tumbling, Philanthropy & Community Investment Director, SCE*)
9:50–10:05am: PEV market update, project overview, and housekeeping (*Brett Williams, UCLA Luskin Center EV Program Director)*
10:05–10:25am: participant self-introductions (*All*)

1st section – roadmap process and TE workforce characterizations

10:25–10:40am: TE occupation categories *(Williams)*
10:40–11:00am: review for omissions and priorities; discussion (All)

11:00–11:15am: break with refreshment

2nd section – existing TE training

11:15–11:30am: TE-related training programs (*Williams*)
11:30–12:00pm: review for omissions; discussion (All)

12:00–1:00pm: lunch (address by Ed Kjaer, SCE)

3rd section – key gaps

1:00–1:15pm: workforce/training matching and gap analysis (*Williams*)
1:15–1:45pm: review for omissions and priorities; discussion (All)

4th section – curriculum development needs and priorities

1:45–2:25pm: reflections on priority curriculum needs (*education-institution participants*)
2:25–2:55pm: identify, prioritize additional curriculum-development opportunities (*All*)

2:55–3:10pm: break with refreshment

Concluding Section

3:10–4:10pm: round-the-room: participant final thoughts and discussion (*moderator: Williams*)
4:10–4:20pm: summary of outcomes and next steps (*DeShazo*)

Adjourn

innovation.luskin.edu/ev

5.2 TE Curriculum Workshop Participants

Last name	First name	Title	Organization
Blekhman	David	Professor, Power, Energy & Transport.	California State University, Los Angeles
Boehm	Michael	E-Mobility Task Force Chair / Executive Director	LAEDC / Advanced Sustainability Institute
Briasco	Scott	Manager of Fleet Eng. & Electric Transportation	Los Angeles Dept. of Water and Power
Davidson	Eldon	Director of Contract Education	El Camino College Business Training Center
DeShazo	J.R.	Luskin Center for Innovation Director / Professor	UCLA Luskin Center / Public Policy
Frala	John	Professor	Rio Hondo College
Gadh	Rajit	Director	UCLA Smart Grid Energy Research Center
Gishri	Tamara	Senior Manager, workforce development lead	California Center for Sustainable Energy
Golden-Stewart	Joanne	Director of Public Policy	LA County Economic Development Corp.
Graham	Robert		EDV Commercialization
Jakovich	Scott	Program Manager, Adv. Transportation & Security	Long Beach City College
Kehoe	Christine	Executive Director	CAi Plug-In Electric Vehicle Collaborative
Kerbel Shein	Alan	Graduate Student Researcher	UCLA Anderson / Luskin
Keros	Alex	Manager, Advanced Vehicle and Infrastructure Policy	General Motors
Kjaer	Edward	Director, Transportation Electrification	Southern California Edison
LeSage	Jon	Owner	LeSage Consulting
Linder	Alison	Senior Regional Planner	Southern CA Association of Governments
Lindy	David	Professor	Rio Hondo College
Malig	Jannet	Depty. Sector Navigator, Adv. Transport. & Renewables	Cerritos College
Miyasato	Matt	Deputy Executive Officer	South Coast Air Quality Mgt District
Nichols	David	Energy Specialist, Mgr. of AB118 Workforce Training	California Energy Commission
Rosebro	Jack	Instructor, curriculum developer	Perfect Sky, Inc.
Saito	Dean	Planning & Rules Mgr., Mobile Source Division	South Coast Air Quality Mgt District
Scott	Paul	LEAF Specialist	Nissan of Downtown Los Angeles
Sedgwick	Shannon	Associate Economist	LAEDC, EPAG
Teebay	Richard	Fleet & Transportation Specialist	County of Los Angeles
Tolley	Flor	Senior Manager, Community Investment	Southern California Edison
Williams	Brett	EV Program Director / Asst. Adj. Prof.	UCLA Luskin Center / Public Policy
Woo	Michael	Dean, College of Environmental Design	Cal Poly Pomona
Xu	Tongxin	Graduate Student Researcher	UCLA Luskin Center for Innovation
Zarate	Christian	Communications/Events	UCLA Luskin Center for Innovation

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UCLA Luskin School *of* Public Affairs

Luskin Center for Innovation

3323 SCHOOL OF PUBLIC AFFAIRS
BOX 951656, LOS ANGELES, CA 90095-1656
310-267-5435 TEL • 310-267-5443 FAX

INNOVATION.LUSKIN.UCLA.EDU