



International
Specialised
Skills
Institute

Electric and Hybrid Vehicle Maintenance, Service and Repair.



Alan Platt

Skills Victoria (TAFE)/ISS Institute Fellowship

Fellowship funded by Skills Victoria



ISS Institute Inc
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Executive Summary

The purpose of this ISS fellowship was to study the learning strategy and science underpinning automotive hybrid vehicle technology in the USA and disseminate this information to the Australian automotive training industry, Government, and others. The fellow will make recommendations to automotive industry stakeholders to assist and guide their decisions on hybrid vehicle technology training in Australia.

While participating in a four week study tour of the USA, the fellow has identified the scope of safety training required for repairers, the learning resources required for facilitation of training, the learning strategies embraced by training organisations in the USA and the scope and availability of professional learning for instructors and repairers.

The fellow has concluded that the current availability of technical information and learning resources available to instructors and practitioners in Australia falls well behind the availability of such resources in the USA. The emphasis on professional learning of safety is noted in the report. Learning strategies for facilitation of training in the USA vary little from those available in Australian TAFE delivery, other than the strategies appear to be better supported by private funding.

Subsequent to the research, the fellow makes recommendations to government and industry stakeholders. These recommendations include the establishment of a dedicated hybrid vehicle training centre, partnered or embedded by a National VET Regulator Organisation. The development of a Qualification or ‘Skills Set’ by Automotive Skills Australia is recommended to underpin and standardise hybrid vehicle training in Australia. Industry is requested to freely support the professional development of trainers and the development of learning resources. Industry is also requested to provide access to hybrid vehicle data to the automotive repair industry at minimal cost. The fellow recommends the integration of hybrid vehicle units into automotive apprenticeship training and a review of occupational health and safety requirements in all units of competency relating to hybrid powered vehicles.

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Abbreviations/Acronyms

ANSI	American National Standards Institute
ASE	Automotive Service Excellence
AQF	Australian Qualifications Framework
ATV	Automotive Training Victoria
BAS	Belt Alternator Starter
BEV	Battery Electric Vehicle
BMS	Battery Management System
EV	Electric Vehicle
CAT	Category rating
CVT	Continuously Variable Transmission
DTC	Diagnostic Trouble Code
eCVT	Electronic Continuously Variable Transmission
ECU	Electronic Control Unit
HESG	Higher Education and Skills Group (formerly Skills Victoria)
HSG	Hybrid Starter Generator
IAME	Institute of Automotive Mechanical Engineers
ICE	Internal Combustion Engine
IMA	Integrated Motor Assist
ITAB	Industry Training Advisory Board
IEC	International Electrotechnical Commission
NATEF	National Automotive Technicians Education Foundation
NTAN	National Tafe Automotive Network
OEM	Original Equipment Manufacturer
NVR	National VET Regulator
RV	Recreational Vehicle
SAE	Society of Automotive Engineers
SCC	Sinclair Community College
SOC	State of Charge
TIS	Technical Information Service
VACC	Victorian Automotive Chamber of Commerce
VAF	Victorian Automotive Forum
VET	Vocational Education and Training

Definitions

Design

Design is problem setting to meet human needs and wants. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product – in business, government, education and training and the community in general. ¹

Innovation

Creating and meeting new needs with new technical and design styles [New realities of lifestyle]. ²

Series Hybrid

A hybrid vehicle design in which there is no mechanical connection between the Internal Combustion Engine (ICE) and the drive wheels. The ICE drives a generator that produces electricity.

Parallel hybrid

A hybrid vehicle design in which the electric motor assists the ICE to propel the vehicle.

Regenerative braking

A hybrid vehicle function that recovers kinetic energy while the vehicle is decelerating and stores it for later use.

Series-Parallel Hybrid

A hybrid vehicle design that can operate as a series hybrid, a parallel hybrid, or both at the same time.

Skills deficiency

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. ³

There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go.

Sustainability

The ISS Institute follows the United Nations NGO on sustainability, “*Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” ⁴

Acknowledgements

Alan Platt would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the ISS Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 200 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia’s ‘Australian Workforce Futures: A National Workforce Development Strategy 2010’:

Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.

International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.⁵

In this context, the ISS Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows’ overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the ISS Institute’s work.

For further information on our Fellows and our work see <http://www.issinstitute.org.au>.

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Acknowledgements

Fellowship Sponsor

The Victorian Government, Higher Education and Skills Group (HESG) formerly Skills Victoria, is responsible for the administration and the coordination of programs for the provision of training and further education, adult community education and employment services in Victoria, and is a valued sponsor of the ISS Institute. The Fellow would like to thank them for providing funding support for this Fellowship.

Supporters

- Fred Jones, Operations Manager (Victoria and Tasmania), Institute of Automotive Mechanical Engineers (IAME)
- Kevin Redfern, Executive Manager, Automotive Training Victoria (ATV)
- Richard Weaver, Technical Training Manager, Stillwell Motor Group

Employer Support

The Fellow would like to acknowledge the support of his employers, Swinburne University of Technology for the support given in the provision of access to the required resources to complete this project.

With special acknowledgement of the support given by the following:

- Barry Jones - Workplace Mentor
- Craig Brittle - Report Writing Mentor
- Fred Jones – Industry Mentor

Organisations Impacted by the Fellowship

- Institute of Automotive Mechanical Engineers(IAME)
- Victorian Automotive Forum (VAF)
- Victorian Automotive Chamber of Commerce (VACC)
- The TAFE (Technical and Further Education) sector
- Country Fire Authority (CFA)
- State Emergency Services (SES)

About the Fellow

Name

Alan Platt

Employment

Automotive Lecturer, Swinburne University of Technology

Qualifications

- Aircraft Mechanic (Airframe), Royal Melbourne Institute of Technology (RMIT), 1982
- Certificate III in Automotive (Mechanical – Light Vehicle) AUR31099, Kangan Institute, 2001
- Certificate IV in Assessment & Workplace Training, Swinburne, University of Technology, 2002
- Certificate IV in Automotive (Repair, Service & Retail), Swinburne University of Technology, 2006
- Diploma of Vocational Education and Training Practice, Swinburne University of Technology, 2010

Membership/s

- Institute of Automotive Mechanical Engineers (IAME)
- Victorian Automotive Forum (VAF)

Short Biography

Alan Platt qualified in 1982 as a licensed aircraft maintenance engineer, specialising in light aircraft airframes and engines. This work activity continued until 1992 when he moved into the field of industrial hydraulics.

Platt was employed in this role for a two-year period that included installation and repair of hydraulic systems to earthmoving machinery, storage and handling equipment, cranes, process machinery, boats/ships, and heavy vehicles.

Platt then joined the Automotive Industry, working for the ARB Corporation. During this period he was heavily involved with Recreational Vehicle (RV) modifications including, differential locks, overdrives, turbo charging diesel engines, suspension modifications including development work in these areas.

The knowledge he gained in transmission modifications led Platt into his next position with Eaton Pty Ltd where he gained extensive experience in the heavy vehicle field working on road ranger transmissions and drive heads, including development of transmissions to adapt them to meet the needs of manufacturers and owners.

Part of his role was to address issues related to vehicle mechanical fault and diagnosis of synchromesh transmissions addressing rectification and improvement of component operation.

The later part of Platt’s career was as owner operator of his own automotive repair business specialising in four wheel drive service and repair, and four wheel drive transmission repairs.

Platt commenced his teaching career in 2001 at Swinburne University of Technology in the Automotive Studies Department.

In 2009 he was awarded TAFE Development Centre teaching fellowship for his excellence in teaching practice and recognition of his professional development involvement.

Aims of the Fellowship Program

Purpose

To experience educational opportunities in the specialist area of Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) technology for the service, repair and diagnosis of Hybrid light Vehicles.

These skills can be transferred into automotive education within the context of the current training environment to meet emerging trends in automotive training and address future needs of Industry.

Aim

To establish a fundamental understanding and skills required to train students, other TAFE teachers and Industry in areas of service, maintenance and fault diagnosis of Hybrid Electric Vehicles in Australia.

A high demand exists for the provision of training in this area to cater for the needs of Industry. Hybrid vehicles have now been sold globally and within Australia in excess of ten years.

Training in this area has only been experienced through the franchised dealer networks that are involved with the sale and servicing of new vehicles. As Hybrid vehicles age, as with normal vehicles, they filter out to the non-franchised dealer networks that have limited access to specialist and product training. This has seen an increasing demand to provide training to this industry sector to address skills gaps and accommodate the needs of this market sector.

Therefore the rapidly changing industry needs around hybrid technology, and the level of electricity engaged in those vehicles mean that specialist training is essential. This is to ensure the safe handling of the service of these vehicles as well as ensuring the cost effectiveness to consumers of an availability of skilled repairers and service technicians for those vehicles.

This Fellowship will allow for dissemination of up to date training for TAFE teachers and industry across Victoria through hosting of training sessions locally. The benefits of this Fellowship will enable the establishment of educational programs in this field in Hybrid technologies, ensuring that TAFE training is relevant and up to date, as well as ensuring the vocational currency of TAFE teachers is addressed.

Additional benefits include:

- Up-skill of employees
- Application to apprenticeship training
- Addressing emerging needs and trends
- Increasing the need for training in sustainable practices
- Increased safety awareness with new systems
- Awareness of green technologies.

The Australian Context

The Automotive Industry is recognised as being one of the fastest moving technological changing global industries.

Ongoing vehicle development, and the emphasis of reducing Green House Gases at both a local and global level is placing increasing pressure on the retail automotive network. The need for increased technical education and training in Hybrid and Electric vehicles is already high and increasing within Australia. “Technological development has outpaced the up-skilling of existing Australian workers” and the demand for skills in ‘green’ automotive technologies - for use in small cars through to Trucks, and in terms of material use and efficient design through to incorporation of alternative fuels and electric drive - is a global phenomenon.” ⁶

New types of EV and HEV are entering the Australian market place on a regular basis. An example exists with the Mitsubishi i-MiEV. This vehicle, which became available after mid 2011, is the first factory built EV to be sold in Australia. I-MiEV is an example of the latest technologies available in this fast changing sector.

Demand is increasing within the automotive industry for education and training to address these expanding skills gaps and build further and future capability.

SWOT Analysis

Strengths

- Addressing emerging Industry trends and demands
- Addressing skills deficiencies
- Reducing the risk to employees regarding high voltage vehicle systems
- Identifying specialist diagnostic skills required with Hybrid / Vehicle systems
- Importing skills and knowledge in to other training areas and contexts
- Building workforce capability
- Establishing and building networking opportunities
- Building opportunities to provide training programs and increase commercial income.

Weaknesses

- Lack of training support (non franchised network)
- Unacceptance and understanding of industry to change quickly to meet emerging trends
- Lack of skilled workers (i.e. skills shortages) in Australia
- Increasing sales of Hybrid vehicles having little impact on understanding of training needs for the future form industry
- Vehicle owners often feel they are obliged to use franchised dealers due to lack of choice.

Opportunities

- Expansion from light vehicle to heavy vehicle
- Development of a number of educational programs locally and internationally
- Build courses in other automotive disciplines, Panel & Paint, Part Dismantlers, and Emergency Services
- Introduction of this technology to new students (Gen Y).

Threats

- TAFE education and training not meeting needs of Industry, loss of revenue
- High voltage systems increasing work place deaths and injuries

Identifying the Skills Deficiencies

The skill deficiencies that currently exist for TAFE teachers and vehicle technicians lie in the lack of knowledge on how to service and repair hybrid vehicles that are currently available for sale in the Australian market. The following skills will be addressed:

Safety - Automotive technicians, repairers, vehicle dismantlers and emergency workers need to gain knowledge and understanding of the new safety requirements that are unique to EV and HEV.

- Research related to EV and HEV integrated safety systems. Discover which are the automated high voltage disconnection systems and which are the manual systems
- Research on the methods to safely disable and work with EV and HEV high voltage systems in order to perform vehicle maintenance and repairs
- Investigation of the various types of EV and HEV safety systems being adopted by the range of vehicle manufacturers.

Aim: To improve knowledge and understanding of the inherent dangers to personnel and the procedures they will need to adopt to prevent injuries whilst working on EV and HEV.

Technology - Automotive technicians need to gain knowledge and understanding of the new technologies that are distinctive to EV and HEV in order to carry out maintenance and repairs.

- Research the 3-Phase AC induction and synchronous electric machine systems that currently drive the EV and HEV. Discover the future trends in this area of technology.
- Investigate regenerative braking strategies of different vehicles. Study the integration with the conventional (hydraulic) braking system.
- Research the different types of batteries that are in use and what are their advantages and disadvantages. Examine battery pack energy management systems.
- Investigate transmission and drive train systems.
- Investigate vehicle accessories that require adaptation from the conventional Internal Combustion Engines (ICE) installation. These include Heating Ventilation and Air-Conditioning (HVAC), power brakes and steering.
- Investigate cooling systems for inverters and electric machines.
- Investigate for the above systems the service requirements of the technician.

Aim: To improve knowledge and understanding of the above systems and the equipment, maintenance and repair techniques considered necessary for EV and HEV.

Diagnostics - Automotive technicians need to gain knowledge and understanding of the EV and HEV control technologies and the diagnosis procedures that are needed in order to identify complex vehicle faults.

- Research electronic management systems common to EV and HEV, including DC-DC converter and inverter systems.
- Investigate the analysis, diagnosis and repair techniques currently being used on EV and HEV systems
- Identify the type of electronic test equipment and their use as required for EV and HEV diagnostics.

Aim: To improve knowledge and understanding of the above systems, the equipment and diagnostic techniques considered necessary for EV and HEV.

Education - TAFE and other National VET Regulators (NVR) involved in automotive training need to train apprentices and trainees who are already being exposed to these new types of vehicles. Technical instructors need to be up skilled to be able to develop resources to assist in the education of EV and HEV. Of particular concern are the safety issues connected to the high voltage systems that are within these vehicles.

- Investigate the delivery techniques of institutes in the USA that are delivering training in this area.
- Examine the physical resources that aid delivery.
- Research available technical information that can be freely used in the development of written resources.
- Analyse the needs of the learners in the industry.
- Identify the equipment required for training purposes.

Aim: The development of training courses for public delivery. Training will also be delivered within the apprenticeship program. The findings of this report will be disseminated to other NVRs and industry bodies through the VAF and IAME in order to help them develop their own training programs.

The International Experience

Destination 1: Sinclair Community College

Location

- Dayton, Ohio, USA

Visit

- Automotive training facility

Contact

- Stephen Ash, Chairperson, Automotive Technology Department, Sinclair Community College

Organisation overview

Sinclair Community College is located in Dayton Ohio with five additional venues to the south. Sinclair College has provided 26,000 students with high-quality college and workforce training for nearly 125 years. In 1989, Sinclair was selected for membership in the prestigious League for Innovation in the Community College in 2001, and became one of the League's elite vanguard colleges. "Vanguard" is a term designated by the League to recognise the top twelve two-year institutions in North America that focus constantly on student and learner access and success. Out of 1,200 community colleges in the nation, Sinclair is one of 20 board member colleges of the League for Innovation in the Community College.

Sinclair's Automotive Technology program provides advanced, hands-on training for skilled entry-level positions in automobile dealerships, independent garages, and auto-related industries. Sinclair's Automotive Technology curriculum is fully accredited by the National Automotive Technicians Education Foundation (NATEF).

The Automotive Technology Program is designed to provide NATEF certified training for students aspiring to become automotive service technicians. Specific corporate training is provided in the following programs, all designed to develop technicians for their respective dealerships: General Motors ASEP (Automotive Service Education Program), Chrysler CAP (College Apprenticeship Program), Ford MLR (Maintenance and Light Repair), and American Honda PACT (Professional Automotive Career Training).

This is a world-class best-practise program and Sinclair's Automotive Technology department is highly recognised as a leader in training for the automotive industry.



Left: Sinclair Community College's Department of Automotive Technology

Objectives

To gain an understanding of how automotive training is structured in the USA, with a specific focus on the training models engaged, to instruct specialists in the field of hybrid vehicles technologies.

- 1. Safety requirements. To investigate the scope of safety training requirements necessary for staff and students when working with high voltage electrical systems.
- 2. Teaching resources required. To source current text books and other written resources currently being used for training. To investigate which vehicles and components are required for practical training?
- 3. Training methodologies. To identify and evaluate the learning strategy employed by Sinclair Community College.
- 4. Staff up-skilling. To research how “The Advanced Automotive Hybrid/Alternative Fuel Technology Institute” operates at Sinclair Community College (SCC) and identify its’ objectives.

Outcomes

1) Safety

- a. Theory is completed before exposure to vehicles. All training for hybrid or electric vehicles is preceded by two, two hour webinars, which include a section on safety. This is a mandatory requirement before participants can access the practical lessons in the workshops.
- b. The industry must be educated about high voltages and the levels that are considered dangerous. It must be assumed that current service personnel are not aware of the potential dangers of working with high voltage DC and AC power. Voltages above 50 V have the potential to kill.
- c. Protective gloves, types and correct usage. Rubber linesman’s gloves are recommended for use when high voltage is likely to be present. They should be rated for a minimum of 1000 volts. The American National Standards Institute (ANSI) class “0” is the accepted standard. Leather “over-gloves” should be used to protect the rubber gloves. Gloves need to be tested in accordance with the manufacturer’s procedures every time they are used.



Above: Removed Prius service plug. Note the use of approved linesman’s gloves and with leather over-gloves.

- d. Test equipment. All meters and test equipment being used must be rated to a minimum of CAT III. This standard is set by the International Electrotechnical Commission (IEC). Checking the meter before use, when testing for high voltage, is essential. The accepted procedure is to set the meter to voltage. Then test a known low voltage, typically a 12 volt car battery. The meter is then used to test for high voltage without changing the settings. Testing for high voltage is primarily used to confirm that the system about to be worked on is not live. NOTE: The vehicle scan tool should be used to monitor live high voltage readings. This ensures that there is a low voltage interface between the high voltage and the vehicle technician.
- e. Components on vehicles that have high voltages present need to be identified. These will vary between different vehicle types. Typically these components will be
 - i. High voltage battery
 - ii. High voltage battery controls
 - iii. High voltage wiring
 - iv. Inverter
 - v. DC-DC converter
 - vi. Air conditioner compressor
 - vii. Motor/generator(s)
 - viii. Capacitors
- f. The identification of high voltage circuits is aided by the standard colour coding of orange. (Society of Automotive Engineers Standard SAE J1673). Components are identified with placarding, using international warning symbols.
- g. Capacitors can be hazardous as they are capable of storing electrical energy for a short time after the high voltage system has been shut down. Passive and active discharge systems are incorporated into the vehicles systems, Manufacturer’s precautions need to be observed, and checking with the correct meter is recommended.
- h. Personnel need to be trained on the individual vehicle shut down procedures. Correct shut down is required as this will turn off the high voltage system. High voltage then should only be present in the high voltage battery pack. Normal maintenance and repairs can then be carried out safely. Hybrid vehicles that have not been shut down correctly can have the internal combustion engine start unexpectedly. This could seriously hurt the repairer who may have their hands in the engine bay. Damage can also be caused to engine components if, for example, engine oil had been drained. Smart keys need to be understood as the vehicle can be re-powered from the key’s physical presence. Moving the key the recommended distance away from the vehicle may still pose a risk. Another key may be present in the vehicles glove box, console, boot etc. Steering wheel warning signs are a better precaution.

2) Learning resources

- a. Vehicles. A range of all hybrid vehicles in common use are required. Hybrid and electric vehicles, whilst sharing some common technologies, vary considerably in construction and design between manufacturers. The most common vehicle on the road world-wide is the Series 2 Toyota Prius. (This is also reflected in Australia.) Sinclair Community College has three of these vehicles dedicated solely to diagnostic training. The USA has a more diverse range of hybrid vehicles than Australia. Consequently, Sinclair’s range includes vehicles such as the Ford Escape, Ford Fusion, Honda Accord and GM Yukon, to name a few. With the range of hybrids emerging from the car manufacturers increasing, the need for more types of vehicles to facilitate training is increasing correspondingly. Fully functioning cars are necessary for road testing and diagnostic purposes, simulated environments are not considered adequate.

- b. Components. In addition to complete cars, an extensive range of major components are required. The emphasis being on those unique to hybrid/electric vehicles. For example, battery packs and controllers, motor/generators, inverters, AC compressors, wiring harnesses and transmissions.
- c. Test equipment. Minimum requirements for test equipment indicate the following: CAT III rated multi meters (Fluke), mega meters (eg Fluke 1587 and Snap On EEDM650C), milliohm meters and oscilloscopes (Pico 4 channel).

Below: Snap On EEDM650C megohmmeter



- d. Diagnostics. Owing to the level of complexity within the electronics of hybrid vehicles, access to factory scanning equipment, online diagnostics and technical service bulletins is required. Diagnosing some problems without the correct equipment and specifications is at best challenging, and at worst, fraught with danger. In the USA, workshops can subscribe to the Toyota Technical Information service (TIS) .Toyota Australia do not supply this service outside of the dealer network. Technicians do need access to this specialised resource.
- e. Text books. The diversity of text books on hybrid and electric powered vehicles is still limited when compared to the scope and volume of resources available for conventional vehicles. Hybrid vehicle technology is still emerging. This will always be the case with the automotive industry. Manufacturers are using different hybrid technologies. The market will determine which type will become the accepted mainstream. Some classification of hybrid types is even unclear between manufacturers. These factors make it challenging for writers to produce consistency in their text books. Some books produced a few years ago have already become somewhat redundant. Fortunately, there are some dedicated writers in the USA who continue to update and revise their work, and subject their papers to extensive peer review. Currently, Sinclair is using Hybrid and Alternative Fuel Vehicles 2nd edition by James D Halderman and Tony Martin as their standard text for hybrid training.
- f. Workshop requirements. Sinclair uses the same classrooms and workshops for hybrid training as they do for conventional vehicles. The only noticeable variation is the requirement for benches with insulated tops for battery pack work. Hoists and transmission repair jigs used on conventional vehicles are suitable.



Above: Toyota Prii lined up for diagnostic training.

3) Learning strategies

A blended learning approach to hybrid training is used at Sinclair. An interactive webinar, and online test, is used to prepare students for the basic safety awareness and general aspects of hybrid technology before they attend the campus. This gives students time to prepare, and reflect, prior to the course. Students have the flexibility to engage from any location (distance learning) at a time that suits them. On campus, learning is facilitated in a teacher centred class of up to 20 students. The practical lessons are embodied in the delivery strategy of each session. This keeps the student engagement high throughout the day. During the practical sessions, students are often divided into small groups. Additional instructors are provided to assist the smaller groups with their learning.

4) Professional development for facilitators

Sinclair Community College hosts 'The Advanced Automotive Hybrid/Alternative Fuel Technology Institute' which is an annual event, 2011 being its fourth year. It is run to assist automotive training institutes in developing curriculum for the new technologies that hybrid vehicles bring with them. The course engages 40 college participants from across the USA. They are given theory and hands on experience through a number of workshops. It is a competitive basis for entry into the course, and participants must meet certain criteria.

As published on SCC's website, to be considered for selection, a faculty member must:

- Teach at an NATEF certified community college
- Hold an ASE Certification A6, A8 (L1 Certification preferred)
- Agree to improve their curricula as a result of attending the Advanced Automotive Hybrid/Alternative Fuel Technology Institute
- Participate in follow-up activities to improve student learning, including an assessment of the workshop conducted by the Miami University Applied Research Institute ⁷

The International Experience

- Participate in five full days of learning

The 2011 workshop had presentations by experts from the following automotive manufacturers:

- Hyundai Motor America
- Toyota Motors Corporation
- American Honda Motor Company
- Ford Motor Company
- General Motors Corporation

Topics included:

- Hybrid technology overview
- History of the development of hybrid technology
- Hybrid drive trains
- Battery pack/inverters
- Compare/contrast of the leading hybrid systems
- Electrical motors/generators

The Advanced Automotive Hybrid/Alternative Fuel Technology Institute is funded by National Science Foundation. This project is supported, in part, by the National Science Foundation, Advanced Technological Education Program.

Destination 2: Sinclair Community College

Location

- Dayton, Ohio, USA

Visit

- EV and HEV Training Program

Overview

A five-day training program followed the one-day information gathering visit. ‘The Advanced Automotive Hybrid/Alternative Fuel Technology Institute’ provides this program for experienced automotive trade facilitators.

Objectives

- To gain knowledge in the most recent developments in hybrid vehicle technology from different manufacturers.
- To study diagnostic procedures.
- To observe training methodologies and resources used during the course.

Outcomes

Hyundai Motor America. Training Manager Central Region: Donald Rotermund, 2011 Hyundai Sonata Hybrid (HEV).

The Hyundai Sonata hybrid first became available in the USA in February 2011. There are currently no plans to manufacture this vehicle in a RH drive version so it is not known weather this vehicle will be

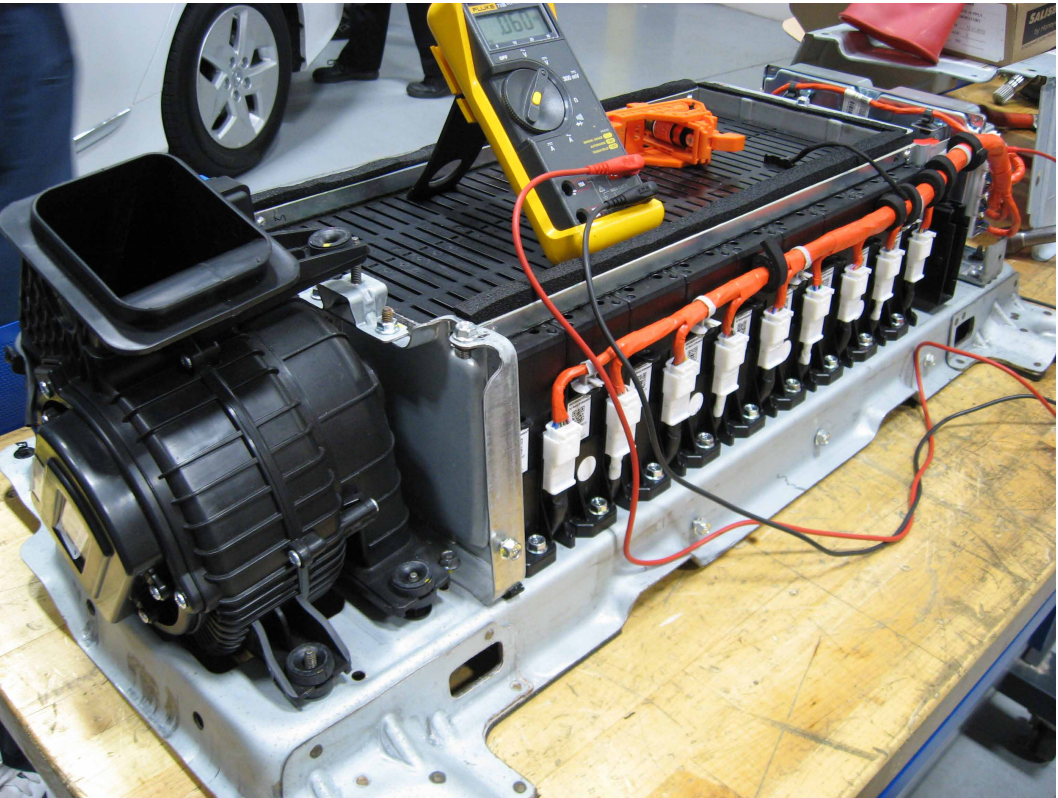
The International Experience

released into the Australian market. The vehicle exhibits some unique technologies some of which will be seen in other manufacturer’s vehicles in the future. It is therefore worth looking at even if this vehicle does not get to Australia.

For the USA Hyundai allows internet access to its workshop manuals for free (KIA also does this in the USA). Factory training and technical service on their hybrids is still only available for Hyundai technicians. Manufacturers are very secretive about their new products although this is somewhat understandable it is a problem for training technicians.

The Sonata hybrid is described as being a full type hybrid with four modes of operation. “Electric Vehicle (EV) Drive Mode”, the HEV is driven only by the electric motor only. “Hybrid (HEV) Drive Mode”, the HEV is driven by both the electric and the petrol engine. “Power Reserve Drive Mode”, the HEV is driven only by the petrol engine. “Regenerative Mode”, the HEV drive wheels are charging the high voltage batteries through the electric motor which has become a generator.

The high voltage HEV battery is a 270 volt Lithium-ion polymer type. These batteries are smaller and lighter compared to equivalent capacity batteries made from Lithium-ion or Nickel-Metal Hydride. These batteries require careful control when being charged and also the management of the battery pack temperature. All these systems are monitored by the Battery Management System (BMS). The battery pack is serviced as an assembly only at this stage. Hyundai report that they have only had a couple of very minor problems so far.



Above: Hyundai Lithium-ion polymer battery. Note the cooling fan at the nearest end, BMS at far end.

The electric Drive Motor is a 270volt 30kw AC brushless permanent magnet motor. This is the motor that drives the vehicle in EV and HEV mode. It is able to be run as a generator in regenerative mode The Drive Motor is not sold as a separate part. If there is a failure the whole transmission needs to be replaced as a unit.

The Hybrid Starter Generator (HSG) is a much smaller motor than the Drive Motor. It has three specific uses:

1. Crank the petrol engine to 1000rpm for starting.
2. Controlling the engine speed to synchronise it with the transmission speed.
3. To work as a charger for the HV battery

The HSG is mounted on to the petrol engine and looks similar to a conventional alternator, but is larger. Its driven by a serpentine belt with tensioners either side.

Due to the effectiveness of regenerative braking, service requirements of the conventional brakes need extra attention. At 15,000 mile service intervals Hyundai are requiring brake slides to be cleaned and lubricated.

Power down of high voltage system is carried out by shutting down the vehicle in the usual way by tuning off the ignition switch. This isolates the high voltage to the battery pack assembly by turning off the Power Relay Assembly (PRA) switches. A further 5 minutes should be allowed for capacitors to discharge. If any repair work requires the disconnection of high voltage components (indicated by orange cabling/conduit) the technician should only proceed if he has been trained on the correct procedure. Linesman gloves should be used whilst tuning off any disconnects and checking with a CATIII multi meter shows if it is safe to proceed.

Irina Novikova is the product trainer for the new Volt and E-Assist vehicles for GM America. Irina is based in Detroit Michigan.

GM is offering 3 ranges of (hybrid) technology.

eAssist

eAssist (115v) technology. This is a mild hybrid system to be used initially in the Buick LaCrosse. All GM 4 cylinder vehicles will adopt this technology in 2012. The mild hybrid is an affordable way to produce a fuel efficient vehicle and get them in to the main stream automotive market. It is not as efficient though as a full hybrid or an EV. eAssist is a version of the older Belt Alternator Starter (BAS) system (micro hybrid) that came on to the US market in 2006. It offered a 15-27% gain in fuel economy in the Saturn Vue. That system used a 36 volt nickel metal hydride battery pack with a 4 kilowatt electric motor/generator. Fuel economy was achieved by shutting off the ICE when the vehicle came to a stop and during deceleration. The system also offered regenerative braking under deceleration and power assist to the ICE when hard acceleration was required.

GM will not identify eAssist technology as a hybrid vehicle. This is a deliberate marketing technique. They believe traditional GM customers may not want to be part of the 'hybrid hype'. GM wants to saturate the US car market with their 4 cylinder eAssist vehicles with no hybrid badges.

The rationale behind flooding the market is to be able to mass produce the vehicles at a volume that will make the introduction of the new technology more cost effective. This will also ensure that GM will be able to meet new stringent fuel consumption standards ⁸ which in turn will lower carbon dioxide emissions.

eAssist reduces vehicle fuel consumption using the following strategies:

- Engine idle stop – ICE turns off during deceleration and stopping
- Power regeneration (15kW) – Uses regeneration of power under braking conditions by converting mechanical energy into electrical energy and storing it in the high voltage battery.
- Electric boost for start off (torque smoothing) and for high power demand situations eg overtaking.
- Aero dynamic improvements particularly to the underbody area of the vehicle
- Special low rolling resistance tyres are used

These all help to reduce the normal engine and driveline losses associated with a conventional vehicle.

eAssist runs a much more powerful electric motor compared to the earlier BAS. 5kw verses 15kw. It requires its own cooling system that is separate from the ICE. The power electronics and accessory power module is contained with the HV battery pack as one unit behind the passenger seat. The lithium-ion battery is a 115 volt and is air cooled. There are no serviceable components within this unit. GM is concerned that the amount of new technology will be overwhelming for technicians. Manufacturers training will become available with time and then component parts will also become available. GM also has concerns for the safety of service personnel dealing with the unique technologies that this system utilises.

Volt

The Chevrolet Volt is not a hybrid according to GM. It is an electric vehicle with extended range. This puts it in a classification of its own. It primarily operates as an electric vehicle that is recharged from the main power grid. One major concern for potential EV owners is what has been termed as 'range anxiety'. People see themselves being stranded by the roadside with out battery power. The Volt system removes this problem. It has the ability to run on pure electric power until its battery drops to 20% soc. It will then start the ICE and run its generator to produce electrical power for the electric motor. In this way the Volt can be used as an EV only if it is used for short daily trips. The Lithium –Ion battery lasts up to 40 miles of emission free driving in EV mode.

The high voltage battery pack is recharged via the charge port on the front left hand side of the vehicle. The standard power adaptor supplied with the vehicle plugs into domestic power outlets. Charge time takes approximately 10 hours for 110 power outlet or 4 – 5 hours with a 240 outlet. It has a proximity detector built into it to disable the vehicle to prevent someone inadvertently driving off with the vehicle plugged in. There are288 lithium-ion cells that make up the 360 V 'T' shaped battery pack. The weight is approximately 400(lbs) making special lifting equipment needed for removal of the pack. To maintain the life of the battery thermal control must be used. The pack creates heat when discharging and needs to be cooled. In cold climates the pack needs to be heated for maximum efficiency. Liquid heating/cooling is used for this purpose.

Although the Volt can be driven entirely on electric power, if it is recharged from the grid, and not driven for more than 40 miles between charging, it will require the ICE to be run occasionally. This is to perform what GM calls maintenance mode. It will automatically go into this condition after approximately one year and run the ICE until it reaches a preset coolant temperature. The ICE will also be run to use up old fuel. The system tracks fuel usage and refuelling events to determine the condition of the fuel. It then runs until the fuel has gone forcing the owner to refill with fresh fuel. Volt is due to be released in Australia late 2012.

Toyota, Sinclair trainers James Truxal & Thomas Freels

The workshop on Toyota concentrated on diagnosis and repair techniques of the Prius. The Prius has been the largest selling hybrid vehicle throughout the world and has been highly reliable. As such some Prius have clocked up high mileages and some diagnosis on these older vehicles has become necessary. Specialised diagnostic equipment is needed by technicians. A lot of the major components

making up the hybrid drive are not serviceable and require replacement as a unit. This means that if the faulty component is not identified correctly it can lead to a very expensive repair being carried out unnecessarily.

Safety

Linesman's safety gloves to the The American National Standards Institute (ANSI) class "0" is the accepted standard for working on the Prius. These gloves are to be used whenever any of the high voltage components or wiring on the vehicle is to be disturbed in any way. The HV system needs to be disabled and then tested with a meter to ensure the HV has been correctly disabled. It is not encouraged in anyway to test or work on any live HV parts. HV testing should be done with a scan tool only. This ensures the technician is protected by the tiers of safety that is built into the vehicle. Direct measurement of HV components using multimeters should only be carried out when a 'zero' reading is expected after disabling of the system. The meter must also be tested on a known voltage source eg a 12 volt cranking battery, prior to use. This ensures the meter has been switched to the appropriate scale and that the leads are in the correct ports. After that has been ascertained the gloves may then be removed. Gloves need to be tested in accordance with the manufacturer's procedures every time they are used. Gloves also have a certification date on them. They can be tested and re-certified. All meters and their attaching leads need to be CAT III rating. Disabling of the HV involves removal of the battery service plug. This plug needs to be placed in a safe place away from the vehicle to prevent someone replacing it whilst the technician is still working on the vehicle. Some technicians use a lockable drawer in their tool box for this purpose.

Equipment

Megohmmeter

HV insulation has a very high resistance. The ohmmeter that is built into the type of multimeter that technicians normally use can not put enough electrical pressure to test the insolation used in the HV system. The megohmmeter is needed for this purpose. There are a several brands that are producing these meters specifically for the automotive market. The meter can apply a 500 volt potential to the insulation to see if there is any leakage. This can be used for testing HV cabling and electric motor windings. These meters can be hazardous and must be used in accordance with the manufacturer's instructions.



Left: Prius high voltage wiring being tested with a megaohmmeter. Note the orange conduit.

Milliohmmeter

This meter is primarily used for looking for short circuits in the windings of electric motors. Once again, the conventional multi-meter technicians currently use is not accurate enough.

Manufacturers depend on using the factory scan tool and access to the TIS or Technical information service

Battery pack

The battery pack contains the nickel-metal hydride cells, system main relays, service plug connector, various sensors and the battery ECU. The battery pack is only serviced as a whole assembly from the manufacturer, but aftermarket repairers are now carrying out repairs on packs that are no longer covered by warranty. This is not being endorsed by the manufacturers.

Diagnosis

Critical to fault diagnosis is access to manufacturer's technical information. In the US technicians can subscribe to Toyotas 'TIS' (Technical Information system). This gives access to online workshop manuals, wiring diagrams, technical service bulletins and other information to service and repair Toyota vehicles from 1990 on. There are different levels of subscription based on the repairer's requirements.

Scan tools which enable the technician to read the DTC (diagnostic trouble codes) and data in the vehicles ECU are essential to these vehicles. Some aftermarket scan tools do access the systems, but for a comprehensive view the manufacturers scan equipment is preferred. Toyota markets its 'Techstream' and 'Techstream Lite' scan tools. They use wireless connection to the internet so technicians can sit in the driver's seat and browse the TIS whilst reading vehicle data and DTCs. Both of these systems require annual subscriptions to stay connected to the TIS. The Techstream is the full tool whilst the 'Techstream Lite' is an interface for a laptop computer.

Another more conventional diagnostic technique is using oscilloscopes. Although commonly used on conventional vehicles they will have new applications for HEV's. One example is the electric coolant pumps for the inverter that do fail. The oscilloscope with an inductive low amps pickup can be used to predict this. Oscilloscopes are also very useful instructional tools for practical demonstrations of current and voltage variations in circuits. These concepts can be difficult for students not yet familiar with electrical theory. The oscilloscope provides an image for them to understand. Often, technicians are visual learners.

Compression testing the ICE must be carried out using the scan tool. The ICE will be cranked by MG1 at approximately 1000 rpm. Audibly the ICE will sound the same as if it is running, but in fact is being driven electrically. All service specifications Toyota gives are for these conditions.

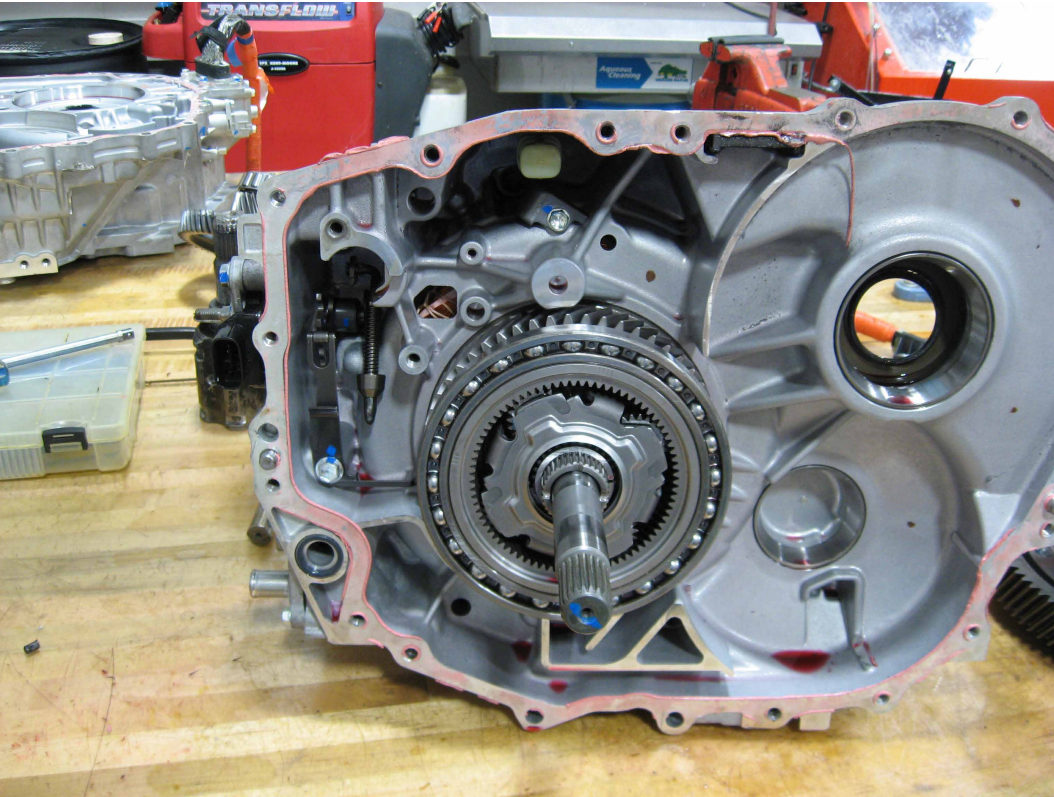
Hybrid Transmissions. Sinclair trainer: John Porter.

Hybrid systems are often defined as series, parallel or series-parallel. These definitions are not clear as some vehicles can change modes under different operating conditions. Manufacturers also have their own terminology that can cause some confusion.

Series hybrids do not use ICE to propel the vehicle directly. The ICE is there to drive the generator to produce electrical power. Generally the transmission in a series system does not provide torque and speed management as in a conventional transmission. This allows the Ice to be designed to give good torque over a small rpm range as its speed is independent of road speed.

Parallel Hybrids provide propulsion through an electric motor or ICE. Because of the comparatively narrow torque curve of the ICE, the parallel hybrid systems benefit from a multi-speed transmission. They can be CVT, manual or automatic.

Series-parallel systems use a power split device. This consists of an ICE, two electric motor/generators and a simple planetary gear set. These transmissions are distinctly different from conventional types and were the subject of the practical workshop session. Participants disassembled and reassembled several Toyota transmissions. The transmission has a power split device and is actually a simple design to work on. Field reports suggest that they are reliable units.



Above: Power split device inside a Toyota transmission.

Honda. Sinclair trainer: Justin Morgan.

Honda has sold hybrids in the US market for a long time now. They offer their ‘integrated motor assist’ (IMA) on several models. The hybrid system is fundamentally the same in all their vehicles and works as a parallel hybrid. Once again the workshop focussed on component identification/location and the diagnostic side of hybrids.

The IMA system is:

A Parallel Hybrid system that uses the ICE & the electric motor/generator together to propel the vehicle. It is classified as a mild Hybrid, incapable of propulsion on the HV battery alone i.e. cannot operate as a BEV. This system has a DC voltage range of 100-160v. The Hybrid system components are packaged in one unit behind the rear seats. This makes the unit very adaptable to other models and also from an instructors perspective lends itself nicely as a teaching aid. One of the significant fuel saving features of the IMA system is the ‘Auto Idle Stop’. The ICE will be disabled under certain conditions, typically when the vehicle speed is below 7mph with the brake applied. There are many parameters that will prevent ‘Auto Idle Stop’ from operating and is important for technicians to understand these when dealing with vehicle owners who may think that they have a system fault. An example is when the windshield defrost is operated, ‘Auto Idle Stop’ is disabled.

Honda service precautions with the IMA specify the following:

- Disconnect the 12v battery before servicing any of the HV system
- Turn off the HV switch and wait 5 minutes to give capacitors time to discharge. The IMA doesn't have a service plug to remove, so service technicians must take precautions against other personnel inadvertently turning the switch back on.
- After the 5 minute wait the system should be checked for HV. Any voltage below 30 is considered safe.
- When removing and refitting the rotor from the rear of the ICE, extreme care must be taken as there is real potential for fingers to be caught between the rotor and the windings. The strength of the magnetic field requires specialised tools to perform this task and the correct procedures must be followed. People with pacemakers should be kept away from the rotor due to the strength of the magnetic field.



Above: IMA windings on the rear of the ICE. The rotor is being fitted with the special tool for removal.

The International Experience

Ford

Ford in the USA has operated hybrid vehicles since 2005. The first vehicle was the Ford Escape followed in 2009 by the Ford Fusion.

Ford Escape runs a similar type of power split device as a Prius. Ford call it the Electronic Continuously Variable Transmission (eCVT). The powertrain incorporates a 65 KW electric traction motor and a 36 KW generator. The system controllers are all contained within a housing that is integral with the transmission case.

A Plug in hybrid version of the Escape has also been under trial.

The Fusion Hybrid was launched in the US in March 2009. It is powered by a 2.5-litre four-cylinder petrol engine, an electric motor and a nickel-metal hybrid battery.

It is capable of driving in electric-only mode up to speeds of 75km/h and has a combined power output of 142kW

There is no definite word from Ford on these vehicles entering the Australian market as yet. A Fusion was observed in Melbourne early 2011 undergoing evaluation.

GM Training Centre. Instructor: Adam Pietrzak

The GM session concentrated on the PHT and the 2ML70 transmission.

The PHT (Parallel Hybrid Truck) is an obsolete design in the USA and won't be seen in Australia. None of its technology is currently been used either.

The 2ML70 transmission which is also called the GM 2 mode is a joint design between GM, BMW, Mercedes and Chrysler. As such it may be seen in other manufacturer's vehicles in the future

The GM TWO mode is the hybrid system that they use in the Yukon pick up truck. This vehicle is not available in Australia.

Destination 3: Automotive Career Development Centre (ACDC)

Location

- Worcester, Massachusetts, USA.

Organisation overview

ACDC was established in 1998. ACDC is a privately owned training provider specialising in hybrid vehicle repair and servicing. They provide hybrid vehicle training across the USA and in Europe. The CEO of the ACDC is Craig Van Batenburg who is also the head instructor. Deb Van Batenburg carries out all the administration of the business and three other technicians assist with the training. The company owns seven hybrid vehicles that are used for training purposes. ACDC is involved with many of the automotive industries throughout the USA and some international companies.

Contact

- Craig Van Batenburg, CEO

Objectives

1. To gain knowledge in the most recent developments in hybrid vehicle technology from different manufacturers.
2. To learn diagnostic procedures
3. To observe training methods and resources during the course

The International Experience

Outcomes

This was a seven day workshop that involved not only working on, but driving a variety of hybrid vehicles. Each participant is allocated a different hybrid vehicle to drive each day. They are fully encouraged to drive them as much as possible to become familiar with them. This was an important process for people who have not been exposed to hybrids before. There are some unfamiliar traits with these cars and driving them helps you understand the technology that is inside. This is Van Batenburg's philosophy.

One thing Van Batenburg has identified as a weakness is the average technician's knowledge of electricity. At the start of the course He puts everyone through a written test to check participants' knowledge of basic electricity. Those that don't get 100% have to attend an additional class. Without this revision the student would have great difficulty in following some of the more technical aspects of the course. There are a high percentage of participants that need this assistance.

Van Batenburg focuses heavily at the start of the course on safety. His instructions on safety are based on the manufacturer's precautions. He especially mentions the equipment ratings for meters and insulating gloves. As a practical demonstration to reinforce the danger of capacitors he discharges one under controlled conditions with a direct short.

The technologies instructed emerge from a combination of manufacturers' information and Van Batenburg's own research. Participants are shown some alternative diagnostic and repair methods to support the equipment manufacturers provide.

The maximum class size on the course is seven participants. This gives an ideal student to instructor ratio of seven to one. Provided with a corresponding number of vehicles, students receive an engaging training experience.

Vehicles that were covered within this course were;

- Toyota Prius
- Ford Escape
- GM Volt
- Honda Insight
- Honda Civic

Destination 4: Hilltown Hybrids

Location

- Plainfield, Massachusetts, USA.

Contact

- Jamie Wooldridge

Organisation overview

Hilltown Hybrids is a small independent repair shop. It is owned and operated by Jamie Wooldridge. Jamie is a qualified 'Master Hybrid Service Technician' and has worked as an automotive engineering consultant. As well as performing service and repair to hybrid vehicles, Hilltown Hybrids has recently commenced repairing HV battery packs.

Objectives

To investigate HV battery reconditioning.

Outcomes

Wooldridge is an independent hybrid repair specialist. He works primarily on the Honda Insight and the Toyota Prius. Although the OEMs’ don’t recommended repairs to HV battery packs, some independents like Hilltown are offering a service that is emerging with the aging of hybrids. Currently Hilltown Hybrids is only servicing the Insight battery pack. The packs are disassembled and individual cells are put through a process of charging and discharging to restore the cell balance. This is a methodical task that takes a long time to preform. The cost of new packs still makes this a viable alternative when you take into account the market value of an older hybrid. The volume of hybrids currently in the Australian market would probably not generate enough demand for this service to be economically viable, but possibly an opportunity for our aftermarket industry to consider in the future.

Concluding remarks for the international experience

This fellowship facilitated the exploration of safety issues that are already impacting the Australian automotive repair industry and emergency services.

The availability of technical information supporting hybrid vehicle technology is freely available in the USA. This indicates the inadequacy of supporting resources in the Australian training sector and the Australian automotive repair industry.

The technical equipment is available for the typical automotive repair workshop, but is not viewed at this stage as essential. The high voltage side involves some specialist equipment, which is readily available in Australia through the electrical industry. However there is a lack of training available to the automotive industry on this equipment. The most significant issue is access to manufacturers’ service and repair information.

Common issues exist between the United States and Australian tradespeople with lack of basic electrical knowledge and skills. In the United States, manufacturers support training and freely distribute technical information to the wider industry.

Socio-economic impacts

The existing cost of full hybrids is contributing to slow consumer uptake, hence the introduction of micro and mild type hybrid vehicles. These vehicles are intentionally priced to be competitive with contemporary motor vehicles. This should facilitate the broader adoption of hybrid technologies. It is questionable whether demand for full hybrids will continue at the current rate in the tightening economic climate. The impact of sustainability practices emerging in society may facilitate a gradual increase in uptake.

Socio-cultural impacts

As suggested, sustainability and world environmental impacts influence the uptake of new technology. Public perception of hybrid type vehicles across the broad US demographic indicates a lack of acceptance. Hence, hybrid branding is not marketed on all manufacturers’ vehicles. This appears to indicate a US cultural preference for large petrol burning vehicles. As the cultural paradigm changes through recognition of global environmental impacts the uptake of hybrid technology is predictable.

Knowledge Transfer: Applying the Outcomes

Dissemination of the learnings of this program will be through two primary sources, Government and Industry.

Industry

The primary stakeholders interested in the dissemination of this research are Automotive Training Victoria and the Institute of Automotive Mechanical Engineers; both were strong supporters of this fellowship. These organisations, with the support of the Victorian Automotive Chamber of Commerce, have driven the dissemination of the information gained from this study.

The information revealed by this research has been presented in forums at these organisations, and at the Victorian Automotive Forum.

The 45 minute presentations were supported by power point presentation. This presentation was subsequently forwarded to the participants by email. The forums were conducted at the following locations and times:

Host	Location	Date
VAF	VACC House St.Kilda	11/11/2011
ATV	ATV office VACC House	13/11/2011
IAME	IAME Victorian branch office, Springvale	08/02/2012

The VAF is a coordinated group of automotive trade instructors from across Victoria with interstate network through the National Tafe Automotive Network (NTAN). These forums advise the direction, benchmarks and scope for automotive apprentice and advanced automotive trade training.

ATV is the state government funded industry training advisory board (ITAB). ATV participates on national industry training advisory bodies

The IAME is a professional association for automotive mechanical engineers. It provides technical support to a large scope of disciplines within the automotive trade across Australia.

Recommendations

Government

Financial support is needed for study in the area of new hybrid and electric vehicle technologies, providing for a similar program to the 'The Advanced Automotive Hybrid/Alternative Fuel Technology Institute'.⁷ This institute should be embedded or partnered by a government funded NVR organisation.

This report will advise Automotive Skills Australia (ASA) who are positioned to respond current trends and initiatives from industry, and guide the development of the Automotive Training Package. We recommend that a skill set or qualification be designed by ASA to inform the design of curriculum to be developed and delivered by the 'Advanced Institute' as proposed above.

Industry

The fellow recommends that the government training sector, at policy level, call on industry to support training organisations nationally.

To develop the necessary technical skills, industry to be called upon to provide professional development for VET practitioners in the automotive industry.

To facilitate the development of learning resources, industry to provide appropriate technical information to training organisations without cost.

To support the automotive retail, service and repair industry, manufacturers make available service and repair information to all stakeholders within the trade at an affordable price.

Professional Associations

Technical information on emerging hybrid technologies be made available to organisations such as the VACC and IAME for further dissemination of information to their members.

National VET Regulator Organisations

The integration of hybrid and electric vehicle training at AQF level three must be integrated into existing automotive apprenticeship programs.

There is an identified need for a strong focus on the safety aspect of repairing hybrid vehicles. Therefore the Occupational Health and Safety component of all units of competency should be reviewed to include hybrid vehicle safety within the scope of the unit descriptor.

The relationships between NVR organisations and industry need to be reinforced to ensure current and valid learning outcomes for all participants.

References

Endnotes

- ¹ *Sustainable Policies for a Dynamic Future*, Carolynne Bourne AM, ISS Institute 2007.
Note: This is a reference to a manual report held on file by ISS Institute.
- ² Ibid.
- ³ *Directory of Opportunities. Specialised Courses with Italy. Part 1: Veneto Region*, ISS Institute, 1991.
Note: This is a reference to a manual report held on file by ISS Institute.
- ⁴ “The United Nations Non Government Organisation (NGO) has worked for many years to create a global buy-in on sustainability. Starting with the definition developed in 1987 this organisation is now working on many fronts to ensure that sustainability is understood and adopted by all sectors of Government, Industry, Education and the Community”.
- The following web site link will enable connection to the activities of this UN NGO that are relevant to this report. <http://unngosustainability.org/>
- ⁵ Skills Australia’s *Australian Workforce Futures: A National Workforce Development Strategy 2010*, pp. 1-2. http://www.issinstitute.org.au/pdfs/WWF_strategy.pdf
- ⁶ Access Economics, Economic outlook for Victorian Automotive Industry (report extract) 30 April 2010
- ⁷ 2011 Summer Institute: Faculty Development for Advanced Automotive Hybrid Technology Final Evaluation Report 2011. Submitted By: Robert L. Seufert, Ph.D., Director, Darlene G. Campbell, Assistant to Director and Senior Research Associate Amy J. Walton, Project Analyst and IT Coordinator Applied Research Center Miami University.
- ⁸ <http://www.whitehouse.gov/the-press-office/2011/07/29/president-obama-announces-historic-545-mpg-fuel-efficiency-standard>

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- United Nations Non Government Organisation (NGO) <http://unngosustainability.org/>