Truck hybrids

Lesson plan for teachers

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STEP AHEAD II

**The support of Professional development of VET teachers and trainers in following of New trends in Automotive Industry
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Truck hybrids

The aim of the lesson: To teach students the basics of Hybrid truck powerline

Activity No.1 Part of the lesson: **EVOCATION**

The aim of the activity: Finding out what students know about the hybrid trucks. Introduction to the topic of hybrid trucks

Step 1	Brief description of the activity	Finding out what students know about the hybrid trucks. Introduction to the topic of hybrid trucks. Brainstorming. Listing the ideas that students come up with, on a whiteboard. Summarizing. As student brainstorm, you can prepare the K – W – L table (Annex 1) on a whiteboard, that will help you structuring the information that students come up with easily.
	Instruction (what you need to tell the students)	What are your first ideas, that come to your mind, in relation to "hybrid trucks"? We are going to write down all that comes to your mind. Please tell everything that you have in mind, even if you are unsure, whether the information you think about is correct or not. Then we summarize.
Step 2	Brief description of the activity	Summarizing the discussion, eventually asking support questions: • What differences there are, if you compare normal combustion engine truck to hybrid truck? • How hybrid truck differs from a hybrid passenger car?

		• What student's opinion about skills of mechanics who repair the hybrid trucks? • Is there structural difference in hybrid trucks, compared to combustion engine trucks? Fill in the information that students already now about this topic into the "K" column of the K – W – L table (Annex 1).
	Instruction (what you need to tell the students)	Now we summarize what you came up with. What do you think: • What differences there are, if you compare normal combustion engine truck to hybrid truck? • How hybrid truck differs from a hybrid passenger car? • What student's opinion about skills of mechanics who repair the hybrid trucks? • Is there structural difference in hybrid trucks, compared to combustion engine trucks?
Step 3	Brief description of the activity	After finding out what students already know, teacher asks them what would they like to know/learn about this topic. Teacher writes their questions or ideas into second column of the K – W – L table.
	Instruction (what you need to tell the students)	Look at the summary of your ideas about this topic. Answer the question on What would you like to learn/find out, what might be missing, or what you are not sure about. We will write these questions or ideas in a second column of the table, under the W column ("Want to know")
Tools for the activity (everything you need to take to the classroom)		Whiteboard (optional), notes, pencils, whiteboard markers, Annex 1 – K – W – L table

Estimated time (max. 40 min.)	20 min.
Notes	Students can make notes resulting from the brainstorming summary.

Activity No. 2 Part of the lesson: **APPRECIATION**

The aim of the activity: Deepening the information about hybrid trucks

Step 1	Brief description of the activity	Work with a text (Annex 2). Let students work in small groups of 3 – 4 people. Their tasks will be to go through the texts, finding out the answers to the questions or ideas listed in W column ("Want to know"), and write them in the column L ("what I Learnt"). In addition, they can all write down the information, that was new to them in the text, in column L ("what I Learnt"), too. In a group, it is good to let each student create their own K – W – L table, adding the information also from the other students to theirs.
	Instruction (what you need to tell the students)	Work with a text (Annex 2). You will work in small groups of 3 – 4 people. Your task is to go together through the texts, finding out the answers to the questions or ideas listed in W column ("Want to know"), and write them in the column L ("what I Learnt"). In addition, you can all write down the information, that was new to you in the text, in column L ("what I Learnt"), too. You work with K – W – L table individually, but as a group, you can present a complex one to the class, collecting the ideas from all the team members in one table.
Step 2	Brief description of the activity	Little quiz (for example Kahoot quiz) to memorise the topic about the PP-show.

	Instruction (what you need to tell the students)	Students should have laptop or smartphone to join the quiz.
Tools for the activity (everything you need to take to the classroom)		Laptop to the teacher, projector, internet connection, smartphones or laptops to the students, notes, pencils.
Estimated time (max. 40 min.)		40 min.
Notes		Teacher must be expert on the field in truck hybrids to answer the question the student might came up with. Any questions that might come up during the lesson are welcome, teacher discuss about them in the lesson.

Activity No. 3 Part of the lesson: **REFLECTION**

The aim of the activity: Students to summarise information they received

Step 1	Brief description of the activity	Compare the main points from activity no. 1 to the notes that have written down during the lesson (activity no. 2). Presenting "L" part of the K – W – L table from each team ("what I learnt")
	Instruction (what you need to tell the students)	Now, each team please present your findings and information that you learnt or gained while reading the texts and that you wrote down in the last column of the K – W – L table. Afterwards, review all the information in the table. Is there any question not answered, that you don´t have information about? If so, can you please find the answer as a homework and bring it to the next lesson….

		Ask students to compare their opinion about truck hybrids before and after the lesson.
Step 2	Brief description of the activity	Lift pitch. Let students work in pairs. One student prefers hybrid truck and the other diesel engine powered truck. Let them in 3 minutes prepare their arguments with the task to persuade each other that they preferred technology/truck is better and why. After 3 minutes, they have 30 seconds to persuade their classmate about their preferences. They arguments can concern eg. the pros and cons of hybrid truck vs diesel engine powered truck.
	Instruction (what you need to tell the students)	At the end of the lesson you are going to work in pairs. One student prefers hybrid truck and the other diesel engine powered truck. You have 3 minutes to prepare your arguments, trying to persuade each other about your preferred technology/which truck is better and why. After 3 minutes, you are going to have 30 seconds to persuade your classmate about your preferences.
Step 3	Brief description of the activity	Volunteers can present their argumentation to the classroom. Using Kahoot application, students can vote for the presenter with the best arguments. Afterwards they can answer few questions through Kahoo quiz about the topic of the lesson.
	Instruction (what you need to tell the students)	Volunteers, you can now present your argumentation to the classroom. Using Kahoot application, you can all vote for the presenter with the arguments that you liked the most. Afterwards you can answer few questions through Kahoot quiz about the topic of the lesson.

Tools for the activity (everything you need to take to the classroom)	Whiteboard, whiteboard markers. K – W- L table (from previous activities) Kahoot application https://kahoot.com/
Estimated time (max. 40 min.)	30 min.
Notes	Student should have the basic knowledge about full hybrid car powertrain before they join this lesson. During the entire lesson, they can work with K – W – L table (Annex 1) individually, while teacher works with the table on a whiteboard. As for the Kahoot application, one student can help preparing the voting or the quiz questions. Resources that you can use with your students: https://trans.info/en/a-fully-electric-and-a-plug-in-hybrid-truck-by-scania-check-out-their-range-199964 https://www.scania.com/ie/en/home/products-and-services/articles/scania-hybrid.html https://www.scania.com/group/en/home/products-and-services/trucks/plug-in-hybrid-truck.html https://driving.ca/chevrolet/features/feature-story/5-hybrid-pickup-trucks-we-can-expect-and-2-we-shouldnt https://www.autoguide.com/auto-news/2019/11/top-8-hybrid-and-electric-pickup-trucks-worth-waiting-for.html https://www.youtube.com/watch?v=iXAI8RZ4Xyw https://www.youtube.com/watch?v=HqmqC5Ajtg8 More resources are listed in Annex 2

ANNEX 1

K – W – L table - Truck hybrids

"K" (I Know)	"W" (I Want to know/learn)	"L" (I Learnt)

ANNEX 2

Hybrid vehicles (passenger and trucks)

A hybrid electric vehicle (HEV) has two types of energy storage units, electricity and fuel. Electricity means that a battery (sometimes assisted by ultracaps) is used to store the energy, and that an electromotor (from now on called motor) will be used as traction motor.
Fuel means that a tank is required, and that an Internal Combustion Engine (ICE, from now on called engine) is used to generate mechanical power, or that a fuel cell will be used to convert fuel to electrical energy. In the latter case, traction will be performed by the electromotor only. In the first case, the vehicle will have both an engine and a motor.

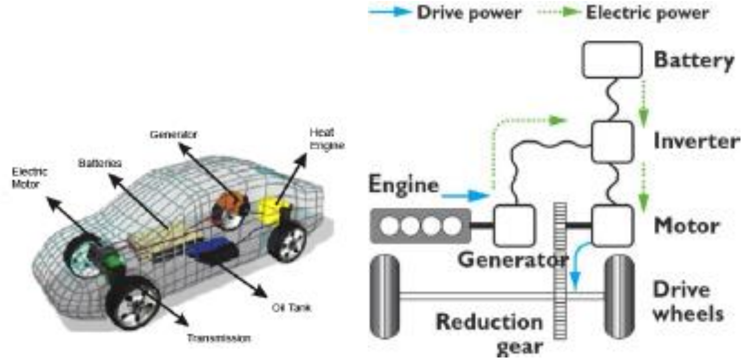
- Depending on the drive train structure (how motor and engine are connected), we can distinguish between parallel, series or combined HEVs. This will be explained in paragraph 1. Depending on the share of the electromotor to the traction power, we can distinguish between mild or micro hybrid (start-stop systems), power assist hybrid, full hybrid and plug-in hybrid. This will be explained in paragraph 2.
- Depending on the nature of the non-electric energy source, we can distinguish between combustion (ICE), fuel cell, hydraulic or pneumatic power, and human power. In the first case, the ICE is a spark ignition engines (gasoline) or compression ignition direct injection
- (diesel) engine. In the first two cases, the energy conversion unit may be powered by gasoline, methanol, compressed natural gas, hydrogen, or other alternative fuels.

Motors are the "work horses" of Hybrid Electric Vehicle drive systems. The electric traction motor drives the wheels of the vehicle. Unlike a traditional vehicle, where the engine must "ramp up" before full torque can be provided, an electric motor provides full torque at low speeds. The motor also has low noise and high efficiency. Other characteristics include excellent "off the line" acceleration, good drive control, good fault tolerance and flexibility in relation to voltage fluctuations.
The front-running motor technologies for HEV applications include PMSM (permanent magnet synchronous motor), BLDC (brushless DC motor), SRM (switched reluctance motor) and AC induction motor.
A main advantage of an electromotor is the possibility to function as generator. In all HEV systems, mechanical braking energy is regenerated.
The max. operational braking torque is less than the maximum traction torque; there is always a mechanical braking system integrated in a car.
The battery pack in a HEV has a much higher voltage than the SIL automotive 12 Volts battery, in order to reduce the currents and the I2R losses.
Accessories such as power steering and air conditioning are powered by electric motors instead of being attached to the combustion engine. This allows efficiency gains as the accessories can run

at a constant speed or can be switched off, regardless of how fast the combustion engine is running. Especially in long haul trucks, electrical power steering saves a lot of energy.

Types by drivetrain structure

In a series hybrid system, the combustion engine drives an electric generator (usually a three-phase alternator plus rectifier) instead of directly driving the wheels. The electric motor is the only means of providing power to the wheels. The generator both charges a battery and powers an electric motor that moves the vehicle. When large amounts of power are required, the motor draws electricity from both the batteries and the generator.



Series hybrid configurations already exist a long time: diesel-electric locomotives, hydraulic earth moving machines, diesel-electric power groups, loaders.

A complex transmission between motor and wheel is not needed, as electric motors are efficient over a wide speed range. If the motors are attached to the vehicle body, flexible couplings are required. Home vehicle designs have separate electric motors for each wheel. Motor integration into the wheels has the disadvantage that the unsprung mass increases, decreasing ride performance. Advantages of individual wheel motors include simplified traction control (no conventional mechanical transmission elements such as gearbox, transmission shafts, differential), all wheel drive, and allowing lower floors, which is useful for buses. Some 8x8 all-wheel drive military vehicles use individual wheel motors.

Advantages of series hybrid vehicles:

- There is no mechanical link between the combustion engine and the wheels. The engine-generator group can be located everywhere.
- There are no conventional mechanical transmission elements (gearbox, transmission shafts). Separate electric wheel motors can be implemented easily.
- The combustion engine can operate in a narrow rpm range (its most efficient range), even as the car changes speed.
- Series hybrids are relatively the most efficient during stop-and-go city driving.

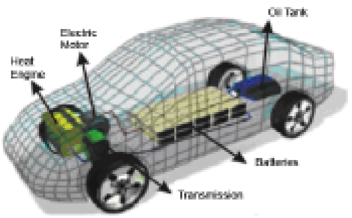
Weaknesses of series hybrid vehicles:

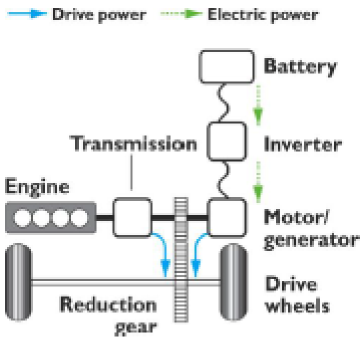
- The ICE, the generator and the electric motor are dimensioned to handle the full power of the vehicle. Therefore, the total weight, cost and size of the powertrain can be excessive.

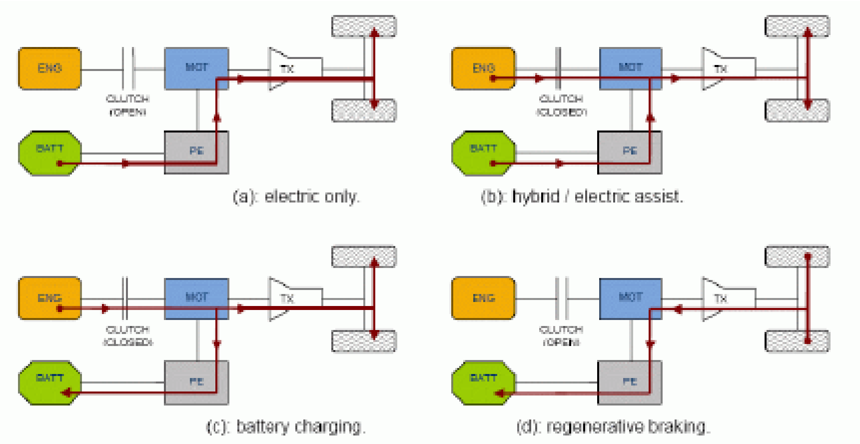
- The power from the combustion engine has to run through both the generator and electric motor. During long-distance highway driving, the total efficiency is inferior to a conventional transmission, due to the several energy conversions.

Parallel hybrid

Parallel hybrid systems have both an internal combustion engine (ICE) and an electric motor in parallel connected to a mechanical transmission. Most designs combine a large electrical generator and a motor into one unit, often located between the combustion engine and the transmission, replacing both the conventional starter motor and the alternator (see figures above). The battery can be recharged during regenerative breaking, and during cruising (when the ICE power is higher than the required power for propulsion). As there is a fixed mechanical link between the wheels and the motor (no clutch), the battery cannot be charged when the car isn't moving. When the vehicle is using electrical traction power only, or during brake while regenerating energy, the ICE is not running (it is disconnected by a clutch) or is not powered (it rotates in an idling manner).







(a) electric power only: Up to speeds of usually 40 km/h, the electric motor works with only the energy of the batteries, which are not recharged by the ICE. This is the usual way of operating around the city, as well as in reverse gear, since during reverse gear the speed is limited.

(b) ICE + electric power: if more energy is needed (during acceleration or at high speed), the electric motor starts working in parallel to the heat engine, achieving greater power

(c) ICE + battery charging: if less power is required, excess of energy is used to charge the batteries. Operating the engine at higher torque than necessary, it runs at a higher efficiency.

(d) regenerative breaking: While braking or decelerating, the electric motor takes profit of the kinetic energy of the he moving vehicle to act as a generator.

Advantages of parallel hybrid vehicles:

- Total efficiency is higher during cruising and long-distance highway driving.
- Large flexibility to switch between electric and ICE power
- Compared to series hybrids, the electromotor can be designed less powerful than the ICE, as it is assisting traction. Only one electrical motor/generator is required.

Weaknesses of parallel hybrid vehicles:

- Rather complicated system.
- The ICE doesn't operate in a narrow or constant RPM range, thus efficiency drops at low rotation speed.
- As the ICE is not decoupled from the wheels, the battery cannot be charged at standstill.

Combined hybrid

Combined hybrid systems have features of both series and parallel hybrids. There is a *double connection between the engine and the drive axle: mechanical and electrical*. This split power path allows interconnecting mechanical and electrical power, at some cost in complexity.
Power-split devices are incorporated in the powertrain. The power to the wheels can be either mechanical or electrical or both. This is also the case in parallel hybrids. But the main principle behind the combined system is the *decoupling of the power supplied by the engine from the power demanded by the driver*.

In a conventional vehicle, a larger engine is used to provide acceleration from standstill than one needed for steady speed cruising. This is because a combustion engine's torque is minimal at lower RPMs, as the engine is its own air pump. On the other hand, an electric motor exhibits maximum torque at stall and is well suited to complement the engine's torque deficiency at low RPMs. In a combined hybrid, a smaller, less flexible, and highly efficient engine can be used. It is often a variation of the conventional Otto cycle, such as the Miller or Atkinson cycle. This contributes significantly to the higher overall efficiency of the vehicle, with regenerative braking playing a much smaller role.
At lower speeds, this system operates as a series HEV, while at high speeds, where the series powertrain is less efficient, the engine takes over. This system is more expensive than a pure parallel system as it needs an extra generator, a mechanical split power system and more computing power to control the dual system.

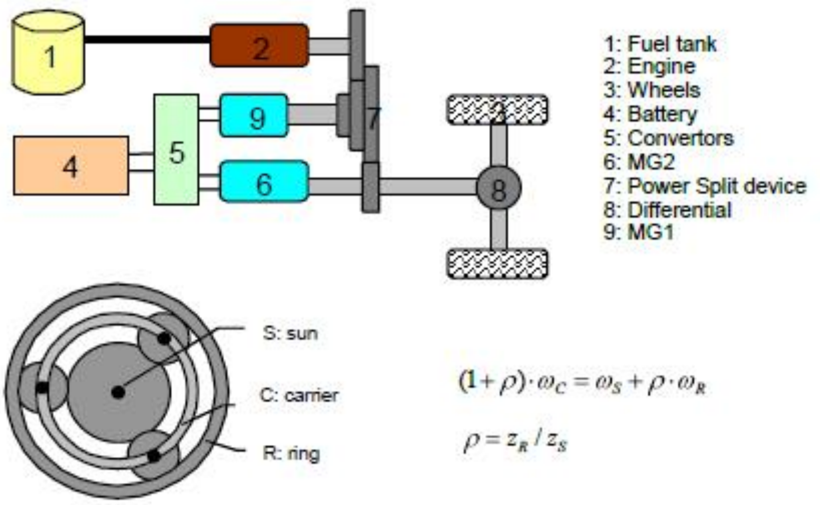
Advantages of combined hybrid vehicles:

- Maximum flexibility to switch between electric and ICE power

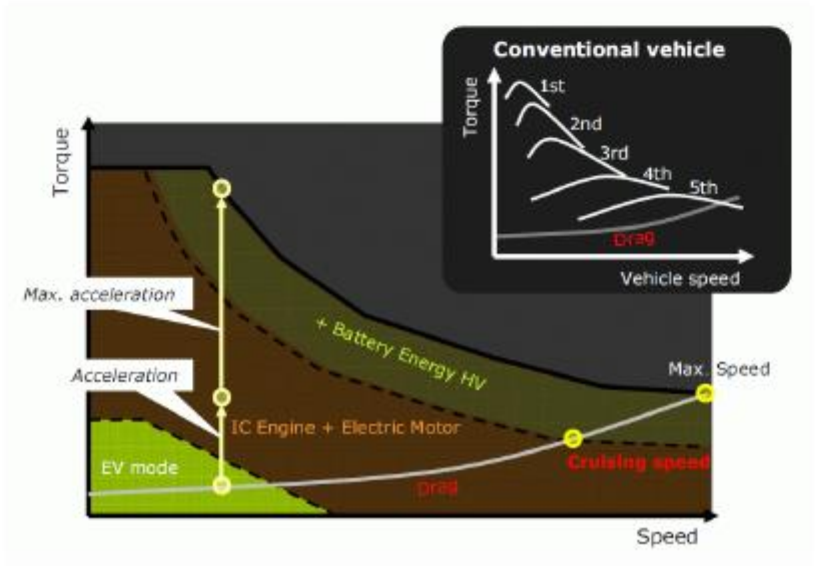
- Decoupling of the power supplied by the engine from the power demanded by the driver allows for a smaller, lighter, and more efficient ICE design.

Weaknesses of combined hybrid vehicles:

- Very complicated system, more expensive than parallel hybrid.
- The efficiency of the power train transmission is dependent on the amount of power being transmitted over the electrical path, as multiple conversions, each with their own efficiency, lead to a lower efficiency of that path (~70%) compared with the purely mechanical path (98%).



Combined HEV with planetary unit as used in the Toyota Prius



Combined hybrid drive modes

Plug-in hybrid (= grid connected hybrid = vehicle to grid V2G)

All the previous hybrid architectures could be grouped within a classification of charge sustaining: the energy storage system in these vehicles is designed to remain within a fairly confined region of state of charge (SOC). The hybrid propulsion algorithm is designed so that on average, the SOC of energy storage system will more or less return to its initial condition after a drive cycle. A plug-in hybrid electric vehicle (PHEV) is a full hybrid, able to run in electric-only mode, with larger batteries and the ability to recharge from the electric power grid. Their main benefit is that they can be gasoline-independent for daily commuting, but also have the extended range of a hybrid for long trips.

Grid connected hybrids can be designed as charge depleting: part of the “fuel” consumed during a drive is delivered by the utility, by preference at night. Fuel efficiency is then calculated based on actual fuel consumed by the ICE and its gasoline equivalent of the kWh of energy delivered by the utility during recharge. The "well-to-wheel" efficiency and emissions of PHEVs compared to gasoline hybrids depends on the energy sources used for the grid utility (coal, oil, natural gas, hydroelectric power, solar power, wind power, nuclear power). In a serial Plug-In hybrid, the ICE only serves for supplying the electrical power via a coupled generator in case of longer driving distances. Plug in hybrids can be made multi-fuel, with the electric power supplemented by diesel, biodiesel, or hydrogen.

For typical driving cycles, the achieved efficiencies are lower. The battery powered EV achieves efficiencies in the range of 50 to 60%. The hydrogen powered EV has a total efficiency of about 13% only at those drive cycles.

Sources:

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