

EE.EES.460 Electrical Energy Storages and Electric Vehicles, 5 cr.

Answer all the **five (5)** questions. The use of calculator is allowed. Answers in Finnish *or* English.

1. Answer TRUE or FALSE (+0.5 for correct answer, -0.5 for incorrect, 0 for empty, total max 6 p.)
 1. New battery technologies are commercially available every year
 2. C-rate states the li-ion battery temperature rating
 3. LFP is safer than LCO
 4. Specific energy is rated in Wh/kg or Wh/litre
 5. Lead-acid battery has higher cell voltage than li-ion
 6. Mode 4 always means DC charging in case of electric vehicles
 7. Schuko and type 2 are common plugs in European EV markets
 8. Electric vehicles consume about 20 kWh/100 km
 9. Smart charging can cause problems for TSO
 10. P2X2P process efficiency is ca. 50-60 %
 11. Sensible heat storage the highest energy capacity of heat storages
 12. Global EV fleet size is over 10 million vehicles

2. Energy storages (6 p.)
 - a) Explain what a flywheel energy storage is, how it works and where it could be used. (3 p)
 - b) What are the three heat energy storage methods and how are they different from each other?

3. Lithium-ion batteries and supercapacitors(6 p.)

Explain in detail what is the difference between lithium-ion batteries and supercapacitors and how they operate.

4. Electric vehicles (6 p.)
 - a) What has been the enabler of current wave of electric vehicles? What is still slowing down adoption of electromobility?
 - b) How are electric vehicles charged at homes and on public charging stations? What are the equipment needed and what they do?

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5. Lifetime costs (6 p.)

Consider operating a city bus line with one of the two possible electric buses: first with large battery and slow charging, and second bus with small battery and quick charging station (expensive). They differ in investment costs, operating costs and battery lifetime (which will need replacement at year X). Which one is financially better option?

	eBus 1 (LFP)	eBus 2 (LTO)
Bus price (body)	100 000 €	
Battery size	250 kWh	50 kWh
Battery price	500 €/kWh	1500 €/kWh
Charging station cost	10 000 €	100 000 €
Battery cycle life	1 500	10 000
Bus energy consumption	1.1 kWh/km	1.0 kWh/km

Values that apply for both:

Distance per year	60 000 km
Electricity cost	0.1 €/kWh
Internal discount rate	11 %

(Hint : discount coefficient is $\left(\frac{1}{1+\frac{p\%}{100\%}}\right)^t$)