TAMPERE UNIVERSITY OF TECHNOLOGY

19.12.2017

Exam of the course *DEE-54206 Electrical Energy Storages and Electric Vehicles*, 5 cr.

Please answer all of the **six (6)** questions. The use of calculator is not allowed.

Please write CLEARLY your name to the answer paper!

Please answer in Finnish, (Swedish) or English.

1. **a)** Describe what are the main strengths and weaknesses of pumped hydro storages and lithium-ion battery storages when used in stationary energy storage applications for the needs of electricity grids. (3 p.)

   b) Describe three potential applications of energy storages in power systems. Why the energy would be stored and used in each of the applications? (3 p.)

2. **a)** What are the four main components of a lithium-ion battery cell (inside the cell casing)? Draw a schematic picture and name the parts. (2 p.)

   b) Describe what happens in each of the four main components of a Li-ion battery cell, when a cell is charged. (*Hint: describe the movement of Li-ions in each component.*) (4 p.)

3. **a)** What are the main strengths and weaknesses of full EVs and plug-in hybrid EVs? (2 p.)

   b) Why buses are a potential application of electrification of transportation? (2 p.)

   c) Describe how V2G or V2H might affect the costs of a full EV user in terms of additional wear and tear for the battery pack. (2 p.)

4. Explain shortly the main motivations and challenges of electrification of road transportation. (6 p.)

5. Explain briefly what kinds of roles EVs could have in power systems in the future, and what are the potential impacts (challenges and opportunities) of EVs to different parts of the power system/grid (6 p.)

PLEASE TURN OVER THE PAPER!

6. Select true or false. You get +1 point of a correct answer and –1 point of a wrong answer. If you leave the boxes empty, you get 0 points. The minimum amount of points of the assignment is 0. (12 p.)

		True	False
a)	Considering CO_2 emissions, today's EVs are zero emission vehicles. (*Hint: do not give the wrong answer*).	❑	❑
b)	NCA mixed oxide is a challenging negative electrode material of Li-ion batteries from safety viewpoint.	❑	❑
c)	When lithium-ion batteries are charged, the charging typically starts with a constant current (CC) phase.	❑	❑
d)	The solid electrolyte interface (SEI) layer on surface of the negative electrode of a lithium-ion cell is very important for the lifetime of the cell.	❑	❑
e)	Mode 3 charging is an AC charging method of EVs and mode 4 is a DC charging method enabling high-power charging.	❑	
f)	The energy efficiency of power-to-gas-to-power (P2G2P) storage is very high.	❑	❑
g)	Flywheel energy storages have high self-discharge rate.	❑	❑
h)	In order to design high-power Li-ion cell, one should use active material powder with big particle size in order to get large surface area.	❑	❑
i)	Super capacitors have typically higher specific energy (Wh/kg) than lithium-ion batteries.	❑	❑
j)	Lithium-plating might happen in the negative electrode of a Li-ion cell if the cell is charged too slowly or with too high cell temperature.	❑	❑
k)	Lithium iron phosphate (LFP) as positive electrode decreases specific energy (Wh/kg) but increases the safety compared to cobalt oxide.	❑	❑
l)	The best storage temperature for batteries is +25 – +35 °C.	❑	

Bonus question. What kind of energy/fuel production/storage system the space company *SpaceX* is going to use on Mars in order to get the rocket back to Earth? (2 p.)

Thank you for participating the course! Have a nice holiday and merry Christmas!

With best regards,
Antti