Tampere University

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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. Battery technology innovations generally enter the market after about 10 years
2. C-rate states the li-ion battery charging and discharging current
3. All lithium-ion battery chemistries have same voltage
4. Specific power is rated in Wh/kg or Wh/litre
5. Lithium-ion battery cell voltage is higher than lead-acid cell voltage
6. DC charging means that the AC-DC converter is in the vehicle
7. All global markets have same plug standards for EV charging
8. Electric vehicle energy consumption is roughly 0.2 kWh/km
9. Smart charging means always charging on the cheapest electricity hours
10. Electricity to hydrogen conversion efficiency is about 60% in electrolysis process.
11. Annual worldwide demand for crude oil has been increasing over the last years.
12. Virtual power plant is a concept where several small devices are aggregated as one resource and provided as controllable energy device.

2. Energy storages (6 p.)

a) Explain what is Power-to-X-to-Power. What are the costs and efficiency? To which applications it would be best suited?

b) Pumped hydro: describe how PHS can be used for both short and long term energy storages and on which kinds of electricity/power markets can it participate. (3 p)

3. Lithium-ion batteries (6 p.)

a) Explain with illustration and in writing how charging and discharging a lithium-ion battery works. (4 p.)
b) Why is battery management system (BMS) important with li-ion batteries? Describe the key functionalities of BMS. (2 p.)

4. Electric vehicles (6 p.)

a) Explain what are the differences between ICE, hybrid, plug-in hydrid and full electric vehicles (3 p.)
b) How will electromobility affect the consumption of electric energy and why is smart charging needed in the future? (3 p.)

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5. Financial value (6 p.)

Consider a case where you have a PV power plant installed at your premises, which produces 5000 kWh annually on average. Your total energy consumption is 16 000 kWh annually and you can use 30 % of the produced energy to compensate for your consumption, the rest is sold to the energy retailer. You are now considering buying a small energy storage system, which would enable you to use 70 % of your production locally to compensate for your consumption. The system would cost 3000 € (one-time investment) and it would have the expected lifetime of 10 years. Is the investment to storage system economically viable, assuming that PV system already exists (and has remaining useful life at least 10 years)? Examine with calculations, use energy price 13 c/kWh for consumed energy, 4 c/kWh for sold energy and 6 % annual discount rate. (Hint: discount coefficient at i^{th} year: $\frac{1}{\left(1+\frac{p\%}{100\%}\right)^{i}}$). (6 p.)

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