Please limit your answer to maximum 10 minutes
(5 min presentation + 5 min for eventual questions)

Exercise 1.1 (PV in Switzerland)

Please describe (preferably as a PPT presentation with 3-4 slides):

- What percentage of rooftops in Switzerland (including residential and industrial buildings) should be covered with PV modules in order to meet the Swiss electricity demand? (assume 18%-efficient modules and realistic performance of PV systems)

- How realistic is this scenario by 2050?

Exercise 1.2 (PV for family Müller)

Please describe (preferably as a PPT presentation with 3-4 slides):

Family Müller in Lausanne consumes 3500 kWh of electricity in a year.

a) What should be the nominal power of a PV system in order to generate this amount of energy? (assume south orientation of modules)

b) What module area is required when the modules have an efficiency of 18%?

c) What is return-on-investment time?

Use lecture notes and web resources

Exercise 1.3 (Shockley–Queisser limit)

Please explain the main steps in derivation of the theoretical limit for the conversion efficiency for unconcentrated light (the Shockley–Queisser limit or detailed balance limit)

(PPT slides or on blackboard – 5 min).

Literature:

W. Shockley and H.J. Queisser, "Detailed Balance Limit of Efficiency of p-n Junction Solar Cells", *Journal of Applied Physics*, Volume 32 (March 1961), pp. 510-519

”Handbook of Photovoltaic Science and Engineering”, 2011
http://onlinelibrary.wiley.com/book/10.1002/9780470974704

L.C. Hirst and N.J. Ekins-Daukes “Fundamental losses in solar cells”, Prog. Photovolt: Res. Appl. 2011, 19, 286-293

Exercise 1.4 (Solar cells in parallel and series)

Please describe (PPT slides or on blackboard):

One p-n junction sola cell has V_{oc} = 0.5 V and J_{sc} = 20 mA cm^{-2}. A second cell of the same area has V_{oc} = 0.6 V and J_{sc} = 16 mA cm^{-2}. Assuming that both cells obey the ideal diode equation, find both values of V_{oc} and J_{sc} when two cells are connected

i) in parallel

ii) in series

Hint: use ideal diode equation and dark saturation current density

Literature:

"Handbook of Photovoltaic Science and Engineering",
http://onlinelibrary.wiley.com/book/10.1002/9780470974704

Exercise 1.5 (Solar module degradation and failure)

Please describe (preferably as a PPT presentation with 3-4 slides – 5 minutes):

- Possible failures of PV modules
- Mechanisms of degradation (light-induced, potential-induced, long-term)

Literature:

"Handbook of Photovoltaic Science and Engineering",
http://onlinelibrary.wiley.com/book/10.1002/9780470974704

PVeducation.org

http://pveducation.org/pvcdrom/modules/degradation-and-failure-modes

web references

Exercise 1.6 (Bypass diodes)

Please describe (preferably as a PPT presentation with 3-4 slides – 5 minutes):

- why bypass diodes are needed for PV modules?

- Two identical modules are connected in series. Module A is radiated with 1000 W/m2 and module B with 500 W/m2. Draw individual I-V curves and the combined curve for the cases:

i. no bypass diodes.
ii. with bypass diodes.

Exercise 1.7 (Material availability)

Please describe (preferably as a PPT presentation with 3-5 slides):

Potential of various photovoltaic technologies for large-scale electricity generation based on the material availability and current production rates. Identify key elements that may potentially limit: c-Si, CIGS, CdTe, DSSC, organo-metallic perovskite and polymer solar cells.

Literature:

The Future of Solar Energy, AN INTERDISCIPLINARY MIT STUDY, 2015

https://mitei.mit.edu/system/files/MIT%20Future%20of%20Solar%20Energy%20Study_compressed.pdf

"Materials availability for thin film (TF) PV technologies development", https://doi.org/10.1016/j.rser.2011.06.012

C. Wadia et. al., "Materials Availability Expands the Opportunity for Large-Scale Photovoltaics Deployment" Environ. Sci. Technol. 2009, 43, 2072–2077

Web references

Exercise 1.8 (PV vs nuclear)

Please present (preferably as a PPT in 2-3 slides):

Compare how much **electrical energy** can be produced from

one gram of natural uranium using the nuclear technology (assuming 0.7% content of U235 isotope in natural uranium and a conventional nuclear reactor of thermal type with light water)

vs

one gram of Si in a silicon solar cell with 180 μm thick wafer and 20% conversion efficiency (assuming lifetime 40 years and PV module location in Lausanne)

Literature: web sources