Exam 47202 Introduction to future energy 2017

-- Lecture 1 (Introduction) —

Q 1-1) What (roughly) is the percentage of global energy supplied by oil?

- [ ] A) 18%
- [ ] B) 23%
- [ ] C) 28%
- [ ] D) 33%
- [ ] E) 40%

Q 1-2) How much power (roughly) does the world economy consume?

- [ ] A) 1.700 GW
- [ ] B) 17.000 GW
- [ ] C) 27.000 GW
- [ ] D) 43.000 GW
- [ ] E) 100 TW

Q 1-3) Why do metals produced as bi-products typically have lower availability for large-scale usage compared those produced as primary products?

- [ ] A) Because they have lower crustal abundance
- [ ] B) Because they are inelastic to price changes
- [ ] C) Because they are elastic to price changes
- [ ] D) Because they are more expensive
- [ ] E) Because they are poisonous to the environment

Q 1-4) What is the main observation called "the demographic transition"?

- [ ] A) That poor countries grow populations very fast
- [ ] B) That rich countries help poor countries to obtain a good standard of living
- [ ] C) That the rich get richer at the expense of the poor
- [ ] D) That the number of childbirths/women increases with improved health care and education
- [ ] E) That the number of childbirths/woman decreases with improved health care and education

-- Lecture 2 (Fluid dynamics) —

Q 2-1) What principle is the Bernoulli equation derived from?

☐ A) Conservation of mass

☐ B) Conservation of momentum

☐ C) Conservation of angular momentum

☐ D) Conservation of energy

☐ E) Purely empirical

Q 2-2) As a steady wind approaches a wind turbine with a given freestream wind speed and pressure of V_1 and p_1. How are these freestream quantities related to the wind speed and pressure immediately before the wind turbine, V_2 and p_2?

☐ A) V_1 > V_2 and p_1 > p_2

☐ B) V_1 < V_2 and p_1 > p_2

☐ C) V_1 = V_2 and p_1 = p_2

☐ D) V_1 > V_2 and p_1 < p_2

☐ E) V_1 < V_2 and p_1 < p_2

Q 2-3) Estimate the wind speed according to 1D momentum theory in the wake behind an ideal wind turbine operating at optimal efficiency, i.e. Betz limit of C_P = 16/27? Assume the freestream wind speed to be 8 m/s.

☐ A) 2.7 m/s

☐ B) 4.8 m/s

☐ C) 5.3 m/s

☐ D) 6.4 m/s

☐ E) 7.3 m/s

Q 2-4) What is the thrust coefficient, C_T, according to 1D momentum theory for an ideal wind turbine operating at optimal efficiency, i.e. Betz limit of C_P = 16/27?

☐ A) C_T = 1

☐ B) C_T = 8/9

☐ C) C_T = 16/27

☐ D) C_T = 2/9

☐ E) C_T = 4/9

-- Lecture 3 (Thermodynamics – Oluf) —

Q 3-1) What is the thermodynamic function that describes the total energy that is released from the process of combustion of methanol at constant pressure?

☐ A) The enthalpy of the reaction

☐ B) The enthalpy of formation of methanol

☐ C) The entropy of methanol

☐ D) The Gibbs free energy of the reaction

☐ E) The Gibbs free energy of formation of methanol

Q 3-2) Which of the following statements can be true for a reversible process?

☐ A) The process takes place at a temperature higher than in the surroundings and it results in heat dissipation in the surroundings

☐ B) The process is accompanied by a loss of capability to perform work

☐ C) Entropy is generated

☐ D) Entropy is not generated

☐ E) There is a net (decisive, resulting) driving force in one direction

Q 3-3) Which one of the following processes is impossible (not possible) in an isolated system

☐ A) Complete conversion of work to work

☐ B) Complete conversion of work to heat

☐ C) Complete conversion of heat to work

☐ D) Complete conversion of heat to heat

☐ E) Complete conversion of work to electricity

Q 3-4) The following enthalpies of formation can be found in a table: ΔH_f (CH_4) = -74.6 kJ mol^{-1}, ΔH_f (O_2) = 0 kJ mol^{-1}, ΔH_f (CO_2) = -393.5 kJ mol^{-1}, ΔH_f (H_2O (l)) = -285.8 kJ mol^{-1}. How much energy is released when methane is combusted?

☐ A) 74.6 kJ mol^{-1}

☐ B) 318.9 kJ mol^{-1}

☐ C) 393,5 kJ mol^{-1}

☐ D) 604.7 kJ mol^{-1}

☐ E) 890.5 kJ mol^{-1}

-- Lecture 4 (Biomass – Lasse) —

Q 4-1) What type of renewable energy resource has the largest energy input to the Danish energy system?

☐ A) Wind

☐ B) Solar

☐ C) Hydro

☐ D) Geothermal

☐ E) Biomass

Q 4-2) What characteristic is not important for biomass gasification for fuel synthesis?

☐ A) A high district heating production

☐ B) A high output of CO and H_2

☐ C) A low content of tars in the output gas

☐ D) A high energy efficiency

☐ E) Biomass fuel flexibility

Q 4-3) What is the energy efficiency (Lower Heating Value, LHV) of the chemical reaction converting CO_2 and H_2 to CH_3OH (methanol) by $CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$?

☐ A) 80%

☐ B) 83%

☐ C) 85%

☐ D) 88%

☐ E) 90%

Q 4-4) By integrating hydrogen from water electrolysis, the biofuel production will be limited by the carbon content of the biomass. Calculate the potential output of DME per kg of biomass input. The biomass carbon content can be assumed to be 45 wt%.

☐ A) 0.63 kg

☐ B) 0.75 kg

☐ C) 0.86 kg

☐ D) 1 kg

☐ E) 1.26 kg

-- Lecture 5 (Water – Michael) —

Q 5-1) The definition of "celerity" of a linear deep-water wave is:

- [ ] A) The speed at which the waveform propagates in space, and is found by dividing the wavelength by the period.
- [ ] B) The ratio between wave height and wavelength, indicating the steepness of the wave
- [ ] C) The time taken for one wavelength to pass through an arbitrary fixed point
- [ ] D) The ratio between the wave's wavelength and the water depth, indicating whether the wave is within the deep-water limit
- [ ] E) The ratio between wave height and angular frequency

Q 5-2) What is the wave frequency (f), period (T), angular frequency (ω), phase velocity (c) of a deep-water wave with a wavelength, λ, of 142 meters? Assume a fluid density of 1025kg/m^3 and an acceleration due to gravity of 9.81 m/s^2.

- [ ] A) f = 0.069 Hz; T = 14.475 seconds; ω = 0.434 rad/s ; c = 9.810 m/s
- [ ] B) f = 0.074 Hz; T = 13.487 seconds; ω = 0.466 rad/s ; c = 21.057 m/s
- [ ] C) f = 0.105 Hz; T = 9.537 seconds; ω = 0.659 rad/s ; c = 14.890 m/s
- [ ] D) f = 0.148 Hz; T = 6.743 seconds; ω = 0.932 rad/s ; c = 10.529 m/s
- [ ] E) f = 0.042 Hz; T = 23.905 seconds; ω = 0.263 rad/s ; c = 5.940 m/s

Q 5-3) Consider two waves with wave heights H1=2.2m and H2= 7.6m, and corresponding wavelengths λ1=142m and λ2=187m. For each wave, calculate the total energy per unit wave width (E_{width}). Assume a fluid density of 1025kg/m^3 and an acceleration due to gravity of 9.81 m/s^2. Select the correct answer.

- [ ] A) $E1_{width}$ = 431.92 kW/m; $E2_{width}$ = 6788.00 kW/m
- [ ] B) $E1_{width}$ = 178.48 kW/m; $E2_{width}$ = 235.04 kW/m
- [ ] C) $E1_{width}$ = 3455.39 kW/m; $E2_{width}$ = 54303.98 kW/m
- [ ] D) $E1_{width}$ = 785.32 kW/m; $E2_{width}$ = 3572.63 kW/m
- [ ] E) $E1_{width}$ = 863.85 kW/m; $E2_{width}$ = 13576.00 kW/m

Q 5-4) Extraction of tidal energy is typically done by exploiting:

- [ ] A) The energy in waves generated by tides in shallow waters
- [ ] B) The temperature gradient energy of incoming and out-going tides
- [ ] C) The difference in salinity of tides
- [ ] D) Potential energy and/or kinetic energy harvesting
- [ ] E) The elastic energy in tides as they are funneled through estuaries

-- Lecture 6 (Wind) —

Q 6-1) What is the main degree of freedom of the wind turbine to measure the blade position during the operation.

- [ ] A) Yaw
- [ ] B) Pitch
- [ ] C) Azimuth
- [ ] D) Tilt
- [ ] E) Cone

Q 6-2) There are list of wind turbines. Please select the rotating drag-based machine

- [ ] A) Three-bladed horizontal axis wind turbine
- [ ] B) Two-bladed horizontal axis wind turbine
- [ ] C) Darrieus type wind turbine
- [ ] D) Three-bladed horizontal axis turbine with diffuser
- [ ] E) Savonius type wind turbine

There is an artificial 5MW wind turbine. Its characteristics are shown below. Rotor diameter: 126m; Hub height: 90m; Wind class: IA, Vref = 50m/s, Iref = 0.16; Thrust is provided below.

Wind speed (m/s)	Thrust (kN)
4	84
5	131
6	189
7	257
8	336
9	425
10	525
11	411
12	353
13	315
14	286

Q 6-3) Please calculate the minimum, mean and maximum blade root flapwise bending moments at 12m/s

☐ A) -4869kNm, 4942kNm, 14753kNm (minimum, mean, maximum)

☐ B) -3553kNm, 4942kNm, 15061kNm (minimum, mean, maximum)

☐ C) -5905kNm, 4942kNm, 14725kNm (minimum, mean, maximum)

☐ D) -1453kNm, 4942kNm, 16153kNm (minimum, mean, maximum)

☐ E) -1810kNm, 1834kNm, 5478kNm (minimum, mean, maximum)

Q 6-4) Please calculate the minimum, mean and maximum tower bottom bending moments at 14m/s

☐ A) -22842kNm, 36990kNm, 96822kNm (minimum, mean, maximum)

☐ B) -15102kNm, 25740kNm, 91602kNm (minimum, mean, maximum)

☐ C) -37692kNm, 25740kNm, 94662kNm (minimum, mean, maximum)

☐ D) -43812kNm, 25740kNm, 95292kNm (minimum, mean, maximum)

☐ E) -31302kNm, 25740kNm, 94842kNm (minimum, mean, maximum)

-- Lecture 7 (Solar) —

Q 7-1) What is the main advantage of CSP over PV?

☐ A) That it is cheaper (lower $/W)

☐ B) That it can run in more geographical locations

☐ C) That it is faster to build

☐ D) That it is cheaper to maintain

☐ E) That it allows energy storage

Q 7-2) The optimal band-gap of a solar cell is a compromise between

☐ A) The cell current and the cell cost

☐ B) The cell current and the cell voltage

☐ C) The cell current and the cell fill-factor (FF)

☐ D) The cell voltage and ambient temperature

☐ E) The cell voltage and the fill-factor (FF)

Q 7-3) If you wish to run an electrochemical process and you need a voltage of more than 1 volt (but less than 2 volts) a tandem cell is a much better choice than a single-bandgap cell. Why?

☐ A) Because the single photon cell cannot provide sufficient voltage

☐ B) Because the single photon cell has a bad fill factor

☐ C) Because the tandem cell provides more current at the desired voltage

☐ D) Because the tandem cell is a simpler design

☐ E) Because the tandem cell is less affected by changes in incident spectrum

Q 7-4) If you build identical photovoltaic plants near Copenhagen and near Rome, you get xx % more annual production in Rome.

☐ A) xx = ~0 %

☐ B) xx = ~15 %

☐ C) xx = ~50 %

☐ D) xx = ~80 %

☐ E) xx = ~110 %

-- Lecture 8 (Nuclear) —

Q 8-1) What is the nuclear fission-share of the European (EU) electricity generation?

☐ A) ~25%

☐ B) ~35%

☐ C) ~45%

☐ D) ~55%

☐ E) ~65%

Q 8-2) What is the approximate energy utilization of natural uranium in a LWR once-through fuel cycle?

☐ A) 1%

☐ B) 5%

☐ C) 15%

☐ D) 25%

☐ E) 35%

Q 8-3) These nuclides are fissile

☐ A) ^{233}U, ^{235}U, ^{238}U

☐ B) ^{233}U, ^{235}U, ^{239}Pu

☐ C) ^{238}U, ^{239}Pu, ^{232}Th

☐ D) ^{233}U, ^{238}U, ^{232}Th

☐ E) ^{235}U, ^{238}U, ^{239}Pu

Q 8-4) Nuclear fusion is based on the interactions of

☐ A) D+T

☐ B) D+U

☐ C) T+U

☐ D) U+n

☐ E) Th+n

-- Lecture 9 (Fuel cells – Oluf) —

Q 9-1) What is the desired role of the electrolyte in a fuel cell

☐ A) Storage of reactants

☐ B) Conduction of electrons

☐ C) Conduction of ions

☐ D) Dissolution of hydrogen

☐ E) Dissolution of oxygen

Q 9-2) What is the role of the catalyst(s) in a fuel cell?

☐ A) It directs the reactants to the electrolyte where the conversion process takes place

☐ B) It is consumed by the electrochemical process

☐ C) It is only there because it is a good electronic conductor

☐ D) It makes the electrochemical process proceed more easily

☐ E) Makes an electrochemical process proceed faster

Q 9-3) What is the usual oxygen catalyst material in a PEM fuel cell?

☐ A) Platinum

☐ B) Iridium

☐ C) Mixed metal oxides

☐ D) Carbon

☐ E) Nafion

Q 9-4) What limits the operating temperature of a PEM fuel cell, practically below 90 °C?

☐ A) The electrolyte membrane dries at temperatures higher than 90 °C and loses the ion conductivity

☐ B) The electrolyte membrane melts at temperatures higher than 90 °C

☐ C) The catalyst loses activity at temperature higher 90 °C

☐ D) Hydrogen and oxygen reacts spontaneously at temperatures higher 90 °C

☐ E) The electrochemical process cannot be controlled at temperatures higher 90 °C

-- Lecture 10 (Batteries - Tejs) —

Q 10-1) What is the theoretical capacity of a typical positive electrode material in a Li-ion battery:

☐ A) ~200 Wh/L

☐ B) ~200 Wh/kg

☐ C) ~200 kWh/kg

☐ D) ~200 mAh/g

☐ E) ~200 Ah/g

Q 10-2) Arrange the following battery chemistries according to their gravimetric energy density (energy per weight), from lowest to highest:

☐ A) Ni-MH < Pb-acid < Li-ion < Ni-Cd

☐ B) Pb-acid < Li-ion < Ni-MH < Ni-Cd

☐ C) Li-ion < Ni-MH < Ni-Cd < Pb-acid

☐ D) Pb-acid < Ni-Cd < Ni-MH < Li-ion

☐ E) Ni-Cd < Li-ion < Pb-acid < Ni-MH

Q 10-3) If a battery with a Coulombic Efficiency (sometimes called “cycle efficiency”) of 99.9 % is charged and discharge once a day, how much of the original capacity is left in the battery after one year?

- ☐ A) 99.6 %
- ☐ B) 96.4 %
- ☐ <u>C) 69.4 %</u>
- ☐ D) 2.5 %
- ☐ E) 0.0 %

Q 10-4) The following overall reaction takes place in a lithium-iodine battery: Li + ½ I_2 → LiI(s). Which component is oxidized and which is reduced?

- ☐ A) Lithium is reduced and Iodine is oxidized
- ☐ <u>B) Lithium is oxidized and Iodine is reduced</u>
- ☐ C) Both Lithium and Iodine are oxidized
- ☐ D) Both Lithium and Iodine are reduced
- ☐ E) Neither Lithium nor Iodine is reduced or oxidized

-- Lecture 11 (Electrolysis – Oluf) —

Q 11-1) Which type of electrolyzer depends on noble metal based catalysts?

- ☐ A) The solid oxide electrolyzer, since only noble metals are stable at the high temperature
- ☐ B) The alkaline electrolyzer, because the alkaline electrolyte is so corrosive
- ☐ <u>C) The PEM electrolyzer, because the environment is acidic due to the sulfonic acid</u>
- ☐ D) All the three types. Only noble metal catalysts are active
- ☐ E) None of the systems need noble metals for catalysts

Q 11-2) What is the maximum theoretical electrical efficiency of an electrolyzer cell with respect to the higher heating value, HHV, ie. With water fed as liquid (based only on thermodynamics at room temperature)?

- ☐ A) There is no maximum. The electrolyzer is not limited by thermodynamics
- ☐ B) ca. 50 % half
- ☐ C) ca. 80% because heat must be evolved
- ☐ D) 100 % because it is not limited by the Carnot maximum
- ☐ <u>E) 121 % because thermal energy can be included</u>

Q 11-3) What is the advantage of a zero-gap configuration

☐ A) Gas leaks are minimized

☐ <u>B) The internal resistance of the electrolyte is small</u>

☐ C) Heat is conducted more efficiently

☐ D) The catalysts work better

☐ E) Less electrolyte is needed

Q 11-4) What is the "thermo-neutral voltage"?

☐ A) Any voltage at which increased temperature does not affect electrode kinetics

☐ B) The voltage at which increased temperature does not increase the conversion rate

☐ C) A voltage that is not affected by temperature

☐ D) The voltage at which the electrolysis process can be driven by heat alone

☐ <u>E) The voltage, 1.48 V, at which the heat produced by internal losses exactly matches the heat demand of the electrolysis process</u>

-- Lecture 12 (Infrastructure – Peter) —

Q 12-1) If you increase the Weighted Average Cost of Capital (WACC) for a given project, the Net Present Value (NPV) goes:

☐ A) To zero

☐ <u>B) Down</u>

☐ C) Up

☐ D) No change (the WACC doesn't affect the NPV)

☐ E) To infinity

Q 12-2) The LCOE is used to:

☐ A) Compare the reliability different energy sources on an equal basis

☐ B) Compare the construction costs of different energy sources on an equal basis

☐ C) Compare the Life-Cycle Operational Environmental impact of different energy sources

☐ D) Compare the running costs (OPEX) of different energy sources on an equal basis

☐ <u>E) Compare the cost of produced energy on an equal basis</u>

Q 12-3) All the car engines of the World running at full power would generate a combined power of roughly:

☐ A) ~1 TW

☐ B) ~10 TW

☐ C) ~100 TW

☐ D) ~1.000 TW

☐ E) ~10.000 TW

Q 12-4) If all the cars in Denmark were electric and participated in a V2G (Vehicle-to-Grid) program they would in practice be able to run the grid for a time period on the order of (give or take a factor of 3):

☐ A) ~20 min.

☐ B) ~1 hour

☐ C) ~4 hours

☐ D) ~1 day

☐ E) ~1 week