Family name:	**First name**:

ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ENVIRONMENTAL ECONOMICS

EXAM OF 22 MAY 2023

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Attention

- **Write your name** at the top of this sheet. It should be the same as at the bottom of this page.
- **No documentation** is authorized, except a dictionary translating English to your language.
- **No device** is authorized except a calculator. If you do not have a calculator, simply indicate the calculations you would do.
- Use the free space at the bottom of some pages and on the back of the exam as scrap paper. Do not use your own paper. **Do not detach the pages**.
- **Write** all your answers **in the spaces** provided for this.
- **Show all your calculations**. The answer alone, even if it is right, is not enough.
- If a question seems false, incomplete or unclear to you, write it down in the answer space. **Do not ask the supervisors any questions**.
- If you want to modify your answer, do so in such a manner that your choice is still clear. **Do not ask your neighbour for an eraser**.
- When you are finished, bring your copy to the front. **You do not need to wait until the end of the exam**.
- If you have to leave, you must hand in your copy first.
- **The exam lasts 1h30 max**.

Problem 1: (4 points)

A regional park is located 10 minutes from city A, with 100,000 inhabitants, and 20 minutes from city B, with 200,000 inhabitants. On average, the inhabitants of city A visit the park 10 times a year and those of city B 5 times. The park costs CHF 1,500,000 per year to operate.

Assumptions for the calculations:

- The inhabitants of both cities have similar incomes and preferences for regional parks
- The cost of a visit is equal to the cost of the time needed to get there, since there is no entrance fee
- The value of time is CHF 0.50 per minute for residents of both cities
- Only residents of the two cities visit the park.
- The social discount rate is 5%.
- The park lasts forever, but possible inflation of prices and costs is ignored.

1) Calculate the cost of visiting the park for an inhabitant of each city.

2) Construct the joint demand curve for the inhabitants of both cities.

3) Calculate the consumer surplus for the inhabitants of each city and the total consumer surplus.

4) A forestry company would like to buy the regional park to exploit its forests. It offers CHF 100 million. Should the park be sold? *Justify your answer*

Scrap area for your calculations

Problem 2: (2 points)

In anticipation of possible electricity shortages in the winter 2022-2023, the Swiss federal government ordered two large mobile power generation units from the USA. These units produce noise levels comparable to the turbines of a passenger airplane. They were not used in the winter of their installation, but the government anticipates that it will have to use them in the future and, therefore, to compensate the people and organisations affected by the noise of these engines. One unit was installed in the village of Birr. About 100 apartments are exposed to its noise, appartements rented for an average of 20 000 CHF per year. Hedonic rent equations estimated for dwellings exposed to different levels of intermittent noise, some close to military airports, show that the reduction would be 5% per year for the noise level expected from the power unit at its expected level of operation for the next three years, until it is no longer needed.

1) What is the one-time compensation that the government has to pay now to the people and organisations affected by the noise of the power unit in Birr?

Here is some more information that you may use or not to answer this question:

- On top of their rent, tenants pay 2 400 CHF/year for heating and electricity
- The landlords incur maintenance and operation costs of 5 000 CHF/year on average
- The common discount rate to estimate property values based on net rents (rents minus costs) is 4% per year
- A quick and quite accurate way to estimate the value of a rental property is to divide its net rent by the common discount rate
- We shall assume that all prices are constant over time, i.e., we ignore inflation

2) Please discuss housing market conditions which could lead you to revise your answer to the first question

Problem 3: (2 points)

On a patch of land expecting construction, the local authority could plant a flower garden. Planting would cost 5 000 CHF. The local population would enjoy it for two years. Their benefit has been estimated at 2 600 CHF per year. In order to simplify, we assume that all benefits accrue 1, respectively 2 years after planting the garden. Recently, the local authority rejected by a tiny margin a project that would have cost 4 000 CHF for a unique benefit, one year later, of 4 160 CHF. Do you think that it would approve the flower garden project? *Justify your answer*.

Problem 4: (1 point)

A factory covered the roof of its plant with photovoltaic panels whose expected production matches the factory's electricity needs, except that the factory is also operated when solar conditions are not sufficient to supply its machines directly with its PV-electricity. Therefore, the factory owner intends to acquire a large battery. He is offered the choice between buying and renting it.

Terms for buying: purchase price = 45 000 CHF, expected lifetime = 10 years, scrap price = 5 000 CHF, maintenance costs = 2 000 CHF/year

Terms for renting: rental price = 7 000 CHF/year

Considering that investing company cash into a battery would cost 6% per year, which is the cheaper option?

To answer this question, the factory owner wishes that you calculate the annual cost for him of both alternatives, using the simplified annuity formula when needed (i.e., the model of the 'triangle' for the amortisation of the investment cost).

Problem 5: (2 points)

A farmer is considering investing 30 000 CHF for a small methane production plant. The yearly net income of the plant over its expected lifetime of 20 years, would be 3 000 CHF, growing at a rate of 2% per year. The table below shows a financial analysis of this project, using a discount rate of 8%.

	Payments	Years	Discount factor	Discounted payments	Sum of discounted payments
Initial investment	-30 000	0	1.00	-30 000	-30 000
Income year 1	3 060	1	0.93	2 833	-27 167
Income year 2	3 121	2	0.86	2 676	-24 491
Income year 3	3 184	3	0.79	2 527	-21 963
Income year 4	3 247	4	0.74	2 387	-19 577
Income year 5	3 312	5	0.68	2 254	-17 322
Income year 6	3 378	6	0.63	2 129	-15 193
Income year 7	3 446	7	0.58	2 011	-13 183
Income year 8	3 515	8	0.54	1 899	-11 284
Income year 9	3 585	9	0.50	1 794	-9 490
Income year 10	3 657	10	0.46	1 694	-7 796
Income year 11	3 730	11	0.43	1 600	-6 196
Income year 12	3 805	12	0.40	1 511	-4 685
Income year 13	3 881	13	0.37	1 427	-3 258
Income year 14	3 958	14	0.34	1 348	-1 911
Income year 15	4 038	15	0.32	1 273	- 638
Income year 16	4 118	16	0.29	1 202	564
Income year 17	4 201	17	0.27	1 135	1 699
Income year 18	4 285	18	0.25	1 072	2 772
Income year 19	4 370	19	0.23	1 013	3 784
Income year 20	4 458	20	0.21	956	4 741

Please answer the questions on the basis of the data and table above.

1) What is the net present value of this project when discounting at 8%?

2) What do we know about the internal rate of return?

3) What is the pay-back period when not considering inflation nor discounting?

4) What is the pay-back period with discounting at 8%?

Scrap area for your calculations

Problem 6: (2.5 points)

The objective is to derive the LCOE for imaginary plant X described in the table below. Assume that the construction of the plant starts today and is completed in a year, which is when it begins producing electricity (the beginning of its lifetime). For simplicity, all costs and energy flows are assumed to accrue at the end of a period. *When answering the questions below, clearly indicate your computations.*

Assumptions for plant X		
Capacity	MW	600
Investment cost	mUSD	2'900
Fixed O&M costs	mUSD/year	24
Variable O&M costs	mUSD/year	12
Fuel cost	mUSD/year	55
Generation	GWh/year	4'362
Lifetime	years	2
Discount rate	-	7%

1) Derive the relevant discount factor for each year.
2) Derive the (non-discounted) costs accruing in each year, expressed in mUSD (million US dollar).
3) Derive the net present value (NPV) of costs, expressed in mUSD.
4) Derive the NPV of electricity produced, expressed in GWh.
5) Derive the plant levelized cost of electricity (LCOE) and give an interpretation in plain English of the metric.
6) Assuming generation in the final year is 20% lower than initially expected, what variables in the table would have to be adjusted in that same year (only indicate the variables not their values).

Problem 7: (3 points)

Indicate whether each of the following statement is true or false.

A correct answer is worth 0.5 points, an incorrect answer is worth -0.5 points, no answer (blank) is worth 0 point. The minimum number of points overall is 0 points.

Statement	True	False
When comparing the competitiveness of different generation technologies, the LCOE metric may be misleading because technologies do not necessarily have the same cost structure and do not necessarily produce the same amount of electricity over their lifetime		
If the Swiss wholesale electricity price increases by 10%, for instance because less hydro power was available, the end-user consumer price will also increase by 10%		
The “merit order effect” describes the phenomenon where the wholesale electricity price decreases as the share of renewable energy sources in the generation mix increases due to their low marginal costs		
The concept of “market liberalisation” refers to the specific procedure of offering different rates to different customers depending on their level of electricity consumption		
If the LCOE of a nuclear plant is smaller than the average (discounted) wholesale electricity price, the investment can typically be considered profitable		
The LCOE metric can be useful to compare, for instance, two peaking technologies, but would fail to capture differing service levels if, for instance, a wind plant is compared to a gas turbine plant		

Scrap area for your calculations

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