University of West Attica	Department of Mechanical Engineering

Master in Energy Systems
ENERGY ECONOMICS

1st Assessment-Project (December 2022, V-9)

"FINANCIAL EVALUATION OF RES-BASED HYBRID POWER STATIONS IN GREECE INCLUDING ENVIRONMENTAL ASPECTS"

You are asked to undertake a preliminary cost-benefit study, associated with the comparison between the implementation of a hybrid RES based solution and a diesel-oil based one, used to cover the electricity consumption of a remote area with total annual electricity consumption of 4.5 GWh_e and peak load demand of 1.1 MW. The hybrid energy solution is based on two different renewable energy technologies; the first regarding the installation of a small wind park (based exclusively on 0.6 MW wind turbines) at a medium-high wind potential (Table I), and the second concerning a small PV power station (based exclusively on 0.5kW_p modern PV panels) to be installed in an appropriate area of high solar potential (Table I). The safe operation of the RES-based hybrid power station includes Li-ion batteries for two days of energy autonomy of the remote consumer (DOD_{max}=90% and total-round trip efficiency equal to 80%) along with the necessary electronics (i.e. AC/DC rectifiers, battery charge controllers, and three 50 Hz 450 kVA inverters). On the other hand, the alternative solution will be based on the operation of three diesel engine generators (each one of 500 kW nominal power), with average efficiency equal to 32%, including the loss of the asynchronous electrical generators. For both technologies examined, environmental aspects will also be taken into account, while the status of the local electricity market should also be examined taking into consideration the existing system of subsidy and support for RES applications in the course of time.

For this purpose, the following should be considered:

- Financial evaluation of the available solutions should be based on the estimation of the investments' (simple and complete) pay-back period, NPV (npv) and IRR value. However, the final evaluation of the proposed solutions should be based also on the estimation of the levelized (on life cycle basis) total electricity production cost (including externalities).
- Investment cost shall derive from the combination of the initial installation cost and the corresponding maintenance and operation cost, considering the entire economic life of each investment and including the possibility of State subsidy.
- Revenues from the operation of the plants should be estimated by using the current selling price of electricity, valid for autonomous island networks, while taxation should also be taken into account. The annual escalation rate of the local market electricity price should also be considered, excluding the case of the simple pay-back method.

- Cost estimation of atmospheric pollution, either caused or avoided, should be based on the island system emission coefficients as well as on the CO_2 charges of existing air pollution quantification schemes, e.g. the current Emission Trading System (ETS).
- Embodied energy values should be drawn from the international literature, presenting also any assumptions adopted, while you may assume that both the wind turbines' and the PV panels' manufacturers are located in Europe.

In this context, using the available information for the local economy parameters, you are asked to deliver an integrated cost-benefit study for the proposed two alternatives, including environmental aspects, while at the end of this assessment you are asked to extend your analysis by investigating land requirement of the entire installation. More precisely, after selecting the nominal power of the hybrid power station and the diesel generators,

PART ONE (50%)

1. Estimate the simple and the complete pay-back period of the proposed investment (*using selected combinations of wind turbines and PV panels*) and compare your findings with the diesel based solution. Note that the estimation of the complete pay-back period must be based on the present values of cash flows. At this point it is important to mention that you should select solutions based on commercial available equipment. Is there any remarkable difference between the simple and the complete pay-back period estimated? What are the limitations of the simple pay-back period as an investment appraisal tool?

   (15%)

2. Estimate the net present value and the internal rate of return (IRR) value of the potential investments under investigation and evaluate your findings. What is the IRR telling you about an investment? Is the net present value the most reliable financial evaluation criterion? Can you choose the most beneficial investment on the basis of the results of questions (1) and (2) using a multi-criteria analysis, taking also into consideration the initial capital to be invested? Discuss your selection/answer.

   (20%)

3. Furthermore, estimate the levelized (on life cycle basis) total electricity production cost of the proposed configurations (excluding the externalities at this point). Rank your proposed solutions on the basis of the LC electricity generation cost and compare your results with the ones of question (2). Comment on your findings.

   (15%)

Note that answering to all the questions is critical for your mark. Give clear and coherent answers to each of the questions and try not to exceed the total maximum of 3,000 words (including figures and tables). Furthermore, make any reasonable assumptions wherever required and since work will be carried out in ***groups of two****, keep in mind that co-ordination is essential.*

Table I: Capacity factor values for the PV Panels and the Wind Turbines in the selected remote island

1st Student Surname 1st Letter	ΘCF_{WT}	2nd Student Surname 1st Letter	CF_{PV}		
A-E	30%	A-F	16%		
F-I	27%	G-L	18%		
J-M	24%	M-R	20%		
N-Z	21%	S-Z	22%		

This project should be submitted in the MSc in Energy Systems platform no later than ***January 30, 2023***

ASSESSMENT READING

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