ENE706 Electricity Storage and Electricity Networks
Coursework Assignment 2023-24

Version 0.0 – 21 February 2024

Design Project: Grid-tied Electricity Storage

You are tasked with developing concept design options for an electrical energy storage system serving a health-care facility, on the outskirts of Belfast, which is aiming to reduce their electricity bills, carbon emissions, and future uncertainties regarding energy costs and supply security. The site has a large flat roof (2000m^2) and an adjacent plot of land (2 Hectares) which is mainly used for carparking (approximately half the area).

The site manager has received quotes from renewable energy equipment suppliers suggesting that solar photovoltaics would cost £750/kWp for ground-mounted panels, £950/kWp for roof-mounted panels, and £1300/kWp for solar carports; and that wind turbines would cost between £2500/kW and £4500/kW depending upon size. The site manager contacted several different suppliers but only two responded and none gave any indication of prices for batteries (so you will need to find this out).

The coursework assignment consists of two parts:

- **Part A** (30% of total mark): Use HOMER Grid software to build an electrical energy model of the healthcare facility using the load profile and utility energy bill tariff data provided. Vary the values of model inputs and examine how this affects the suggested cost-optimal electrical energy storage system size.
- **Part B** (70% of total mark): Investigate options for alternative electrical energy storage systems and develop at least two alternative concept design options for the site. Use the HOMER Grid model to compare the whole-life economic viability and environmental benefits of your design options. Consider the possibilities for including emerging innovative technologies which are not currently commercially available.

Further details and instructions for Part A

Use HOMER Grid software to build an electrical energy model of the healthcare facility using the load profile and utility energy bill tariff data provided (files available on Blackboard).

Assume that the renewable energy supply will be provided by 1MWp of solar panels located somewhere on the site (see details on Page 1).

Use the HOMER Grid optimiser to determine a cost-optimal size for an electrical energy storage system. You will need to make various assumptions regarding model inputs such as:

- Costs of solar equipment and batteries
- Derating factors for the PV plant
- Possible future energy tariff changes
- Possible future load demand increases
- Likelihood of future power outages
- Cost of finance to pay for initial capital expenditure (represented by discount rate)
- Inflation rates and assumed project lifetime

The main aim of Part A of the assignment is to assess how sensitive your model is to the uncertainties associated with your assumptions about the model inputs. Vary the values of model inputs and examine how this affects the suggested cost-optimal electrical energy storage system size.

Deliverables and marks:

A1: **HOMER Grid model** (*.hgrid file) – *10% of overall module mark*
You should send a copy of your HOMER Grid model with its inputs and results corresponding to one of the scenarios discussed in your short report (A2).

A2: **Short report** (maximum 500 words, *.pdf) – *20% of overall module mark*
The report should mainly consist of tables detailing all the scenarios you examined – which input variables you investigated, what ranges of input values you considered, and how these inputs affected the output results of the model. Please identify clearly which scenario corresponds with the submitted HOMER Grid model (A1). Briefly discuss your key findings about which variables, assumptions, and uncertainties have the greatest impact upon the cost-optimal size of the electrical energy storage system.

You are also required to submit a skeleton draft outline of the Part B assignment report on this same date (**B1 on the next page**).

Submission deadline:

Sunday 24th March 2024

The Blackboard submission dropbox will close at 23:59

Further details and instructions for Part B

There are four main tasks for this part of the assignment:

B1. Prepare a draft skeleton structure for your report (**this must be submitted at the same time as Part A**) which should consist of a contents page with main headings and sub-headings together with your initial ideas about tasks B2, B3 and B3 below.

B2. Undertaken research by reviewing academic and commercial literature to identify emerging innovative energy storage technologies. Critically analyse the literature to identify key performance indicators quantifying technical benefits, costs, and environmental impacts of the emerging innovative energy storage technologies, and compare these to existing established technologies. Consider issues such as levelized cost of storage (£/kWh), cost of power delivery capacity (£/kW), storage duration and charge/discharge rates (seconds, minutes, hours, days, months) round-trip efficiency and standing losses (%), energy density (kWh/m^3, kW/m^3, kWh/kg, kW/kg), and environmental impacts (materials and land use).

B3. Develop <u>at least two</u> alternative concept design options for the site examined in Part A. You may choose to change the size of the solar array, add wind turbines, and add back-up power sources such as diesel generators (which could potentially run on biofuel). You may also choose to use one of the emerging innovative energy storage technologies (from in B2) by making assumptions about what their future costs might be. Evaluate the whole-life economic viability of each option using your HOMER Grid model. Discuss the technical feasibility and environmental benefits of each option paying particular attention to CO_2 emissions.

B4. Decide which option you would recommend for the site and justify why you would make that recommendation. Develop the business case for your chosen solution and examine the viability of the investment under a range of possible scenarios and circumstances. Identify and discuss any additional (current or future) values streams (such as arbitrage and grid support services) which could be monetized or used to support the business case.

<u>Deliverables and marks:</u>

All of the above should be contained within a single report of maximum 2500 words (excluding tables and figures) and maximum 15 pages of A4. The report should be submitted to Blackboard in *.pdf format. Marks will be apportioned as follows:

- Structure and content – *10% of overall module mark*
- Introduction, background, and context – *5% of overall module mark*
- Electrical energy storage system literature review – *20% of overall module mark*
- Technoeconomic evaluation of chosen solution – *15% of overall module mark*
- Business case for recommended option – *15% of overall module mark*
- Presentation, referencing, use of English – *5% of overall module mark*

<u>Submission deadline:</u>

Sunday 21st April 2024

The Blackboard submission dropbox will close at 23:59

Assessment rubric

Criterion	<40%	40-49%	50-59%	60-69%	>70%
HOMER Grid model ***Part A1 (10%)***	Model contains significant errors and misses several crucial elements of the assignment brief.	Model contains significant errors or misses several crucial elements of the assignment brief.	Model generally compiled correctly but has errors and/or is somewhat inconsistent with the assignment brief.	Model compiled correctly but has minor errors.	Model compiled correctly in accordance with the assignment brief and is free of errors.
Initial report ***Part A2 (20%)***	Insufficient and/or vague, largely irrelevant information, unrelated to the assignment brief.	Limited evidence that the model has been used correctly and several aspects of the assignment brief have been missed.	Provides evidence that the model has been used correctly, but several aspects of the assignment brief have been missed or conclusions are inappropriate.	Provides evidence that the model has been used correctly but one aspect of the assignment brief has been missed.	Provides evidence that the model has been used correctly in accordance with the assignment brief. Sensitivity of the model has been examined thoroughly. Model inputs and assumptions are realistic and evidence-based.
Structure and content of main report ***Part B1 (10%)***	Report content fails to respond to most aspects the assignment brief and is poorly structured.	Report content fails to respond to some aspects the assignment brief and is poorly structured.	Report content covers most aspects the assignment brief, but structure is weak.	Report content covers most aspects of the assignment brief and is reasonably well structured.	Report content responds fully to the assignment brief and is well structured.
Introduction, background, and context ***Part B2.1 (5%)***	Insufficient and/or vague, largely irrelevant information, unrelated to the background context of the project.	Limited or irrelevant information and description of main issues related to the project.	Sufficient background information and synthesis of a range of contextual issues and information.	Critical collation and synthesis of a wide range of resources, issues and information which clearly establish the context of the project.	Critical insightful evaluation and synthesis of a wide range of views, issues and complex information which demonstrates extensive understanding and a highly reflective approach.

Literature review ***Part B2.2 (20%)***	Little or no evidence of wider reading, relying only on materials supplied during the course.	Limited use of current academic and industry standard resources and relying principally on textbooks and non-industry standard material.	Showing knowledge of a range of academic and industry-relevant resources and ability to source current industry data but shows limitations in the scope of material accumulated.	Considerable range of academic and industry literature/data, demonstrating breadth and depth of reading. Identification of key material informing the design process.	Extensive range of literature/data demonstrating breadth and depth of reading. Identification and integration of new or innovative material informing the design process.
Technoeconomic evaluation of chosen solution ***Part B3 (15%)***	No technical details of the proposed solution are presented; no discussion of technical feasibility or constraints; and no evaluation of environmental considerations.	Few technical details of the proposed solution are presented or description is unclear. Discussion and evaluation of technical and environmental considerations is unclear or lacks credibility	Proposed solution is outlined in a reasonable level of technical detail. Limited discussion or evaluation of technical and environmental considerations and/or limited evidence that alternative options have been considered.	Proposed solution is outlined in a reasonable level of technical detail. Technical feasibility and environmental benefits have been assessed and alternative options have been considered.	Proposed solution is outlined with detailed technical specification. Technical feasibility and environmental benefits have been assessed based on evidence from literature. Advantages and disadvantages of the proposed solution have been evaluated relative to alternative options.
Economic evaluation, Business case, and Recommended Option ***Part B4 (15%)***	No economic analysis is performed and/or calculations are incorrect, recognised methods not used.	Limited economic analysis is performed; however calculations are mostly incorrect, or recognised methods are used incorrectly.	Basic economic analysis is performed and or calculations are mostly correct, recognised methods are used but no critical discussion added.	Detailed economic analysis is performed, key economic parameters are evaluated using recognised methods, and results are critically assessed.	Excellent detailed economic analysis is performed, a wide range of economic parameters are considered, relevance is analysed and results are critically assessed.
Presentation, referencing, and use of English (5%)	Poorly presented document, inconsistent formatting and/or inadequate use of diagrams. Incorrect grammar; little/no use of citations/referencing or attempt to follow referencing conventions.	Unsatisfactory presentation, grammar, spelling, and use of figures and tables. Inadequate use of citations and/or limited attempt to follow referencing conventions.	Acceptable presentation, use of figures and tables, grammar and spelling. Adequate use of citations and attempted to follow referencing conventions.	Very good quality presentation, with figures and tables, using correct grammar and spelling. Comprehensive and correct use of citations and references.	Excellent, well-directed presentation, logically structured, using precise grammar and correct spelling. Clear and relevant figures and tables. Excellent and extensive use of citations and references.