**Foreword:**

In the CSE407 - Green Computing course, the *Midterm Assessment Project* is an open-ended Complex Engineering Problems (EP), with multiple solutions. The task could be performed in groups; however the assessments (i.e., report, demonstration and oral examination) would be taken **individually for each student on the Midterm Assessment week.**

*In the Summer 2025 semester, the course instructors decided to go with an energy profiling task. The scale of the task could be adjusted after consultation with the course instructor.*

**Requirements:**

* Students will utilize IoT technology to monitor the energy consumption of a computer lab or an IT infrastructure or any household appliance for a justifiable period.
* Students will prepare an energy monitoring dashboard/webpage with detailed real-time wattage and summarized historical information (e.g., wattage at any minute, energy usage in kWh after each day, daily operating costs, energy usage trend charts, IT load vs. non-IT loads, for individual devices and/or collectively for the infrastructure as a whole).
* Students will implement control functionalities (e.g., simple On/Off, speed control) from the dashboard.
* Students would consider the financial and business aspects in the context.
* Students would do PESTLE analysis/SWOT analysis on the project.

**Project Title:**

**IoT based real-time energy monitoring and control from a dashboard**

**Assessment:**

**Marks: 15% (**Demonstration: **05%**, Viva: **05%**, Report: **05%**) of the overall course grade.

*Detailed level-wise breakdown and EP-wise breakdown are given at the end of this document.*

**Demonstration and Viva: Right after the midterm week,** each session would take **approximately 30 minutes.** [**from August 3 to August 6, 2025**]

**Report:** The student must produce an electronic copy of the report during the Demonstrations and Viva, and it needs to be submitted through the Moodle system afterwards.

**Report Template:** [**CSE407 - Midterm Assessment Report Template.docx**](https://docs.google.com/document/d/103r8zjovrr-wl75jN7o4kRbTGlbxK6vb?rtpof=true&usp=drive_fs)

The report must be **in the given template**, which should contain the following:

|  |  |
| --- | --- |
| **Section** | **Instruction** |
| **Executive Summary:**  (1 minute read) | 1 Page Summary of the whole report, like Abstract, but of multiple paragraphs.  (*To be written at the very end, but placed at the very beginning of the report*) |
| **Brief description of the work:** | **Describe** the overall procedure in simple terms, and **with a flowchart** (containing steps like *Planning and Researching Measuring, Data exporting, Data processing and analysis, Data Presentation*, and whatnot!) |
| **Detailed description of the steps:**    **0. Planning**  1. Researching  2. Purchasing  3. Configuration  4. Next steps??  5. After that??  6. Then what??  7. Now? | Describe each of the steps mentioned above.    **0. Planning**  First find a feasible device that can be measured and explore your options of measuring devices. Buy or Build? API key free or not? Decide first. (elaborate)    **1. Researching**  Is the decision feasible? Is the product available? Is the current rating enough for the chosen device? If it does not work? What would be your plan B? (elaborate)    **2. Purchasing**  Where did you buy it? Give links and describe.  Show money receipts.  Provide a table showing the costs of the devices.  (elaborate)  ……. |
| **Challenges and Hiccups:** | **Discuss** which problems did you encounter and how did you fix/overcome/bypass them? |
| **Demonstration:** | **Give link** to the energy dashboard<https://xyz.iot/cse407>  **Show pictures of** the device/infrastructure you have measured**.**  **Show pictures of** the measurement setup.  **Show** how data is being captured.  **Show** the raw data and how the processing is done.  **Show** the analysis method and visualization interface(s).  **Demonstrate** the user experience with a user manual in PDF format. Prepare it as a PDF user manual to be handed out.  **Link** the user manual in the dashboard. |
| **Discussion on the issues:** | **Tick** the issues you have addressed in this project in the given checklist. *(see explanations below)*  **Discuss** the issues one by one. |
| **Complex Engineering Problem:** | **Mention how EP1 and EP2 were addressed** (will be evaluated during the oral examination).  *(see explanations below)* |
| **Appendices:** | Appendix should contain any code, data sheet, attachments relevant to the project. |

**Checklist:**

**List the issues you have considered. In the report, describe how you addressed each of the issues.**

|  |  |
| --- | --- |
| **Issues** | **Remarks (if any)** |
| \*Planning and Researching? |  |
| Data Collected? |  |
| Data Stored? |  |
| Data Displayed in the dashboard? |  |
| \*Realtime or stored data? |  |
| \*Wattage of the chosen device? |  |
| \*Wattage of the measuring equipment? |  |
| \*AC Power: Why/not apparent power?  Why/not Instantaneous Power? AC power vs. DC power? |  |
| \*Documentation |  |
| \*Safety factor considered? |  |
| \*Safety: Electrical Insulation and Isolation? |  |
| \*Caution with overclocking/flushing |  |
| \*API Issues: Did you get it? How? If not, how did you solve this problem? |  |
| \*UI/UX issues?  Standard components of an energy dashboard? |  |
| \*User Manual? |  |
| \*Future Extensions and Limitations? |  |
| \*Installation, Operation and Maintenance? |  |
| \*Recurring costs |  |
| \*Cost Accounting? |  |
| \*Business Aspects? Cost savings and ROI?  Value of this product/service? Justification? |  |
| \*Reliability?  Never failed? Any fail-safe mechanisms? |  |
| \*Accuracy? Calibration? |  |
| \*Data quality?  Sampling rate?  Crosstalk and interference? |  |
| \*Scalability? |  |
| \*Interoperability? |  |
| \*Data Security?  Important or not in this case? |  |
| \*Compliant with regulations? |  |
| \*Environmental Impacts?  PESTLE analysis? |  |
| \*SWOT analysis |  |

**Explanations of Issues to be considered:**

The given problem has multiple solutions, and depending on the choice, several issues may occur. The students are expected to address some of these relevant issues in the report. During the viva and demonstrations, these issues will be further discussed with the students to assess the level of effort.

**Issue: Planning and researching**

Why did you choose that?

Identify the devices that you want to monitor. This could include computers, printers, routers, etc. Install energy meters on these devices to measure their energy consumption.

**Assessment Criteria: How much research did the student do to initialize the project?**

**Issue: Wattage for the chosen device**

Calculate the **AC current rating** that the equipment can handle. Use Power Factor 0.8 and 20% safety factor.

Here is a sample calculation:   
***Watt/KVA rating of the equipment:*** *500 Watts, Supply voltage: 220 Volts,*

***Current rating:*** *(500/220) Amperes = 2.273 Amperes,*

***Power Factor:*** *0.8 (Leading),*

***Maximum current:*** *(2.273/0.8) Amperes = 2.841 Amperes*

***Current with 20% safety rating:*** *(2.841\*1.2) Amperes = 3.409 Amperes.*

*Hence, the* ***measuring equipment (switch/relay/plug) must withstand at least 3.409 Amperes*** *of current. Therefore, a c****ommercially available 10A/20A switches could be used.***

**Assessment Criteria: Did the student calculate the wattage and current rating beforehand?**

**Issue: AC Power Considerations**

Understand why apparent power (kVA) is used instead of instantaneous power (Watt). Also, consider whether you’re dealing with AC or DC power.

**Assessment Criteria: Did the student discuss the issues related to different types of AC power, and justified which type of AC power was considered?**

**Issue: Documentation of procedure and Troubleshooting**

Document the entire process, including any problems encountered and how they were resolved.

**Assessment Criteria: Was the documentation good enough to understand the process?**

**Issue: Wattage of the measuring equipment**

Calculate the Wattage of the measuring equipment.

**Assessment Criteria: Did the student consider the wattage and current rating of the measuring equipment?**

**Issue: Safety Issues**

Ensure that all equipment is properly insulated and electrically isolated to prevent any accidents.

**Assessment Criteria: Did the student address and discuss the general safety issues?**

**Issue: Caution with overclocking and flushing new firmware**

Remember, safety is paramount when dealing with electrical equipment. Overclocking or flashing a different firmware may cause the device to overheat and potentially cause a fire.

**Assessment Criteria: Did the student overclock the process or flushed a new firmware? Did the student consider the safety issues for that?**

**Issue: API Issues**

If an API is used to collect data, ensure that it’s working correctly. If not, troubleshoot and resolve any issues. Was the API free? How did you manage to get it? What was the hack?

**Assessment Criteria: Did the student address and discuss the API related issues?**

**Issue: User Interface and Experience (UI/UX)**

The user interface of the dashboard should be intuitive and easy to use. Consider conducting user testing to identify any potential issues. Explain how the interface would be easy for non-technical users to understand.

* **Components of the dashboard should** display detailed real-time and summarized historical information on energy consumption. This could include wattage at any minute, energy usage in kWh after each day, daily operating costs, energy usage trend charts, IT load vs. non-IT loads, etc.
* **Control Functionality** (e.g., **simple On/Off**, speed control, temperature control) needs to be implemented.

**Assessment Criteria: Does the dashboard contain all the required information? Is the UI/UX intuitive?**

**Issue: User Manual**

**Prepare a user manual** for the dashboard and demonstrate how to use it.

**Assessment Criteria: Is the User Manual friendly enough for non-tech users to understand?**

**Issue: Future work and Limitations:**

Check if any Energy pattern is detected. Can an Energy profile be developed from this? Could inefficient appliances be identified? Could energy management decisions be taken from this data?

**Assessment Criteria: Did the student consider the future work and limitations?**

**Issue: Installation, Operation and Maintenance**

* Consider the **maintenance requirements** of the system. This could involve regular calibration of sensors, software updates, etc. How often should maintenance be required?

**Assessment Criteria: Did the student consider the periodic maintenance issues? How frequently would maintenance be required?**

**Issue: Recurring costs**

Consider the **cost** of **installation, maintenance, and operation** over the life of the system.

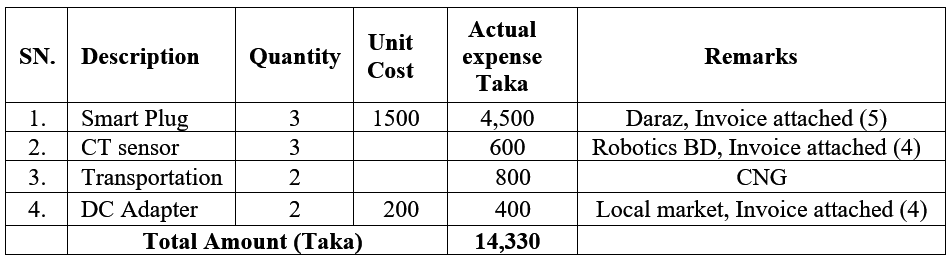
**Assessment Criteria: Did the student consider the recurring costs? Were these costs considered in the ROI and other financial calculations?**

**Issue: Cost Accounting**

Keep track of all expenses related to the hardware and make necessary accounting adjustments.

**Assessment Criteria: Did the student perform accounting adjustments and provided invoices?**

**Sample table showing the costs of the equipment**



**Issue: Business Aspects**

* Consider how submetering can generate or save money. This could involve reducing energy consumption, identifying inefficient devices, etc. **Calculate t**he Return-On-Investment for such a project for your context.
* How much money would you pay for a product or a service like this one? Justify your answer. **Perform valuation of the project.**

**Assessment Criteria: ROI calculated? Justification of the value of the product/service provided? Recurring costs considered?**

**Issue: Real-time data or Stored data**

It is expected that the data will be collected and displayed with acceptable latency, ideally, in real time.

**Assessment Criteria: Can the system handle real-time data?**

**Issue: Data Quality**

Ensure that the data collected is of high quality. Check for any interference or crosstalk with neighboring devices and signals. Also, consider the sampling rate of the data.

**Assessment Criteria: Did the student consider the quality of the data? How were the issues of interference/crosstalk addressed? What was the sampling rate of the data?**

**Issue: Data Security**

Ensure that the data collected is securely stored and transmitted. This is particularly important if you’re dealing with sensitive information.

**Assessment Criteria: Did the student consider the issue of data security?**

**Issue: Scalability**

Consider how the system could be scaled up to monitor larger infrastructures. This could involve adding more sensors or improving the data processing capabilities.

**Assessment Criteria: Did the student discuss how to scale up or down this solution?**

**Issue: Reliability**

Ensure that the system is reliable and can operate continuously without failure. This might involve using high-quality components and implementing fail-safe mechanisms.

**Assessment Criteria: Demonstrate that reliability of the system by discussing and displaying the continuity of the data collection.**

**Issue: Accuracy**

The accuracy of the measurements is crucial. Make sure the sensors and meters you’re using are accurate and calibrated correctly. **Discuss how you calibrated the measurements, or why it was not required.**

**Assessment Criteria: Did the student consider the accuracy and take necessary steps to improve it?**

**Issue: Interoperability**

If the system is to be integrated with other systems (e.g., a building management system), ensure it is compatible and can communicate effectively with these systems.

**Assessment Criteria: Did the student consider the interoperability issues?**

**Issue: Regulatory Compliance**

Depending on your location, there may be regulations governing the collection and use of energy data. **Explain how you made sure that your project complies with the relevant regulations.** (Attach the permission letter from the University authority, for home equipment, refer to the invoice to show that you were the owner. For wireless data transmission, mention that the signal is within the 2.4GHz ISM band. In viva, you may be asked to explain what the ISM band is?)

**Assessment Criteria: Did the student consider the compliance issues and address them?**

**Issue: Environmental Impact**

Consider the environmental impact of your project. This could involve looking at the energy consumption of the monitoring system itself or considering how the project could help reduce overall energy consumption or how mass submetering could help energy management and efficiency.

Additionally, perform a PESTLE analysis to address the impacts from different viewpoints.

**Assessment Criteria: Did the student perform a PESTLE analysis?**

**Issue: SWOT Analysis**

Considering the other solutions for submetering, a **SWOT** analysis could be performed to identify the **drivers** of the solution and **barriers** to implementing the solution.

**Assessment Criteria: Did the student identify the drivers and barriers through a SWOT analysis?**

**Breakdown of marks:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Task** | **Teaching- Learning Method** | **CO** | **Mark of Cognitive Learning Level** | **Mark of Psychomotor Learning Levels** | | **Mark of Affective Learning Level** | **CO Mark** |
| **C3** | **P2** | **P3** | **A2** |
| Monitoring and Controlling the energy consumption, with report, demonstration, and viva.  **(Marks:** *Demonstration: 05, Viva: 05, Report: 05*) | Class Lectures, Discussions, Fieldwork | CO2 | 5 |  | 5 | 5 | 15 |
| **Total** |  |  | **5** |  | **5** | **5** | **15** |

The Midterm Assessment addresses the following ***Complex Engineering Problems (EP).*** The report must mention how EP1 and EP2 were addressed and will be evaluated during the oral examination.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Level** | **Attribute** | **Characteristics of Complex Engineering Problems** | **Rubrics Design** | **Mark** |
| EP1 | Depth of knowledge required | **Cannot be resolved without in-depth engineering knowledge** at the level of one or more of K3, K4, K5, K6, or K8 which allows a fundamental-based, first principles analytical approach | **Analyze** the problem using a specified knowledge profile.  **Evaluate** the problem under such circumstances towards providing an effective solution. | **05** |
| EP2 | Range of conflicting requirements | **Involve wide-ranging or conflicting** technical, engineering, and other issues | **Compare** the conflicting technical, engineering, and other issues arising to solve the problem.  **Assess** the conflicting requirements and provide a satisfactory proposal towards solving the problem. | **10** |