

Introduction to Energy Engineering Capstone

Introduction to Energy Engineering Capstone Project
Course/Program Level: Senior/year undergraduate or graduate

1. Purpose of the Capstone

Goal	What it means for the student	Typical deliverables
Integrate theory & practice	Apply fluid, thermodynamics, heat transfer, and systems modeling concepts learned in earlier courses	Design report, prototype, simulation models
Solve a real-world problem	Work on a challenge supplied by industry, government, or a research lab	Feasibility study, cost-benefit analysis
Develop professional skills	Project planning, team coordination, technical writing, oral presentation	Gantt chart, meeting minutes, poster
Demonstrate innovation	Identify gaps in current energy technologies and propose novel solutions	Patent-style claims, proof-of-concept tests

2. Typical Project Themes

Category	Example Topics	Core Engineering Areas Involved
Renewable Generation	Design of a small-scale solar thermal collector, micro-wind turbine optimization	Solar thermal, aerodynamics, materials
Energy Storage	Modeling a hybrid battery-supercapacitor system for grid support	Electrochemistry, power electronics, control
Energy Efficiency	Retrofit of HVAC system in a commercial building using IoT sensors	Thermodynamics, building science, data analytics
Carbon Management	Life-cycle assessment of a bio-fuel production pathway	LCA methodology, process integration, economics
Smart Grids & Microgrids	Real-time dispatch algorithm for a campus microgrid with renewable sources	Power systems, optimization, communications

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3. Project Lifecycle (Step-by-Step)

Project

Phase	Key Activities	Typical Outputs
1. Problem Definition	• Meet sponsor/mentor • Clarify objectives, constraints, success criteria	Project charter, stakeholder matrix
2. Literature & Technology Review	• Survey patents, journals, standards • Identify knowledge gaps	Annotated bibliography, technology gap analysis
3. Concept Generation	• Brainstorm alternatives • Perform preliminary sizing calculations	Concept sketches, decision matrix
4. Feasibility & Trade Study	• Energy balance, thermodynamic cycles, exergy analysis • Cost estimation (CAPEX/OPEX)	Feasibility report, Pareto chart
5. Detailed Design	• CAD/CFD modeling, circuit schematics, control algorithms • Component selection	3D models, simulation files, BOM
6. Prototype / Simulation	• Build hardware or run high-fidelity simulations • Collect performance data	Test plan, data logs, validation plots
7. Evaluation & Optimization	• Compare results with design targets • Sensitivity analysis	Performance summary, optimization recommendations
8. Documentation & Presentation	• Write final report, prepare poster/slides • Conduct defense or demo	Final report, presentation deck, video demo
9. Reflection & Knowledge Transfer	• Capture lessons learned, update project repository	Lessons learned log, handover documents

4. Core Technical Content

Subject	Typical Application in the Capstone
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Thermodynamics & Heat Transfer

Cycle analysis (Rankine, Brayton), heat exchanger design, thermal storage sizing

Fluid Mechanics

Aerodynamic performance of turbines, pump/pipe network analysis, CFD for flow optimization

****Electrical**