



Western Technical College

## 10660164 Energy Storage Solutions

### Course Outcome Summary

#### Course Information

<b>Description</b>	This course will cover energy storage from renewable energy sources allowing continuous energy production from an intermittent supply. Students will investigate current and emerging battery technology storage options along with capacitor storage solutions. Other types of energy storage will also be discussed such as compressed air, pumped water storage, flywheel storage as well as any new or emerging technologies as they become available.
<b>Career Cluster</b>	Architecture and Construction
<b>Instructional Level</b>	Associate Degree Courses
<b>Total Credits</b>	3
<b>Total Hours</b>	54

#### Pre/Corequisites

Prerequisite 10481108 Energy Modeling 2

#### Textbooks

*Photovoltaic Systems – with CD*. 3rd Edition. Copyright 2012. Dunlop, James. P. Publisher: American Technical Publishers, Inc. **ISBN-13:**978-1-935941-05-7. Required.

#### Learner Supplies

Safety glasses with side eye protection that meet Z87 OSHA guidelines. **Vendor:** Campus Shop. Required.  
Amatrol 206-CSUB4 Elearning License. **Vendor:** Campus Shop. Required.

#### Course Competencies

##### 1. Explore the need for energy storage solutions.

###### Assessment Strategies

1.1. Oral Presentation

###### Criteria

*You will know you are successful when*

- 1.1. you justify the chosen storage system.
- 1.2. you describe pros and cons of chosen storage system.
- 1.3. you explain it's effect on the supply curve.

#### **Learning Objectives**

- 1.a. Research wasted capacity.
- 1.b. Explore renewable energy variability.
- 1.c. Examine the energy demand curve compared to the supply curve.

## **2. Explore current technologies for storing energy.**

#### **Assessment Strategies**

- 2.1. Written Objective Test

#### **Criteria**

*You will know you are successful when*

- 2.1. you calculate energy density for a storage system.
- 2.2. you explain the different types of storage.
- 2.3. you describe the pro and cons of the different types of storage technology.

#### **Learning Objectives**

- 2.a. Explore the history of energy storage.
- 2.b. Explore hydro pumped storage.
- 2.c. Explore battery storage.
- 2.d. Explore mechanical storage.
- 2.e. Explore pumped gas storage.
- 2.f. Explore capacitor storage.

## **3. Analyze current and emerging battery storage technology.**

#### **Assessment Strategies**

- 3.1. Project

#### **Criteria**

*You will know you are successful when*

- 3.1. you construct a battery bank.
- 3.2. you calculate the energy density of the battery bank.
- 3.3. you measure the energy output of the battery bank.
- 3.4. you use an electronic load to measure battery bank performance.

#### **Learning Objectives**

- 3.a. Explore types of lithium ion batteries.
- 3.b. Explore flow batteries.
- 3.c. Identify trends in battery storage and technology.
- 3.d. Examine how and where batteries are used.
- 3.e. Examine energy discharge rates for batteries (i.e heat).
- 3.f. Examine different battery chemistries and their energy densities.

## **4. Examine pumped and compressed energy storage systems.**

#### **Assessment Strategies**

- 4.1. Scenario Response
- 4.2. Written Objective Test

#### **Criteria**

*You will know you are successful when*

- 4.1. you explain the ethical implications for pumped hydro storage.
- 4.2. you calculate the pumped storage potential for a site.
- 4.3. you discuss the potentials of compressed storage.
- 4.4. you identify the needs for compressed storage based on geographical location.
- 4.5. you calculate the potential storage capacity for compressed storage.

- 4.6. you compare and contrast pumped storage to compressed storage.
- 4.7. you identify the safety concerns with pumped and compressed storage.

**Learning Objectives**

- 4.a. Examine how surplus capacity is saved, stored and used.
- 4.b. Identify geographic locations for pumped hydro storage.
- 4.c. Identify geographic locations for compressed energy storage.
- 4.d. Research reasons for storing energy in compressed or pumped systems.

**5. Explore the use of mechanical systems to store energy.**

**Assessment Strategies**

- 5.1. Oral Presentation
- 5.2. Project

**Criteria**

*You will know you are successful when*

- 5.1. you describe the energy storage in a flywheel system.
- 5.2. you explain how the energy is extracted from a flywheel system.
- 5.3. you explain the conversion from mechanical to electrical energy.
- 5.4. you identify the conversion efficiency of a flywheel system.
- 5.5. you design a flywheel system with a generator.
- 5.6. you build the flywheel based on design.
- 5.7. you test the energy output of the flywheel.
- 5.8. you troubleshoot the system and make revisions based on measurements or observations.

**Learning Objectives**

- 5.a. Define flywheel storage (vacuum, open air, etc.).
- 5.b. Calculate storage potential from flywheels.
- 5.c. Explore current flywheel usage.
- 5.d. Examine components of a functioning flywheel.
- 5.e. Design a flywheel system.
- 5.f. Collaborate with team to design and construct the flywheel system.

**6. Explore current and future usage of capacitors for storing energy.**

**Assessment Strategies**

- 6.1. Project

**Criteria**

*You will know you are successful when*

- 6.1. you list the different types of capacitors.
- 6.2. you select a capacitor type for your project.
- 6.3. you calculate the amount of storage for your capacitor.
- 6.4. you contrast the allowable DOD of a capacitor system compared to a battery system.
- 6.5. you test your capacitor system.
- 6.6. you measure and verify the output using electronic load.

**Learning Objectives**

- 6.a. Define different types of capacitors (electrolytic, Mylar, ceramic, etc.).
- 6.b. Calculate the amount of storage.
- 6.c. Measure the amount of usable storage.
- 6.d. Identify the components of a capacitor storage system.
- 6.e. Construct a capacitor storage system.
- 6.f. Explore high-capacity capacitors.
- 6.g. Define allowable depth of discharge (DOD) of a capacitor system compared to a battery system.

**7. Construct an energy storage project.**

**Assessment Strategies**

- 7.1. Project

**Criteria**

*You will know you are successful when*

- 7.1. you describe the project focus.
- 7.2. you define the need for energy storage.
- 7.3. you list the components of the storage system.
- 7.4. you describe what each components in the system will do.
- 7.5. you integrate the components together in a system.
- 7.6. you identify how each component interacts within a storage system.
- 7.7. you test the operation of your storage system.
- 7.8. you troubleshoot and repair as needed.

**Learning Objectives**

- 7.a. Identify a project focus.
- 7.b. Identify project components.
- 7.c. Calculate the storage capacity.
- 7.d. Construct the storage project.
- 7.e. Test and measure the storage project.
- 7.f. Verify the calculations.
- 7.g. Troubleshoot system to correct errors.