



Investigate and Innovate with CSIRO

# Thermal Energy Storage

**Year level:** Years 5-6, 7-8, 9-10

**Duration:** Teacher specified

**Core concepts:** renewable energy storage and Australia's energy transition

## Teacher guide



### Acknowledgement of Country

CSIRO acknowledges the Traditional Owners of the lands, seas and waters of the area that we live and work on across Australia. We acknowledge all Aboriginal and Torres Strait Islander peoples and their continuing connection to their culture and pay our respects to Elders past and present. CSIRO is committed to reconciliation and recognises that Aboriginal and Torres Strait Islander peoples have made contributions to all aspects of Australian life including culture, economy and science.



'Eternal Wisdom,  
Infinite Innovation'  
artwork by Rachael Sarra, working  
with Gilimbaa.

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## Overview

### *Safety considerations:*

- It is recommended to hold a class discussion regarding the possible risks and mitigation strategies prior to starting the activity.
- Appropriate PPE should be worn during this activity.
- **Caution:** students should be supervised while building the solar trough and while removing objects from the solar trough as they may be very hot.

### Key learning goals:

Slide 3 in Thermal Energy Storage – Thermal Energy Classroom Power Point Presentation.

CSIRO research: [Concentrated solar thermal research - CSIRO Book \(Page 14\)](#)

Concentrated Solar Thermal (CST) technology uses many sun-tracking mirrors, called heliostats, to focus sunlight onto a tower to create very high temperatures. This heat can be used to make steam to generate electricity or to power industrial processes. CSIRO's solar research centre in Newcastle has Australia's largest solar tower facility, where scientists are testing ways to store and use this heat more efficiently even when the sun isn't shining. Their research includes using hot particles and special metals to store solar energy and developing new ways to make hydrogen fuel from sunlight. This work helps industries reduce greenhouse gas emissions and move towards a cleaner, more sustainable energy future for Australia.

Associated documents: [Investigate and Innovate with CSIRO webpage](#)

- Thermal Energy Storage - Student Workbook
- Thermal Energy Storage - Classroom PowerPoint Presentation (PPT)
- Australian Curriculum and Syllabus links and rubrics

### Icons:

Throughout the investigation you will see these icons (below) to highlight the type of activity and guidance recommended.



# What is the LIA Framework?

The Australian Academy of Science Launch, Inquire, Act (LIA) framework helps us structure scientific investigations so that students:

- **Launch** by exploring and connecting to real-world phenomena,
- **Inquire** by investigating and analysing questions, and
- **Act** by applying, communicating and reflecting on our findings.

It's a way to learn science like real scientists do!

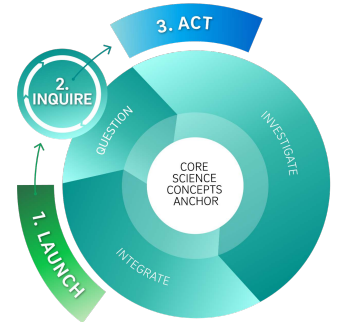





Figure 1 LIA Framework from the Australian Academy of Science.

<b>PHASE 1: LAUNCH</b>	<p><b>Purpose:</b> get curious, connect to the world, and ask a great question.</p> <p><b>What you'll do:</b> Explore a phenomenon or scenario. Think about your own experience and ask: "What's going on here?". Identify what you already know and what you wonder about. Discuss why the topic matters.</p> <p><b>Key questions:</b></p> <ul style="list-style-type: none"> <li>• What do I see or experience?</li> <li>• What might be happening?</li> <li>• Why is this important?</li> </ul>	 <b>Launch</b>
<b>PHASE 2: INQUIRE</b>	<p><b>Purpose:</b> design and carry out an investigation to answer your question.</p> <p><b>What you'll do:</b> Formulate a testable question. Plan your investigation: decide variables, controls, method. Collect data (measure, record, repeat). Graph and analyse results to spot trends or patterns.</p> <p><b>Key questions:</b></p> <ul style="list-style-type: none"> <li>• What variables will I change, and what will I measure?</li> <li>• How will I make it reproducible?</li> <li>• What do my results show?</li> </ul>	 <b>Inquire</b>
<b>PHASE 3: ACT</b>	<p><b>Purpose:</b> use your findings to communicate, reflect, and apply to the real world.</p> <p><b>What you'll do:</b> Draw conclusions based on your evidence. Reflect on your method: what worked, what could you improve? Apply your understanding: how does your investigation link to real-life scientific research or technology? Share your findings through a poster, presentation, or video.</p> <p><b>Key questions:</b></p> <ul style="list-style-type: none"> <li>• What did I learn and why does it matter?</li> <li>• How could I do better next time?</li> <li>• How can this knowledge be used in the real world?</li> </ul>	 <b>Act</b>

## Scientific Inquiry Continuum

The Scientific Inquiry Continuum describes the progression from teacher-directed to student-directed investigation. It supports educators in scaffolding investigation experiences so that students gradually develop the skills and confidence to think, question, and work like scientists.

This continuum is referenced throughout the investigation to help teachers identify the level of inquiry embedded in each activity. Educators are encouraged to move flexibly along the continuum based on students' prior knowledge, readiness, and learning context.

To explore the concept further, please complete [‘The Power of Inquiry and Explicit Teaching: A Dual Approach to Teaching and Learning’ e-Module linked here.](#)

### *Scientific Inquiry Continuum*



#### **Limited Inquiry**

Also referred to as closed or confirmation, can be used for novice learners that may need more structure and scaffolding when introducing new learning concepts. The teacher provides the question(s), method(s), and expected results. Students confirm known principles through structured activities.

#### **Structured Inquiry**

Ideal for learners who can manage investigations with guidance. The teacher provides the question and method, but students collect and interpret their own data to reach conclusions

#### **Guided Inquiry**

Supports students developing independence and ownership of their learning. Promoted higher-order thinking and critical analysis. The teacher provides the question(s), but students design and carry their own methods, collect data and draw conclusions.

#### **Open Inquiry**

Student designed and are highly successful once students are proficient in managing independent learning or when a concept needs to be extended for students beyond the key outcomes.

The slides and activities throughout this investigation are labelled with icons that indicate the corresponding inquiry stage. These markers are intended as a guide only. Please use professional judgment to adapt, combine, or re-sequence activities to suit the learners and curriculum goals.

## Classroom PowerPoint (PPT) presentation guide

In the PPT, activities correspond with a specific stage or stages of the Scientific Inquiry Continuum and the Australian Academy of Science Education Launch, Inquire, Act (LIA) Framework to guide teachers and students through a thermal energy storage investigation.

Consult the equipment lists (Investigation: Build a solar trough – Page 12) provided in each investigation and adjust resource items and quantities according to student or group numbers.

Inquiry and Framework stages	Slide # Classroom PowerPoint Presentation (PPT) Page # (Student Workbook)	Teacher guidance	Student guidance
	<b>Slide 2</b> <b>Page 3</b>	Teacher reference slide – Scientific Inquiry Continuum, LIA Framework and icon explanation.	Student reference sheet – Launch, Inquire, Act (LIA) framework and icon explanation.
	<b>Slide 3</b>	Learning Objectives – each colour represents the stage of the Scientific Inquiry Continuum.	
<b>Limited, Structured, Guided - Launch</b>	<b>Slide 4</b> <b>Page 4</b>	<i>Launch phase – Formative assessment</i> - Lead the initial discussion on ‘Thermal Energy Storage’ by encouraging a whole class discussion, think-pair-share and independent recording of prior knowledge of the student workbook on Page 4.	<i>Launch phase</i> - Students record initial thoughts/prior knowledge on Page 4 in workbook.  Refer to Page 3 to explore ‘Launch Phase’ in more detail, if required.
	<b>Slides 5-8</b>	Explore ways we store a variety of household items and electricity through a whole-class discussion. Record initial thoughts on the board. Refer to presenter notes for discussion starters.	Participate in whole-class discussion.

	<p><b>Slide 9</b> <b>Page 5</b></p>	<p><i>Formative assessment -</i> Guide students to complete the 'Thermal Energy Storage' pre-investigation knowledge assessment on Page 5. Students will then complete the same activity at the end of the investigation to compare their knowledge. Possible answers can be found in the Classroom Presentation presenter notes.</p>	<p>Complete Page 5 'Thermal energy storage Attempt 1' at the beginning of the investigation and 'Attempt 2' at the end of the investigation.</p>
	<p><b>Slides 10-11</b> <b>Page 6</b></p>	<p><i>Formative assessment -</i> Explore concentrated solar thermal energy technology and ambient solar radiation through observation of the solar heliostat field and tower at CSIRO's solar thermal research facility and a parabolic trough solar collector.  Pose the questions to the students (Questions are found in the presenter notes) and instruct the students to complete the labelling activity on Page 6. Answers can be found on Slide 42</p>	<p>Students label the features of the solar heliostat field and tower at CSIRO's solar thermal research facility and a parabolic trough solar collector.</p>
	<p><b>Slide 12</b></p>	<p>Watch the video, 'The energy transition and the future of renewable energy storage'.  Refer to presenter notes for extension discussions.</p>	<p>Watch the video 'The energy transition and the future of renewable energy storage'. Contribute to discussion.</p>
<p>Limited, Structured, Guided – Inquire</p>	<p><b>Slide 13</b> <b>Page 3</b></p>	<p><i>Inquire Phase –</i> Explain the purpose of the inquire phase to design and carry out an investigation to answer the focus question.</p>	<p>Refer to Page 3 to explore 'Inquire Phase' in more detail, if required.</p>
	<p><b>Slides 14-15</b> <b>Page 7</b></p>	<p>Explore 'Inquire' phase by comparing/contrasting concentrated solar thermal technology and ambient solar heating/radiation.</p>	<p>Complete Page 7 comparing/ contrasting concentrated solar thermal technology and</p>

			ambient solar heating/radiation.
	<p><b>Slides 16-24</b> <b>Page 8-9</b></p>	<p>Explore the Question Formulation Technique (QFT) process with your students (slide 16). Explain 'Rules for generating questions' on slide 17 preparing students for the activity. Show the students the concentrated solar thermal technology and ambient solar heating/radiation images (slide 18) as stimulus for generating a focus question. Complete the phases of the QFT (instructions on each slide and presenter notes):</p> <ol style="list-style-type: none"> <li>1. Produce – Slide 19 (<i>Optional – use sticky notes for this activity</i>).</li> <li>2. Improve - Slide 20</li> <li>3. What makes a good question? - Slide 21</li> <li>4. Refine – Slide 22</li> <li>5. Prioritise – Slide 23</li> <li>6. Focus question breakdown - Slide 24 (See presenter notes for focus question example).</li> </ol>	<p>Students independently, with a partner and/or in groups of 3-4 complete Page 8 – Investigation focus question activity during the 'Produce' phase of the QFT.</p> <p>Students complete Page 9 with their group to identify their focus question.</p>
	<p><b>Slides 25-29</b> <b>Pages 10-23</b></p>	<p>Guide students to complete the investigation – Build a Solar Trough.</p> <p>Start with the introduction of the quote "<i>Only mad dogs and Englishmen go out in the midday sun</i>" and discuss.</p> <p>Refer to presenter note on Slide 25 for introduction to the investigation.</p> <p><b>Note:</b> <i>If additional brainstorming is required, please refer to the 'Open Inquiry' Planning page 38.</i></p> <p>Slide 26 – Investigation: Build a Solar Tough</p>	<p>Students record their focus question, variables and prediction (Page 10-11) and work through investigation (Pages 12-14). Students can keep a detailed 'Process Diary (Pages 15-20) throughout the investigation. Students can also record their results/findings (Pages 21-22) to inform them of the next phase of the investigation.</p>

		<p>(Instructions in presenter notes)</p> <p>Slide 27 – Part 1: Build a Solar Trough (Instructions on the slide)</p> <p>Slide 28 – Part 2: Heating the Object (Instructions on the slide)</p> <p>Slide 29 – Part 3: Recording Thermal Energy (Instructions on the slide)</p> <p><b>Note:</b> <i>Equipment list, method and diagrams are available in the Student Workbook Pages 12-14).</i></p> <p><i>For Limited and Structured – consider dividing the class and have one half conduct the investigation outside (direct sunlight) and one half of the class conduct the investigation inside (indirect/filtered sunlight through a glass window).</i></p>	
	<p><b>Slide 30-33</b> <b>Pages 23-25.</b></p>	<p>Lead whole-class discussion comparing observations of the investigation and analysis of results.</p> <p>Slide 30- Analysis</p> <p>Slide 31-Discussion</p> <p>Slide 32-Evaluation</p> <p>Slide 33- Conclusion</p> <p>Guide the students to compare their initial prediction of the investigation (Page 11) to the results of their investigation (Page 21-22).</p> <p>Instruct the students to complete the analysis, discussion, evaluation, and conclusion questions on Pages 23-25.</p>	<p>Students complete the analysis, discussion, evaluation, and conclusion questions on Pages 23-25.</p>

<p><b>Slide 34</b> <b>Page 3</b></p>	<p><i>Act Phase</i> – Explain the purpose of the act phase as using the findings of the investigation to communicate, reflect, and apply to the real world.</p>	<p>Refer to Page 3 to explore the ‘Act Phase’ in more detail, if required.</p>
<p><b>Slides 35-36</b> <b>Slides 37-38 (optional)</b> <b>Page 26</b></p>	<p>Watch videos on Slides 35-36 and lead discussion about types of decarbonisation initiatives within the thermal energy space in Australia.</p> <p>Slide 35 – MGA Thermal Demonstration Plant – Decarbonising Industrial Heat Slide 36 – CSIRO’s Concentrated Solar Heliostat Field</p> <p><i>Summative Assessment</i> - Guide students to complete the ‘Thermal Energy Storage’ post-investigation knowledge assessment on Page 5 of the student workbook. Students can compare their knowledge.</p> <p><i>Optional - Structured inquiry</i> – Slides 37- 38 – additional guidance for discussion and diagram activity. Notes to lead discussion can be found in the presenter notes.</p>	<p>Participate in whole-class discussion and watch the videos. <i>Optional</i> - complete the diagram activity on Page 26.</p> <p>Complete ‘Attempt 2’ of the Thermal Energy Storage’ post-investigation knowledge assessment on Page 5.</p>
<p><b>Slide 39</b> <b>Pages 27-28</b></p>	<p><i>Summative Assessment</i> - Explain how students will present their results and communicate their understanding of thermal energy storage. Students can use Pages 27-28 to plan their presentations.</p> <p>Provide ample class time for the students to plan, prepare and present their work to the class. Instructions for</p>	<p>Students will prepare a presentation and use Pages 27-28 to plan.</p>

		group presentation can be found on slide 39.	
	<b>Slide 40 Page 29-30</b>	Instruct the students to complete the Investigation Reflection page independently.	Students to complete the Investigation Reflection page independently.
	<b>Slides 41 Page 29</b>	Glossary – teacher to determine whether students populate the glossary independently (on Page 44) or through explicit teaching.	Students to complete glossary on Page 44.

## Additional resources

	<b>Slide # Classroom PowerPoint Presentation (PPT) Page # (Student Workbook)</b>	<b>Teacher guidance</b>	<b>Student guidance</b>
<b>Open Inquiry – Launch, Inquire, Act</b>	<b>Pages 33-43</b>	For students engaging in the Open Inquiry for Thermal Energy Storage provide the ‘Science Investigation Planner’ pages to guide them through their independent investigation.	Independently work through the ‘Science Investigation Planner’ pages 33-43 to explore the Thermal Energy Storage topic.
<b>Optional Supplemental Resources</b>	<b>Pages 15-20</b>	Process Diary – Optional	
	<b>Page 31-32</b>	Take it further – Optional extension activities	
	<b>Pages 45-49</b>	Page 45 – Notes Pages 46-47 – Research Journal Page 48 – Graph paper (5mm) Page 49 – Graph paper (10mm)	



## Formative and summative assessments

FOR REFERENCE: (CLASSROOM PPT SLIDE #/STUDENT WORKBOOK PAGE #)

### Formative

- About the topic (Slide 4/Page 4) – Assess students' initial ideas, experience, and any connections they may have about thermal energy storage.
- Thermal energy storage pre and post assessment (Slide 9/Page 5) before and after the investigation to assess an increase in learning before and after the investigation.
- Label solar thermal heliostat and parabolic trough solar collector (Slides 10-11/Page 6)

### Summative

- Student presentation (Slide 39/Pages 27-28) can be assessed used to assess students learning. Refer to the 'Investigate and Innovate with CSIRO Australian Curriculum and Syllabus links and rubrics' document for assessment guidance.

## EXAMPLE - Thermal Energy Storage – Lesson overview

Teachers can use this example unit of work to guide their planning.

Week / Lesson	Lesson Duration	LIA Phase	Thermal Energy Focus	Student Instruction	Teacher Instruction
Week 1 – Lesson 1	60 min	Launch	<b>Introduction &amp; Context</b> – Exploring how solar energy can be stored as heat.	Participate in the “hook” activity (image/video/discussion on solar thermal systems). Complete a short pre-quiz to share prior knowledge.	Introduce the unit context (Australia’s renewable energy goals). Facilitate pre-diagnostic quiz and discussion on energy storage challenges.
Week 1 – Lesson 2	60 min	Launch	<b>Question Generation (Question Formulation technique) &amp; Planning</b> – Turning curiosity into testable questions.	Brainstorm broad questions about solar energy and heat. Work in groups to refine one question into a testable investigation. Identify variables and draft a simple method.	Guide question development. Explicitly teach independent/dependent/controlled variables. Support students in designing a reproducible test plan.
Week 2 – Lesson 3	60 min	Launch → Inquire	<b>Safety &amp; Skills Practice</b> – Building investigation skills before the experiment.	Practise measuring temperature accurately and handling hot objects safely. Conduct a mini-practical activity using a safe heat source to collect and log data.	Model correct thermometer use, timing, and data recording. Lead safety briefing and reinforce lab procedures.
Week 3 – Lessons 4–5	2 × 60 min (or 1 × 90 min double)	Inquire	<b>Constructing the Solar Trough</b> – Applying design and STEM skills to build equipment.	Follow a template to cut, assemble, and line the solar trough with reflective material. Perform simple quality assurance (QA) check with peers.	Provide templates and supervise construction. Ensure safety during cutting and assembly. Encourage teamwork and precision.
Week 4 – Lesson 6	60 min	Inquire	<b>Pilot Testing &amp; Method Refinement</b> – Trial run to refine variables and data accuracy.	Conduct a short outdoor pilot investigation to test setup, placement, and thermometer readability. Adjust procedure based on findings.	Support troubleshooting of equipment and data collection issues. Facilitate reflection discussion on refining the method.

<b>Week 5 – Lessons 7–8</b>	2 × 60 min (or 1 × 90 min double)	<b>Inquire</b>	<b>Main Data Collection</b> – Comparing concentrated and ambient solar radiation.	Carry out full investigation outdoors. Collect temperature data at set intervals, ensuring consistency and repeatability.	Supervise outdoor testing and ensure safety protocols. Support timing intervals and data recording accuracy.
<b>Week 6 – Lesson 9</b>	60 min	<b>Inquire → Act</b>	<b>Data Clean-up &amp; Initial Analysis</b> – Organising results and identifying patterns.	Input data into tables or spreadsheets. Identify outliers, calculate averages, and discuss initial observations.	Model data organisation and demonstrate error-checking. Provide feedback on accuracy of results.
<b>Week 7 – Lesson 10</b>	60 min	<b>Act</b>	<b>Graphing &amp; Sense-Making</b> – Visualising results and interpreting findings.	Graph temperature over time for both ambient and concentrated conditions. Annotate and interpret trends.	Guide students through constructing accurate graphs. Prompt critical thinking with questions like “What does this tell us about heat storage efficiency?”
<b>Optional Week 8 – Lesson 11</b>	60 min (weather contingency)	<b>Inquire → Act</b>	<b>Indoor Repeat or Comparison Test</b> – Using lamps or infrared sources if outdoor testing not possible.	Replicate test indoors with alternate heat source to compare energy transfer.	Provide substitute materials and assist students in comparing new data with prior results.
<b>Week 8–9 (Extension)</b>	60 min	<b>Act</b>	<b>Reflection &amp; Connection to Research</b> – Applying learning to real-world science.	Reflect on results and reliability. Research how CSIRO and MGA Thermal use similar principles in real energy storage. Present key findings.	Facilitate group discussions linking classroom investigation to Australian Concentrated Solar Thermal technology (CST) research. Support final reflection and presentation preparation.

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**Contact us**

1300 363 400

+61 3 9545 2176

[csiro.au/contact](https://www.csiro.au/contact)

[csiro.au](https://www.csiro.au)

**For further information**

**CSIRO Education and Outreach**

1300 363 400

[education@csiro.au](mailto:education@csiro.au)

[csiro.au/education](https://www.csiro.au/education)